Heartland Network Monitoring Plan
Developed for the National Park Service
Inventory and Monitoring Program:

Phase I

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Statement of Purpose

The Heartland Network Monitoring Program will deliver current, consistent, and credible information on the condition of key natural resources within participating parks.

The Heartland Network will

collect, analyze, summarize, and report the most current information on status and trends for each park

use the latest applicable technologies to acquire data through field activities and remote sensing.

where possible, place information into a larger regional context via collaboration with outside partners

involve experts from universities and elsewhere to augment our research and analytical capabilities and to help us develop new monitoring techniques where needed

use rigorous quality assurance procedures to verify the accuracy of our estimates and validate our analytical results in order to produce verifiable results

As a result Park Management, as well as other Federal, State, and County agencies and interested organizations and individuals will be able to rely on the credibility of the Heartland Network's information to make critical management and policy decisions.

ACKNOWLEDGMENTS

The Heartland Network monitoring program is the result of the dedication and hard work of a lot of people within and outside the National Park Service. The authors particularly wish to thank the Heartland Network parks' Superintendents for their support of the program and the Natural Resource Managers and other park personnel for their time and most especially their input into the development of the Heartland Network Monitoring Program.

1 Introduction to Phase I Report

The Heartland Network Monitoring Plan will ultimately document the foundation of the network's long-term natural resource monitoring program. This Phase I document includes sections one through three of the overall plan. The first two sections record the 'institutional history' - long-term natural resource monitoring in the NPS and individual Heartland Network parks. The next four sections outline the 'scientific platform' - statistical rigor and scientific credibility of the monitoring work. The last several sections establish a 'work plan' - monitoring implementation and reporting mechanisms. (Phases II and III will include the balance of the Monitoring Plan sections. Phase II will be available on April 1, 2003 and Phase III on April 1, 2004.)

Knowledge about the condition of the natural resources within the Heartland Network parks is fundamental in order to conserve and manage them. The servicewide goals of the National Park Service's (NPS) Inventory and Monitoring (I&M) Program are:

- To determine status and trends
- To provide early warning
- To provide data to understand the nature and condition of ecosystems and to provide reference points
- To provide data to meet legal and Congressional mandates
- To provide a measure towards performance goals

On a Servicewide level, the characteristics of an effective monitoring program are defined as:

- Being relevant to current management issues
- Able to anticipate future issues
- Scientifically credible
- Providing information to managers and researchers in a timely manner
- Linking directly to management decision-making

This Monitoring Plan is unique to the Heartland Network, one of thirty-two networks in the NPS I&M program. The Heartland Network includes 15 parks; eleven of which are non-prototype parks and four Prairie Cluster prototype parks. In the Heartland Network, the Prairie Cluster is responsible for the monitoring activities, budgeting, and reporting related to the prototype parks and TAPR. The Heartland Network is responsible for overseeing monitoring activities, budgets, and reporting related to non-prototype parks, except TAPR. Funding sources dedicated to all 15 Heartland Network parks (e.g., NPS Water Resources Division (WRD) monitoring funds), afford the opportunity for all 15 parks to collaborate on monitoring activities. Hence, this Monitoring Plan includes descriptions of all 15 Heartland Network parks, full monitoring program information for the non-prototype parks, and aquatic monitoring program information for prototype parks. Additional monitoring information for the prototype parks is available from the Prairie Cluster.

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2 Introduction and Background

2.1 Heartland Network and NPS I&M Program

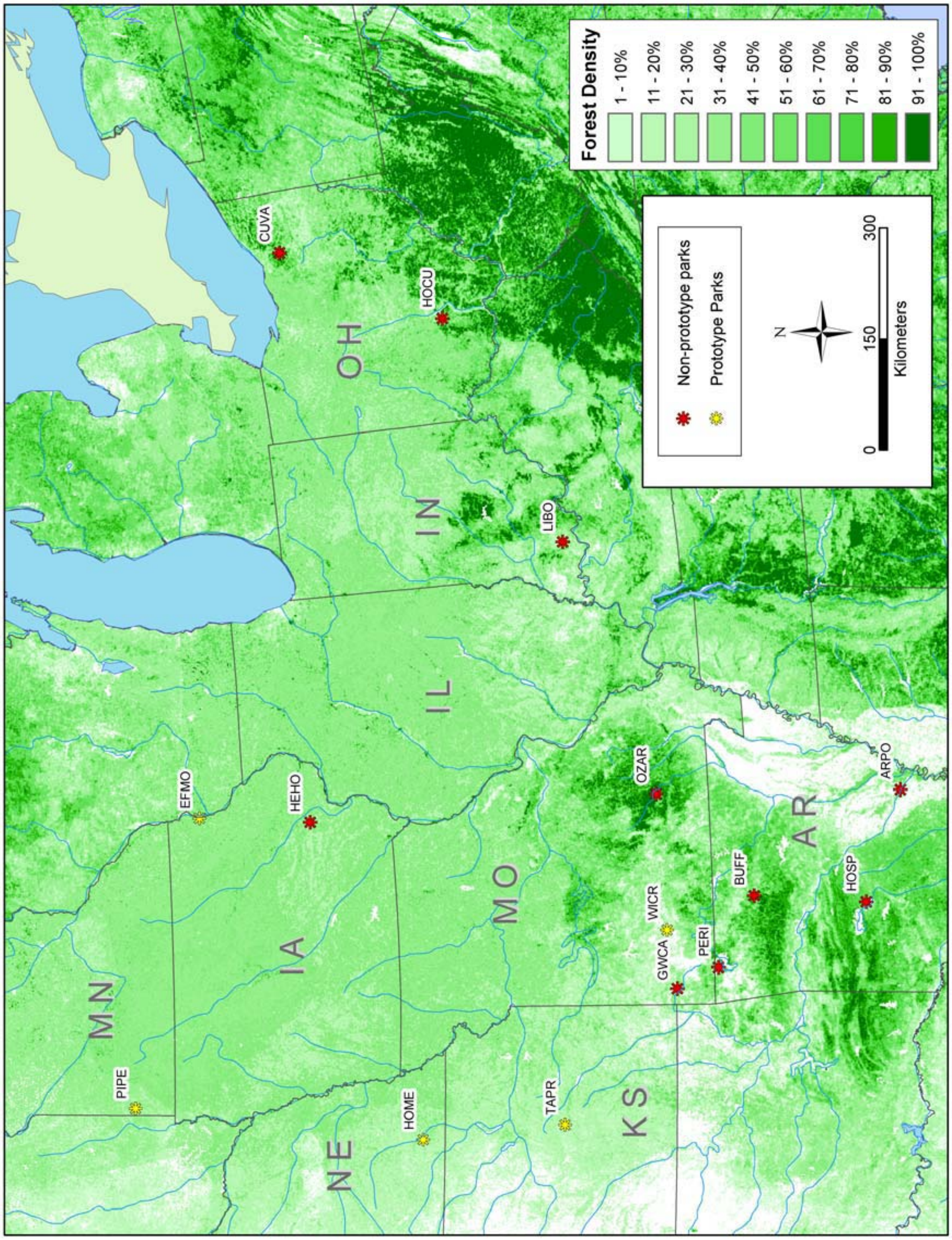
2.1.1 Structure of the Heartland Network

This Monitoring Plan is unique to the Heartland Network, one of thirty-two networks in the National Park Service (NPS) Inventory and Monitoring (I&M) Program. The I&M networks were organized to efficiently inventory and monitor the natural resources of the member parks. The Heartland Network is an affiliation of 15 parks within the Midwest Region. The Heartland Network is composed of Washington funded staff and Arkansas Post National Memorial (ARPO), Buffalo National River (BUFF), Cuyahoga Valley National Park (CUVA), Effigy Mounds National Monument (EFMO), George Washington Carver National Monument GWCA), Herbert Hoover National Historic Site (HEHO), Homestead National Monument of America (HOME), Hopewell Culture National Historical Park (HOCU), Hot Springs National Park (HOSP), Lincoln Boyhood National Memorial (LIBO), Ozark National Scenic Riverways (OZAR), Pea Ridge National Military Park (PERI), Pipestone National Monument (PIPE), Tallgrass Prairie National Preserve (TAPR), and Wilson's Creek National Battlefield (WICR).

Four of the Heartland Network parks are part of the 'Great Plains Prairie Cluster Prototype'. Established in mid-1990s, the Prairie Cluster was the first prototype monitoring effort to address monitoring in small parks. Prairie Cluster staff collect monitoring data at HOME, EFMO, PIPE, WICR, Agate Fossil Beds National Monument (AGFO), and Scott's Bluff National Monument (SCBL). The latter two parks are in the Northern Great Plains Network. The overall goals of the Prairie Cluster are to assess the effectiveness of resource management and to detect any degradation of park natural resources from external threats. Sampling protocols address three high-priority management issues: (1) sustainability of small remnant and restored prairie ecosystems, (2) the effects of external land use and watersheds on small prairie preserves, and (3) the effects of fragmentation on biological diversity in small prairie parks.

Based on funding allocation, the level of monitoring conducted by the prototypes in the NPS I&M program is more comprehensive and more intensive than what the networks will be able to undertake. In the Heartland Network, the Prairie Cluster Prototype staff and parks are responsible for the monitoring activities, budgeting, and reporting related to the prototype parks and TAPR. The Heartland Network staff, Board of Directors, Technical Committee, and parks are responsible for overseeing monitoring activities, budgets, and reporting related to non-prototype parks, except TAPR. Funding sources dedicated to all 15 Heartland Network parks (e.g., NPS Water Resources Division (WRD) monitoring funds), afford the opportunity for all 15 Heartland Network parks to collaborate on monitoring activities. Hence, this Monitoring Plan includes descriptions of the 15 Heartland Network parks, full monitoring program information for the non-prototype parks, and aquatic monitoring information for prototype parks. Additional monitoring information for the prototype parks is available from the Prairie Cluster.

Figure 2.1 Locations of the 15 Heartland Network parks (Source: USDA, 1991)



2.1.2 Purpose of the National Park Service's Long Term Natural Resource Monitoring Program

An understanding of the current and projected conditions of natural resources in national parks is fundamental to the National Park Service's (NPS) ability to protect and manage parks. National Park managers are confronted with increasingly complex and challenging issues, and managers are being asked to provide scientifically credible data to defend management actions. The purpose of monitoring is to develop broadly based, scientifically sound information on both current status and long-term trends in composition, structure, and/or function of park ecosystems. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage park resources (Fancy 2002).

Many of the threats to park resources, such as exotic species and air and water pollution, originate from areas outside of the park boundaries, thereby resulting in the need for an ecosystem approach to understand and manage the park's natural resources. Long-term ecosystem monitoring is essential for several reasons: to enable managers to make better informed management decisions, to provide early warning of abnormal conditions in sufficient time to develop effective mitigation measures, to convince other agencies and individuals to make decisions that also benefit parks, to satisfy the mission of the NPS as defined in legislation and policy, and to provide reference data from relatively pristine sites for comparison with data collected outside of parks (Fancy 2002).

The NPS Inventory and Monitoring (I&M) Program will chart the course and provide the leadership and information resources needed by the NPS to preserve and protect natural resources placed under its trust by the American people into the 21st Century and beyond. Through its accomplishments, the I&M Program will further enhance the stature of the NPS as an international leader in natural resources management and stewardship (NPS-75).

2.1.3 Legislation and NPS Policy and Guidance

The National Park Service Organic Act of 1916 established the goal of the NPS to "conserve" resources in an "unimpaired state" for future generations.

2.1.3.1 National Park Service Organic Act, 1916

> The mission of the National Park Service is "...to promote and regulate the use of the Federal areas ... as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations".

Fulfilling this goal requires an understanding of the status and trends of the resources both temporally and spatially. Long-term natural resource monitoring through the I&M program and this Monitoring Plan provides this essential information.

The 2001 NPS Management Policies and 1998 National Parks Omnibus Management Act, outlined below, established policies regarding natural resource monitoring. These policies are further supported in the 1999 NPS Natural Resource Challenge Program goals. The Government Performance and Results Act provide a means to track progress related to specific monitoring objectives.

2.1.3.2 2001 NPS Management Policies

The NPS will monitor natural systems on its holdings and will measure anthropogenic influences that alter those systems. The NPS will use the results of monitoring and research to understand the detected change and to develop management actions when appropriate. The NPS will:

- Identify, acquire, and interpret needed inventory, monitoring, and research data, including applicable traditional knowledge, to obtain information that will help park managers to reach park management goals and objectives provided for in legislation 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, including interrelationships with visitor carry capacities to detect or predict changes in resources 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.

2.1.3.3 1999 Natural Resource Challenge goals

- National parks are preserved so that this generation and future generations can enjoy, benefit, and learn from them.
- Management of the national parks is improved through a greater reliance on scientific knowledge.
- Techniques are developed and employed that protect the inherent qualities of national parks and restore natural systems that have been degraded; collaboration with the public and private sectors minimizes degrading influences.
- Knowledge gained in national parks through scientific research is promulgated broadly by the National Park Service and others for the benefit of society.

2.1.3.4 National Parks Omnibus Management Act, 1998

The Secretary shall undertake a program of inventory and monitoring of NPS resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources. The monitoring program shall be developed in cooperation with other Federal monitoring and information collection efforts to ensure a cost-effective approach. The Act reinforced that individual parks also need to have strategic and annual performance plans as required in the Government Performance and Results Act, described below.

2.1.3.5 Government Performance and Results Act (GPRA)

Requires the NPS to set goals (strategic and annual performance plans) and report results (annual performance reports). The NPS Strategic Plan contains four 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.

Several other legislative acts, enacted over the past forty years, apply to or require in specific cases monitoring of natural resources within parks. Important acts include:

2.1.3.6 Endangered Species Act, 1973

Requires federal agencies to ensure that any action authorized, funded or carried out does not jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modifications of critical habitat.

2.1.3.7 Clean Water Act (Federal Water Pollution Control Act of 1972 as amended)

Sets objectives for restoring and maintaining the chemical, physical, and biological integrity of the nation’s waters. Also, the act regulates discharge of pollutants and requires federal agencies to avoid adverse impacts from modification or destruction of navigable streams and associated tributaries, wetlands, or other waters.

2.1.3.8 Clean Air Act, 1970

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.

2.1.3.9 National Environmental Policy Act (NEPA) of 1969

The basic national charter for environmental protection. 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 NPS emphasis is on minimizing negative impacts and preventing "impairment" of park resources as described and interpreted in the NPS Organic Act.

2.1.3.10 National Trails System Act, 1968

Establishes a national system of recreational, scenic, and historic trails and prescribes the methods and standards for adding components to the system.

2.1.3.11 Land and Water Conservation Fund Act, 1965

Establishes a fund, administered by the NPS, "to assist the States and federal agencies in meeting present and future outdoor recreation demands and needs of the American people."

2.1.3.12 Wilderness Act, 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.

2.1.3.13 Outdoor Recreation Act, 1963

Lays out the Interior Department's role as coordinator of all federal agencies for programs affecting the conservation and development of recreation resources. The secretary of Interior is directed to prepare a nationwide recreation plan and provide technical assistance to states, local governments and private interests to promote the conservation and utilization of recreation resources.

2.1.4 NPS I&M Program Goals and Heartland Network Tenets and Objectives

The NPS Washington Office (WASO) identified five NPS servicewide monitoring program goals outlined below (Fancy 2000). The Heartland Network, one of 32 NPS I&M Program networks, has adopted the servicewide goals and developed some additional network-specific tenets and objectives to guide the Heartland Network long-term monitoring activities.

2.1.4.1 NPS I&M Program Goals

- 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 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

2.1.4.2 Heartland Network I&M Program Tenets

- The Heartland Network will achieve efficiency in implementing monitoring by sharing resources.
- Every park in the Heartland Network will have their highest priority monitoring need addressed in the process of developing the monitoring plan.
- All aspects of the Heartland Network monitoring program will be guided by sound scientific principles.
- The Heartland Network will build a foundation to institutionalize long-term monitoring within parks.

2.1.4.3 Heartland Network I&M Program Objectives

- Heartland Network monitoring priorities will be commensurate with the complexity of parks' issues and significance of parks' resources as determined by enabling legislation, strategic planning objectives, and regional and national conservation significance.
- Where possible to achieve economies of scale, common monitoring themes will be derived from the top park priorities.
- Park-specific priorities not covered by a common theme will also be addressed.
- Objective and scientifically credible information will be provided to the parks in a timely way so the information can be used in management decisions.
- Partnerships will be developed to leverage monitoring resources and to place the monitoring results within a regional context.

- Periodic assessment/review will be implemented to assure that monitoring is still addressing top park priorities.
- The Network will maintain flexibility to respond to episodic or catastrophic events.
- Monitoring will address, where possible, issues of public concern.
- Information about the Heartland Network program and generated from monitoring activities will be shared with the greater public through avenues such as web pages, meetings, presentations, and posters in the parks.

2.1.5 Heartland Network Parks' Enabling Legislations

The enabling legislations for the Heartland Network parks can be grouped into general categories commemorating the life of an individual or group, a historical event in North America, or occurrence of significant natural or cultural resources in the United States (Table 2.1).

2.1.6 Heartland Network Parks' Strategic Goals for Performance Management (GPRA)

The general GPRA goal category of 'park resources' focuses on the condition of natural and cultural resources with goals related to threatened and endangered species, air quality, water quality, historic structures, museum collections, cultural landscapes, archeological sites, resource inventories, and disturbed lands. These areas of concern focus on the condition of the resources, including restoration of impaired resources, and protection and maintenance of resources in good condition. The most common GPRA goals for parks in the Heartland Network are restoration of disturbed lands, containment of exotic vegetation, acquiring or developing the NPS inventory datasets, assuring stable populations of federally threatened and endangered species or species of special concern, identifying vital signs for long-term monitoring, improving water quality, and protecting wildlife habitat (Table 2.2).

Table 2.1 Enabling Legislation and Related Time Period for Heartland Network Parks

Park	Related Time Period	Enabling Legislation Overview
Commemorate an Individual's Life:		
LIBO	1816 to 1831	To preserve the site associated with the boyhood and family of the 16th President of the United States, Abraham Lincoln.
HEHO	1874	To preserve and commemorate historically significant properties associated with the life of the 31st President of the United States, Herbert Hoover.
GWCA	1881	To memorialize the birthplace and childhood of Dr. George Washington Carver and to preserve the setting of the Moses Carver farm.
Commemorate a Culture or Historic Event in America's History:		
HOCU	200 BC - AD 500	To commemorate the Hopewell culture and preserve their historic mounds and earthworks. The term Hopewell describes a broad network of beliefs and practices among different Native American groups over a large portion of eastern North America. The Ohio River Valley was a focal point of the Hopewell culture.
EFMO	500 BC	To preserve and commemorate Eastern Woodland prehistoric mounds constructed in the shape of mammals, birds, or reptiles. This monument contains 195 mounds of which 31 are effigies, and the others being conical, linear and compound.
ARPO	Pre-European settlement through Early 1800's	Memorial Unit: To preserve and commemorate the site of the first European settlement of the lower Mississippi Valley (1750's – early 1800s). Osotouy Unit: To preserve and commemorate the spiritual home of the Quapaw Tribe and the former homes of Woodland and Mississippi cultures. The Osotouy Unit may also be the site of the first Post of Arkansas (1686).
WICR	1861	To commemorate the Battle of Wilson's Creek, fought on August 10, 1861. This was the first major Civil War battle site west of the Mississippi Rivers. The battle led to greater federal military activity in Missouri, and set the stage for the Battle of Pea Ridge in March, 1862.
PERI	1862	To preserve and commemorate the Civil War battle, fought March 1862, that saved Missouri for the Union and allowed Union forces gain control of the Missouri and Mississippi Rivers.
HOME	1862	To commemorate the Homestead Act of 1862 and its effects upon the settlement of the West as well as advancements in agricultural technology.
PIPE	1600s-Current	To preserve and manage the ethnological, historical, archeological, and geological resources in their natural tallgrass prairie environment and the management of the pipestone (Catlinite) quarries in a way that provides all Native Americans with free access to quarry pipestone and to fashion and carve from it the articles relating to their cultures.

Table 2.1 (continued) Enabling Legislation and Related Time Period for Heartland Network Parks

Park	Related Time Period	Enabling Legislation Overview
Commemorate Natural Resources:		
TAPR	Pre-European settlement	To preserve, protect, and interpret a rare tallgrass prairie ecosystem on the Spring Hill Ranch in the Flint Hills. This ecosystem is remnant of a prairie that once covered 400,000 mi^2 of North America.
BUFF	Current	To conserve and interpret an area containing unique scenic and scientific features, and preserve the Buffalo River as a free flowing stream for the benefit and enjoyment of present and future generations. The Buffalo River is one of the few remaining unpolluted, free-flowing rivers in the lower 48 states.
CUVA	Current	To preserve and protect the historic, scenic, natural, and recreational values of the Cuyahoga River and the adjacent lands and to provide needed recreational open space necessary to the adjacent urban environments.
HOSP	Current	To preserve and protect the hot springs flowing from the southwestern slope of Hot Springs Mountain.
OZAR	Current	To conserve and interpret unique scenic and other natural values and objects of historic interest, including preservation of portions of the Current River and the Jacks Fork River as free-flowing streams, preservation of springs and caves, management of wildlife, and provision for use and enjoyment of the outdoor recreation resources.

Table 2.2 Summary of performance goals grouped by general categories, specific goal numbers, and the Heartland Network Parks for which this goal is applicable

General category	Goal #	Parks with this GPRA goal
Resources maintained	1a	HEHO
Disturbed lands restored	1a01A	CUVA, HOCU, OZAR
Disturbed lands restored	1a09B	OZAR
Disturbed lands restored	1a1A	ARPO, BUFF, CUVA, EFMO, HOSP, OZAR, PIPE, WICR
Disturbed lands restored	1b01A	OZAR
Exotic vegetation contained	1a1B	CUVA, EFMO, GWCA, HOCU, HOSP, OZAR, PIPE, WICR
Natural resource inventories acquired or developed	1b01	PERI, PIPE, TAPR
Stable federal T&E species or species of concern populations	1a2D	PIPE
Stable federal T&E species or species of concern populations	1a2X	ARPO, CUVA, GWCA, WICR
Stable federal T&E species or species of concern populations	1b02D	PIPE
Vital signs for natural resource monitoring identified	1b3	CUVA, HEHO, HOCU, HOSP, LIBO, OZAR, PIPE, TAPR
Water quality improvement	1a04	BUFF, HOSP, WICR
Water quality improvement	1a4	CUVA, HOSP, OZAR, PIPE
Water quality improvement	1b1	BUFF
Wildlife habitat protected	1a01A	OZAR
Wildlife habitat protected	1a02c	BUFF
Wildlife habitat protected	1a02D	GWCA, WICR
Wildlife habitat protected	1a2A	BUFF
Wildlife habitat protected	1a9B	OZAR

2.1.7 Heartland Network Monitoring Program Audiences

The information provided by the Heartland Network Monitoring Program is relevant to a variety of audiences. Park Resource Managers will make use of monitoring information to increase confidence in their decisions and improve their ability to manage park resources. Program work will also be of interest to park interpretation staff who regularly interact with the public about park natural resources; maintenance personnel who interact daily, in many cases, with the natural resources; and law enforcement officers who insure visitor safety and legal issues sometimes related to interactions with the park natural resources. As long-term trends develop there will be potential to generate predictive models to help guide future management decisions. Thereby enabling Superintendents to confront and mitigate threats to their parks and operate more effectively in legal and political arenas.

On a regional level, through outreach and partnerships, federal, state, and county agencies and adjacent landowners faced with similar natural resource problems can benefit from the information generated through the Heartland Network monitoring program. Where possible, these partnerships will also increase the scope of the Heartland Network monitoring program information and development. Academic partners and other external scientists will find the projects and data from this program an asset for studies of ecosystem structure and functions. Their work can complement the program and provide enhanced information to the program, parks, and public. On a national level the NPS directly benefits via an understanding of the overall status and trends of the natural resources and ultimately on the sustainability of those resources. The broadest audience that will benefit from this program and its products is the general public who will come to the parks in the decades to come.

2.2 Heartland Network Monitoring Program: Determining Measurable Objectives and Vital Signs, and Producing Useful Park Information

The following sections outline the planning and technical design processes used in developing the Heartland Network Monitoring Program. The overall technical design is presented initially, followed by detailed step-by-step information within the overall design.

2.2.1 NPS Planning Process for Monitoring

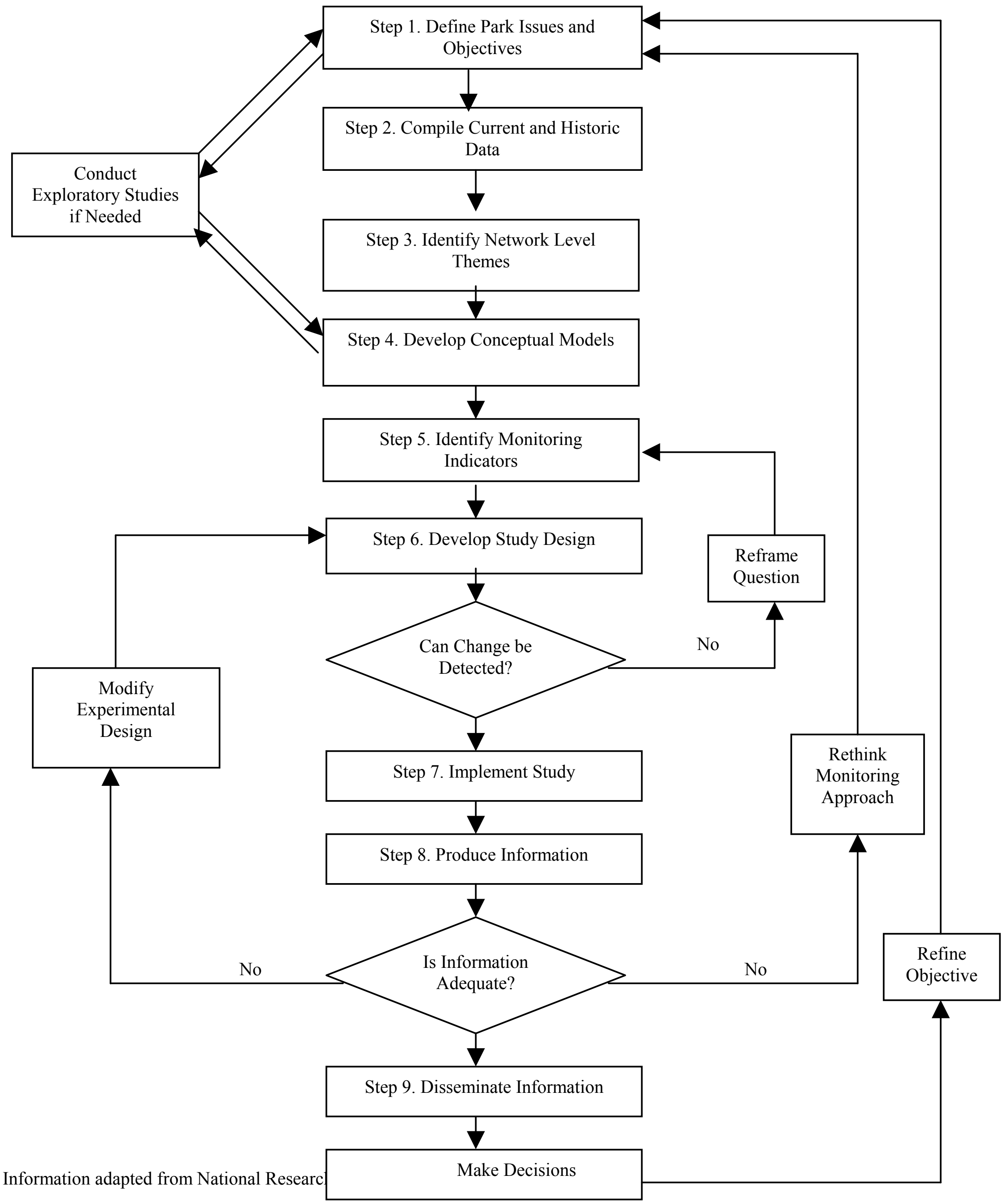
The planning process for developing the Heartland Network Monitoring Program, guided by the *Recommended Approach to Developing a Network Monitoring Program* (NPS 2000), includes seven general steps:

1. Establish a network Board of Directors and a Science Advisory committee. (Detailed information in Section 9.1 of Phase III)
2. Summarize existing data and understanding. (Detailed information in Section 2.2.2.4 of Phase I)
3. Prepare for and hold a scoping workshop. (Detailed information in Sections 2.2.2.3 and 4.1 of Phases I and II)
4. Write a report on the workshop and have it widely reviewed. (Detailed information in Section 4.1 of Phase II)
5. Hold meetings to decide on priorities and implementation approaches. (Detailed information in Section 4.3.2 of Phase II)
6. Draft the monitoring strategy. (Phases I presented in this document)
7. Have the monitoring strategy reviewed and approved. (Phase I due October 1, 2002; Phase II due April 1, 2003; and Phase III due April 1, 2004)

2.2.2 Heartland Network Monitoring Program Technical Design

In 2000, the NPS first drafted a guide for developing a long-term monitoring program, details have been in subsequent years. In conjunction with the most recent NPS guidance, the Heartland Network monitoring program incorporated design recommendations provided by other monitoring programs in North America, including the National Research Council (NRC). The NRC (1990) technical design process was based on two principles. First, specific monitoring design decisions can only be made after management objectives and related information needs are clearly established. Second, monitoring designs must reflect cause-effect relationships while accounting for variability and uncertainty. The overall monitoring design in Figure 2.2 illustrates the critical link between the information needs of managers and the task of data collection, analysis, interpretation, and reporting.

Figure 2.2 Overall steps in designing and implementing the Heartland Network Monitoring Program (this overview includes Phases I, II, and III)



Information adapted from National Researc

2.2.3 Detailed technical design of Phase I of the monitoring program

2.2.3.1 Step One: Define Park's Natural Resources, Issues, and Management Objectives

Step one incorporates several aspects, including identifying park's natural resources and their importance beyond park boundaries (regional and national context), and articulating park's natural resource concerns and management objectives (local context) (Figure 2.2). These objectives may result from a park's enabling legislation or legal mandates (e.g., endangered species), or from planning documents, such as the General Management Plan (GMP), Resource Management Plan (RMP), or GPRA goals.

2.2.3.1.1 Network Scoping Workshops

The Heartland Network parks began formulating monitoring issues and objectives during two inventory/monitoring workshops in February and March 2000. Prior to the first workshop, park Natural Resource Managers completed a survey identifying pertinent significant natural resources, current or potential threats, and potential indicators. The first workshop included taxonomic experts, park natural resource professionals, and Prairie Cluster Long Term Ecological Monitoring (LTEM) staff. The group developed preliminary eco-region based conceptual models in the form of comprehensive matrices indicating current and possible stressors, the resources they may affect, and potential indicators for monitoring. Additionally, lists of potential park-specific monitoring projects were developed. In the weeks between the two workshops, park Natural Resource Managers discussed potential projects at their respective parks. During the March workshop, park projects were rated by importance.

In April 2001, Heartland Network parks held a third workshop at Hot Springs, AR to further develop the aquatic components of the Heartland Network Monitoring Program. A primary goal of the workshop was to refine and articulate each park's specific aquatic monitoring objectives and questions. Workshop participants included NPS park, network, regional, and WASO personnel, and several subject experts. In November 2001 a fourth network-level workshop was held at Cuyahoga Valley, OH, this workshop focused on terrestrial monitoring issues. Prior to the workshop, resource managers were asked to refine respective park-specific terrestrial monitoring objectives and questions. A primary goal of the workshop was to develop a list of potential indicators and corresponding protocols based on the park-specific objectives and questions. Workshop participants included NPS park, network, and regional personnel, and several subject experts. At the conclusion of the 2001 workshop, information was still lacking from several parks, hence there was a need to gather additional data.

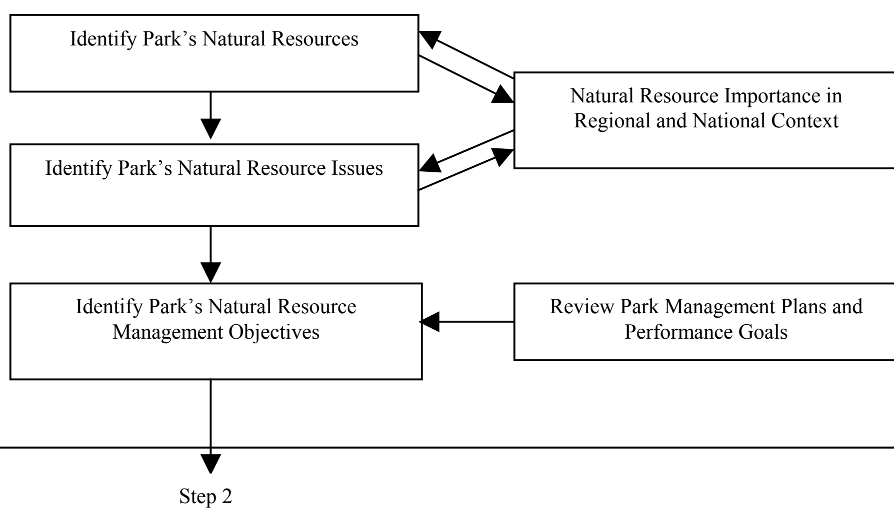
2.2.3.1.2 Park Specific Monitoring Information

In order to effectively answer important park questions (a critical goal of the Heartland Network monitoring program) a clear understanding of each park's management issues and objectives is essential. In February 2002, park Natural Resource Managers re-assessed and re-prioritized monitoring issues identified in 2000. Park Natural Resource Managers, in conjunction with other park staff, documented management objectives for each issue and, for the top three park priority issues, provided documentation on the following:

- What is the issue?
- Where is it occurring?
- What is the temporal or spatial scale of the issue (e.g., in general, how long has it been occurring or how much of the park is affected)?
- How is the issue changing over time or space (if, in fact, it is changing)?
- Why might the changes be taking place (is there something causing them)?
- Why is this issue a concern to the park and the public?
- How does this issue relate to the overall natural resources of the park?

Appendix A through O (Tables A.2 through O.2) includes detailed information on each park's top three natural resource monitoring priorities. Prototype parks were not required to provide this information for this plan. Monitoring information on EFMO, HOME, PIPE, TAPR, and WICR is available from the Prairie Cluster LTEM Prototype program.

Figure 2.3 Step one: Define Heartland Network parks' natural resources, monitoring issues, and objectives



2.2.3.2 Step Two: Compile Current and Historic Natural Resource Data from the Parks and Region

2.2.3.2.1 Data Mining

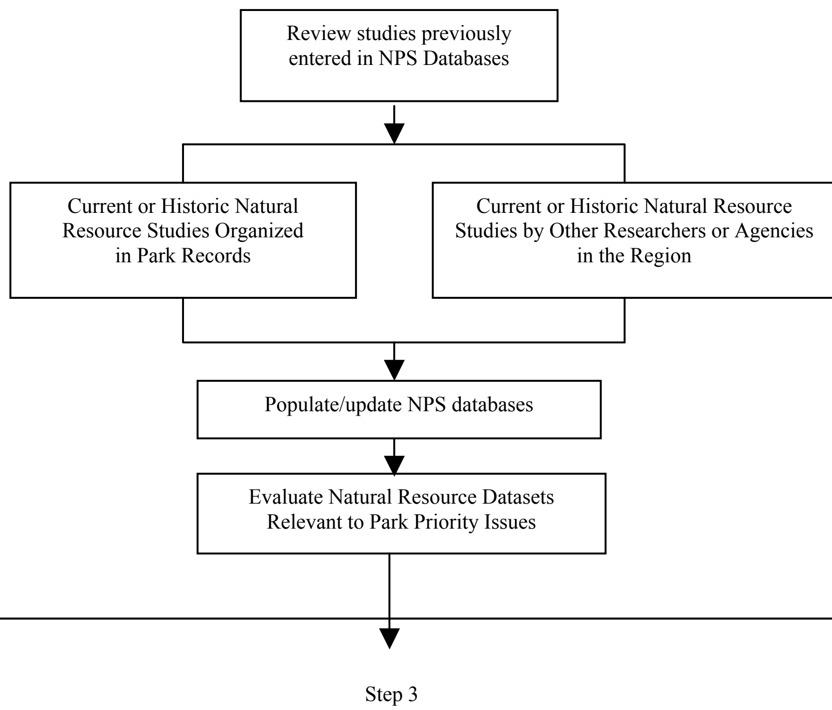
In the spring of 2002, the Heartland Network Data Manager developed a series of steps and guidelines to facilitate data mining at the parks and to produce complete documentation of previous studies (Figure 2.4). Data mining was divided into a number of tasks that included:

- Inventory current resources within NPS information databases – Evaluate existing NatureBib, Dataset Catalog, and GIS Clearinghouse data.
- Determine completeness of NPS databases – Review completeness of databases. In general, most parks determine the databases to be approximately 70% complete.
- Develop data mining guidelines – These guidelines helped select the most relevant materials, given the time constraint.
- Train park staff to update records – Staff attended a one-day training session for data mining techniques and an introduction to NatureBib.
- Collect natural resource materials – Collect natural resource data from park archives, local agencies, researchers that have done studies in the park, and any other identified sources.
- Organize materials within parks – Parks were encouraged to develop a natural resource library and develop an effective indexing system to quickly locate documents.
- Update records in NPS databases – Parks entered natural resource studies not currently in the NPS database into NatureBib.
- Analyze and evaluate materials – Selected datasets and documents were reviewed by experts for their research design and usefulness in contributing to the monitoring plan (this activity is part of Phase II).

Appendix P includes more detailed information on the Heartland Network data mining methods. The Heartland Network Data Manager (Brent Frakes), with the assistance of Data Managers from other networks and prototypes, developed a manual of that provides a standardized approach to data mining. This manual is available on the data management intranet web site at ftp://ftp.nps.gov/incoming/DataManager/.

Appendix A through O (Tables A.1 through O.1) includes all the parks' data mining results through May 2002. This information will also be located, with periodic updates, on the Heartland Network website http://www1.nature.nps.gov/im/units/index.htm.

Figure 2.4 Step two: Compile current and historic natural resource data from the Heartland Network parks and surrounding regions



2.2.3.3 Step Three: Define Monitoring Themes and Synthesize Corresponding Legal and Ecological Parameters with the Parks' Monitoring Objectives and Questions

2.2.3.3.1 Monitoring Themes and Workgroups

After the parks identified and prioritized their respective natural resource monitoring issues, the results indicated that several parks had relatively similar issues that could be grouped together into network level 'monitoring themes'. Details about these themes and the respective parks are discussed in Section 2.4. Themes identified included:

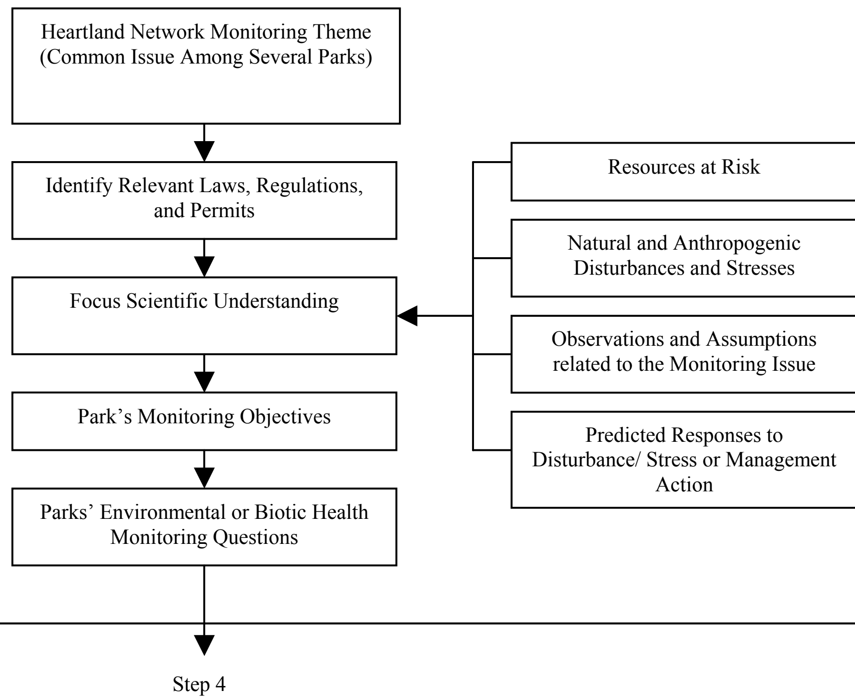
- plant communities,
- exotic plants,
- aquatics,
- land use changes, and
- wildlife.

Five 'workgroups' were subsequently organized to further develop the monitoring program for each theme. Theme workgroups were comprised of park staff; Regional and Network I&M Coordinators and NPS personnel with a subject area expertise; and subject matter experts outside the NPS. The Aquatic Workgroup also collaborated with the NPS Water Resource Division (WRD), which provided some monitoring funds. The Plant Community Workgroup collaborated with the NPS Fire-Monitoring Program, which is conducting fire-related monitoring in several of the Heartland Network parks. Likewise, the Exotic Plant Monitoring Workgroup coordinated program development with input from WASO Exotic Plant Management Team.

2.2.3.3.2 Park Scoping Workshops

After park issues and management objectives were articulated, additional information/data was provided by each park, including: any known relevant federal and state laws, regulations, or permitting; types and extent of natural disturbances and stresses within the region; and the park's monitoring objectives and questions (Figure 2.5). A few parks developed their data independently. At most of the parks, the Heartland Network Coordinator and Data Manager conducted scoping meetings to facilitate development of the monitoring data. Park personnel involved in this process included the Superintendent (in many cases), Natural Resource Manager, other park staff with any interest or expertise in natural resources, and, at some parks, outside subject matter experts who have been doing research in the park. The data was gathered from the group interactively into a database. Monitoring questions developed by the parks will be discussed and refined in subsequent workgroup meetings, incorporating conceptual models and external expertise. (Due to the variety of state aquatic monitoring standards, the Heartland Network also contracted with the University of Kansas for additional data about state and federal water quality monitoring regulations.)

Figure 2.5 Step three: Synthesize, by monitoring theme, the Heartland Network parks' monitoring objectives and questions incorporating legal and ecological parameters



2.2.3.4 Step Four: Develop Stressor-Based Ecosystem Level Conceptual Models

Literature reviews of the dominant ecosystems within the Heartland Network provide an understanding of the structure and functions of the ecosystems. Stressor-based, ecosystem-level conceptual models provide additional understanding of important components and linkages. A combination of park information, literature reviews, and conceptual models will be used in Phase II for selecting potential monitoring indicators/vital signs (Figure 2.6).

Conceptual models were developed for four dominant ecosystems found in the Heartland Network: forests, prairies, rivers, and wetlands the latter including riparian ecosystems, and freshwater marshes and swamps. In addition to the four ecosystem models, a fifth model was developed to understand land use changes. The model will integrate the ecosystem models at a landscape scale.

With the exception of the prairie model, the ecosystem conceptual models adopted the format used by the South Florida Ecosystem Restoration Program (Ogden et al. 1997, SCT 1997). Each model includes a narrative description and a schematic diagram. Diagrams follow a top-to-bottom hierarchy that identifies natural and anthropogenic drivers, specific stressors on natural systems, ecological effects resulting from stressors, and recommended ecological attributes/indicators and measures for each attribute. Each model also delineates ecological linkages between the stressors and attributes and recommends the most appropriate measures for each attributes.

2.2.3.4.1 Conceptual Models Developed

Forest ecosystem model: The Heartland Network contracted with Dr. David Weinstein, Boyce Thompson Institute, Ithaca, NY to develop a stressor-based conceptual model for deciduous forest ecosystems. Additional models may be needed as specific perturbations to the parks' forest ecosystems are identified (e.g. gypsy moth or atmospheric deposition).

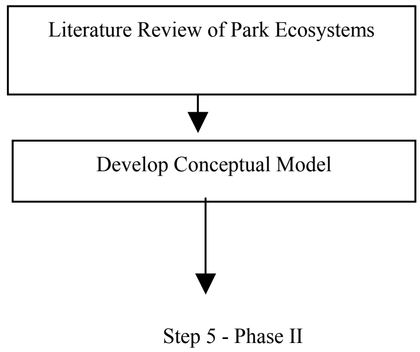
Large River ecosystem model: The Heartland Network contracted with Dr. Charles Rabeni, University of Missouri, Columbia to develop a stressor-based conceptual model for Ozark Plateau river ecosystems.

Wetland model: Dr. Daren Carlisle, NPS Midwest Region Aquatic Ecologist, developed a stressor-based conceptual model for wetland ecosystems found in temperate climates with deciduous vegetation cover.

Prairie ecosystem model: The Prairie Cluster LTEM Prototype developed a prairie ecosystem conceptual model in conjunction with their monitoring program. This model was made available to the Heartland Network.

Landscape analysis model: The Heartland Network contracted with by Dr. Andrew Hansen, Montana State University, to develop a conceptual model for landscape scale monitoring. The model integrates information from the ecosystem-level models to understand regional land use change. This model will help identify which parks are most vulnerable to land use change and how land use change can be most effectively monitored.

Figure 2.6 Step four: Develop stressor-based ecosystem level conceptual models pertinent to the Heartland Networks identified natural resources



2.2.4 Phase II Information

This section will be developed as the plan progresses.

2.2.5 Phase III Information

This section will be developed as the plan progresses

2.3 Overview of the HN Parks, Their Natural Resources, and Management Objectives

One of the first steps in designing a natural resource monitoring program is to have a clear understanding of the resources involved. For the Heartland Network this means a clear understanding of the natural resources within each of the 15 network parks. As illustrated previously in Figure 1.1, the Heartland Network covers a large geographic region from Ohio to Kansas and Minnesota to Arkansas with park sizes ranging from 65 ha (160 ac) to 38,757 ha (95,730 ac) (Table 2.3). Each park in the network encompasses several types of ecosystems, including rivers, lakes, springs, prairies, wetlands, and forests (Table 2.4). Information about state and federally listed threatened and endangered species, both vegetation and wildlife, within the Heartland Network parks is included at the end of this section (Table 2.5).

Table 2.3 Park Size and Annual Visitation for the Heartland Network Parks

Park Name	Park Code	Area (ha)	Area (ac)	Annual Visitors (approx # people.)
Arkansas Post National Memorial	ARPO	303	747	50,000
Buffalo National River	BUFF	38,757	95,730	1,000,000+
Cuyahoga Valley National Park	CUVA	13,332	32,943	3,500,000
Effigy Mounds National Monument *	EFMO	1,023	2,526	
George Washington Carver National Monument	GWAC	85	210	50,000
Herbert Hoover National Historic Site	HEHO	75	186	201,000
Homestead National Monument of America *	HOME	65	160	40,000
Hopewell Culture National Historic Park	HOCU	262	647	35,000
Hot Springs National Park	HOSP	2,247	5,549	
Lincoln Boyhood National Memorial	LIBO	81	200	175,000
Ozark National Scenic Riverways	OZAR	32,709	80,790	1,500,000
Pea Ridge National Military Park	PERI	1,741	4,300	100,000
Pipestone National Monument *	PIPE	115	283	80,000
Tallgrass Prairie National Preserve **	TAPR	4,411	10,890	18,150
Wilson's Creek National Battlefield *	WICR	709	1,790	190,000

* Parks in the Prairie Cluster Long-Term Ecological Monitoring Prototype
** TAPR is not currently not in Prairie Cluster Long-Term Ecological Monitoring Prototype, but a formal proposal has been made to change the park status. 2001 was the fourth full year of limited interpretations and visitor services program.

Table 2.4 Ecosystems by Area within the Heartland Network Parks

Park	Rivers/ Streams (linear miles)	Springs (number)	Lake/ Ponds (# and size in acres)	Wetlands (# and size in acres)	Forest (acres)	Savanna (acres)	Prairie (includes restoration) (acres)	Mowed Lawn/ Fields (acres)	Developed Land (acres)
ARPO									
BUFF	175	>500	350 (totaling 175 ac)	10 ac	88,970	4,000	650	1,900	200
CUVA	220	0	70 (ranging from 0.5 – 12 ac)	1,214 (ranging from 0.1 – 199 ac)	24,200	0	0	2,600	1,560
EFMO			100			70	80		
GWCA					60		130		
HEHO	<1	0	0	0	0	Under Development	81, includes riparian	50	50
HOCU	3.5 along park boundary, but not in park	Present, but number unknown	1 @ 1 acre	Unknown	110			652 (includes grass-lands)	145
HOME					60		100	4	
HOSP									
LIBO	0	0	<1, man-made pond	0	150	0	0	30	20
OZAR	134	>300	Unknown	Unknown	75,000	0	0	2,400	200
PERI					3,600			400	300
PIPE	60	0	2 ponds, approx 1 ac total	3	NA	16	244	4 developed area, 8 ceremonial Grounds (mowed 2 times/yr)	7
TAPR									
WICR									

Additional detailed park information is included in Appendices A through O, including annotated bibliographies, park priority issue narratives, location maps, and other imagery. The appendices also include information from other NPS Divisions. Appendix Q includes 2001 Air Research Division (ARD) reports on wet and dry deposition and ozone for each of the Heartland Network parks.

The following sections provide individual park information including a brief park background, descriptions of the park's natural resources in park-specific, regional, and national contexts, and the park's specific natural resource issues and related management objectives.

2.3.1 Arkansas Post National Memorial (ARPO)

2.3.1.1 Park Background Information and Enabling Legislation

ARPO, also known as the "Post of Arkansas", is located in southeast Arkansas (Appendix A, Figure A.1). ARPO was federally designated in 1960 to "*preserve and commemorate the site of the first European settlement of the lower Mississippi Valley"*. Over the past few hundred years, ARPO has been a strategic military post, a river port, and a commercial center. Within park boundaries, the political history of ARPO includes time periods from the French Colonial (1686-1763, 1800-1803), Spanish Colonial (1763-1803), American Revolutionary War ("Colbert Incident", 1783), "Early American" (1803-1830's), a Civil War battle (1862-1863), and the demographic ebb-and-flow of Post villages throughout the years.

The site of ARPO became a part of the United States during the Louisiana Purchase of 1803. By 1819, the site was a thriving river port, the largest city in the region, and selected as the capital of the Arkansas Territory. During the Civil War, Confederate troops tried to maintain tactical control of the Arkansas River, and in 1862 they constructed a massive earthen fortification known as Fort Hindman. By January 1863, Union troops destroyed the fort and adjacent river port town, ensuring control of the Arkansas River.

As of 2002, ARPO consists of two units, the Memorial unit (main unit) and the Osotouy unit, totaling 304 ha (750 ac). The Memorial unit (158 ha, 389 ac) was originally established as a State Park in 1929. The Osotouy unit (146 ha, 361 ac) was established in 1998 to preserve, commemorate, and interpret the Indian mound site, as well as the possible site of the first "Post of Arkansas", circa 1686. The Osotouy unit is regarded as the spiritual and cultural homeland of the Quapaw tribe, and was the former home of Woodland and Mississippian cultures. Numerous mound sites and archaeological features presently exist including three Indian mounds and a plaza (a centralized meeting area).

ARPO's General Management Plan (GMP) objectives related to natural resources:

ARPO's Resource Management Plan (RMP) objectives related to natural resources:

ARPO's natural resource related GPRA goals:

> 1a1A: 14% of targeted parklands, disturbed by development or agriculture, as of 1999 [10 of 70 acres] are restored.
> 1a2X: The population of alligators (state-listed threatened species) are at scientifically acceptable levels in Arkansas Post National Park.

ARPO's Cultural Landscape Report or (CLR) other document objectives related to natural resources:

The following section describes ARPO's natural resources, park issues/priorities, and management objectives are discussed.

2.3.1.2 ARPO Natural Resources

An annotated bibliography of selected natural resource studies completed for ARPO is included in Appendix A (Table A.1). Appendix A (Figure A.2) includes a map of ARPO's land cover, roads, trails, and water bodies.

2.3.1.2.1 Geology and Water

ARPO is situated in the Atlantic Plains Geologic Province on an escarpment above the Arkansas River. It consists of terraced landscape, flat terrain, and is interspersed with bayous and swamps. The Memorial unit, consists of a peninsula surrounded by rivers, wetlands and bayous. Moore and Post Bayous lie along the north/northwest border, and Post Bend, a backwater of the Arkansas River, lies on the north and northeastern border. Both bayous, as well as the backwater, empty into the Arkansas River along the southern edge of the Memorial unit.

The Osotouy unit, 146 ha (361 ac), is primarily land based. The southwestern portion is bordered by Lake Dumond, an old oxbow of the Arkansas River. The southern border is contiguous with U.S. Fish and Wildlife Service land while the remaining boundaries abut private land. Menard Bayou enters the Osotouy unit from the east and exits out across the northern boundary.

ARPO does not have any bodies of water listed as 303(d) Impaired or Outstanding Natural Resource Waters.

2.3.1.2.2 Soils

ARPO soils consist of parent material of loess 1 to 8 ft thick overlying an older alluvium (Westerbury, 1976). This loess was originally part of an older alluvium brought into the area during a glacial period. ARPO's soils are strongly acid throughout, with a moderate natural fertility, and a have medium organic matter content. Soil types at ARPO consist of:

> *Grenada silt loam* - moderately well drained and strongly acidic throughout. Runoff is slow with excess water posing a moderate hazard.
>
> *Calloway silt loam* - less acidic than the Grenada and have low organic matter content. Runoff is slow and moisture is a moderate hazard.
>
> *Tichnor silt loam* - strongly acidic, frequently flooded, and usually found around water or bayous. Runoff is slow or ponded, and excess water is a severe or very severe hazard.

ARPO's soils have changed considerably during the past 200 years, due to farming, leveling, dams, natural (natural river course) and unnatural (irrigation deters) modification of the shoreline.

2.3.1.2.3 Vegetation

ARPO includes a wide range of plant communities including bottomland and upland forests, wetlands, rivers, backwater areas, fresh water marshes, cane breaks, isolated prairie relics, and manicured lawns (Appendix A, Figure A.2). Dr. Robert Irving (1977) conducted a study in 1997 and wrote a report on the forest communities and flora of the Memorial unit. He recorded 272 vascular plant species, none of which were listed as rare, endangered, or threatened as defined by the 1976 Smithsonian List of Rare and Endangered Plant Species. Dr. Irving noted that the forest communities of ARPO strongly reflect the variations of past land use and topography. All of ARPO's forest have been disturbed in some way and are in varying stages of succession. Species of special interest included *Sabal minor* (blue palm), the only native palm in Arkansas, and *Taxodium distichum* (bald cypress), a species associated with wet or submerged soils.

Today, the Memorial unit land base is 116 ha (286 ac) and consists of 13 different vegetation types which range from primarily oak dominated forest to pine stands, as well as a restored prairie and several, chronologically diverse, successional deciduous forest stands.

The Osotouy unit consists of common bottomland species including *Taxodium distichum* (bald cypress), *Carya illinoensis* (pecan), *Platanus occidentalis* (sycamore), and occasional small stands of *Quercus spp. (*oak) as well as some tall grass areas. At one time, an area known as the "little prairie" extended into this unit.

An exotic plant inventory, funded by the I&M Program, is in progress and will be completed by 2003.

2.3.1.2.4 Wildlife

A formal mammal inventory has not been completed for the Memorial or Osotouy units, however incidental data has been collected during other research studies. *Odocoileus virginianus* (white-tailed deer) is recorded as a common occurrence at the park**.** A herpetofauna inventory was initiated through the Inventory and Monitoring Program (I&M Program) and completed in 2001. ARPO has two herpetofauna species of concern; *Alligator mississippiensis* (American alligator) and *Macroclemys temmincki* (snapping turtle). A bird inventory, initiated by the I&M Program, is in progress and will be completed during 2002.

2.3.1.3 ARPO's Natural Resource Issues and Management Objectives

ARPO's terraced landscape is one of the few within the nation. The majority of landscapes similar to ARPO are currently not protected from agriculture and/or forest industries. The land base portions of ARPO's Memorial and Osotouy units have undergone significant changes over the past 300 years due to both natural and cultural impacts but is currently, since its inclusion in the National Park System, one of the few natural strongholds left in the area. ARPO provides an oasis for many different flora and fauna species, including some threatened/endangered species and species not currently listed, but whose populations are declining in adjacent lands.

The top four natural resource issues and related park management objectives for ARPO are summarized below. Appendix A (Table A.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below, however these are not necessarily in order of priority.

2.3.1.3.1 Land-Use Change (Priority Issue #1)

In order to better manage the park per the General Management Plan, Cultural Landscape Report, and legislative directives it is important to know what is happening outside park boundaries and realize what effects, if any, they predict to the park over time.

The management objective is to determine what changes are taking place and how they will impact the park's resources. Fortunately, because the park is included within areas of concern for the U.S. Army Corps of Engineers, aerial photographs will be available for purchase within these time frames.

Pesticide, herbicidal, and fertilizer overspray is a problem from aerial applications on adjacent lands. These sprays have the potential to affect and/or alter the native flora and fauna of the park. Detailed documentation regarding the input of overspray does not currently exist, however, it is noted that ARPO is subject to periodic oversprays.

The management objective is to determine if pesticides, herbicides, and fertilizer over spray occurs at the park and if so what effect are they having on park resources. Assessing the potential for risks to visitors and employees is also an important objective.

2.3.1.3.2 Erosion (Priority Issue #2)

Soil erosion occurring within the park and surrounding region has the potential to destroy and/or degrade the significance of the extant landscape thereby altering resources such as critical habitat for flora and fauna. Erosion of natural resources is a well documented at ARPO. Several existing fishing areas at the Memorial Unit are heavily utilized and significant footpaths to these locations have resulted from this use. *Myocastor coypus* (nutria) may also be a cause of riverbank erosion (See ARPO exotic species section).

Cultural resources at the park, such as the Civil War Rifle Pits and Indian mounds, are currently forested. Park management is concerned that erosion may be occurring in these areas due to the existence of trees and/or visitor use. The management objective is to determine if erosion, attributable to the existence of trees and/or the use of resources, is occurring and if it can be mitigated.

2.3.1.3.3 Prescribed Fires (Priority Issue #3)

The effects of prescribed burning on park ecosystems and forest health are primary points of interest for resource management at ARPO. In the past, prescribed fires at resulted in adverse affects. The increased sunlight exposure to the forest floor, resulted in the prescribed burn areas to become invaded by exotic vegetation. Unfortunately, there is currently little known about fire effects on lowland bottomland and terrace landscapes.

The last prescribed burn at ARPO took place in 1994, burning several acres of the Memorial unit. The use of prescribed burning has currently been halted, until research can be completed for several projects including fire history and Cultural Landscape Reports.

The management objective is to determine what effects past fire regimes have had on vegetation composition and structure and if prescribed burning is appropriate. The forest health management objective is to assess forest health so that required plans can be written and necessary management actions, if any, can be conducted in accordance with the General Management Plan (GMP), Cultural Landscape Report (CLR), and other guiding management documents.

2.3.1.3.4 Exotic Vegetation Species (Priority Issue #4)

Land immediately adjacent to the Memorial and Osotouy units is either under agricultural cultivation or being logged. Exotic plant species are taking advantage of these disturbed areas become established. Some exotic species are invasive and can compete native flora thereby eliminating or significantly decreasing regeneration. If invasive exotics are not controlled they will spread to surrounding private, state and federally owned land.

Four invasive exotic species that are being heavily managed for reduction at ARPO are: *Poncirus trifoliata* (trifoliate orange), *Ligustrum japonicum* (common privet), *Ligustrum sinense* (Chinese privet), and *Lonicera japonica* (Japanese honeysuckle). *P. trifoliata* (trifoliate orange), has currently overtaken approximately 4 ha (10 ac) of the Memorial unit and other areas of smaller size. Even though the quantity of exotic vegetation seems small at the Memorial unit presently, when the total land base is considered, roughly eight to nine percent of the unit is made up of exotics. Although exotics exist at the Osotouy unit, little is known of their current status.

The management objective at the park is to eliminate *P. trifoliata, L. japonicum*, *L. sinense*, and *L. japonica*, as well as any other invasive exotic species, in all vegetation types through the use of mapping and herbicide application.

2.3.1.3.5 Tick-Borne Diseases

Tick abundance and tick-borne disease frequency are important considerations within the park, region, and nationally because of their potential to affect visitor/employee health, safety and the enjoyment of National Parks. Relative tick abundance has been documented and specific management techniques have been suggested for monitoring purposes at the Memorial Unit. An assessment of tick-borne disease frequency and vector-host-vegetation relationship was completed in 1999 (Eads, 1999).

The management objective is to determine when ticks reach threshold levels in specific areas at the Memorial Unit so that mitigation measures can be initiated if criteria are met.

2.3.1.3.6 Herpetofauna

ARPO provides habitat for the federally endangered, *Alligator mississippiensis* (American alligator). A study, conducted at ARPO, documented habitat use and relative abundance indices of the *A. mississippiensis*. This study details aspects of the environment that seem to influence alligator habitat use.

Potential alligator encounters pose a problem for some visitors. To reduce visitor and employee safety risks, the management objective at the park is to determine what size restrictions are needed and where locations of high alligator density occur, so that habitats can be altered to reduce alligator occurrences.

Acris crepitans blanchardi (Blanchard's cricket frogs) are abundant in the park, as documented by the I&M herpetofauna inventory, but not outside of park boundaries. It appears ARPO is providing a refuge for this species. Hence, the management objective is to document annual trends of this frog population.

Turtle die-offs are a perceived concern at the Memorial Unit. One species affected by die-offs is *Macroclemys temminckii* (alligator snapping turtle), the largest freshwater turtle in North America. The management objective is to determine if die-offs are in fact happening and if so why.

2.3.1.3.7 Opportunistic Wildlife Species

Dasypus novemcinctus (armadillo) populations vary seasonally and annually at the park. There have been reported claims filed against the park from visitors falling into holes and injuring themselves, however, it has not been proven these are armadillo holes. Park maintenance is constantly filling in holes and has had to replace major tractor components (e.g., axles) after inadvertently driving into holes. It has also been suggested that archeological resources are being damaged and destroyed by *D. novemcinctus* activities.

It is assumed that *D. novemcinctus* are competing for habitat with native animals, especially *Mephitis mephitis* (skunk) populations. It has been suggested that their diets are similar. Anecdotal evidence suggests that *M. mephitis* numbers increase when *D. novemcinctus* abundance decreases. The park management objectives are to reduce the possibility of visitors/employee safety risks; implement a plan to decrease *D. novemcinctus* populations, if their numbers or actions warrant it; and determine what effect they have on *M. mephitis* abundance.

Odocoileus virginianus (white-tailed deer) relative abundance is estimated to be high within park boundaries. Park management is concerned about the viability of resource preservation over time due to a presumed overabundance of *O. virginianus* populations, possible vegetative impacts, and the lack of predators on this species. A two-year study was conducted at ARPO on affected vegetative families and species by *O. virginianus* populations. Although the information provided from this study will be used primarily as baseline data, it will impart information on the existence of plant associations and species within the park thereby allowing management to determine areas and/or species of concern as per the Cultural Landscape Report and other management documents.

Over time, park management would like to measure the relative abundance of *O. virginianus* and their associated resource impacts.

2.3.1.3.8 Exotic Wildlife Species

Exotic wildlife species in relation to bank erosion is also a concern at ARPO. The west riverbank of the Arkansas River has been stabilized. However, bank erosion is threatening cultural deposits on the east bank. One explanation for bank erosion is the large semi-aquatic herbivorous mammal, *Myocastor coypus* (nutria), digging into the riverbank, causing the acceleration of land and cultural deposit loss, including a historic cemetery. *M. coypus* were initially introduced from South America to North America to be farmed for their fur. Since their introduction, some animals have escaped these farms and established localized breeding in habitats such as marshes, lake edges, and areas with emergent or succulent vegetation along the banks. In ARPO, *M. coypus* exist in ponds, sloughs, marshes, and around the entire perimeter, excluding the northern boundary of the park.

The management objective is to determine *M. coypus* abundance and adequate management techniques to deter or eliminate the erosional effects and safety hazards caused by them.

2.3.1.3.9 Wetlands

Wetlands at ARPO have not been studied at this time, so there are questions concerning wetland net gain or loss, the affects from exotic species, and possible contaminant levels. The management objective is to determine what and where wetlands occur and if contaminant levels exist within them due to agricultural practices within and upstream of associated watersheds at the Memorial and Osotouy units.

2.3.1.3.10 Rising Water Levels

The extent of water fluctuations and its affect on critical habitats is currently unknown at ARPO. The management objective is to determine if nearby water levels are rising above those that the U.S. Army Corps of Engineers historically agreed to and if so, their frequency and elevations.

2.3.2 Buffalo National River (BUFF)

2.3.2.1 Park Background Information and Enabling Legislation

BUFF is located in the Ozark Highlands of northern Arkansas (Appendix B, Figure B.1). Congress established the Buffalo River as the first National Scenic River in the United States in 1972 "*for the purposes of conserving and interpreting an area containing unique scenic and scientific features, and preserving as a free flowing stream an important segment of the Buffalo River in Arkansas for the benefit and enjoyment of present and future generations*". The Buffalo River is one of the few remaining free-flowing rivers in the lower 48 states, encompassing 241 km (150 miles) from the Boston Mountains to the White River. The park has approximately 38,771 ha (95,730 ac) of the Buffalo River Sub-Basin land, out of an encompassing 347,074 ha (857,607 ac).

Native Americans occupied the BUFF site for over 10,000 years (Dick, 2001). European settlement, beginning in the 1820s, changed much of the forestland into farming monocultures. Today areas surrounding the park boundaries are still being farmed and logged.

BUFF's GPRA goals related to natural resources:

- 1a02C: By Sept 30, 2005, 15 (22%) of the 67 mine openings having bat habitat will be protected by F/W approved gates.
- 1a04: By Sept 30, 2005, water quality within Buffalo River meets all water quality standards 90% of the time in 95% of tests conducted annually for water quality parameters identified within the Water Quality monitoring reports issued for BUFF.
- 1a1A: By September 30, 2005, 188 (25%) of the 747 acres of disturbed lands targeted in the 1997 RMP are restored.
- 1a2A: By Sept 30, 2005, 15 (22%) of the 67 mine openings having bat habitat will be protected by F/W approved gates.
- 1b1: By Sept 30, 2005, develop 20% new data sets (10) for hydrology data through additional water quality projects identified in approved natural resource management documents completed for buffalo National River in 2000.

The following section describes BUFF's natural resources, park issues/priorities, and management objectives.

2.3.2.2 BUFF Natural Resources

An annotated bibliography of selected natural resource studies completed for BUFF is included in Appendix B (Table B.1). Appendix B (Figure B.2) includes a map of BUFF's rivers and road.

2.3.2.2.1 Geology and Water

The Ozark Highlands region is characterized by narrow valleys, which are separated by steep winding ridges and broad mountaintops. Geologically, BUFF lies in the Ozark Physiographic region. The region is subdivided into the Springfield Plateau, Salem Plateau, PreCambrian Dome, and Boston Mountains. The Springfield Plateau is composed of Mississippian limestone, chert, sandstone, and shale. The Salem Plateau is composed of sedimentary rocks of the Ordovician, Silurian, and Devonian. These rocks are primarily limestone/dolostone and clean sands. The karst topography of the Ozark Physiographic region has resulted in a large number of sinkholes, springs, and seeps. BUFF has the largest cave system in the state of Arkansas.

The mainstem of the Buffalo River is not dammed, however, the White River into which the Buffalo flows is extensively dammed. The Buffalo River is indirectly impacted these dams. The natural flows (especially high flows) of the Buffalo River transport sediment and maintain important physical habitat attributes such as pool depth and volume, spawning reds, riffle-pool spacing, scour pool formation, biological drift and migration, and energy transport.

Portions of the Buffalo River have been designated by State agencies as impaired because of non-point pollution (Arkansas Department of Pollution Control and Ecology, 1992). In 1995, the Natural Resources Conservation Service implemented a watershed protection/water-quality improvement project in the middle portion of the Buffalo River watershed to address documented water-quality degradation associated with land-use impacts. The Buffalo River and a major tributary, Richland Creek, are both State listed as Outstanding National Resource Waters.

2.3.2.2.2 Soils

Soils in BUFF vary from fairly thick and sandy to very thin and gravelly. The Springfield plateau soils tend to be thin and poor, composed of chert and clay. The Salem plateau soils vary from fairly thick and sandy to very thin and gravelly. The source of the Buffalo River is in a region composed primarily of Pennsylvanian clastic sediments where the soils are sandy to clayey.

2.3.2.2.3 Vegetation

Vegetation communities within BUFF include *Quercus spp.* (oak), *Carya spp*. (hickory), *Fagus grandifolia* (beech), and *Castanea pumila var. ozarkensi* (Ozark chinquapin) forests; relic *Quercus stellata* (post oak) barrens; *Juniperus virginiana* (Eastern red cedar) and sandstone glades; and rare *Arundinaria gigantea* (river cane) communities. An inventory and mapping project of BUFF's river's rare plant communities, funded by the I&M Program, was completed in 2001. Forty-two populations of rare plants are associated with the springs and seeps in BUFF.

2.3.2.2.4 Wildlife

Over 300 caves exist in BUFF, including the longest cave system in the state. The caves provide habitat for many bat species, including, *Myotis grisescens* (gray bat), *Myotis sodalis* (Indiana bat), *Corynorhinus townsendii ingens* (Ozark big-eared bat), and *Corynorhinus townsendii ingens* (Ozark big-eared bat). A bat inventory to determine additional caves containing rare bats (funded by the I&M Program) is in progress and will be completed in 2003.

BUFF maintains the Ozark region's only *Cervus elaphus* (elk) herd, with approximately 400 animals. Historically, *C. elaphus* used to be found in various habitats all through North America, including Arkansas. In 1981, the Game and Fish Commission, in cooperation with the National Park Service and private citizens, initiated an elk restoration project in northwest Arkansas. Today, the Arkansas elk range covers approximately 91,058 ha (225,000 ac), but most of the herd occurs in the middle and upper Buffalo National River corridor. *C. elaphus* populations are monitored annually by aerial surveys.

Sixty fish species have been documented in BUFF, ten endemic to the Ozarks Highlands Region. Large numbers of aquatic macroinvertebrates species are found in the river, its tributaries, and springs. BUFF is considered by the Fish and Wildlife Service to provide a refugia for declining species such as the fish species, *Notropis ozarcanus* (Ozark shiner). Additionally, the Buffalo River is a State designated "blue-ribbon" smallmouth bass sport fishery, with numerous other sport fishes present as well. A fish inventory to gather additional information on riffles and deep pools (sponsored by the I&M Program) is in progress and will be completed by 2003.

Bird (determine presence of rare neotropical migrants) and herpetofauna (first year) inventories are in progress and will be completed by 2003.

2.3.2.3 BUFF's Natural Resource Issues and Management Objectives

BUFF was established for the purpose of preserving the Buffalo River as a free-flowing river. Due to high visitation numbers in water-based activities, monitoring and addressing public health concerns are integral components of BUFF's mission. Protection of water quality is listed as a primary management objective in every major management related document (i.e., GMP). The State of Arkansas is also actively involved in developing and implementing management strategies to protect the river's water quality.

The top four natural resource issues and related park management objectives for BUFF are summarized below. Appendix B (Table B.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below, however these are not necessarily in order of priority.

2.3.2.3.1 River Integrity: Biotic and Physical Components (Priority Issues #1 and #2)

BUFF provides habitat for at least 60 native fish species, ten endemic to the Ozarks Highland Region. An even greater number of aquatic macroinvertebrates species are found in the river, its tributaries, and springs. BUFF is also home to declining species such as the *Notropis ozarcanus* (Ozark shiner) and 23 species of native mussels. Aquatic communities have been evolving in the Buffalo River for eons and have adapted to the specific chemical, physical, and biological properties naturally present in their environment. Disturbances caused by man's activities can disrupt the natural balance of individual organisms or entire communities in complex ways.

Land-use changes and stream channel alterations are affecting streams in much of the mid-west, although the Buffalo River provides a typically more protected natural environment where native communities and natural processes may be perpetuated given adequate management practices, there are concerns. These concerns include:

- Population declines of freshwater fish and invertebrate species;
- Exotic species competing with native species for habitat.
- Degradation and loss of physical aquatic habitat;
- Hydrologic modification of regional waterways (i.e., Bull Shoals Dam on the White River) creating thermal barriers and affecting fish migration; and
- Increased sedimentation and run-off.

Many of the concerns listed above may have irreversible effects on aquatic communities if not properly monitored and/or mitigated. Management objectives include monitoring possible causes of habitat degradation, changes in run-off and sediment supply, the cumulative impacts of exotic species, and migration barriers.

2.3.2.3.2 Water Quality, Abiotic (Priority Issue #3)

Water quality is rapidly declining in rivers throughout northern Arkansas and southern Missouri as regional development increases at some of the fastest rates in the nation (Mott, 1997; Peterson, 1998; Peterson et al., 1998; USDA, 1999). The impact of land-use change and pollution is an ongoing concern for park management. Known water-quality pollutants for the Buffalo River include the following:

- Non-point source pollution (chemical, agriculture, logging, urban landscapes);
- High fecal coliform concentrations;
- Leachates from mining;
- Areas of naturally occurring metals; and
- Possibly copper-chromium-arsenic wood treatment facilities.

In the past, water-quality monitoring has shown a correlation between agricultural non-point source chemical pollution (Mott, 1997; Mott et al, 1999, Scott and Hofer, 1995; Steele and Mott, 1998). BUFF's management objective is to "preserve the Buffalo River as a free-flowing system". The management objective within the context of the I&M Program is to continue monitoring for water quality impacts from point and non-point sources.

2.3.2.3.3 Endangered Species (Priority #4)

Over 300 caves are currently documented in the park, many of which are being utilized by bats. BUFF provides critical habitat for the following three federally endangered species:

- *Myotis grisescens* (gray bat) – improving in most of its range, and may soon be down listed to threatened.
- *Myotis sodalis* (Indiana bat) – declining in Arkansas. The largest hibernaculum for this species lies less than thirty meters outside park boundaries.
- *Corynorhinus townsendii ingens* (Ozark big-eared bat) – declining over its entire range and is in danger of extinction. It is has very specific roost requirements and is not tolerant to disturbance.

Although not federally listed, *Myotis leibii* (eastern small footed bat), the smallest bat in eastern North America, has been noted in at least one cave inside the park.

Primary management objectives include species population monitoring, human disturbance assessments, and habitat utilization. Bat populations have been monitored at BUFF since about 1984, however, the bat roost knowledge in the Lower Buffalo Wilderness is inadequate at this time. A systematic study of caves and abandoned mines within this area is being funded by the I&M Program (2001-2002). This study will provide a better understanding, as well as a more complete documentation, of the bat species found at BUFF.

2.3.2.3.4 Adjacent Land Use Changes

Adjacent land use changes outside BUFF boundaries have consequences for the park's watershed and other natural resources. Only 11% of the Buffalo River watershed is within the park boundary; 29% is held by Arkansas State Game and Fish Commission and the U.S. Forest Service and 60% is privately owned. Conversion of forest to pasture outside BUFF boundaries is resulting in significant deforestation. Illegal dumping in sinkholes and hollows is a widespread problem that brings trash and hazardous materials to the Buffalo River through underground karst drainages or surface tributaries. The mountainous nature of the Ozark Highlands region combined with the numerous highways that transect the watershed have resulted in a number of hazardous materials spills from truck transport accidents.

Other land-use activities in the Buffalo River basin includes cattle grazing; swine, dairy and poultry confined feeding operations; urbanization with sewage treatment plants and storm-water runoff; gravel mining; cold tail waters from dams; discharge of fill material into the river channel to maintain roads; stream channelization; removal of riparian vegetation; past lead-zinc mining operations; and impounding of river tributaries.

The impact of land-use change on water-quality and sediment load is an ongoing concern for park management. Maintaining the free-flowing nature of the Buffalo River is becoming an increasing challenge as development continues in the watershed. The management objective is to quantify the status and trend of various land use categories (e.g., roads, agriculture, forest, pasture, urban, water features) within the Buffalo River watershed, including karst interbasin recharge areas. Informed management decisions and public education can then be accomplished based on accurate and timely land classifications and summaries.

2.3.2.3.5 Springs and Groundwater

Spring systems provide unique habitat for native plant and animal species. Springs also provide the critical base-flow that supports the river's flow during dryer periods. Due to the karst terrain present in the watershed, contaminated groundwater can rapidly migrate through underground conduits to the park and emerge at springs relatively unfiltered. BUFF's management objective within the context of the I&M Program includes monitoring spring and groundwater quality as primary base-flow contributors to the Buffalo River.

2.3.2.3.6 Bird Habitat

BUFF's continuous corridor provides high quality habitat for resident and migratory bird species. An expected bird species list along the Buffalo National River was completed in 1996 (Dechant and Smith). An inventory, funded by the I&M Program, is in progress for rare cane plant communities and neotropical migrants. This work will be completed in 2002.

2.3.2.3.7 Habitats of Concern

BUFF has listed these four habitats as areas of concern:

- Glades - rocky barrens dominated by a herbaceous flora with sparse woody vegetation (Nelson, 1987). Glades are recognized as small remnants of once expansive native habitats in the region.
- Barrens - unique plant communities containing localized species recognized by Arkansas Natural Heritage Commission as some of the last remaining ecosystems of their type in the State.
- *Arundinaria gigantea* (river cane) communities - contain dense habitat for *Limnothlypis swainsonii* (Swainson's warbler) and other neotropical birds. Maintenance of these river cane communities offsets neotropical habitat loss in other portions of the southeastern United States by creating a refuge and promotes riparian integrity.
- Old field systems - provide critical successional habitat for various native wildlife ranging from small mammals and neotropical birds to ungulates.

The management objective is to determine the effect of active management (e.g., prescribed fire, native grass plantings, thinning) on improving or harming targeted habitats of concern and their associated floral and faunal communities.

2.3.2.3.8 Herpetofauna

Herpetofauna inventory and monitoring efforts can provide baseline data for local interpretations of ecosystem health and for regional and national assessments/comparisons. The management objective is to protect aquatic habitats from excessive nutrient loading and other biologically damaging factors such as increased siltation from deforestation and development. The I&M Program funded a herpetofauna inventory in 2002.

2.3.2.3.9 Forest Plant Communities

Upland and bottomland forests are being fragmented by forestry/agricultural practices and urban development. Stress from climate change, exotic species [e.g., *Lymantria dispar* (gypsy moth)], natural infestations [e.g., *Enaphalodes rufulu*s (red-oak borer)], and lack of natural fire regimes are having widespread impacts on the native forests of the Ozarks region. There is a potential loss of native species and increased encroachment of exotic species due to changes in documented fire cycles of 3-5 year intervals to 50-100 year intervals (Guyette, 1993; Guyette, 1994; Johnson and Schnell, 1985)..

2.3.2.3.10 Exotics Wildlife Species

While Buffalo River and its tributaries support a diverse biological community, exotic species are also present and appear to be altering native communities within the river, tributaries, springs, and terrestrial habitats. As of 2002, the primary exotic wildlife species BUFF include *Corbicula fluminea* (Asian clam), *Dreissena polymorpha* (zebra mussel), *Sus scrofa* (feral pigs), and *Lymantria dispar* (gypsy moth).

C. fluminea was introduced in 1938 and is now considered widespread in Arkansas. Preliminary evidence indicates they are out-competing native mussel species and benthic invertebrates for limited habitat and food resources (Usrey, 2001).

D. polymorpha (zebra mussel) is making its way into the lower White River with unknown consequences for the Buffalo River. *D. polymorpha* originates from the Balkans, Poland, and the former Soviet Union. Most of the biological impacts of *D. polymorpha* in North America are not yet known. However, it is known from other areas of the world that *D. polymorpha* have the potential to severely impact unionids (native mussels) by interfering with their feeding, growth, locomotion, respiration, and reproduction.

S. scrofa, introduced originally for hunting or escaped from farms, destroys both terrestrial and aquatic habitat used by native wildlife. *S. scrofa* can also damage sensitive plant/animal communities; transmit diseases to domestic livestock, pets, and humans; act as predators on ground nesting bird populations; and cause damage to agricultural crops.

L. dispar (gypsy moth) originated in Europe and Asia and was introduced into North America in the late 1800's. *L. dispar* is known to feed on the foliage of hundreds of species of plants in North America, but its most common hosts are *Quercus* (oak) species. A full infestation of this species can result in defoliation of great swaths of forest, especially oak related species. *L. dispar* infestations at BUFF have been addressed with relative success so far, based on limited introductions.

The management objective for these exotic species is to reduce the threats of environmental degradation and habitat loss of native species of flora and fauna.

2.3.2.3.11 Ungulates

BUFF's ungulate populations include both *Odocoileus virginianus* (white-tailed deer) and *Cervus elaphus* (elk). These ungulates are ecologically and recreationally important to the region, as they are both native components of the ecosystems and major game species. Browsing and grazing can promote new plant growth and help maintain successionally diverse areas provided the pressures do not become too extensive.

The management objective is to maintain healthy and viable herds and to ensure that neither species become nuisance animals.

2.3.3 Cuyahoga Valley National Park (CUVA)

2.3.3.1 Park Background Information and Enabling Legislation

CUVA, located in northeastern Ohio, encompasses over 13,332 ha (32,943 ac) of relatively undeveloped open space between the metropolitan sprawls of Cleveland and Akron, Ohio (Appendix C, Figure C.1). CUVA was established in 1974 to *"preserve and protect the natural and recreational values of the Cuyahoga River and adjacent lands".*

The Cuyahoga River and the efforts to restore its water quality provide a compelling focus for environmental discussion that has international interest as well. In 1936, a spark from a blowtorch ignited floating debris and oil, thereby setting the river on fire. Recurrent fires plagued the river until 1969, when one fire caught national attention, which helped spur a great deal of environmental legislation. As a consequence, large point sources of pollution have received significant attention from the Ohio Environmental Protection Agency. Water quality has since improved and in 1998 the Cuyahoga River was designated as one of 14 American Heritage Rivers heralding its comeback. The Cuyahoga River is part of the Great Lakes Ecosystem, the greatest system of fresh water lakes in the world. The river drains into Lake Erie bringing with it positive or negative impacts depending on its water quality. Creation of CUVA was, in part, a response to the burning river, and water quality remains an ongoing issue facing the park and the region.

CUVA's GMP (1977) objectives related to natural resources include the following:

- To preserve natural park lands under the concept of "total environment" or ecosystem perpetuation and ensure that all visitor-use activities are appropriate to their setting.
- To design park facilities to take advantage of natural climatic conditions and incorporate environmentally neutral technology wherever feasible.
- To cooperate with federal, state, and local agencies in the monitoring of environmental quality.

CUVA's RMP (1999) goals related to natural resources include the following:

- RMP goal 1N: water quality in the river, streams and other surface waters of the park is maintained or improved so that healthy aquatic ecosystems are restored, human health is protected and visitor experiences are enhanced.
- RMP goal 2N: managers will restore, maintain or enhance the quality of ground waters within the park consistent with all pertinent laws.
- RMP goal 6N: preserve, protect and manage the native animal life so it is compatible with other ecosystem components and park uses. Objectives include to manage problematic native species or individuals when natural processes fail.
- RMP goal 6N1: Establish baseline data (density, numbers, distribution, habitat requirements, habitat quality etc) for all species. Specific actions for this goal

include monitoring deer and coyote populations and studying the ecological role of coyotes in the park.
- RMP goal 7N: preserve and protect native plant life and fungi so as to be compatible with the park ecosystem and uses.
- RMP goal 9N: preserve, protect and restore the park ecosystem to the extent possible. Objectives include monitoring critical ecosystem components and processes to characterize condition, trends and responses to management actions and to eliminate or minimize man-caused fragmentation of the natural landscape.

CUVA's GPRA goals as they relate to natural resources include the following:

- 1a01A: By September 30, 2005, 30% of targeted acres at Cuyahoga Valley National Park disturbed by erosion by the Cuyahoga River, as of 1999, are restored.
- 1a1A: By September 30, 2005, 20 of 185 acres (10.8%) of targeted parklands at Cuyahoga Valley National Park disturbed by development, as of 1999, are restored.
- 1a1B: By September 20, 2005, 8 of 130 acres (6.1%) of Cuyahoga Valley lands impacted by exotic vegetation targeted by September 30, 1999, are contained.
- 1a2X: By September 30, 2005, 25% of Cuyahoga Valley populations of plant and animal species of special concern are at scientifically acceptable levels.
- 1a4: By September 30, 2005, the Cuyahoga Valley National Park will still have impaired river bacterial water quality, but with definitive plans for improvement.
- 1b3: By September 30, 2005, Cuyahoga Valley will identify vital signs for natural resource monitoring.

CUVA prepared a Statement for Management (SFM) in 1993 that states "in addition to preserving natural and historic resources, the National Park Service also has the task of restoring abused resources." The SFM objectives are to work cooperatively with local communities to increase awareness for the impacts to and preservation of the Cuyahoga River, and to continue planning, management, research, and monitoring efforts to insure restoration, protection and preservation of all CUVA's natural resources.

The following sections describe CUVA's natural resources, park issues/concerns, and management objectives.

2.3.3.2 CUVA's Natural Resources

An annotated bibliography of selected natural resource studies completed for CUVA is included in Appendix C (Table C.1). Appendix C (Figure C.2) includes a map of CUVA's roads, trails, and hydrology.

2.3.3.2.1 Water and Geology

The main natural feature of the park is the Cuyahoga River Valley situated in a transition zone between the Central Lowlands to the west and the Appalachian Plateau to the east. More than 35 km (22 mi) of the Cuyahoga River pass through CUVA. The Cuyahoga River drains more than 1,288 km^2 (800 mi^2) of Northeastern Ohio; only 6.5% of this drainage area is within CUVA. Valley walls and tributary ravines characterize the watershed with steep forested slopes rising 100 to 600 feet above the floodplain. More than 20 perennial streams totaling over 200 mi in length exist within the park boundary. Some of the larger tributaries (e.g., Tinkers Creek and Furnace Run) drain areas larger than 81 km^2 (50 mi^2) while most others range between 3–32 km^2 (2-20 mi^2). Additional unmapped ephemeral streams and headwaters also exist.

Water quality in the Cuyahoga River has been historically poor with ongoing major concerns relating to Akron's Waste Water Treatment Plant discharges, combined sewer overflows, faulty septic systems, increased urbanization and erosion (Ohio EPA 1999). Similar impacts affect water quality in park streams. Water quality, habitat quality, and macroinvertebrate communities vary across park streams from good to poor (Stewart et al. 1998). However, in general, most park streams meet the warm water habitat standards set by the State of Ohio (Ohio EPA 1999). Water quality of the Cuyahoga River is gradually improving, however segments of the river are still on the Clean Water Act's 303(d) list of impaired waters. The park annually monitors nineteen streams for physical and chemical water quality characteristics. Riparian buffer zones for the river and its tributaries vary in size and quality, but range from several hundred feet of relatively healthy forested riparian buffer to virtually no buffer at all in some highly impacted areas.

2.3.3.2.2 Soils

CUVA is located on the glaciated portion of the Allegheny Plateau. The valley is filled with a variety of glacially deposited silts, sands, clays and gravels. Soils tend to be clay-like, unstable, and most are poorly drained. Subsoils are often alkaline. Many sand and gravel deposits have been mined, and the silt-rich floodplain resulted in widespread topsoil removal prior to CUVA's establishment.

2.3.3.2.3 Vegetation

CUVA encompasses a diverse mosaic of natural vegetation types interspersed among various human-developed land uses. Located in the glaciated Allegheny Plateau of northeastern Ohio, natural vegetation of the park currently is comprised of approximately 80% mixed-mesophytic forest (Braun 1961), predominantly of oak-hickory associations but also including maple-oak, oak-beech-maple, maple-sycamore, pine-spruce, and hemlock-beech associations. The long history of intensive land uses has left the park with forests possessing vast differences in community age and structure.

The forests of CUVA can be broadly categorized as upland or bottomland forests, based on landscape position. In the upland forests, the dominant vegetation is a mix of hardwood trees, mainly oaks, maples and beech. The groundcover in the upland forests tends to be sparse. In bottomland forests, the predominant vegetation is mainly deciduous hardwood trees, mainly *Fraxinus spp*. (ash), *Populus deltoides* (cottonwood), *Platanus occidentalis* (sycamore) and *Acer rubrum* (red maple). The groundcover in these forests tends to be thicker than in the uplands. A recent study has suggested that the ability of bottomland forests to regenerate over time is being severely impacted by continued high deer densities, while in upland forests, species diversity seems to decrease when exposed to deer browsing under current conditions at CUVA (NPS 2001c). Twenty-one state-listed rare plant species are known to occur in CUVA.

The forests are heavily fragmented by roads, suburban development, recreational areas (ski areas, sledding hills, picnic areas, golf courses, events sites), a railroad, utility corridors, and agricultural lands throughout the park. The largest and oldest semi-contiguous tracts of mature forest are between approximately 304 and 729 ha (750 and 1,800 ac) in size. Even these tracts, however, are internally fragmented and dissected, with correspondingly large amounts of habitat edge, which reduces their habitat value for forest interior species.

Interspersed among these forests are other natural habitats including older field habitats in various stages of succession (approximately 6%), wet meadows, and other wetland habitats (approximately 5%). Suburban lands comprise approximately 3% of the landscape, and include regularly mowed open areas such as lawns, golf courses, and cemeteries. Cultivated agricultural lands make up approximately 4% of the park.

Over 900 plant species occur in these various habitats. Nearly 20% of the species found in CUVA are exotic species not native to the area. The high number of exotics is probably due to the disturbance history of the park. While there are many exotic species, less than ten are considered invasive species. Invasive plants are those which invade a habitat, displacing native vegetation and often forming large monocultures with limited habitat value.

In 2001, plant inventories, funded by the I&M Program, were conducted to document the distribution and abundance of exotic plant species.

2.3.3.2.4 Wildlife

Faunal species detected in the park include 194 species of birds, 91 aquatic macroinvertebrates, 43 fish, 32 mammals, 22 amphibians, and 20 species of reptiles. In addition, 56 butterfly species have been documented in the park.

Populations of a number of wildlife species have increased substantially in the last decade both locally and regionally, to the extent that these species have recently reached nuisance levels within the park. Most notably, *Procyon lotor* (raccoon), *Marmota monax* woodchucks, *Branta canadensis* (Canada geese), and *Odocoileus virginianus* (white-tailed deer) are ubiquitous throughout the park, and consistently generate the greatest number of conflicts with humans. Additionally, *Castor canadensis* (beaver) and *Canis latrans* (coyotes) have increased in numbers over the last decade and the incidence of human conflict with these species has also become more frequent.

Detections of the federally-threatened *Heliaeetus leucocephalus* (bald eagle) have been limited to 1-2 non-breeding individuals seen perched near the Cuyahoga River during winter months. No nests have been found within the park, though nests have been found in neighboring counties. Natural habitats within CUVA provide breeding habitat for a minimum of 105 terrestrial bird species. A total of 15 breeding species are "of concern" for conservation. At least 10 species are of conservation concern nationally or regionally and are priority species as determined by the international conservation consortium, *Partners in Flight* (Hunter et al. 1993; PIF 2002). Most of these species of concern have exhibited steep population declines throughout their range or regionally due to habitat loss and degradation

Thirteen bird species detected in the park are Threatened or Endangered in the State of Ohio (ODNR 2002). Many of these species are transients that do not breed in the park. Some breeding species utilize primarily wetland habitats.

The presence of the federally listed endangered Indiana bat (*Myotis sodalis*) was documented in 2002 as a direct result of an inventory funded by the I&M program. The park contains an abundance of apparently suitable habitat.

2.3.3.3 CUVA's Natural Resources Issues and Management Objectives

CUVA is an oasis of natural resources predominantly surrounded by urban and suburban land uses. As such, the land and water resources combine to form the most naturally functioning ecosystem of so large a scale in the region. Because these resources have been protected from most man-caused disturbances they exhibit uniqueness with immeasurable value throughout the Midwest. The animals, plants and minerals coexisting in this natural equilibrium must be preserved and nurtured.

A long history of use by man and a variety of internal and external influences combine to make CUVA an extremely complex area to manage. Internal factors such as high visitor use, park development, mixed land ownership and road maintenance and external activities such as utility corridors, suburban development, agricultural practices and mineral extraction combine to have potential adverse impacts on natural resources and pose serious ecological threats.

The top four natural resource issues and related park management objectives for CUVA are summarized below. Appendix C (Table C.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below.

2.3.3.3.1 Exotic Vegetation Species (Priority Issue #1)

An increase in exotic vegetation species presents a serious threat to the existence of native, rare plant communities and wildlife habitat at CUVA. Of the approximately 3,000 species of plants known to occur in the wild in Ohio, about 75% are native or occurred in Ohio before the time of European settlement, circa 1750. The other 25%, which average between 700-800 species, have been introduced. Some species become very invasive and displace native plants in woodlands, wetlands, prairies, and other natural areas. In Ohio, several exotic plants are invading woodlands and displacing native spring wildflowers. Other exotic plants are impacting wetlands by creating monocultures of *Lythrum salicara* (purple loosestrife) with limited habitat value (ODNAP 2001).

While the extent of the *Polygonum cuspidatum* (Japanese knotweed) populations are unknown, it is anticipated to be a major problem. *P. cuspidatum* was probably initially introduced to the United States for erosion control and as a landscape ornamental. This species of knotweed spreads quickly to form dense thickets that can alter natural ecosystems or interfere with landscaping.

The exotic species populations at CUVA are a landscape scale issue that must be dealt with through a multi-tiered approach. At a minimum this would consists of managing exotic species on park land, encouraging adjacent land partners to manage invasive species, cooperating with other agencies to encourage control of invasive plants on private land in the Cuyahoga watershed, and educating the general public about the issue.

The management objective is to control/minimize exotics in rare plant communities and wetlands, while improving habitat for threatened and/or endangered species. To first accomplish this objective, the overlap of exotics and rare species must be determined (i.e., overlay maps of invasives and native plant communities). Then, the effectiveness of invasive removal on rare plant (including threatened/endangered species) and wetland communities and habitat can be assessed, mitigated, if necessary, and monitored.

2.3.3.3.2 Wetlands (Priority Issue #2)

According to Ohio's Department of Natural Resources in 2002, wetlands are crucial components of most ecosystems and are an imperiled natural resource, especially in Ohio where only 10% of the state's original wetland and marsh habitats remain. As wetland losses continue, the wetlands within CUVA become increasingly valuable at a regional and national level.

A recent park-wide wetland inventory indicates that more than 1,200 wetland areas encompassing approximately 688 ha (1,700 ac) exist in CUVA (Davey Resource Group 2001). Most CUVA wetlands are small, with only 190 greater than an acre in size and only 35 greater than 4 ha (10 ac) in size. Additional small wetlands may yet remain undetected. Wetland types found in the park include marshes, wet meadows, scrub/shrub wetlands and forested wetlands. Small emergent wetlands occurring in isolated depressions fed by surface water are most common. Small wetlands are also often found at the head of small, intermittent drainage ways, adjacent to ponds or as hillside seeps where groundwater flows out of a hillside. Many wetlands are partially or completely forested or include a shrub component. The largest wetlands are located within the Cuyahoga River floodplain and include emergent, shrub, and forested areas. In addition to providing habitat for many plants and animals, special wetland characteristics such as vernal pools which serve as breeding areas for amphibians and potential roosting trees for the endangered *Myotis sodalis* (Indiana bat) exist in some of these wetland areas. Wetland systems in CUVA have been greatly affected by many years of disturbance and land use changes within the Cuyahoga Valley. The Ohio & Erie Canal, railroad and roadbeds, dredging of stream channels, utility corridors, filling and grading activities, topsoiling, beaver impoundments, landfills and gravel pits, and drainage for agriculture have all profoundly influenced the current configuration of this large wetland system. Not all disturbances have resulted in a decrease in wetland area. In fact, many of the disturbances may have increased the size of wetlands. Additionally, *Castor canadensis* (beavers) continue to be active in the park and this has also affected the size and distribution of wetlands.

CUVA wetland inventories have identified that 86 out of 1,214 wetlands have exotic plant species. Forty-three of the wetlands are either partially or wholly dominated by exotic vegetation. The 86 identified wetlands, including all of the largest riparian wetlands in the park, for a total 440 ha (1,088 ac); have exotic vegetation covering a total of approximately 5 ha (12 ac). Park staff is concerned about potential impacts to park wetlands resulting from changes in landscape and land use practices both within the park as well as adjacent to park boundaries.

In addition to wetland areas, more than 100 lakes and ponds dot the park landscape, with approximately 70 existing on federal lands. Ponds on federal land range in size from less than 1/10 of an acre to more than 10 acres (e.g., Virginia Kendall Lake). All ponds except one are human-made (i.e., artificial), with many originally created to serve as small farm ponds. Long-abandoned ponds usually have reverted to a more natural state and now have wetland characteristics. Such ponds are treated as natural wetlands, assigned protective buffers and managed for natural resource values. However, no monitoring of wetlands currently exists. Protocols for long term monitoring for the variety of wetlands in the park need to be developed and implemented. Park management objectives include determining net gain/loss of wetlands, the effect and removal of exotic species on native species, and determining trends in contaminant levels.

2.3.3.3.3 Overabundance of Native Species (Priority Issues #3)

Deer populations have been monitored in CUVA since 1990 using roadside spotlight surveys (NPS 1987b). Results of those surveys have demonstrated a population increase of approximately 9% annually over the past 12 years, with the population doubling in that period of time. Current estimates of deer densities within CUVA range between 47-89 deer per square mile at various locations across the park, approximately 2-4 times higher than densities shown elsewhere to be associated with significant adverse impacts on forest ecosystems (Marquis 1974; Alverson et al. 1988; Tilghman 1989). Since 1996, winter deer distribution across the park has been examined using transect surveys of fecal pellet groups at up to 200 survey locations established in a systematic grid spanning the entire park (NPS 1997d). Results of those surveys have indicated that deer are distributed patchily across CUVA, with a few areas of very high relative abundance, surrounded by areas of relatively uniform, moderate abundance.

Heavy deer browsing has been documented to have serious deleterious effects in forests, old fields, and agricultural lands of CUVA (Labovitz 1994; NPS 2000c; NPS 2001c). Data from an experimental study, using 10m x 10m deer exclosures begun in 1999, indicate that deer browsing in fields and forests appears to be suppressing seedling growth and forest succession/regeneration (NPS 2001c). At current levels of deer browse, less than 2% of *Trillium grandiflorum* (large-flowered trillium forest plants) produce flowers, compared with 23% of plants excluded from deer browsing (NPS 2000c). High levels of deer browse also have an adverse impact on species richness and abundance of forest understory birds (Petit 1998).

Rapid increase (15% annual) of deer populations between 1990-1996, along with a concurrent rise in deer-vehicle collisions and apparent impacts on vegetation led to preparation of an Environmental Assessment and Deer Management Plan (NPS 1997b) that recommended reduction of the deer population through culling. However, the final Environmental Assessment and accompanying Finding of No Significant Impact (NPS 1997c) were ultimately withdrawn due to a lawsuit, and no deer management has been implemented. Since that time, the rate of population increase has slowed and numbers detected during spotlight surveys appear to be fairly stable. Yet, impacts on forest habitats over this stable period have been substantial (NPS 2000c, 2001c). While numerous long term monitoring programs for deer population and their impacts on other natural resources exists, the overabundance of deer will continue to be a major issue for park management. Other long term monitoring of deer populations and their impacts may need to be established in the future.

*Canis latrans (*coyote*)* expanded into southwestern Ohio in 1919 (Weeks et al. 1990) and now occupies all counties in the state. *C. latrans* was first detected in CUVA in the late 1980's. *C. latrans* populations have been monitored in CUVA since 1993 using auditory (vocal response to taped howls) counts. An index of abundance generated from these counts suggests an annual population increase of 14%, with the population doubling in the nine-year period (NPS 1993a). Habitat preferences of coyotes in CUVA are not currently known.

Direct interactions between the public and coyotes remain relatively rare, though the frequency of complaints is increasing. Public awareness of the presence of coyotes in the park and concern about potential injury to themselves or pets has increased in the last two years.

Dealing with an overabundance of native animal populations, especially *O. virginianus*, and to some extent *C. latrans*, are challenging for park managers. Elimination of some plant species, reduction of some forest regeneration, changes in habitats, and visitor safety are some concerns related to overabundance of *O. virginianus*. Dealing with overabundance of native wildlife such as *O. virginianus* and *C. latrans* is a local, regional, and national problem across the eastern United States. Solutions on a park level will undoubtedly require cooperation from partners outside the park as well.

Park management wants to maintain *C. latrans* population levels, while reducing human/coyote incidents and adverse impacts on other wildlife [i.e., *Urocyon cinereoargenteus* (gray fox) and *Vulpes vulpes* (red fox)]. To accomplish this the park must first understand the role of *C. latrans* in park ecosystems.

2.3.3.3.4 Adjacent Land Use Changes (Priority Issue #4)

Over the last several years, the landscape surrounding the park has become increasingly urbanized while park lands have devolved to more natural conditions, remaining a relatively undeveloped, pastoral valley with one of the largest intact tracts of forest. Surrounding urban and suburban development has impacted the water quality of the Cuyahoga River and its tributaries and may affect park wetlands as well. Park water quality monitoring data will need to be correlated to the larger landscape level changes that have occurred over the past 25 years. Trends in sediment and nutrient loading, bacteria levels, riparian buffers and hydrology can be correlated to changes in land use and used as a tool in management decisions concerning development in the watershed that may affect park resources.

Other issues related to urbanized land-use changes include increased habitat fragmentation, increased impervious surfaces, habitat loss, and increased pressure on wildlife populations.

At this time adjacent land use affects on wildlife populations are unknown. Ecosystem modeling may be used a management tool to aid in predicting some of these affects. Information gained through modeling may assist in determining direct disturbances to wildlife populations, as well as affects on reproduction, distribution and diversity. Land cover variables such as age of forests or percentage of fragmentation could be modeled making it possible to identify threats to rare plants and target monitoring of invasive plants on sensitive areas in the watersheds.

2.3.3.3.5 Water Quality

Pollution problems still persist and, for this reason, portions of the Cuyahoga River Watershed have been classified as one of the 43 Great Lakes Areas of Concern, warranting the development of a Remedial Action Plan. The portion of the river traveling through CUVA is within the area of concern. At this time the Cuyahoga River has an extensive, multi-agency monitoring program already in place. Of the 326 watersheds in Ohio, 276 contain at least one listed segment (303d). Federal water pollution control laws require a total maximum daily load (TMDL) for all water bodies in non-attainment with state water quality regulations. The TMDL will cover impaired river segments not in compliance with Ohio water quality standards through the park. Also included will be several park tributaries including Tinkers Creek, Brandywine Creek and Chippewa Creek. Depending on the outcome of the TMDL, additional long term monitoring components may be identified that compliment existing programs. Water quality remains an important issue for the park.

2.3.4 Effigy Mounds National Monument (EFMO)

2.3.4.1 Park Background Information and Enabling Legislation

EFMO is located along the Mississippi River in northeastern Iowa (Appendix D, Figure D.1). EFMO was established by Presidential Proclamation 2860, on October 25, 1949, "*to preserve and commemorate the Eastern Woodland culture and their prehistoric mounds because of the variety of their forms, which include animal effigy, bird effigy, conical and linear types"*. EFMO contains 1,022 ha (2,526 ac) with 195 mounds of which 31 are effigies. The Eastern Woodland Indians built mounds from about 500 BC until the early European contact period.

EFMO park is divided into four units totaling 599.6 ha (1481 ac). These units include the following:

- North unit – contains 56 mounds, including 4 effigy mounds (all bears)
- South unit – contains 35 mounds, including 17 effigies mounds (12 bears, 5 birds)
- Sny Magill unit – contains 96 mounds, including 5 effigy mounds (12 bear, 5 birds). This unit is about 18 kilometers (11 miles) south of the headquarters area and contains the largest extant concentration of Indian mounds (about 100) in the United States.
- Heritage Addition unit –
-

EFMO's GMP objectives related to natural resources:

EFMO's RMP goals related to natural resources:

EFMO's GPRA goals include the following:

- 1a1A: By September 30, 2005, 10% of land disturbed by prior development or agricultural use and targeted for restoration, is restored.
- 1a1B: By September 30, 2005, exotic species identified in the monument's Resource Management Plan are contained in a ten-acre area.

EFMO is a prototype park. While the following sections provide a brief synopsis of EFMO's natural resources and management issues, a more comprehensive look into these issues can be obtained from the Prairie Cluster.

2.3.4.2 EFMO's Natural Resources

An annotated bibliography of selected natural resource studies completed for EFMO is included in Appendix D (Table D.1).

2.3.4.2.1 Geology and Water

EFMO is located in the 'driftless' or non-glaciated area of northeastern Iowa on the Paleozoic plateau and Silurian escarpment of the Interior Plains Geologic Province. Jordan sandstone is the dominant geologic strata which makes up the bluffs in EFMO and is an important aquifer for the area.

EFMO is a geologically unique area of erosional topography drained by an intricate system of rivers and streams. The erosional forces cut through a plain leaving high divides and precipitous bluffs towering up to 152 m (500 ft) above adjacent waterways.

About 45 ha (110 ac) of ponds and lakes are found with in the floodplains of the Mississippi River, the Yellow River, and Sny Magill Creek.

2.3.4.2.2 Soils

Fayette silt loams are the principal soils of the hilltop prairies at EFMO. These soils are comprised of loess and are well-drained. Fayette soils have 4 to 16% slopes on ridge sides.

Goat prairie soils are found in areas of steep rocky land and have developed from a variety of various parent materials. In many areas the topsoil is very thin or absent and solid bedrock is exposed. The slopes range from 18% to 60%.

2.3.4.2.3 Vegetation

EFMO lies in a transition zone of several vegetation communities. Early survey records indicate that this area of northeastern Iowa was a heavily forested region interspersed with oak savannas and prairie openings that penetrated into the forest area along ridge tops. Today the steep hillsides of the Mississippi bluff lands are dominated by climax maple-basswood and oak-hickory forests.

EFMO's mixed hardwood forests total approximately 486 ha (1,200 ac). EFMO's upland forests are primarily mature stands of *Acer saccharum* (sugar maple) and *Tilia americana* (basswood). Dominant overstory species in the North unit include *Quercus alba* (white oak), *Quercus borealis* (red oak), *Populus grandidentata* (big-tooth aspen), *Carya ovata* (shagbark hickory), and *Tilia americana* (basswood). The Sny Magill unit is a river floodplain that is inundated yearly by spring floods. The dominate overstory vegetation in this area is *Acer saccharinum* (silver maple), *Ulmus americana* (elm), *Fraxinus pennsylvanica* (green ash), and *Quercus bicolor* (swamp white oak).

Approximately 40 ha (100 ac) of old field openings are managed as restored prairie. An area of about 12 ha (30 ac) has been treated as part of an oak grove or savanna restoration project. On south facing bluffs, small prairie openings, referred to as 'goat prairies', persist in areas with shallow soils and warmer, drier micro-climatic conditions.

EFMO's prairie vegetation has been monitored annually since 1997, including rare plant distribution and persistence. Exotic plant and forest community inventories, funded by the I&M Program, are scheduled for 2003.

2.3.4.2.4 Wildlife

Small mammals and herpetofauna inventories have been completed at EFMO. Inventories of mid-size and large mammals, bats, and fish data are still needed.

A bird inventory documenting nesting activity of raptors, especially *Buteo lineatus* (red-shouldered hawk), is in progress and is scheduled for completion in 2002. In addition, this inventory, funded by the I&M Program, objectives are to record baseline avian fauna relative abundance to compliment existing park data and to establish permanent survey points.

2.3.4.3 EFMO's Natural Resource Issues and Management Objectives

Impacts to water quality is a concern at EFMO. In the past, fish kills have occurred in the Yellow River due to periodic untreated sewage discharges from a meat-packing plant about 32 kilometers (20 miles) upstream from EFMO. Water quality data has been collected on the Yellow River for the last 10 years. Dousman Creek in the Heritage Addition is a high-quality native trout stream that had been stocked by the State with exotic trout species. The State believes that sufficient quality habitat exists for natural reproduction to be occurring. The Sny Magill unit contains the mouth and 0.8 km (1/2 mile) of the lower reach of Sny Magill Creek. Sny Magill Creek is a trout stream with good water quality and has been part of a 10-year water quality study.

Other natural resource issues at EFMO include exotic plant control, maintenance and restoration of remnant native plant communities, and management of existing forest communities.

2.3.5 George Washington Carver National Monument (GWCA)

2.3.5.1 Park Background Information and Enabling Legislation

GWCA is located in Newton County in the southwest corner of Missouri (Appendix E, Figure E.1). It was established by an act of Congress on July 14, 1943 *"to memorialize the birthplace and childhood of Dr. George Washington Carver and to preserve the setting of the Mosses Carver farm"*.

Born a slave on the Moses Carver farm, Dr. George Washington Carver rose to become an eminent teacher, humanitarian, botanist, agronomist, and pioneer conservationist. Dr. Carver first became famous for his work with peanut and sweet potato plants while a professor at Tuskegee Institute in Tuskegee, Alabama. He taught the poor southern farmers to grow those crops, which would enrich the soil, in addition to the cotton crops they had grown for years. Even though Dr. Carver's fame was for his scientific efforts, his legacy continues to be for his humanitarian efforts to improve the lives of others.

GWCA encompasses 85 ha (210 ac) of the original 97 ha (240 ac) Moses Carver farm. The remainder of the 12 ha (30 ac) is currently under private ownership. Included within park boundaries are three small streams, the Williams pond, 1881 Carver house, birthplace site, Carver cemetery, and several fields.

GWCA's GMP objectives related to natural resources:

GWCA's RMP goals related to natural resources:

GWCA's GPRA goals related to natural resources include the following:

- 1a2X: By Sept 30, 2005, 2 (17%) of the 12 populations of plant and/or animal species of special concern are at scientifically acceptable levels.
- 1a4: By Sept 30, 2005, 1 (25%) of 4 of the FY 1997 federally listed candidate T&E species not having critical habitat at GWCA and not requiring NPS recovery actions have improved (stable) status.
- 1b3: By Sept 30, 2005 5 (3%) of 178 acres of GWCA lands impacted by exotic vegetation targeted in 1999 are contained.

The following sections describe GWCA's natural resources, park issues/concerns, and management objectives.

2.3.5.2 GWCA's Natural Resources

An annotated bibliography of selected natural resource studies completed for GWCA is included in Appendix E (Table E.1). Appendix E (Figure E.2) includes a map of GWCA's roads, trails, and rivers.

2.3.5.2.1 Geology and Water

GWCA lies in the Springfield plateau. The topography consisting of gently rolling uplands dissected by stream channels that carry water from natural springs and excess drainage water during rainy periods. Elevation ranges from 317 m to 329 m (1040 ft to 1080 ft).

Three small streams occur in GWCA: Carver Branch, Harkins West, and Williams Branch. The latter two flow into Carver Branch, which is a tributary of Shoal Creek. The park also has two springs of historical and natural significance, Carver Spring and Williams Spring. Both of these springs are in close proximity to the Carver trail. Several areas of GWCA experience wet conditions throughout much of the year. The south central, west central and east central parts often have standing water in them during the winter and spring. Some of the water results from runoff, while much of it results from groundwater seepage.

GWCA does not have any bodies of water listed as 303(d) Impaired or Outstanding Natural Resource Waters.

2.3.5.2.2 Soil

Soil several feet in thick is present nearly everywhere at GWCA. Hagerstown and Eldon silt loams and Baxter gravelly loam being predominant soil types in the park.

2.3.5.2.3 Vegetation

Approximately 53 ha (130 ac) of GWCA are in various stages of restoration to native tallgrass prairie. Approximately 24 ha (60 ac) are upland or riparian forests. Surrounding farmlands also possess somewhat of a mosaic pattern with alternating grassland pastures and forest. The remaining 8 ha (20 ac) of GWCA make-up the areas surrounding the administrative/housing and visitor center/maintenance complexes.

An exotic plant inventory, funded by the I&M Program, was initiated in 2001 and will be completed in 2002. A vascular plant inventory, funded the I&M Program, is in progress and will be completed in 2003.

2.3.5.2.4 Wildlife

GWCA's wildlife studies consist of small mammals inventories for prairie communities, a bird species list, and invertebrates sampling (conducted annually during 1988-1997). A herpetofauna inventory, funded by the I&M Program, began in 2001 and will be completed in 2002. A fish inventory, funded by the I&M Program, will be completed in 2002.

2.3.5.3 GWCA's Natural Resources and Management Objectives

The top four natural resource issues and related park management objectives for GWCA are summarized below. Appendix E (Table E.2) includes a narrative written by Park Management on these top four priority issues.

2.3.5.3.1 Plant Communities (Priority Issues #1 and #2)

Prairie

Approximately 32 ha (80 ac) of GWCA were farmed in the last 30 years under a variety of special use permits. Many of these areas were restored to native prairie. Management activities including seeding, planting, mowing, haying and prescribed burning were used as part of the restoration process. In recent years “restoration activities” have consisted mainly of mowing, haying and prescribed burning. These areas are now in a variety of stages of restoration to native prairie, however, at this time exotic plant species are becoming a problem for prairie restoration success.

Ultimately, GWCA would like to see their restored prairies viable with native plants and animals. GWCA is interested in not only restoring its native prairies, but also using this valuable ecosystem as an educational tool and outdoor classroom for local and regional schools today, as well as the future.

Management objectives include incorporating prescribed burning; exotic species assessment and removal; native species plantings; recording species abundance and richness; and ultimately maintain a healthy prairie ecosystem. These results would then be compared with the Diamond Grove Prairie, a privately owned prairie near GWCA.

Riparian Forest

GWCA’s riparian forest canopies have closed in over the years. GWCA is considering selectively removing some vegetation to establish a more open canopy. GWCA’s management objective is to maintain forest cover as a buffer for riparian zones. GWCA is also interested in measuring possible increases in temperature related to opening the canopy overstory along the riparian zones.

2.3.5.3.2 Exotic Plant Species (Priority Issue #3)

GWCA’s prairies are currently being invaded with exotic plant species including, *Lonicera spp.* (honeysuckle), *Sorghum halepense* (Johnson grass), *Securigera varia* (crown vetch), and *Lespedeza cuneata* (lespedeza). There is a potential problem with invasive *Cirsium spp.* (thistle) found in high abundance on adjacent lands. Many of the adjacent landowners currently have farms and graze the land extensively, thus creating a disturbed habitat inviting to exotic species establishment and growth.

GWCA is in the process of writing a Fire Management Plan to use prescribed burning for controlling exotic plant species, but will not able to burn until 2004. GWCA hopes that prescribe fires will provide a viable native seed bed, while reducing the number of exotic plant species and encroaching native woody plants such as *Rhus spp*. (sumac), *Rubus spp*. (blackberries), *Smilax spp.* (woody briars), and *Vitus* spp. (grape vine), which are also invading restored prairies.

GWCA’s management objective includes tracking exotic species and woody plants that are encroaching into the prairie. GWCA would also like to determine where the 'hot spots' or invasion corridors are and where, if possible, they are originating.

2.3.5.3.3 Herpetofauna (Priority Issue #4)

A herpetofauna inventory, funded by the I&M Program, began in 2001 and will be completed in 2002. GWCA management objectives are to determine what species, especially frogs and salamanders, are present among its aquatic areas, if and what species are increasing or decreasing over, what rate these changes are occurring, and chemically test water sources in conjunction with biomonitoring. Information on the status of herpetofauna may assist in providing direction for the management of aquatic systems.

2.3.6 Herbert Hoover National Historic Site (HEHO)

2.3.6.1 Park Background Information and Enabling Legislation

HEHO is located in east-central Iowa within the city of West Branch (Appendix F, Figure F.1). It was established in August 12, 1965 to *"preserve in public ownership historically significant properties associated with the life of the 31st United States President, Herbert Hoover".*

Settlement began in West Branch during 1850, along the banks of the west branch of the Wapsinonoc Creek. Prior to settlement of the area HEHO's landscape was quite different. Highlands previously consisted of prairie and savanna cover. Early settlers removed trees in the mid 1800's and a second wave of immigrants started farming the prairie in the 1880's.

Today HEHO is approximately 76 ha (187 ac), which includes the Wapsinonoc Creek, Hoover Creek, a small cottage where Herbert Hoover was born in 1874, a black-smith shop, the first West Branch school house, a small church, the Isaac Miles Farm, the Thompson Farm, approximately 30 historic structures and associated landscape, Village Green, the graves of President and Mrs. Hoover, and the Herbert Hoover Presidential Library-Museum (National Archives and Records Administration). Natural resources on site include a small tributary to Wapsinonoc Creek referred to as Hoover Creek, a large park-like landscape, and reconstructed tallgrass prairie with small savanna areas. The natural resources on site contribute to the park mission by creating a serene landscape that appropriately commemorates the life and times of Herbert Hoover.

HEHO's GMP identifies park strategies, programs, and actions necessary to manage visitation and best protect park resources. The GMP maintains that HEHO will manage its resources to provide a serene setting to support the commemorative emphasis of the site. As responsible stewards, HEHO will manage these resources to a level that meets all applicable laws, policies, and National Park Service standards, while being a good neighbor to surrounding landowners and the city. It also seems appropriate that landscape cover should compliment the time period represented in the historic core and mirror the types of cover President Hoover would have known during his time in West Branch. Compatible landscape enhances the interpretive opportunities on site.

The RMP nests within the authority of the General Management Plan (GMP) and relates directly to resource management on the site. The RMP expresses a primary goal to be the appropriate stewardship of its natural resources, so as to support the commemorative nature of the site. The RMP states, "The natural resources of the site, in addition to those included within the cultural landscapes and identified by the Congress … include the west branch of the Wapsinonoc and a 76-acre reconstructed tallgrass prairie." RMP associated projects and goals include, but are not limited to the following:

- HEHO-N-400 Conduct Baseline Natural Resources Inventories
- HEHO-N-411 Stabilize and Rehabilitate the Wapsinonoc Creek tributary

- HEHO-N-420 Conduct Prairie Management Program
- HEHO-N-421 Conduct Vegetation Survey
- HEHO-N-422 Control Exotic Species and Noxious Weeds
- HEHO-N-423 Conduct Prescribed Burn Program
- HEHO-N-424 Restore Prairie Vegetation
- HEHO-N-425 Propagate Native Prairie Plants
- HEHO-N-427 Maintain Prairie Demonstration Plot
- HEHO-N-430 Develop Geographic Information System
- HEHO-N-450 Enhance Interpretation of Natural Resources

While the GMP and RMP, guide land use practices within park boundaries, they do not relate to actions outside of park boundaries. Little attention has been given to affecting change beyond the borders or in education of the local population in resource issues. The GMP and RMP do not call for proactive education, but such considerations should be part of the education/interpretation long range plan.

HEHO's natural resource related GPRA goals include the following:

- Ia: By September 30, 2005, park resources will be preserved, protected, and maintained in good condition.
- 1b3: By September 30, 2005, the park has identified its vital signs for natural resources monitoring.

HEHO's Cultural Landscape Report (CLR) recommends management approaches that interface the cultural resources with the natural resources. The CLR refers to Hoover Creek as "a degraded, but still character-defining feature of the site". It also recommends increasing the awareness of the larger landscape that Herbert Hoover knew, which would include riparian areas, woodlots, savannas, and prairie. The CLR also calls for re-establishing a native stream bank ecology within the riparian.

The following sections describe HEHO's natural resources, park issues/concerns, and management objectives.

2.3.6.2 HEHO's Natural Resources

An annotated bibliography of selected natural resource studies completed for HEHO is included in Appendix F (Table F.1). Appendix F (Figure F.2) includes a map of HEHO's roads, trails, and stream.

2.3.6.2.1 Geology and Water

HEHO lies on the northern edge of the Southern Iowa Drift Plane, which is characterized by abruptly rolling hills. Side hill seeps can occur where loess and glacial till meet at lower levels of HEHO's hillsides (HEHO Fire Management Plan, 2001).

Hoover Creek (unofficial name), a small tributary, of the west branch of the Wapsinonoc Creek, flows through HEHO. Geomorphologists and other experts believe that creeks such as the mainstream of the Wapsinonoc were heavily treed and fed by linear sloughs and swamps prior to European settlement. Land use changes, such as farming, began to alter the hydrology from a ground water based system to one consisting primarily of surface water runoff. The linear sloughs began to incise and stream channels developed because of the increase run-off. This is what created Hoover Creek in the late 1800s.

As of 2002, surrounding private properties with the potential to affect HEHO consists of agricultural land, residential areas (some on septic systems), a golf course, and abandoned agricultural land being developed for commercial and residential purposes. All of these land uses may impact the water quality in HEHO. The west branch of Wapsinonoc Creek drains a watershed of approximately 1,214 ha (3,000 ac) above the confluence with Hoover Creek, which drains approximately 688 ha (1,700 ac). Anecdotal flood history suggests that the creek has exceeded its banks 18 times in 11 years. Data were collected for floods in 1960, 1967, and 1993. The floods of 1967 and 1993 appear to be the largest events in recent history.

None of HEHO's bodies of water are currently listed as 303(d) Impaired or Outstanding Natural Resource Waters, but there is a possibility this listing could change after being tested. Only large order streams have been surveyed within the state of Iowa.

2.3.6.2.2 Soils

Soil types at HEHO originated from loess deposition, wind blown plant material, on top of pre-Illinoisian glacial material. Native prairie once dominated the silt-loam soils and developed rich top soil. HEHO's soils consist of the following five distinct silty-clay-loam types:

- Tama silty-clay-loam,
- Coco-Ely-Judson complex,
- Colosilty clay loam,
- Downs silt loam, and
- Adair clay loam.

These soils have moderate to moderately slow permeability and are susceptible to sheet erosion. Generally, Tama-Downs soils occur on uplands with Colo-Ely alluvium complex in drainages.

Erosion and fracturing can be a constant problem with friable clay/loess soils. Approximately five feet of topsoil at the HEHO site was lost from poor soil conservation practices during 100 years of agricultural use. Soil loss from the uplands was reduced by planting native prairie plants. Soils are still lost at a significant rate within the riparian area.

2.3.6.2.3 Vegetation

HEHO's vegetative landscape includes 0.20 ha (5 ac) of historic neighborhood, 20 ha (50 ac) of mowed grass, 33 ha (81 ac) of reconstructed tallgrass prairie with small savanna areas and riparian, and a working 8 ha (20 ac) row-crop farm, belonging to the NPS, but on a life-time lease to a farmer (lies on the western border). The reconstructed tallgrass prairie was originally seeded in the spring of 1971 with five species of native grasses [*Andropogan geradii* (big bluestem), *Panicum virgatum* (switch grass), *Sorghastrum nutans* (Indian grass), *Andropogon scoparium* (little bluestem), and *Bouteloua crtipendula* (side oats gama)]. Park managers added forbs in 1976, and made subsequent additions of forbs and *Elymus canadensis* (Canada wild rye) in 1992 and 1994. In 1997, a savanna was created on the southeast ridge of the prairie to separate the Gravesite from development along the interstate. The reconstructed tallgrass prairie at HEHO has a 30-year history in which best management techniques of the day were sometimes employed, and periods during which managers left the prairie to prevailing forces without intrusion of active management.

In 1964, Hoover wrote a memo to his son asking him to establish a nut tree grove on the grounds of the Memorial Library at West Branch. In 2000, this request was fulfilled when volunteers planted 200 trees immediately south and west of the Gravesite. The tree species included *Juglans nigra* (walnut), *Juglans cinera* (butternut), *Carya laciniosa* (shellbark hickory), *Carya ovata* (shagbark hickory), *Corylus americana* (hazelnut), and *Castanea dentata* (American chestnuts).

A plant inventory was completed for HEHO in 2000. An exotic plant inventory for the prairie, funded by the I&M Program, is scheduled for 2003.

2.3.6.2.4 Wildlife

HEHO has expected species lists for mammals, birds, herpetofauna, and fish. Hoover Creek was sampled once in 2000 and twice in 2001 for benthic macroinvertebrates. Herpetofauna and bird inventories, funded by the I&M Program, are in progress and will be completed by the end of 2003. A mammal inventory, funded by the I&M Program, is scheduled for 2003.

2.3.6.3 HEHO's Natural Resource Issues and Management Objectives

The top four natural resource issues and related park management objectives for HEHO are summarized below. Appendix F (Table F.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below, however these are not necessarily in order of priority.

2.3.6.3.1 Water Quantity and Riparian Health (Priority Issues #1)

Water quantity can pose a significant threat to the natural and cultural resources on site. Park buildings in the floodplain are vulnerable to flood danger (i.e., there has already been reports of water in maintenance shed during storms). In the past, the main stem of the Middle Branch has backed up and flooded the town of West Branch.

Streams that did not exist 150 years ago, such as the Hoover, have cut paths through areas that were once wetlands and seeps. These creeks are very susceptible to flash flooding or drying during periods of drought. Surface water runoff presents the greatest potential for flooding the values on site and decreases water quality in the stream.

The U.S. Geological Survey provided the results of HEC-2 modeling for the flood of 1993, once believed to be a 50 to 100 year flood, and determined that Wapsinonoc Creek will have floods of similar magnitude to that of 1993 on average once every 25 to 30 years. The flood of 1993 inundated the maintenance facilities, visitor center entrance, Herbert Hoover Presidential Library-Museum, and several historic buildings' basements; isolated the Friends Meetinghouse; and threatened numerous cultural values on site. Since that model was run, there has been additional development within the upstream watershed, which could increase the frequency of flooding.

In June 2001, HEHO park service personnel, Natural Resources Conservation Services (U.S. Department of Agriculture), Army Corps of Engineers (Department of Defense), City of West Branch, U.S. Geological Survey, and other experts gathered to assess the creek. During this meeting, it was acknowledged that management of the creek must involve the entire watershed. As of 2002, a draft Stream Management Plan addressing rehabilitation of the stream and riparian area went into review. Rehabilitation of the stream and riparian area are targeted as ways to mitigate future flooding.

HEHO's management objectives include determining how land-use decisions within the park impact the stream (i.e. mowing inside the stream banks), and considering major flood abatement or mitigation projects. Changes in management practices and rehabilitation efforts should be assessed through time. Resource conditions monitored before, during, and after changes in practices will assist managers in determining the best management practices.

2.3.6.3.2 Prairie Plant Communities (Priority Issue #2)

A functioning prairie is a complex system of interdependent flora, fauna, and microbial species. Small, reconstructed prairies are incomplete facsimiles of the native prairie that once dominated the plains and covered 85% of Iowa. At least 98% of Iowa's prairies have been lost since the mid 19th century. Restored, reconstructed and remnant prairies provide islands of habitat for grassland species.

The reconstructed tallgrass prairie at HEHO has a 30 year history of active or passive management. The prairie was originally established to manage runoff and erosion from overland flow above the Library-Museum, and to complement the serenity of the Gravesite by providing space between the highway and the Hoover graves. Today HEHO's goal is to be good stewards of the landscape on site by the following methods:

- Create a diverse plant community and ecological integrity that wildlife species can benefit from;
- Improve and maintain healthy native habitats;
- Improve visitor experience through education and aesthetic appeal;
- Conserve soil and water resources;
- Reduce maintenance costs on the grounds;

- Assess, control, and monitor the intrusion of exotic plant species; and
- Continue to provide a serene landscape for visitors to reflect on the life and times of Herbert Hoover.

At a time when the public has become more aware of the values of prairie, managers must consistently use best management techniques to promote this landscape cover. Care must be taken to prevent the growth of noxious weeds that are detrimental to the site and to surrounding land owners. Proper care of the landscape will positively affect water quality and reduce water quantity and energy flow in the stream.

2.3.6.3.3 Water Quality (Priority Issue #3)

Iowa currently has 157 streams listed as 303(d) Impaired. Experts expect that the number will jump to 2000, once they survey small streams, such as the Wapsinonoc, for water quality under the Clean Water Act. Shifts in water quality and quantity can indicate changes in hydrology that may impact the park.

Periodic assessment of water quality has revealed that water coming into the park is of poor quality with excessively high loads of nitrate-nitrogen, *Escherichia coli* (E. coli), and sedimentation. Water quality issues are closely related to water quantity, particularly with respect to sediment loading. Because the riparian is not functioning, water exiting HEHO carries high sediment loads as well. As stream rehabilitation efforts progress, stream water quality monitoring can function as an indicator of success in establishing a functioning riparian corridor.

Traditional best management practices and flood abatement techniques will tend to improve water quality in and beyond HEHO. Monitoring of water quality before, during, and after rehabilitation and education of upstream riparian to landowners will create partnerships in rehabilitation efforts and provide feedback on successes with watershed goals outside the park. Water quality monitoring will also be one measure of the affects of riparian rehabilitation.

2.3.6.3.4 Land-Use Changes (Priority Issue #4)

Land use practices contribute to changes in water quality and quantity, and the intrusion of invasive species. Farm density has changed over the years within HEHO’s watershed. During the 1920s, farms were small (150 acres average) and animals provided the power for cultivation. Farmers grew various row crops, raised animals, and devoted land to pasture creating a diverse mosaic of land uses. By 1990, the usual farm in this region was 809 ha (2,000 ac) in size and the mosaic of crop diversity had disappeared. The current trend is for farms to continue to become larger and to support seasonal monoculture.

Much of the land immediately around HEHO, particularly upstream, has been recently urbanized. Changes in land use affect many natural resources on site, including, vegetation, soils, water quality and quantity, and wildlife.

Monitoring land use practices will provide the park with better understanding of how rainfall and runoff within a changing landscape will affect park resources, thus providing managers with information to guide them in determining best flood mitigation techniques. At present, flooding may occur from two sources, water flowing down Hoover Creek and water backing up in Wapsinonoc Creek. Hydrologists can use land-use data to estimate flood recurrence within the park and project the source of flooding. Monitoring of land-use changes provides empirical evidence of the impacts of development on stream discharge, as well as increased awareness of the impacts agriculture best management practices (i.e., riparian buffers) on the park. This will help to support partners' efforts to reduce flood water coursing down the local streams.

Monitoring of land-use changes, coupled with monitoring plant community changes in the prairie and riparian corridor, will allow managers to better understand the relationship between surrounding land-use and occurrence of exotic and invasive plants. Land-use changes will affect the distribution of wildlife in the area as well.

2.3.6.3.5 Invasive Exotic Plant Species

Invasive exotic plant species are always a concern, but especially in an agricultural state. Invasive exotics pose a threat to prairie community integrity, stream rehabilitation, and park aesthetics. Surrounding landscapes and land-uses provide a potential source of exotic weeds and invasive plants for the HEHO prairie and Hoover Creek riparian corridor. Some of the most extensive invasions of exotic plants occur along drainages from surrounding agricultural land and within flood plain of the creek. Fencerows and mowed areas of the park are planted in *Poa pretensis* (Kentucky bluegrass), *Festuca spp.* (fescue), and *Bromus inermis* (smooth brome grass). The CLR has recommended that a rougher lawn mix be adopted in the cultural landscape areas. Changes in turf grass species may affect the rate of encroachment on the prairie and into the riparian.

Phalaris arundinacea (Reed canary grass) and various woody plants such as *Ulmus pumila* (Siberian elm) and *Elaeagnus angustifolia* (Russian olive) create constant management challenges. Escaped ornamentals from the cultural landscape of the site, such as *Lonicera tartarica* (Tartarian honeysuckle) have invaded the prairie as well. HEHO hopes to monitor and manage invasive exotics as part of its overall management plan to ensure the integrity of the prairie and riparian corridor.

2.3.6.3.6 Butterflies

Eventually, HEHO would like to determine the diversity and abundance of butterfly species found within the park and to note changes in composition over time. Butterflies are a resource interest because they attract visitors and can be indicators of pesticide over spray that may impact important, but less conspicuous, prairie pollinators. Many species have been observed, particularly in the prairie. HEHO serves as a major staging area both migrating *Danaus plexippus* (monarch butterflies) and green dragon flies.

2.3.6.3.7 Herpetofauna

Herpetofauna, particularly amphibians, are on the decline, locally and nationally. Management techniques, such as fire, affect herpetofauna populations. HEHO would like to research the number of species and relative abundance, as well as monitor precipitous changes in those populations over time. Stream rehabilitation is expected to have a positive impact on herpetofauna and documentation of these changes would be an indicator rehabilitation success.

2.3.6.3.8 Pesticide Overspray

HEHO is concerned about possible pesticide overspray from adjacent lands and its impacts on park natural resources. The management objective is to determine if pesticide overspray is drifting into the park from neighboring applications. If pesticides are discovered to drift, either through water or air, HEHO would monitor impacts of the pesticides on species composition and populations of plants, wildlife, and invertebrates.

2.3.6.3.9 Deer Populations

Damage done by *Odocoileus virginianus* (white-tailed deer) has become a controversial problem at HEHO and in the region. Land-use changes, absence of natural predators, and public sentiment have facilitated population increases. Park management objectives include monitoring populations and abundance, with the goal of determining the possible threat to natural and cultural resources on site and whether the park is contributing to *O. virginianus* damage on neighboring private lands.

2.3.7 Homestead National Monument of America (HOME)

2.3.7.1 Park Background Information and Enabling Legislation

HOME is located in southeast Nebraska (Appendix G, Figure G.1). It was established in March 1936 to "commemorate the Homestead Act of 1862 and its effects upon the settlement of the West as well as advancements in agricultural technology". Signed into law in 1862 by Abraham Lincoln after the secession of southern states, this Act turned over vast amounts of public land to private citizens, totaling 109,269,000 ha (270,000,000 ac). The Homestead Act granted 160 acres of free land to claimants allowing many people the opportunity to own land who previously could not, such as women and former slaves. The requirements for this free land were that a homesteader must be the head of a household, at least 21 years of age, live on the land, build a home, make improvements and farm for 5 years.

Daniel Freeman claimed the land in 1863 where HOME is now located. This was one of the first homesteads claimed. HOME's purpose is to interpret the history of the country and the effect of the Homestead Act on people's lives. HOME totals 79 ha (195 ac), of that total a 66 ha (163 ac) are the original Daniel Freeman homestead and the Freeman schoolhouse.

HOME's GMP objectives related to natural resources:

HOME's RMP goals related to natural resources:

HOME's GPRA goals related to natural resources include the following:

HOME is a prototype park. While the following sections provide a brief synopsis of HOME's natural resources and management issues, a more comprehensive look into these issues can be obtained from the Prairie Cluster.

2.3.7.2 HOME's Natural Resources

An annotated bibliography of selected natural resource studies completed for HOME is included in Appendix G (Table G.1).

2.3.7.2.1 Geology and Water

HOME lies within the glaciated Drift Hill Region of Southeast Nebraska. Underlying formations of bedded limestone and shale indicate that this area was once at the bottom of the ocean. The gently rolling topography of HOME has an extreme relief of 21 m (70 ft). The average elevation is approximately 384 m (1,260 ft) above sea level, with the highest point rising to 402 m (1,320 ft).

2.3.7.2.2 Soils

2.3.7.2.3 Vegetation

The vegetation at HOME is roughly two-thirds reconstructed prairie and one-third woodland. The restored tallgrass prairie, approximately 40 ha (100 ac), includes dominant grass species such as *Adropogon gerardii* (big bluestem), *Adropogon scoparius* (little bluestem), and *Sorghastrum nutans* (Indian grass). Common forbs include *Solidago spp*. (goldenrods), *Helianthus spp*. (sunflower), *Armorpha canescens* (lead plant), and *Lespedeza capitata* (roundhead lespedeza). The Freeman School grounds contain an approximately 0.75-acre remnant of untilled native prairie.

About 24 ha (60 ac) of the park are deciduous riparian forest, dominated by *Quercus spp.* (oak), *Acer saccharinum* (silver maple), *Celtis occidentalis* (hackberry), *and Populus spp.* (cottonwood). Native understory vegetation includes *Prunus americana* (wild plum), *Cornus florida* (dogwood), and *Symphoricarpos orbiculatus* (coralberry).

Annual prairie plant community data, including composition and structure, has been collected by the Prairie Cluster since 1996. A riparian forest inventory, funded by the I&M Program, is in progress and will be completed by 2002. An exotic species inventory, funded by the I&M Program, is scheduled for 2003.

2.3.7.2.4 Wildlife

Little is known about HOME's mammal, herpetofauna, and fish species. A mammal inventory, funded by the I&M Program, is scheduled for 2003. A herpetofauna study, funded by the I&M Program, is in progress and will be completed in 2002. Macroinvertebrates have been sampled annually by the Prairie Cluster at two sites on Cub Creek since 1996. A breeding bird survey was completed in 1998.

2.3.7.3 HOME's Natural Resource Issues and Management Objectives

Environmental concerns at HOME stem mainly from the current trend in adjacent agricultural land use. *Zea mays* (corn), *Triticum aestivum* (wheat), and *Sorghum bicolor* (grain sorghum) are the major agricultural crops surrounding HOME's borders. Two anhydrous ammonia fertilizer plants operate north of the Freeman school. On the northeast, a large residential subdivision borders HOME.

Water quality in Cub Creek is another concern since the creek winds through the HOME and is the drainage for several thousand acres of farmland. The USGS (United States Geological Survey) operates a gauging station on the Big Blue River at Barneston. No physical or chemical data is collected for Cub Creek, however, HOME does collect macroinvertebrates data during the summer under the Prairie Cluster water quality monitoring protocol.

2.3.8 Hopewell Culture National Historical Park (HOCU)

2.3.8.1 Park Background Information and Enabling Legislation

Hopewell Culture NHP is located in south central Ohio near Chillicothe in Ross County (Appendix H, Figure H.1). The park was established as Mound City Group National Monument on March 2, 1923 because *"the Mound City Group of prehistoric mounds is an object of great historic and scientific interest and should be permanently preserved and protected from all depredation and from all changes that will to any extent mar or jeopardize their historic value"*. The park was expanded and the name changed to Hopewell Culture national Historical Park by legislation signed on May 27, 1992.

As a result of the 1992 legislation the park is now composed of five geographically separate units encompassing a total of 475 ha (1,170 ac). The National Park Service owns 367 ha (907 ac) as of September 2002 and the HOCU's partner, the Ohio Historical Society, own 35 ha (85 ac). The remaining 72 ha (178 ac) are in private ownership, but the park has an active land acquisition program and is close to settling on two additional tracts. In addition, the park owns 30 ha (75) ac in excess of the authorized boundaries because park boundaries do not match ownership lines and the excess was acquired as uneconomical remnants. The five units at HOCU include the following:

- **Mound City Group (Park Headquarters):** preserved by Presidential proclamation in 1923 and is 49 ha (120 ac);
- **Hopeton Earthworks:** acquired from 1998 to 2001 in several parcels and totals 118 ha (292 ac);
- **Hopewell Mound Group:** since1997 several parcels of land have been acquired and acquisition is still continuing as of 2002, totaling 121 ha (300 ac) thus far;
- **Seip Earthworks:** since 2000 several parcels of land have been acquired and acquisition is still continuing as of 2002, totaling 96 ha (236 ac), which includes 34 ha (85 ac) of Ohio Historical Society land; and
- **High Bank Works:** since 2000 several parcels of land have been acquired and acquisition is still continuing as of 2002, totaling 80 ha (197 ac).

The primary resource at each unit is the remnants of large prehistoric geometric earthworks and mounds built by the Hopewell culture (200 BC – AD 500). Each site has a history of disturbance to both the natural and cultural resources, in particular as a result of agriculture.

Mound City Group is the original unit of the park. The land was first acquired from a local farmer by the War Department for use as a training camp during World War I. It was then designated as a National Monument in 1923 and transferred to the NPS in the 1933 government-wide reorganization. The unit contains the primary visitor services amid reconstructed earthworks maintained in turf grasses. The remainder of the property is either riparian woodland along the Scioto River or a large hay field leased to a neighboring prison.

The Hopeton Earthworks unit was purchased by the NPS to preserve the site from impending sand and gravel mining. All of the site was farmed prior to NPS acquisition and is leased to local farmers, however that will be phased out at this site within the next few years. Archeological research is on going at Hopeton Earthworks. While most of the site is agricultural, a small portion of the site is a forested ravine containing Dry Run, a small, intermittent stream.

The Hopewell Mound Group unit is still being acquired. Although most of the site is in hay fields, 7 ha (17 ac) are forested. A small unnamed spring run was dammed to create a one-acre pond. The remainder of the site was farmed and continues to be mowed for hay. The North Branch of Paint Creek runs along the south boundary of this unit, while Sulphur Lick Creek borders the east park boundary.

The Seip Earthworks unit is also still being acquired. The NPS now owns most of the unit with a central portion of the site owned by a private, non-profit organization, the Ohio Historical Society. This parcel is small area of reconstructed earthworks maintained in turf grasses. The entire site has been farmed with much acreage still in agriculture. Paint Creek forms the west and south boundaries of this unit. According to Ohio's Environmental Protection Agency (EPA), Paint Creek is a high quality stream that has good biological diversity. One of the Ohio EPA's stream monitoring stations is located at this unit.

The High Bank Works unit includes a small area of forest along the shores of the Scioto River. The remainder of the unit has been in agriculture. One former field is fallow, and the second is mown for hay. Agricultural uses will be phased out at this site. An abandoned railroad line and associated borrow pit are also present.

Hopewell Culture NHP's GMP objectives related to natural resources include:

- The park educates the public about the daily lives, contributions, perceived values, and interactions of the Hopewell peoples with other peoples and environment around them.
- The significant sites in the park and related sites are protected and preserved by various means, and the local community feels a sense of stewardship for these and other sites.
- Intrusions have been removed and potential new intrusions or impacts are actively resisted by the park and partners.

Hopewell Culture NHP's 1995 RMP goals related to natural resources include:

- The need for information on the landscape at the time of the Hopewell and at the time of Euro-American settlement. This will enable the park to determine the feasibility of reconstructing a prehistoric or historic landscape at Mound City and at the other sites. Information about the probable makeup of the landscape during the Hopewell period, and 300 years ago when the first Europeans arrived, needs to be established through research before any restoration begins.

- The need for baseline information on the park's flora and fauna including populations, distribution, endangered or threatened species, and mapping.
- The need to identify resources that require protection and to develop and implement plans to protect them, particularly those on the newly authorized sites. This includes both resources covered by the Archeological Resources Protection Act and natural resources vulnerable to activities such as poaching.
- The need to adequately assess the impacts land use and associated developments are having or may have on park resources.
- The need to stabilize the new sites with appropriate ground cover as they are added to the park and agriculture is discontinued.

The park does not have a cultural landscape report. The information about prehistoric and contact period landscapes and vegetation are not available at this time. It will require extensive research to develop this information. Therefore, it is not feasible to prepare a CLR in the near future. In the meantime, HOCU and the Midwest Regional Office are preparing a vegetation management plan for the park. *"The document provides a conceptual framework for making decisions with specific direction on how to achieve a desired future condition for the earthwork sites. The desired future condition is an established, sustainable groundcover dominated by native grasses and non-invasive exotics that allows for ongoing archeological research and interpretation."*

HOCU's GPRA natural resource related goals include the following:

- 1a01A: By Sept 30, 2005, 75 (18.75%) of 400 acres of Hopewell Culture NHP lands disturbed by prior development and agricultural use and targeted (by September 30, 1999) for restoration are restored.
- 1a1B: By Sept 30, 2005, 100 (66.7%) of 150 acres of Hopewell Culture NHP lands impacted by exotic vegetation targeted by September 30, 1999, is contained.
- 1b3: By Sept 30, 2005, Hopewell culture NHP has identified its vital signs for natural resource monitoring.

The following sections describe HOCU's natural resources, park issues/concerns, and management objectives.

2.3.8.2 Hopewell Culture NHP's Natural Resources

An annotated bibliography of selected natural resource studies completed for HOCU is included in Appendix H (Table H.1). Appendix H (Figure H.2) includes a map of HOCU's roads, trails, and rivers.

2.3.8.2.1 Geology and Water

The five units of HOCU are located within the Appalachian Plateau topographic province on floodplains or Wisconsin age terraces consisting predominantly of sandstones and shales. The park is located at the terminus of the last continental glacier.

The park is in the Scioto River watershed, and three of the units are adjacent to segments of the Scioto River and its tributaries. The boundaries of the park do not contain these streams, but the park has an interest in water management issues for recreation and resource management. These tributaries include Paint Creek and North Fork of the Paint Creek. The State of Ohio intensively monitors the condition of the Scioto and its tributaries. All surface waters in Ohio are listed as 303(d) Impaired because of concerns about mercury concentrations in fish. Portions of the Scioto River, including all segments adjacent to the park, are listed as 303(d) Impaired primarily for agricultural run-off and other non-point pollution sources. Water quality in the Paint Creek tributary is listed as Outstanding Natural Resource Waters. The North Fork of the Paint Creek is a primarily spring feed river and has relatively good quality water.

2.3.8.2.2 Soils

The soils in all park units are silt loam underlain by sand and gravel typified as the Fox-Ockley-Genesee-Ross soil association.

2.3.8.2.3 Vegetation

All of HOCU's vegetation has been disturbed. Suburban growth, mineral extraction, plowing, soil erosion, logging, and artifact collecting all threaten park natural resources. All five HOCU sites are situated along rivers and creeks, with forest and grassland riparian landscape. The five sites also contain lawn areas, upland forests, and farm fields. Plant species consists of a mixture of crops, and native and exotic vegetation.

Extensive vegetation sampling has been completed at all units of HOCU. Herberia specimens and records are housed in the collection area at HOCU.

2.3.8.2.4 Wildlife

As of 2002, no studies have been completed for mammals, fish, or invertebrates at HOCU. A herpetofauna inventory, funded by the I&M Program, is in progress and will be completed in 2003. Mammal and fish inventories, funded by the I&M Program, are scheduled for 2003. A riparian bird survey has been completed during the spring and fall seasons every year since 1996 by the local Valley Bird and Nature Club and park personnel. The I&M Program is funding a bird inventory in 2003 for all park units and compiling the bird surveys from the past twenty years.

Each year the State of Ohio monitors for *Lymantria dispar* (gypsy moth) to track the spread of this species throughout the state. Park staff assists with this effort by placing *L. dispar* traps at several locations in the Park.

The Ohio Environmental Protection Agency monitors aquatic species diversity and water quality on the Scioto River and its tributaries, Paint Creek and the North Fork of Paint Creek. This effort provides the park with sufficient information to track the condition of the aquatic resources adjacent to the park. The fish inventory scheduled for 2003 will focus on intermittent streams and the recently acquired one-acre pond.

2.3.8.3 HOCU's Natural Resource Issues and Management Objectives

The top four natural resource issues and related park management objectives for HOCU are summarized below. Appendix H (Table H.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below, however these are not necessarily in order of priority.

2.3.8.3.1 Invasive Plant Species (Priority Issue #1)

Fallow farm fields in this area are commonly overgrown with *Multiflora rose* (Rosa multiflora). In some places dense thickets of honeysuckle, *Lonicera japonica* (Japanese honeysuckle) and *Lonicera tatarica* (Tartarian honeysuckle), are well established and inhibiting the regeneration of native plants. Other invasive plants such as *Vinca minor* (periwinkle), *Sorghum halepense* (Johnson grass), *Ailanthus altissima* (tree of heaven) and *Vitis aestivalis* (summer grape) are also inhibiting native plant reproduction. These species, as well as others, present several management problems for the park. The larger woody species have the potential to damage buried archeological resources that are the primary resource of the park. Thickly growing species, such as *M. rose*, also make archeological survey extremely difficult. The invasive species make it difficult to establish and maintain the preferred vegetation cover.

The management objective is to establish a monitoring program to track the presence and abundance of known invasive species on park lands and to identify locations of new points of colonization. The program also needs to be able to detect new species and allow the park to control new invasions in a timely and cost-effective manner. Additionally, the park wants to control pest plant species to avoid being identified as weed source by neighboring farmers.

2.3.8.3.2 Forest Plant Communities (Priority Issue #2)

The Hopewell Mound Group unit has the largest and most intact forest in the park. Roughly 7 ha (17 ac) of second growth forest occupies the upper terrace at the site. This forest is changing from a coniferous forest to a deciduous forest, primarily *Quercus spp*. (oaks). One of the pending condemnation actions will increase the forest land total, adding 34 ha (83 ac) to this unit. In addition there are smaller wooded areas at the Mound City Group and along the Paint Creek banks at Seip Earthworks. Lower terrace and flood plain forest species include *Plantanus occidentalis* (sycamore), *Populus deltoides* (cottonwood), *Acer negundo* (box elder), *Acer saccharinum* (silver maple), and *Aesculus glabra* (Ohio buckeye). Upper terrace forest species include *Quercus rubra* (red oak), *Carya cordiformis* (bitternut hickory), and *Carya ovata* (shagbark hickory).

The management objective is to detect trends in species composition, age, health, and secession within these forested areas. The park is also concerned about the possible threat of the *Lymantria dispar* (Gypsy moth), which has already devastated many forests in the eastern United States.

2.3.8.3.3 Population and Diversity of Native Fauna (Priority Issues #3 and #4)

Changes in the diversity, health, and population of native fauna could be an important indicator of stressors affecting the park. These could be particularly important in identifying impacts from neighboring agricultural and forestry operations. However, without completed inventories of the fauna it is not possible to select the most appropriate species for a monitoring protocol. HOCU has limited knowledge about the native fauna occurring in the park. The best available data sets are for bird species, however, herpetofauna (in progress, 2002), mammal, fish, and bird inventories will be completed by 2003.

2.3.8.3.4 Overabundance of Native Fauna

Marmota monax (ground hogs) and *Citellus tridecemlineatus* (thirteen-lined ground squirrel) are a concern at HOCU for several reason. These species dig holes in the earthworks thus creating concerns about archeological protection and visitor safety. At this time their population numbers are unknown. The park management objective is to record species abundance and to determine how these species impact the earthworks and visitor safety.

2.3.8.3.5 Water Quality, Abiotic

Water quality concerns include erosion in riparian areas along the river, sludge on lower fields leading into the North Fork of Paint Creek, and arsenic contamination.

2.3.8.3.6 Adjacent Land-Use Changes

Suburban and rural development is occurring in the vicinity of all of the units at the park, and is particularly intense near the Hopewell Mound Group and Hopeton Earthworks. Some of these concerns include a nearby paint factory, contamination (i.e., lead shot) and noise from the local gun club, neighboring agricultural impacts (i.e., herbicides, pesticides), stormwater run-off, timber harvesting, loss of natural resource habitats, possible spills from adjacent roads and railroads, and mining quarries.

2.3.8.3.7 Small Mammals

As the park converts agricultural lands to grasslands and forests there are likely to be changes to the variety and populations of small mammals. Changing to grassland may increase the number of voles, shrews, deer mice, foxes, coyote, raccoons, muskrats, beavers, otters, and bats. The populations of small predators, such as fox and coyote, are unknown and have not been considered an issue for the park, but these populations will very likely change with the change in habitat.

2.3.8.3.8 White-Tailed Deer

It is not clear if *Odocoileus virginianus* (white-tailed deer) are having an impact on the park resources at this time. Deer populations could become an issue for several units of the park especially if the units become “islands” surrounded by residential development.

2.3.9 Hot Springs National Park (HOSP)

2.3.9.1 Park Background Information and Enabling Legislation

HOSP is located in west central Arkansas at the southeastern edge of the Ouachita Mountains (Appendix I, Figure I.1). HOSP was first set aside as the Federal Hot Springs Reservation on April 20, 1832 to protect the hot springs flowing from the southwestern slope of Hot Springs Mountain. This makes HOSP the oldest park currently in the National Park system. Hot Springs Reservation became Hot -Springs National Park by a Congressional name change on March 4, 1921. HOSP is approximately 2,206 ha (5,450 acres) and is adjacent to the City of Hot Springs.

HOSP is infamous for its thermal springs and therapeutic bathhouses. The hot springs are a result of the unique geology of the area in combination with the present topography. Bathhouse Row is a group of eight bathhouses built between 1911-1923 and is one of the last remaining collections of historic bathhouses in the United States (General Management Plan, 1986). Bathhouse Row is the area where the thermal springs emerge from the earth. Today, all but one bathhouse is closed.

The park's enabling legislation mandates the thermal waters be preserved and provided to the public in an unending and unaltered supply. HOSP may be the only park in the system required by law to give away its natural resource.

HOSP's GMP objectives related to natural resources:

HOSP's RMP goals related to natural resources:

HOSP GPRA goals related to natural resources include the following:

- 1a04: By Sept 30, 2005, 28 (100%) of captured underground thermal and cold springs of Hot Springs National Park are in good condition.
- 1a1A: By Sept 30, 2005, 45 (75%) of 65 acres of Hot Springs National Park's targeted lands disturbed by development, as of FY 1999, are restored.
- 1a1B: By Sept 30, 2005, exotic vegetation (including kudzu, cherry laurel, and privet) on 8 (50%) of 15 targeted acres of Hot Springs National Park lands, as of FY 1999, are contained.
- 1a4: By Sept 30, 2005, Hot Springs National Park has unimpaired surface water quality.
- 1b3: By Sept 30, 2005, Hot Springs National Park has identified its vital sings for natural resource monitoring.

The following sections describe HOSP's natural resources, park issues/concerns, and management objectives.

2.3.9.2 HOSP's Natural Resources

An annotated bibliography of selected natural resource studies completed for HOSP is included in Appendix I (Table I.1). Appendix I (Figure I.2) includes a map of HOSP's land cover, roads, trails, and rivers.

2.3.9.2.1 Geology and Water

The geothermal aquifer(s) of HOSP is thought to be approximately 19 to 24 km^2 (12 to 15 mi^2) in extent, although its precise boundary is unknown. The combination of complex stratigraphy and structural trapping structures found in the surface geomorphology within and around the park make definitive delineation of the geothermal aquifer(s) difficult and expensive.

The water at HOSP is geothermally heated at an unusually shallow depth of several thousand feet. The water then rises through faults in the Hot Springs sandstone formation to emerge from the thermal springs. Through radiocarbon dating, this process has been determined to take over 4,000 years.

A thermal water distribution system consisting of covered concrete basins around the orifices of the hot springs and collection and distribution lines has been in place for many years. Two cold water springs, a few intermittent and perennial streams, and a few small lakes also occur within the boundaries of HOSP. The cold water springs, Whittington and Happy Hollow Springs, and thermal water fountains are used by the public as sources of drinking water. The perennial streams include Gulpha Creek, Whittington Creek, Bull Bayou, and Hot Springs Creek. All four of these creeks are part of the Greater Mississippi Watershed; flowing first into Lake Hamelton, then Lake Catherine, Ouachita River, Red River, and finally into the Mississippi River. The headwaters of Gulpha Creek, Hot Springs Creek, and Bull Bayou are outside park boundaries. The headwaters for Whittington Creek are within park boundaries.

2.3.9.2.2 Soils

2.3.9.2.3 Vegetation

Most of HOSP supports dense forest cover, however it is unlikely that there is much old growth forest in the park, with the possible exception of a 61 ha (150 ac) stand of *Pinus echinata* (shortleaf pine) on the north slope of Sugarloaf Mountain (General Management Plan, 1986). Prohibitions on timber cutting were not implemented until HOSP came under the jurisdiction of the National Park Service in 1916. Nearly all of the additional land acquired since 1972 has either been farmed, mined, logged, or cleared.

Forest vegetation in HOSP is within a transition zone between the upland hardwood forests characteristic of the Ozark Plateau to the north and west and the southern of *P. echinata* associations of the Gulf Coastal Plain to the south.

A vegetation inventory focusing on the distribution and composition of pine-oak/hickory woodlands, funded by the I&M Program, was completed in 2002. An exotic plant inventory will be completed by 2003.

2.3.9.2.4 Wildlife

As of 2002, little is known about HOSP mammal species and fish species. A fish inventory was initiated in 2002, funded by the I&M Program, and will be completed by the end of 2003. During 2002, a herpetofauna inventory, funded by the I&M Program, was completed. A local chapter of the Audubon Society regularly monitors bird species in the park.

2.3.9.3 HOSP Natural Resource Issues and Management Objectives

The top four natural resource issues and related park management objectives for HOSP are summarized below. Appendix I (Table I.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below, however these are not necessarily in order of priority.

2.3.9.3.1 Geothermal Springs, Physical and Chemical (Priority Issue #1)

At the most fundamental level, the thermal waters of HOSP are valued as a unique and healthy drinking water source for local and commercial consumption and for the recreational and therapeutic value of thermal water baths. As such, assuring continued excellent water quality in the interest of public health and safety is a primary concern HOSP. People come from other states, as well as the local region, to collect the water and take it home to use. Many hold the perception that water from the hot springs tastes unique.

The management objective is to monitor flow volumes, clarity (turbidity), temperature, and water quality (i.e., change in mineral content and pH for taste) trends to ensure that spring health is maintained.

2.3.9.3.2 Adjacent Land-Use Change (Priority Issue #2)

The clear need exists for delineating the recharge area that contributes the cold-water component of flow that mixes with the thermal springs. Land-use changes within that recharge area presents a major threat to the integrity of the geothermal waters. The following activities outside park boundaries are affecting, or have in the past, the thermal springs:

- Mining,
- Oil pools (i.e., transformers and PCBs),
- Commercial enterprises (i.e., theme park),
- Paved surfaces (decreased permeability, increased run-off),
- Agricultural activities, and

- Rapidly increasing urbanization of Garland and Hot Springs Counties may be impacting the health of the aquifer in a detrimental manner.

Land-use changes can result in accelerated sheet flows, which can then potentially increase erosion and flood events. HOSP is located in a narrow valley where building and parking lot construction has cut off the toe slope of the mountains on both sides of the valley. As a result, landslides have occurred particularly following freeze-thaw periods.

The management objective is to map any changes in topographic drainages, record pollutants, keep a record of potential pollutants from adjacent lands, recontour and revegetate areas after HOSP buildings are removed to decrease erosion and run-off, while increasing ground permeability.

2.3.9.3.3 River: Water Quality (Priority Issue #3)

Gulpha Creek is a perennial stream that enters the park at Stone Bridge and flows through the Hot Springs campground. As Gulpha Creek flows through campground, people play and fish in it. Therefore water quality is linked to a human health issue.

Bull Bayou forms the boundary of HOSP (park property includes both sides of the both bank). Bull Bayou runs through a Class 4 dump [231 ha (570 ac)] before entering the park. Bull Bayou is a slough formed as a result of backwater from a dam on Ouachita River. People swim in the bayou, therefore water quality is a human health issue.

Wittington Creek dumps into Hot Springs Creek before the creek enters the canal under the main street of Bathhouse Row, Highway 7. Wittington Creek runs through some areas of dense real estate, joins the Graves gravel pit (full of trash), and goes through two additional dumps (one dump is NPS and is no longer used, but contains old materials). There is also a gravel quarry within the watershed.

Historically, fish kills have occurred due to dumping in Hot Springs Creek. Other impacts to the stream include agricultural runoff importing nutrient loads into the system, especially during high flow events. Similarly residential use of Cloradain to treat termites may be transported to the creek by over land flow during storm events. Methamphetamine labs are a problem as dumping piles have been found near the creek. Trucks on Gulpha Gorge Road (HWY 70b), one of the two highways transport hazardous materials through the area and in the past accidents and spills have occurred adjacent to the Hot Springs Creek.

The management objective includes a baseline of water quality in relation to *E. coli*, fecal coliform, trace elements, heavy metals, and Volatile Organic Compounds (VOC's).

2.3.9.3.4 Exotic Vegetation Species (Priority Issue #4)

The following exotic species are found at HOSP: *Pueraria lobata* (kudzu), *Prunus laurocerasus* (cherry laurel), and *Lespedeza cuneata* (lespedeza).

P. lobata, introduced from Japan, is an extremely destructive exotic species that moves into disturbed areas incredibly fast and dominates by covering vegetation, buildings, and anything else it can grow on or over. As residential lots are reclaimed by the park and buildings are removed the *P. lobata* becomes established and kills the native vegetation. *P. lobata* does not seem to be as much of a problem in undisturbed areas.

The management objective for *P. lobata* is to completely eradicate it from the park, although that will be difficult because cutting *P. lobata* does not destroy it, nor do most herbicides. In the past, HOSP was somewhat successful in destroying this species with a cut stump herbicide application, but this form of control has to be a persistent action to be effective.

The management objective for *P. laurocerasus* and *L. cuneata* also includes eradication from the park.

2.3.9.3.5 Old Growth Forests

Based on ring analysis it appears that HOSP has the oldest stand of oak-hickory-pine, over 400 years old, in the state of Arkansas. One stand, 16 to 20 ha (40 to 50 ac), is located on the edge Hot Springs Mountain. Another stand, 36 ha (90 ac), is located to the side of Sugarloaf Mountain near Cedar Glades Road. The management objective is to protect and maintain these stands of old growth forests. These areas can be used as a teaching tool for a significant and rare ecosystem.

2.3.9.3.6 Wetlands

A wetland, approximately 40 ac in size, is located in a low-lying area north of Stone Bridge. The headwaters of Gulpha Creek are near the wetland. There are no trail or fire road accesses in the area, plus the area is gated so the wetland has remained relatively unimpacted. The management objective is to gather baseline data on the wetland.

2.3.9.3.7 Forest Plant Communities

HOSP is concerned about the health of its vegetation. One major concern is the impact of insects including the *Lymantria dispar* (gypsy moth), *Enaphalodes rufulu*s (red-oak borer) and pine bark beetles. Other concerns include impacts from ice storms, diseases, exotic plant and animal species, and declines in understory vegetation populations [*Cercis canadensis* (redbud), *Cornus spp*. (dogwood), *and Rhododendron roseum* (wild azalea).

2.3.10 Lincoln Boyhood National Memorial (LIBO)

2.3.10.1 Park Background Information and Enabling Legislation

LIBO is located in Spencer County in southwest Indiana (Appendix J, Figure J.1). LIBO was established by an Act of Congress on February 19, 1962 to *"preserve the site associated with the boyhood and family of Abraham Lincoln".* The roughly rectangular-shaped property is 81 ha (200 ac) and encompasses the western 32 ha (80 ac) of the original quarter section owned by Thomas Lincoln, including several cultural and interpretive elements.

At some time during the mid-1800's, the majority of the current LIBO property was cleared and several buildings were erected. Lincoln City, which includes the LIBO property, was platted in the 1870's. Interest in the LIBO property as a historical landmark, specifically the gravesite of Nancy Hanks Lincoln also occurred around this time. During the mid-1920's Olmsted was hired to develop a landscape plan for the park. Implementation of the Olmsted plan occurred from the late 1920's through the early 1940's. The plan included a formally landscaped walkway or "allee", memorial building, and tree plantings on the remainder of the property. Olmsted's plan was meant to draw the visitor's focus, upon entering the south end of the Memorial, towards the gravesite and peaceful forest setting. During the mid-1970's, several buildings and roads were removed and farm fields were abandoned in the North Forty.

LIBO's GMP revisions are currently in progress. A completed document is expected in early 2003.

LIBO's RMP states a need for prescribed fire and exotic species management.

LIBO GPRA goal related to natural resources include:

- 1b3: By Sept 30, 2005, Lincoln Boyhood National Memorial has identified its vital sings for natural resource monitoring.

The following sections describe LIBO's natural resources, park issues/concerns, and management objectives.

LIBO's Natural Resources

An annotated bibliography of selected natural resource studies completed for LIBO's is included in Appendix J (Table J.1). Appendix J (Figure J.2) includes a map of LIBO's land cover, roads, trails, and water bodies.

2.3.10.1.1 Geology and Water

LIBO is located in the Wabash Lowlands physiographic province of southwestern Indiana in a transition to the Crawford Upland to the east (Schneider, 1966). Elevation in the park ranges from about 415 feet to 512 feet above sea level, providing about 100 feet of relief. The land above 450 feet is comprised of steep sloping hills dissected by shallow ravines. Below 450 feet, the landscape is gently undulating. The highest sites occur to the south and the lowest within the North Forty.

The land is underlain by Pennsylvanian age sedimentary rocks; sandstone, shale, and thin Carbondale Group coals (State of Indiana, 1970). The lowland surficial material is alluvium derived from weathered shale and sandstone. The upland surficial material is comprised mainly of weathered loess derived from late Wisconsin time Wabash River outwash (Schneider, 1970). The property was unglaciated.

The only permanent water source at LIBO is a small man-made pond. During the spring, the northern one-third of the park contains several ephemeral pools and streams that are not obvious during the remainder of the year.

2.3.10.1.2 Soils

Soil types in LIBO consist of silt loams derived from alluvium and loess. Five soil series occur within the Memorial with varying characteristics. The chart below lists these characteristics and the woodland types normally associated with each soil series.

Series	Parent Material	Drainage	Associated Tree Species
Atkins	alluvium	Poor	*Liquidambar styraciflua* (sweet gum), *Platanus occidentalis* (sycamore), *Quercus palustris* (pin oak), *Acer rubrum* (red maple), *Fraxinus spp.* (ash), and *Liriodendron tulipifera* (tulip tree)
Bartle	alluvium	Poor	*Liquidambar styraciflua*, *Platanus occidentalis*, *Quercus palustris*, *Acer rubrum*, and *Betula nigra* (river birch)
Stendal	alluvium	Poor	*Liquidambar styraciflua*, *Platanus occidentalis*, *Quercus palustris*, *Acer rubrum*, and *Populus deltoides* (cottonwood)
Tilsit	loess	Moderately-well	*Quercus alba* (white oak), *Quercus velutina* (black oak), hickory, *Fraxinus spp.* (ash), and *Liriodendron tulipifera*
Wellston	loess	Well	*Quercus alba*, *Quercus velutina*, *Quercus rubra* (red oak), *Carya spp.* (hickory), *Liriodendron tulipifera*, and *Fagus grandifolia* (American beech)
Zanesville	loess	Well	*Quercus alba*, *Quercus velutina*, *Carya spp.* (hickory), *Fraxinus spp.* (ash), and *Liriodendron tulipifera*

Well-drained soils occur in the high relief areas in the southern half of LIBO. Poorly drained soils are associated with flat land in the North Forty and ephemeral drainages in the southern property.

2.3.10.1.3 Vegetation

Pavlovic and White in 1989 (NPS MWR-15) analyzed presettlement vegetation using General Land Office survey notes from Sanford and Henri from 1805. They showed that the presettlement vegetation of Spencer County, which includes LIBO, was a mosaic of upland xeric and mesic oak-hickory forest with patchy mesic mixed forest areas grading into bottomland forests along streambanks. The upland forest were dominated by *Quercus alba*, *Quercus velutina*, *Carya ovata* (shagbark hickory), and *Carya glabra* (pignut hickory). The upland forest and portions of the North Forty probably were shrub-filled and savanna like or oak woodland. The original land surveyors noted that a large portion of the property had been burned. Savanna-like openings may have occurred on the west facing slopes of the upland forests west of County Road 300E through naturally or Native American ignited fire.

The genetic origin of the trees planted by the CCC during the Olmstead plan implementation is unknown. Much of the present forest dates to this era, although there are a small number of older and apparently open-grown trees. Forests in the North Forty date primarily to the mid-1970s, although trees and shrubs that decorated previously existing lawns in this area were not generally removed and still exist. Planting experiments and exotic vegetation removal have been attempted on several occasions throughout LIBO between 1985 and 2002.

Pavlovic and White established permanent vegetation plots that were surveyed in 1985 and 1996/1997. Analyses of the changes in that 11-12 year period are currently underway. Data includes tree size, species, and abundance and shrub species density. Preliminary results from the data reveal that the majority of the vegetation at LIBO is oak dominated forest/woodland. The hill where the graveyard is located is the least disturbed area and contains the oldest trees; primarily *Quercus spp.*, *Carya spp.*, and *Acer saccharum* (sugar maple). More mesic species such as *Liriodendron tulipifera*, *Liquidambar styraciflua*, and *Acer spp.* dominate the lower elevations of the park.

A full plant list and herbaria specimens were assembled in 1989 by Pavlovic and White, however, plant data is currently in paper format and old databases. Updating these databases and adding spatial components was a high priority for LIBO, so in 2001 the I&M Program funded the development of a natural resource database to include the addition of GIS layers. The expected completion date for this project is 2002.

Another high priority for LIBO is documenting the distribution and abundance of exotic vegetation species. As of 2002, the exotic plant species compromise over 17% of the species present at LIBO. An exotic plant inventory, funded by the I&M Program, is scheduled for 2003.

2.3.10.1.4 Wildlife

A wildlife inventory was completed in 1996-97. The inventory included large and small mammals, reptiles and amphibians, and birds. One hundred and two species were detected with none listed as threatened or endangered. The only permanent water source is a man-made pond and there has been no fishing or stocking since the early 1990's.

2.3.10.2 LIBO's Natural Resource Issues and Management Objectives

The top four natural resource issues and related park management objectives for LIBO are summarized below. Appendix J (Table J.2) includes a narrative written by Park Management on these top four priority issues.

2.3.10.2.1 Forest Plant Communities (Priority Issue #1)

Approximately 49 ha (120 ac) of LIBO is forests. The current overstory trees forests were planted by the Civilian Conservation Corps in the 1930's and 1940's using seedlings of unknown origin that were available from the Indiana State Nursery in Vallonia, Indiana. It appears that in planting little consideration was given to the species planted in the xeric and mesic areas of the property, the result is a forest of unusual composition. The fact that LIBO's forests were a Civilian Conservation Corps project holds some historic value as a written and photographic history but does not preclude intense management of the vegetation.

LIBO's primary natural resource issue is the provision of a landscape representative of the early settlement period in Southern Indiana (including oak/hickory and mixed deciduous forests). Secondary is that the forest's function is restored to the degree possible within the constraints of the ecology of the system and the small size of LIBO. Anticipated reductions in air quality due to new industries within the area are a concern, as well as the potential arrival of *Lymantria dispar* (gypsy moth). The initiation of prescribed fire management at the Memorial will also impact the forest communities.

The natural resource management objectives for LIBO's forests are to approximate the conditions encountered by the Lincoln family and other southern Indiana pioneers; detect the presence of *L. dispar;* determine the native forest composition and structure; and determine species of concern. Tree associations listed previously with LIBO's soil information were included as partial evidence of the invasion of mesic species into areas that should contain tree species indicative of well-drained soil conditions. Prescribed fire in these areas is desired to shift the balance towards those species.

2.3.10.2.2 Exotic Plant Species (Priority Issue #2)

Exotic species are found throughout LIBO in varying densities. Adjacent land use, farming and rural residential areas provide the means for invasion into LIBO. Species of primary concern include *Lonicera japonica* (Japanese honeysuckle), *Dioscorea oppositifolia* (Chinese yam), and various less aggressive ornamental shrubs and grasses.

Management objectives include the following: detect the presence and spatial abundance of exotic plant species; provide an indication of the source of exotics to serve as an early warning mechanism; utilize monitoring data to allow for adaptive management and actions to be taken to prevent future infestations; provide data on the effectiveness of exotic species treatments; and determine if control efforts are successful over time throughout the park [specifically, within the northern 16 ha (40 ac) and the eastern side of the park 20 ha (50 acres)].

2.3.10.2.3 Land-Use Change (Priority Issue #3)

LIBO has a long history of diverse land use and disturbance; first as a small farm site, then as the site of a small town, and finally as the site of a Civilian Conservation Corps reforestation project. Land-use adjacent to LIBO is shifting from agricultural to residential and industrial uses.

Park management's involvement in local planning concerning land-use changes may become necessary to protect the sensitive resources at LIBO, both natural and cultural. Management objectives include obtaining the large-scale information needed to protect park resources, provide an early warning of potential impacts, and detect impacts from agriculture, urbanization, and industrialization to LIBO's resources.

2.3.10.2.4 Air Quality (Priority Issue #4)

The air quality of LIBO is at risk due to the industrialization within Spencer and surrounding counties. Several monitors are in place within Spencer County. The management objective is to determine the air quality at LIBO and then monitor for early detection of potential impacts to park natural resources.

2.3.10.2.5 Wildlife

Species diversity and densities, particularly those of small mammals, predators, and amphibians are lower than expected for oak/hickory forest in southern Indiana. The management objective is to improve abundance and diversity of wildlife by improving overall forest conditions.

2.3.11 Ozark National Scenic Riverways (OZAR)

2.3.11.1 Park Background Information and Enabling Legislation

OZAR is located on the Ozark Plateau in south central Missouri (Appendix K, Figure K.1). OZAR was establish in 1964 as the first park in the National Park Service specifically designated to preserve the scenic river experience. It was mandated to *"conserve and interpret unique scenic and other natural values and objects of historic interest, including the preservation of the Current River and the Jacks Fork River as free-flowing streams, preservation of springs and caves, management of wildlife, and provision for use and enjoyment of the outdoor recreation resources"*. This enabling legislation subsequently served as the template for the Wild and Scenic Rivers Act of 1968.

OZAR contains almost 32,695 ha (80,790 ac), including 216 km (134 mi) of the Current River and its major tributary the Jacks Fork River. The Current River Basin includes cold-water habitat maintained by a nationally ranked spring discharge system with warm-water habitats in reaches dominated by runoff. The Current River Basin is known nationally for its highly distinctive aquatic fauna. OZAR provides for various recreational enjoyments including canoeing, fishing, boating, sight-seeing, camping, horseback-riding, and wildlife and plant viewing.

OZAR's GMP objectives related to natural resources:

- Within the natural zone, natural resources and processes will be preserved and will remain largely unaltered by human activity.
- Within the Outstanding Natural Features Subzone, resources will be managed to provide visitor access while protecting the conditions and processes that make the areas outstanding and unique.
- Within the Environmental Protection Subzone, some areas encompass geological, scientific, and ecological characteristics that are sufficiently unique or fragile to warrant special protective consideration.
- It is the objective of the National Park Service to maintain the natural abundance, behavior, diversity, and ecological integrity of native animals in natural portions of the riverways and to rely primarily on natural processes to regulate populations of these species.

OZAR's RMP goals related to natural resources:

- Rehabilitate and perpetuate park scenery, waters, wildlife, and natural and cultural features for high quality public use, enjoyment and appreciation.

OZAR's GPRA goals related to natural resources include the following:

- 1a4: By September 30, 2005, Ozark NSR has unimpaired water quality.

- 1a01A: By Sept 30, 2005, 7 of 27 (26%) acres identified in 1999 as impacted by visitation will be stabilized to prevent additional deterioration; and 11 of 162 (7%) acres of habitat are in an improved condition compared to 1999.
- 1a09B: By Sept 30, 2005, 43 of 85 (50%) of Ozark NSR's sensitive caves are in a lightly disturbed or better condition.
- 1a1A: By Sept 30, 2005, 3 (3%) of Ozark NSR's 106 acres of lands disturbed by prior development and agriculture, as of 1999, are restored.
- 1a1B: By Sept 30, 2005, Lespedeza cuneata (lespedeza) is contained on 65 (100%) of 65 acres targeted in Ozark NSR's NRMAP for treatment.
- 1a9B: By Sept 30, 2005, 500 square feet of Ozark NSR's targeted cave floors are restored.
- 1b01A: By Sept 30, 2005, 7 of 27 (26%) acres identified in 1999 as impacted by visitation will be stabilized to prevent additional deterioration; and 11 of 162 (7%) acres of habitat are in an improved condition compared to 1999.
- 1b3: By Sept 30, 2005, Ozark NSR has identified its vital signs for natural resource monitoring.

The following section describes OZAR's natural resources, park issues/priorities, and management objectives.

2.3.11.2 OZAR's Natural Resources

An annotated bibliography of selected natural resource studies completed for OZAR's is included in Appendix K (Table K.1). Appendix K (Figure K.2) includes a map of OZAR's roads and water bodies.

2.3.11.2.1 Geology and Water

OZAR is situated on karst topography that evolved from the dissolution of underground pathways, conduits and caverns that have surface expressions of sinkholes, losing springs, caves, and springs. As a result, the entire area is underlain by impressively complex pathways of water and energy flow, where surface constituents can disappear into the ground only to emerge from springs within the park days or years later.

Over 250 springs are known in OZAR. Based on radio-isotope measurements, the water discharging from the springs may have fallen as rain yesterday or be thousands of years old. The park contains four of the top ten springs in Missouri, including Big Spring, which is one of the largest springs in the United States. Big Spring delivers 273 million gallons of water per day to the Current River.

Missouri Statute 10 CSR 20-7.031 designates the Current and Jacks Fork Rivers from their headwaters through the park as Outstanding National Resource Waters (ONRW). These rivers constitute two of only three rivers designated as Missouri ONRWs. In 1998, a 303(d) reach listed for fecal coliform bacteria was established on a 5-mile stretch of the Jacks Fork River from the town of Eminence, Missouri to its confluence with the Current River. Approximately 3 miles of this 5-mile reach are within the OZAR boundaries.

2.3.11.2.2 Soils

Soils along the park have formed primarily in loess, hill slope sediments/residuum or gravelly alluvium. Most soils are highly weathered Ultisols and Alfisols with a mesic temperature and humid moisture regimes. Soils range from shallow unconsolidated materials over bedrock to deep, highly weathered soils in hillslope sediments. Bedrock outcrops and fragipans are common. Alluvial soils on upland drainages, terraces and floodplains are deep, coarse-textures and have medium base saturation.

2.3.11.2.3 Vegetation

OZAR has various plant community habitats including glade/savanna, seeps/springs, bluffs/rock outcrops, fens, riparian thickets, gravel bars, floodplains, and forests. A substantial amount of vegetation inventory data has been collected in the park. An inventory of rare *Arundinaria gigantea* (river cane) communities and the development of a GIS model of park locations for unique plant communities (i.e., bluffs, fens, caves, glades), both projects funded by the I&M Program, are scheduled for 2003.

2.3.11.2.4 Wildlife

A comprehensive mammal study was completed in 1991, however bat habitats were not adequately addressed. A bird inventory, funded by the I&M Program, is in progress and will be completed in 2003. This bird inventory will compliment and verify existing records on the avian fauna, as well as document locations of two federally listed threatened and endangered species, *Dendroica cerulea* (Cerulean warbler) and *Limnothlypis swainsonii* (Swainson's warbler). A herpetofauna inventory, funded by the I&M Program, was completed in 2001 and documented 73 herpetofauna species in OZAR, including 13 turtle species, 13 salamander species, 13 frog species, and 27 snake species.

The Current River Basin contains 112 of the 270 fish species known to occur in the entire Mississippi River, including six endemic species and one subspecies found only in the Current River. Fish have been surveyed in most of OZAR's water bodies, except in caves. An inventory is desired for these cave fish species.

2.3.11.3 OZAR's Natural Resource Issues and Management Objectives

The top four natural resource issues and related park management objectives for OZAR are summarized below. Appendix K (Table K.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below, however these are not necessarily in order of priority.

2.3.11.3.1 River Integrity, Biotic (Priority Issue #1)

The Ozark Plateau contains one of the only "relatively intact" temperate headwater streams left in the North American continent (Abell et al 2000). The region is nationally known for its highly distinctive aquatic fauna, especially crayfish (surface and hypogean) and herpetofauna. The Current River Basin contains almost half of the fish species found in the Mississippi River and a large number of herpetofauna. One giant salamander species, the *Cryptobranchus alleganienis bishopi* (Ozark hellbender), is a candidate for federal listing as an endangered species. The basin also supports 219 benthic invertebrate taxa (Duchrow 1977).

As of 2002, a full inventory of the aquatic biota within the park has not been completed. Population studies have been conducted on a number of game fish species, but non-game species information is lacking. With the exception of crayfish, the invertebrate communities within the park needs a more comprehensive assessment. Understanding the variability of aquatic biota communities within an Ozark stream remains to be done. Quantifying and linking impacts of watershed activities and park visitor activities on aquatic habitat and biota, and developing a prioritization of protection mechanisms, is also needed. Until this research is accomplished, it is unclear how these river systems are being affected and what kind of mitigation is necessary.

The management objectives include compliance with park and national (i.e., Endangered Species Act) legislation to conserve and interpret the "unique and natural values" of the park through inventory, research, and monitoring of park aquatic ecosystem, while providing "for the use and enjoyment of outdoor recreational resources", which includes harvesting according to State regulations. OZAR's goals also include working with watershed partners to protect park values, by clarifying linkages from watershed activities to park values.

2.3.11.3.2 River Integrity, Physical (Priority Issue #2)

Abiotic factors (flow, physical habitat, water quality, and energy sources) provide the template for the overall biological integrity of park river systems. Flow regimes carve and maintain physical habitat conditions, and also carry energy sources contributing to the river's water quality. High visitor use levels, increases in river ford use, and increase in outboard motor size, have increased harassment and led to degradation of water quality and physical habitat. Aquatic physical habitat is apparently undergoing a readjustment from past land and river uses. Log drives during the early 1900's scoured in-stream woody habitat, and riparian grazing in the mid-1900's caused an influx of gravel due to entrainment and head-cutting. This gravel wave is still working its way through the basin channel network.

The management objectives for physical aquatic integrity include the following:

- Identify stable/unstable geomorphic zones, model gravel-routing, and assess park development decisions at the scope of channel-altering floods.
- Construct a model of aquatic integrity for OZAR by establishing the variability associated with flow, physical habitat, water quality and energy sources, and develop vital signs indicators for tracking the status of these components.
- Comply with enabling legislation mandate to maintain free-flowing character by addressing removal of low-water crossing at Cedargrove.

2.3.11.3.3 Springs, Abiotic (Priority Issue #3)

The USGS has called the freshwater spring system of the OZAR "world-class and unparalleled in North America" (USGS, 1997). The uniqueness of the spring resource was identified in P.L. 88-492 when establishing OZAR, which mandated the "preservation of springs". Springs serve as "underground tributaries" to the mainstems of the Current and Jacks Fork Rivers and contribute over 60% of the flow to these rivers. Spring conduits, spring branches, and spring conduits provide important diversity of thermal and structural habitat for fish and invertebrate species, and critical scenic features for park visitors.

A key mandate of OZAR's enabling legislation is "preservation of springs". A Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Superfund site has recently been listed within the recharge zone of Big Spring. Activities within the watershed and the interconnectivity of the surface and sub-surface features in a karst terrain make pollutant contamination a very viable concern. The management objective include assessing whether the "preservation of springs" is occurring regarding flow quantity, quality, and clarity, as well as maintenance of naturalness of spring communities.

OZAR manages two-thirds of the Outstanding National Resource Waters within the state of Missouri, which mandate no lowering of water quality. A recent trend analysis of basic physiochemical/biological parameters shows continued good surface water quality, with the primary exception of fecal coliform bacteria levels. The park continues to keep watch on potential lead mining activities within recharge zones of its major springs. The management objective is to comply enabling legislation mandate to provide for public use and enjoyment by removing the 5-mile reach of the Jacks' Fork from the 303(d) Impaired list.

2.3.11.3.4 Adjacent Land-Use Changes (Priority Issue #4)

Compared to national trends, the historic low population density within the Current River watershed has helped protect park features from catastrophic change due to most adjacent land use practices (see below for exceptions). This situation is changing as demographics and low land prices encourage increased residential, industrial, and recreational development, with relatively little environmental protection regulations. The inherent susceptibility of karst terrain to pollution of subsurface waters, and the dependence of the park mandates upon the high quality of subsurface waters, puts park resources at high risk. Recorded impacts from mining, agriculture, logging, and recreation include lead pollution of a major park spring, agricultural chemicals in river sediment, logging erosion and increased road network, and physical, visual, and noise disturbance from horse use, ATVs, and tubes/boats.

The park enabling legislation directs OZAR to enter into agreements for land use and development programs, for preservation and enhancement of the natural beauty of the landscape, and for the conservation of outdoor resources in the watersheds of the Current and Jacks Fork Rivers. The management objective is to understand the high priority areas and the need for these agreements as they have the risks to impact park resources.

2.3.11.3.5 Threatened and Endangered Species

The Ozark region is a one of the oldest exposed land masses in North America and has been free of glaciation or inundation for at least 200 million years. These conditions, combined with climate changes, produce trends in endemism, relicts, and edge of range distributions for many Ozark species, particularly crayfish, fish, aquatic insects, and cave-related species. The park presently supports federally endangered and threatened species, state endangered species, and state listed species for conservation concern (Table 2.5). These rare species utilize a variety of habitats including caves, riparian forest, giant cane, seeps, blufftops, upland forests, spring branches, deep river pools, and forest canopy openings.

The management objectives include compliance with the provisions of the Endangered Species Act and prioritizing conservation efforts based on sound science, while providing for other provisions of the enabling legislation.

2.3.11.3.6 Visitor Use Impacts

Since the late 1990s visitor use levels and activities have exploded in their ability to create visible impacts to park resources, and cause changes to visitor experiences. ATV and horse-use are the two primary activities negatively impacting park resources through fecal coliform contamination, off-road/trail erosion, increased and unmanaged access, visitor use conflicts, water quality degradation, exotic plant distribution, and noise impacts. One of the nation's largest cross-country trail ride operations is located adjacent to the park, and can house between 500-4,000 horses per week, multiple times per year. In addition, crowded conditions from tube use densities, and noise and wakes from outboard motorboats are significantly degrading park visitor experiences.

The management objective is to comply with park legislation to provide "for the use and enjoyment of outdoor recreational resources" while establishing methods and limits to protect park resources in the process. In addition, objectives include documenting the carrying capacity for horse, ford, and boat use; evaluating noise impacts from boat activities; and updating OZAR's River Use Management Plan.

2.3.11.3.7 Habitats of Concern

The Ozark region is the center of biodiversity for the state of Missouri. Many of the habitats providing this diversity are unique spots within a broad forest matrix. High quality examples of Missouri natural communities occur within OZAR, including glades, fens, forests, cliff, caves, rivers, streams, sloughs, spring, spring branches, and washes. With the exception of the forests and some river community types, sites are relatively small, discrete areas harboring a set of distinctive environmental conditions. They are subject to enormous edge influence given their size. Therefore, tracking, management and protection of these unique sites within the larger forest and river matrix is required to preserve "natural features" and meet park legislative mandate.

The management objectives are to identify, map, and protect high priority habitats of concern in planning and management activities; document status and viability of these habitats and their species through time; understand connectivity of these habitats in their regional context; and develop innovative educational opportunities for students and park visitors to recognize and become familiar with these unique habitat types.

2.3.11.3.8 Plant Communities

OZAR is part of the largest contiguous track of forest left in the Midwest. The vegetative landcover provides the scenic setting for park visitors as they float on the river surface. Landform divides the park into approximately 75% upland and 25% riparian/floodplain habitat types. Both of these habitats provide critical filtering mechanisms for watershed runoff, as well as important habitat for river valley residents and migrants. Each of these habitats have undergone a series of land use practices, including extensive logging in the late 1800's, and intensive farming and grazing within the bottomlands in the 1900's, which have altered their trajectory for potential natural communities.

Management objectives include mitigation and restoration planning for OZAR's upland and riparian forest communities; determining how major vegetative communities of the park fit in with regional conservation priorities; determining the important cultural landscape and wildlife objectives for the open fields within the park; and determining what vegetation management is warranted and on what time scale.

2.3.11.3.9 Invasive Exotics (Plants and Animals)

Once ranked relatively low with less than 11% exotic vegetation species, increased recreational use is changing the level of priority for exotic plant management within the park. Exotic plant species such as *Lespedeza cuneata* (lespedeza) and garlic onion, are spreading throughout OZAR, due to increases in horse and ATV use, increases in acreage of disturbed lands, new road and trail access, contaminated horse feed, and adjacent land plantings. Once established, seeds are spread throughout the floodplain during flood events. Anticipated faunal invasive exotic species include *Lymantria dispar* (gypsy moths) and *Dreissena polymorpha* (zebra mussels).

Management objective include determining the major vectors of invasive plants species, how these invasives should be managed and what plant communities are most susceptible to invasive exotic species.

2.3.11.3.10Birds

Many bird species of Partners in Flight (PIF) conservation priority have centers of abundance in this region. OZAR may be one of the most important centers for the rare warblers, *Limnothlypis swainsonii* (Swainson's warbler) and *Dendroica cerulea* (Cerulean warbler), in the state of Missouri, pending ongoing inventories. OZAR's extensive oak-hickory-pine and riparian forests, grasslands, and the variety of seral stages within the park combine to provide an important, diverse refuge for forest interior birds, neotropical migrants, and grass/shrub species.

2.3.12 Pea Ridge National Military Park (PERI)

2.3.12.1 Park Background Information and Enabling Legislation

PERI is located three miles west of the town of Garfield in Benton County, Arkansas (Appendix L, Figure L.1). PERI was established in 1956 to *"preserve and commemorate the March, 1862 civil war battle that saved Missouri for the Union and allowed Union forces to gain control of the Missouri and Mississippi Rivers".* PERI's mission statement is "*to preserve the cultural and natural resources therein; to commemorate, interpret and foster the appreciation of associated historical events; and to promote resources stewardship through education".* PERI contains 1,740 ha (4,300 ac) of land.

PERI's GMP objectives related to natural resources:

PERI's RMP goals related to natural resources:

PERI's GPRA goals related to natural resources include the following:

- 1b01: By Sept 30, 2005, 12 (100%) of 12 primary Pea Ridge National Military Park natural resource inventories identified in a Resource Management Plan are acquired or developed.

The following section describes PERI's natural resources, park issues/priorities, and management objectives.

2.3.12.2 PERI's Natural Resources

An annotated bibliography of selected natural resource studies completed for PERI's is included in Appendix L (Table L.1). Appendix L (Figure L.2) includes a map of PERI's land cover, trails, roads, and rivers.

2.3.12.2.1 Geology and Water

PERI contains two perennially flowing creeks, Lee Creek and Williams Hollow, as well as several man-made and natural ponds. PERI does not have any bodies of water listed as 303(d) Impaired or Outstanding Natural Resource Waters.

2.3.12.2.2 Soils

Soils in PERI consists primarily of Toloca silt-loam, Peridge silt-loam, Captina silt loam and Jay silt loam. The soil types occur with slopes of 1-3%, provide fertile topsoil, and are somewhat poorly drained.

2.3.12.2.3 Vegetation

PERI's landscape is comprised primarily of deciduous hardwood forests [1,457 ha (3,600 ac)], however is also includes ledges/bluffs, riparian zones, caves, restored prairies, glades (limestone and sandstone), fields. These forest communities include post-oak-blackjack-oak woodlands, oak-hickory forests and mixed hardwood forest types. PERI has a hay lease field program that involves 223 ha (550 ac) of the park.

A plant inventory to document the occurrence of 90% of vascular plants in PERI was funded by the I&M Program and completed in 2002. An exotic plant inventory, the first one ever conducted in PERI, was also funded by the I&M Program and completed in 2002.

2.3.12.2.4 Wildlife

A small mammals inventory was completed in 1971; however, bat species were not included during this study. A bat inventory, funded by the I&M Program, is in progress and will be completed in 2003. Bird and herpetofauna inventories were conducted in 1998 and 2000, respectively. A fish inventory is in progress and will be completed by 2002.

2.3.12.3 PERI's Natural Resource Issues and Management Objectives

The top four natural resource issues and related park management objectives for PERI are summarized below. Appendix L (Table L.2) includes a narrative written by Park Management on these top four priority issues. Additional natural resource issues, of a lower park priority, are also summarized below, however these are not necessarily in order of priority.

2.3.12.3.1 Overabundance of White-Tailed Deer (Priority Issue #1)

Park managers believe that *Odocoileus virginianus* (white-tailed deer) over-browsing will significantly impact the parks diverse and regionally important vegetation species. Hunting is prohibited in the park, and in the absence of predators, *O. virginianus* has become more abundant, threatening the parks plant communities and the regeneration of trees, therefore altering the landscape critical to the fulfillment of the park's mission.

The park management objective is to continue the development of a monitoring plan to evaluate trends in the park's deer population and their impacts to vegetation in the park.

2.3.12.3.2 Rare/Threatened Amphibians (Priority Issue #2)

Rana sylvatica (wood frog), identified in a 2002 herpetofauna inventory and funded by the I&M Program, has been in serious decline in the area for some time. Once common in Missouri and Arkansas, *R. sylvatica* is now rare in Missouri. While these animals are still fairly common in central and southern Arkansas, the population at PERI is one last remaining in the northern region of Arkansas. Prior to 1999, pond filling was common which resulted in loss of habitat loss for this species.

Management objectives are to determine if populations are increasing or decreasing at PERI, then mitigate appropriately.

2.3.12.3.3 Plant Communities (Priority Issue #3)

PERI is concerned about the overall health of its 1,457 ha (3,600 ac) of forested lands. While these forests are highly significant to the management of the park, very little is known about their health and condition. Since before 1930, fields have been converted to forests at PERI. As of 2002, no specific threat has yet been identified to affect PERI's forest health, except for the decline of *Castanea ozarkensis* (Ozark Chinkapin) throughout the region due to the devastating *Cryphonectria parasitica* (chestnut blight fungus). *C. ozarkensis* has been noted to occur at five places in PERI.

PERI's management objectives include restoring forests to mimic how they would have looked in 1862 (pre-fire suppression); develop a basic forest health monitoring program to provide the early warning signs necessary to intercept significant damage; and the afforestation of fescue fields taken out of production in 2001.

2.3.12.3.4 Land-Use Changes (Priority Issue #4)

Changes in land-use outside the boundaries of the park will inevitably affect the park. Rapid growth and development outside the park threaten the visual integrity of the park's cultural landscape. There is a relatively large tract of forest in an area adjacent to PERI that is undergoing urbanization. A new freeway is scheduled to be built from Shrevesport to Kansas City. Increased development around the park may magnify issues currently within the park, such as increased deer populations, increased trails to park boundaries, additional wells from housing developments (with impacts to water tables), introduction of exotics from surrounding areas, and impacts on water quality.

The management objective is to increase public awareness about adjacent land-use changes that adversely affect the park and put the park in a larger land context.

2.3.12.3.5 Exotic Vegetation Species

PERI has a long history of cattle grazing, fire suppression and other human introduced disturbances. Fire suppression and logging has changed the character of the park's forests significantly since 1862. Agricultural development in the park before establishment has also dramatically changes large areas of the park. This myriad of disturbances have led to the introduction of exotic and invasive plants.

Some of these species have become naturalized and may not pose a serious threat to the parks plant communities, others are more invasive. Exotic vegetation species at PERI include the following: *Lonicera japonica* (Japanese honeysuckle), *Cirsium vulgare* (bull thistle), *Lespedeza cuneata* (lespedeza), *Rosa multiflora* (mulitflora rose), *Sorghum halepense* (Johnson grass), *Hedera helix* (English ivy), and creeping euonymus. The management objective is to eradicate these invasive exotic species from the park.

2.3.13 Pipestone National Monument (PIPE)

2.3.13.1 Park Background Information and Enabling Legislation

PIPE is located in southwest Minnesota and borders the north side of the City of Pipestone (Appendix M, Figure M.1). Pipestone National Monument was established by an Act of Congress on August 25, 1937. Approximately 116 acres were set aside for three purposes: (1) to administer and protect the pipestone quarries, reserving the quarrying of pipestone for Indians of all tribes, (2) to protect cultural and natural resources within the monument boundaries, and (3) to provide for the enjoyment and benefit of all people. A second Act was passed on June 18, 1956 that authorize the addition of up to 250 acres from the Pipestone school reserve. A total of 167 acres was added on to the Monument. Subsequent proclamations and legislation have broadened the area's purpose to include other features of historical and scientific interest.

Values to be protected include the geologic resources, the historic and prehistoric cultural resources, vegetation, and wildlife found within the monument's boundaries. Both the enabling legislation and the Organic Act mandate that these values be maintained unimpaired for future generations.

PIPE's GMP objectives related to natural resources:

Pipestone National Monument is currently preparing a General Management Plan. The plan will identify the strategies, programs, and actions necessary to manage visitation and best protect the Monument's resources. This document describes resource conditions and visitor experiences to be achieved in the Monument. Requirements are based on the Monument's purposes, significance, special mandates, administrative commitments, and the body of laws and policies directing the management of the national park system. The GMP will address safety and desired future conditions for the Monument's natural resources.

PIPE's RMP goals related to natural resources:

The following goals are from the Monument's 1996 Resource Management Plan. Many of the goals are the same although there may be additions when the plan is updated.

- Determine visual appearance of the monument through cultural landscape investigations, and Catlin's painting. The target time period is the mid- to late-1800's
- Decrease the invasion of woody species so all problem areas can be maintained in one season and eventually all problem areas can be eliminated.
- Decrease the invasion of exotic plant species so all problem areas can be maintained in one season and eventually all problem areas can be eliminated.
- Generate a cooperative atmosphere with local entities.

- Collaboratively manage the Pipestone Wildlife Management Area with the Fish and Wildlife Service and the Minnesota Department of Natural Resources.
- Develop solid baseline data and continue monitoring for water quality in Pipestone Creek.
- Introduce into the interpretation division the concept of ecosystem interpretation by involving both quarry and prairie in programs.
- Develop a fire management program that would help achieve restoration goals through the use of experimental burns to determine the appropriate timing of fires to bring about the intended ecological effects desired. The fire management program would follow the set standard and guidelines in place for fire management in the NPS.

PIPE's GPRA goals related to natural resources include the following:

- 1a1A: By Sept 30, 2005, 5% of targeted disturbed Monument lands as of 2000 (4 of 78 acres) are restored.
- 1a1B: By Sept 30, 2005, exotic vegetation on 3% of targeted acres of Monument lands as of 2000 (8.3 of 277 acres) are contained.
- 1a2D: By Sept 30, 2005, 1 of Pipestone National Monument's identified populations of federally threatened and endangered species with critical habitat on Monument lands and/or requiring NPS recovery actions, as of 1999, have a stable status. Threatened: *Platantherea praeclara* (western prairie fringed orchid)
- 1a04: By Sept 30, 2005, Pipestone National Monument has impaired water quality.
- 1a02D: By Sept 30, 2005, 1of Pipestone National Monument's identified populations of federally threatened and endangered species with critical habitat on Monument lands and/or requiring NPS recovery actions, as of 1999, have a stable status. Endangered: *Notropis topeka* (Topeka shiner)
- 1b01: By September, 30, 2005, 12 (100%) of the 12 primary Pipestone National Monument natural resource inventories identified in the Monument's resource management plan are completed.
- 1b3: By Sept 30, 2005, Pipestone National Monument has identified its vital signs for natural resource monitoring.

PIPE's CLR or other document objectives related to natural resources:

- Pipestone National Monument uses a Prairie Management Plan and vegetative survey developed in 1986 (Becker 1986) to help guide management activities of the tallgrass prairie.

PIPE is a prototype park. While the following sections provide a brief synopsis of PIPE's natural resources and management issues, a more comprehensive look into these issues can be obtained from the Prairie Cluster.

2.3.13.2 PIPE's Natural Resources

An annotated bibliography of selected natural resource studies completed for PIPE's is included in Appendix M (Table M.1).

2.3.13.2.1 Geology and Water

PIPE is located on slightly sloping land in a shallow glacial valley. Pipestone Creek flows over the Sioux Quartzite outcrop forming Winnewissa Falls. Above the falls the creek has been channelized by blasting and dredging and now flows well below the original creek bed. Below the falls the creek retains some of its original characteristics. Pipestone Creek flows through Lake Hiawatha and eventually out the north boundary of PIPE into Indian Lake and the Pipestone Wildlife Management Area, which is owned by the United States Fish and Wildlife Service and managed by the Minnesota Department of Natural Resources Division. The federally endangered *Notropis topeka* (Topeka shiner) occurs in Pipestone Creek.

2.3.13.2.2 Soils

Soils are from glacial-derived tills, loess and alluvium and vary in depth, fertility, and productivity. In 1976, the USDA Soil Conservation Service identified 13 different soil types within PIPE. The 1986 Prairie Management Plan describes these soils which are the Lamoure, Trotsky, Brookings, Vienna, Kranzburg, Athelwold, Hidewood, Whitewood, Ihlen, Rock Outcrop-Ihlen complex, Ihlen-Rock outcrop complex, the Lahmoure and La Prairie, and Estelline soils.

2.3.13.2.3 Vegetation

PIPE mainly consists of the following plant communities; virgin native prairie, restored prairie (once old field communities), degraded prairie, and oak savannas. A 4.5 m (15 ft) high Sioux quartzite outcrop runs north south through the eastern half of PIPE. The vegetative community, Sioux quartzite prairie, found along this outcrop is considered a significant resource at PIPE and has been designated by The Nature Conservatory *"as endangered throughout its range and one of the few intact examples of this rare community type"*. Numerous rare plant species occur through out this habitat. A small population of the federally threatened, *Platanthera praeclara* (western prairie fringed orchid), is found at PIPE. The Prairie Cluster prototype has implemented vegetation monitoring and rare species monitoring at the Monument.

A woody plant species inventory, funded by the I&M Program, is scheduled for 2003. Eight ha (20 ac) of forest and sporadic woody areas throughout PIPE will be inventoried.

2.3.13.2.4 Wildlife

A small mammal study was conducted at PIPE in 1988. Mid-size and large mammals have been documented in the Monument's natural history database established in 1999. The Monument initiated an insect collection in 2000. Over 125 species and 450 specimans have been collected since its initiation. The Prairie Cluster prototype program has completed surveys for bird and butterfly species. State listed rare wildlife species documented for the Monument include: *Ammodramus henslowii* (Henslow sparrow), *Hesperia dacotae* (Dakota skipper), and *Chelydra serpentina* (common snapping turtle).

Herpetofauna and fish (with an emphasis on *Notropis topeka*) inventories, funded by the I&M Program, are in progress and will be completed in 2003.

2.3.13.3 PIPE's Natural Resources Issues and Management

Water quality and loss of habitat are high priorities at PIPE. Development of lands adjacent to PIPE, pesticide and sediment run-off from agricultural lands, and the periodic discharge of toxicants and accidental spillage of contaminants from commercial activities upstream have had adverse affects to the park's water resources. Stream alteration outside the Monument has changed the course of Pipestone Creek and changed habitats with in the Monument. Development and land activities upstream and adjacent to the Monument increase the likely hood of exotic plant species with in the Monument's boundaries. There was a loss of about 40 native plant species between the 1960's and 1980's with about _ of these being wetland species. Water quality and the control of exotic plants is a high management issue for the Monument.

The management objective is to gather the necessary data to fully understand park resources and related threats.

2.3.14 Tallgrass Prairie National Preserve (TAPR)

2.3.14.1 Park Background Information and Enabling Legislation

TAPR is located in the heart of the Flint Hills region of east central Kansas (Appendix N, Figure N.1). Established on November 12, 1996, the 4409 ha (10,894 ac) preserve represents a remnant of the once vast, but now rare, tallgrass prairie ecosystem that previously covered over 643,720 km^2 (400,000 mi^2) of North America.

The National Park Trust (NPT), a private non-profit land conservancy, purchased what is now known as TAPR in 1994 and continues to own the property, but will donate a small portion [up to 73 ha (180 ac)] to the National Park Service (NPS). The NPS will manage the private property under a cooperative agreement, in partnership with the NPT. An interim cooperative agreement is in place. When NPT purchased the property the mineral interests for the entire preserve were retained by Boatman's Bank (Trustee), now Bank of America, for a period of 35 years (beginning June 1994). The Trustee assigned the oil and gas exploration working interest to Chisholm Resources, Inc., with 25 gas wells currently available for production. In March 1995, the NPT and Edward Bass of Fort Worth, Texas signed a 35-year grazing lease involving 40 ha (98 ac) of the preserve. A buy-back provision for all or part of the grazing rights is included. The lease provides for annual spring burns and the use of an early intensive stocking regime.

TAPR contains a unique collection of 60 known structures and features that tell the story of human interaction with the prairie environment, from pre-contact times to the present, from the prehistoric and historic American Indians to the ranch heritage of the past 125 years. TAPR, the former Z Bar/Spring Hill Ranch, is a designated National Historic Landmark representing an outstanding example of the transition from the open range to the enclosed holdings of the large cattle companies of the 1880's.

TAPR's GMP objectives related to natural resources:

TAPR's RMP goals related to natural resources:

TAPR's GPRA goals related to natural resources:

- 1b01: By Sept 30, 2005, 6 (55%) of 11 TAPR basic natural resource inventories, identified as of 1999, are completed.
- 1b3: By Sept 30, 2005, TAPR has identified its vital signs for natural resource monitoring.

TAPR's CLR or other document objectives related to natural resources:

TAPR's enabling legislation required the preparation of a General Management Plan (GMP), which, in conjunction with an Environmental Impact Statement (EIS), was completed and approved in December 2000. During this GMP/EIS process, the general public and various interest groups and organizations, including an advisory committee created by the legislation, provided considerable input. The focus of the plan's preferred alternative (proposed action) is the integrated management of the natural and cultural resources of the preserve.

While the following sections provide a brief synopsis of TAPR's natural resources and management issues, a more comprehensive look into these issues can be obtained from the Prairie Cluster.

2.3.14.2 TAPR's Natural Resources

An annotated bibliography of selected natural resource studies completed for TAPR's is included in Appendix N (Table N.1).

2.3.14.2.1 Geology and Water

TAPR is wholly within the Flint Hills physiographic province. The Flint Hill were formed by the erosion of a belt of resistant limestone and softer shale and sandstone that includes 40 separate formations and measures 914 m (3,000 ft) in total thickness (Jones, 1999). The highest elevations exceed 500 m (1,600 ft) and the lowest are 350 m (1,150 ft) in the Cottonwood River Valleys (GMP, 2002).

TAPR's landscape is rich in riparian areas (springs, seeps, and intermittent and perennial streams). The major aquatic resources within TAPR are Palmer Creek and Fox Creek. Palmer Creek is a tributary to Fox Creek, located in the northern portion of TAPR and flowing west to east. Fox Creek is a major tributary to Cottonwood River, which bisects the preserve flowing north to south.

2.3.14.2.2 Soils

TAPR's soils are derived from limestones, sandstones, and shales. The soils may be relatively deep in the bottoms of the larger stream valleys, but are typically thin on the flanks and tops of the hills themselves; bedrock exposures are visible throughout the region (Jones, 1999). The soils are excessively drained, and runoff is rapid with slopes ranging from 30-50% (GMP, 2000).

2.3.14.2.3 Vegetation

TAPR is dominated by unplowed tallgrass prairie, and perpetuated by fire, climate, and grazing. For grazing purposes, the Flint Hills have been burned essentially every year since the 1880's. Basic prairie vegetation information has been collected by the Prairie Cluster, but more inventories targeting seeps, springs, and exotic species, are needed. An exotic plant inventory, funded by the I&M Program, is scheduled for 2003.

2.3.14.2.4 Wildlife

Herpetofauna (aquatic and terrestrial), deer (possible overabundance concern), and fish [with a specific emphasis on the *Notropis topeka* (Topeka Shiner)] inventories, funded by the I&M Program, are in progress and will be completed by 2003. Birds presence/absence data has been collected by the Prairie Cluster, although there is a need for additional *Tympanuchus cupido* (greater prairie-chicken) data.

2.3.14.3 TAPR's Natural Resource Issues and Management Objectives

The top three natural resource issues and related park management objectives for TAPR are summarized below. Appendix N (Table N.2) includes a narrative written by Park Management on these top three priority issues.

2.3.14.3.1 Plant Communities (Priority Issue #1)

As of 2001, more than 400 species of vascular plants (native and non-native) had been identified within TAPR. No plants identified so far are included on the state threatened, endangered, or Species in Need of Conservation (SINC) list (Kansas Department of Wildlife and Parks, Strategic Plan 1991-1996). Recent attempts by Lauver (1998) to classify vegetation alliances and plant communities found eight plant community types occurring within the preserve. The preserve is dominated by the *Andropogon gerardii* (big bluestem), *Sorghastrum nutans* (Indian grass), *Schizachyrium scoparium* (little bluestem), Flint Hills herbaceous vegetation community, or tallgrass prairie. Prairie is found on nearly level land as well as steep slopes on uplands and on a wide array of soils. Other community types such as the Bulrush-Spikerush Marsh and Limestone outcrops are very narrow and found in small patches (Lauver 1998). The floodplain forests along Fox and Palmer Creeks are examples of the ash-elm-hackberry-burr-oak-black-walnut floodplain forest community. It is characterized by nearly level bottoms and terraces along major streams and rivers (Lauver 1998). The bottomland along Fox Creek is currently planted in *Bromus inermis* (smooth brome grass). The NPT recently purchased (March 2001) back out of the lease the 319 ha (787 ac) bottomland area. The GMP envisions that most of this bottomland will be restored to tallgrass prairie. This floodplain community has been called the rarest in the state because of the tendency, historically, to plow these deeper soils and to replace native vegetation with agricultural or grazing crops (National Park Service, 1998 Enhancement Report). As the preserve moves toward a heterogeneous disturbance regime, involving varied fire and grazing, monitoring of plant communities will be critical in determining whether we are maintaining the processes that allow for a full expression of species.

2.3.14.3.2 Exotic Vegetation Species (Priority Issue #2)

An exotic plant inventory has not been completed for the preserve, but is scheduled for 2003. To date, over 30 plant species classified as "non- native" within the state of Kansas have been found within the preserve. Many of these plant species do not constitute a serious threat to the resource, some species, such as some members of the Bromus group or *Melilotus spp*. (sweet clovers), are only of concern in severely impacted or overgrazed prairies. *Andropogon bladii (*Caucasian bluestem) represents a serious threat and has been found within the preserve. Control of this species is difficult because it responds positively to fire and is not impacted by mowing or normal grazing regimes. So far it has been found on the preserve in three sites, the largest, approximately one acre in size. While *Lespedeza cuneata* (lespedeza) has not been found within the preserve to date, it poses a potentially serious threat to the tallgrass prairie ecosystem in the future. The preserve's enabling legislation requires the park to comply with applicable state noxious weed, pesticide, and animal health laws.

2.3.14.3.3 Diversity and Populations of Native Wildlife (Priority #3)

Little is known about animal species at TAPR, with the exception of a recently completed bird inventory and follow-up monitoring effort conducted in 2001. A total of, 134 different bird species have been documented. A fish community and *Notropis topeka* (Topeka shiner) inventory effort took place at the preserve last year. Twenty-five fish species were recorded. The *N. topeka* was recorded in a third order stream where it had not been found before. The *N. topeka* is federally listed as an endangered species. Another species which was also found, the *Luxilus cardinalis* (cardinal shiner), is a state SINC species. Fish monitoring effort will continue this year. Herpetofauna and deer population inventories, funded by the I&M Program, to begin in 2002.

2.3.15 Wilson's Creek National Battlefield (WICR)

2.3.15.1 Park Background Information and Enabling Legislation

WICR is located in southwest Missouri, 16 km (10 mi) south of the City of Springfield (Appendix O, Figure O.1). The park was established by an Act of Congress on April 22, 1960 to "*preserve and commemorate the Battle of Wilson's Creek; the first major Civil War battle west of the Mississippi River"*. WICR is also the place where General Nathaniel Lyon died, the first Union General killed in the Civil War. The park encompasses 709 ha (1,750 ac), which includes 75% of the historic battlegrounds.

WICR's GMP objectives related to natural resources:

WICR's RMP goals related to natural resources:

WICR's GPRA goals related to natural resources:

- 1a1A: By Sept 30, 2005, 5% (10 acres) of 200 acres of lands disturbed by prior development or agriculture use and targeted for restoration, are restored.
- 1a02D: By Sept 30, 2005, 50% (1 of 2) of 1997 federally listed threatened and endangered species not having critical habitat and not requiring National Park Service recovery actions have improved status.
- 1a04: By Sept 30, 2005, 66% (2 of 3) of the sites sampled the previous year for macro-invertebrate conditions in Wilson's Creek and Shuyler Creek have improved or have not changed from the 1989 baseline year.
- 1a1B: By Sept 30, 2005, 7% (14 acres) of 200 acres of lands impacted by exotic vegetation targeted by September 30, 1999, is contained.
- 1a2X: By Sept 30 2005, Native Species of Special Concern. 50% of population of plant and animal species of special concern (e.g., state-listed threatened or endangered species, endemic or indicator species or native species classified as pests) identified and monitored at Wilson's Creek by the I & M Prairie Cluster are at scientifically acceptable levels.

WICR's CLR or other document objectives related to natural resources:

WICR is a prototype park. While the following sections provide a brief synopsis of WICR's natural resources and management issues, a more comprehensive look into these issues can obtained from the Prairie Cluster.

2.3.15.2 WICR's Natural Resources

An annotated bibliography of selected natural resource studies completed for WICR's is included in Appendix O (Table O.1).

2.3.15.2.1 Water and Geology

WICR's karst topography has five caves with approximately 18 m (60 ft) of undeveloped cave passages. Two caves have been mapped and initial surveys have been made. All caves are closed to the public until a complete inventory of resources can be completed and staff can make an informed decision about their future management.

The primary watershed at WICR is Wilson's Creek. The portion of Wilson's Creek located within WICR is in the upper portion of the 3,781 km^2 (1,460 mi^2) James River Watershed. The watershed terminates at Table Rock Lake near Branson, Missouri, and is an economically important resource to the region. An upstream sewage treatment plant discharges 42.5 million gallons of treated sewage effluent each day into Wilson Creek. During low flow periods an estimated 80% of the water flowing in the creek is treated sewage effluent (Draft GMP, 2002).

2.3.15.2.2 Soils

Primary soils at WICR are deep, stony and chert silt loam to shallow soils (9 to 20 inches in depth) over fractured limestone that have been formed by weathering of underlying parent material, including limestone, dolomite, sandstone, and shale (NPS, 1988). In addition, alluvial soils are present along Wilson's Creek and its tributaries. Limestone glades with shallow, rocky soils are scattered throughout the park and support vegetation different from other areas in the park, including several species of rare and protected plants (Draft GMP, 2002).

2.3.15.2.3 Vegetation

There are approximately 445 hectares (1,100 acres) of disturbed land that park staff are trying to restore, through an active fire program, to oak savanna or historic fields, reminiscent of conditions that were present during the Civil War Battle. Approximately 121 ha (300 ac) of vegetation are burned each year under the direction of well-trained fire management personnel. Over 202 ha (500 ac) of the park are infested with exotic plant species. The most studied plant within the park is *Lesquerella filiformis* (Missouri bladderpod), a federally endangered plant species.

2.3.15.2.4 Wildlife

Bat, fish, and herpetofauna inventories, funded by the I&M Program, are in progress and will be completed in 2002. This is the first comprehensive bat inventory at WICR, although the federally endangered species *Myotis grisescens* (Gray bat) has been studied within the park, including limited distribution and composition data. Aquatic macroinvertebrates are inventoried annually under the Prairie Cluster water quality protocols.

2.3.15.3 WICR's Natural Resource Issues and Management Objectives

WICR's management concerns include adjacent land-use changes (i.e., urbanization), invasive exotic plant species, and water pollution. Development in the surrounding areas of Springfield, Republic, and Battlefield, have dwindled available wildlife habitat thus making the park a "haven" for various wildlife.

Non-native plants currently inhabit about 202 ha (500 ac) of the park. A restoration plan was developed by the Missouri Department of Conservation in 1986, and was implemented by WICR in 1987 to restore its land to match the 1861 landscape and reduce abundance of non-native plants. Since the implementation of the restoration plan, native species and historical plant communities are gradually increasing their range within the park (Draft GMP, 2002).

There have been two recent fish kills, in 1996 and 2000, in Wilson's Creek due to sewage spills upstream from the park. It is almost impossible for the park to manage upstream effects on water quality within Wilson's Creek, compounded by the fact that only a small fraction of the creek runs through WICR. Park management does maintain a healthy riparian corridor through WICR.

Table 2.5 Heartland Network Federal and State Listed Species as Outlined in NPSpecies Database

Category	Order	Family	Latin Name	TSN#	Listing	Park	Park Status
Amphibian	Anura	Ranidae	Rana sylvatica	173440	State	OZAR	Present in Park
Amphibian	Anura	Ranidae	Rana pipiens	173443	State	OZAR	Present in Park
Amphibian	Caudata	Plethodontidae	Hemidactylium scutatum	173678	State	CUVA	Probably Present
Amphibian	Caudata	Ambystomatidae	Ambystoma annulatum	173594	State	OZAR	Unconfirmed
Amphibian	Caudata	Cryptobranchidae	Cryptobranchus alleganiensis bishopi	208176	State	OZAR	Present in Park
Amphibian	Caudata	Plethodontidae	Hemidactylium scutatum	173678	State	OZAR	Present in Park
Amphibian	Caudata	Ambystomatidae	Ambystoma laterale	173599	State	EFMO	Present in Park
Bird	Anseriformes	Anatidae	Cygnus buccinator	174992	State	OZAR	Present in Park
Bird	Anseriformes	Anatidae	Anas rubripes	175068	State	CUVA	Present in Park
Bird	Ciconiiformes	Falconidae	Falco peregrinus	175604	State	LIBO	Probably Present
Bird	Ciconiiformes	Accipitridae	Pandion haliaetus	175590	State	LIBO	Probably Present
Bird	Ciconiiformes	Accipitridae	Ictinia mississippiensis	554268	State	LIBO	Present in Park
Bird	Ciconiiformes	Accipitridae	Circus cyaneus	175430	State	LIBO	Probably Present
Bird	Ciconiiformes	Ciconiidae	Coragyps atratus	175272	State	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Buteo platypterus	175365	State	LIBO	Probably Present
Bird	Ciconiiformes	Accipitridae	Buteo lineatus	175359	State	LIBO	Probably Present
Bird	Ciconiiformes	Accipitridae	Accipiter striatus	175304	State	LIBO	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	State	HOME	Unconfirmed
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	State	HEHO	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	State	LIBO	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	LIBO	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	HOME	Unconfirmed
Bird	Ciconiiformes	Accipitridae	Circus cyaneus	175430	State	HEHO	Present in Park
Bird	Ciconiiformes	Ardeidae	Nycticorax nycticorax	174832	State	OZAR	Present in Park
Bird	Ciconiiformes	Podicipedidae	Podilymbus podiceps	174505	State	GWCA	Present in Park
Bird	Ciconiiformes	Accipitridae	Accipiter cooperii	175309	State	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Accipiter striatus	175304	State	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Buteo lineatus	175359	State	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Circus cyaneus	175430	State	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Pandion haliaetus	175590	State	OZAR	Present in Park
Bird	Ciconiiformes	Ardeidae	Ardea herodias	174773	State	OZAR	Present in Park
Bird	Ciconiiformes	Ardeidae	Botaurus lentiginosus	174856	State	OZAR	Unconfirmed
Bird	Ciconiiformes	Ardeidae	Egretta caerulea	174827	State	OZAR	Present in Park
Bird	Ciconiiformes	Ardeidae	Ixobrychus exilis	174846	State	OZAR	Unconfirmed
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	LIBO	Probably Present
Bird	Ciconiiformes	Ardeidae	Ixobrychus exilis	174846	State	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	ARPO	Historic
Bird	Ciconiiformes	Laridae	Chlidonias niger	176959	State	EFMO	Probably Present

Category	Order	Family	Latin Name	TSN#	Listing	Park	Park Status
Bird	Ciconiiformes	Falconidae	Falco peregrinus	175604	State	EFMO	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	State	EFMO	Probably Present
Bird	Ciconiiformes	Accipitridae	Circus cyaneus	175430	State	EFMO	Probably Present
Bird	Ciconiiformes	Accipitridae	Buteo lineatus	175359	State	EFMO	Probably Present
Bird	Ciconiiformes	Laridae	Sterna forsteri	176887	State	EFMO	Probably Present
Bird	Ciconiiformes	Ardeidae	Botaurus lentiginosus	174856	State	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	State	CUVA	Present in Park
Bird	Ciconiiformes	Ardeidae	Nyctanassa violacea	174842	State	CUVA	Unconfirmed
Bird	Ciconiiformes	Ardeidae	Nycticorax nycticorax	174832	State	CUVA	Present in Park
Bird	Ciconiiformes	Laridae	Chlidonias niger	176959	State	CUVA	Present in Park
Bird	Ciconiiformes	Phalacrocoracidae	Phalacrocorax auritus	174717	State	CUVA	Present in Park
Bird	Ciconiiformes	Scolopacidae	Bartramia longicauda	176610	State	CUVA	Present in Park
Bird	Ciconiiformes	Scolopacidae	Gallinago gallinago	176700	State	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Pandion haliaetus	175590	State	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Accipiter striatus	175304	State	GWCA	Present in Park
Bird	Ciconiiformes	Scolopacidae	Bartramia longicauda	176610	State	GWCA	Present in Park
Bird	Ciconiiformes	Laridae	Chlidonias niger	176959	State	LIBO	Probably Present
Bird	Ciconiiformes	Ardeidae	Egretta caerulea	174827	State	GWCA	Present in Park
Bird	Ciconiiformes	Ardeidae	Ardea herodias	174773	State	GWCA	Present in Park
Bird	Ciconiiformes	Accipitridae	Pandion haliaetus	175590	State	GWCA	Unconfirmed
Bird	Ciconiiformes	Accipitridae	Circus cyaneus	175430	State	GWCA	Present in Park
Bird	Ciconiiformes	Laridae	Sterna antillarum	176923	State	EFMO	Unconfirmed
Bird	Ciconiiformes	Accipitridae	Buteo lineatus	175359	State	GWCA	Present in Park
Bird	Ciconiiformes	Podicipedidae	Podilymbus podiceps	174505	State	OZAR	Present in Park
Bird	Ciconiiformes	Accipitridae	Accipiter cooperii	175309	State	GWCA	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	TAPR	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	TAPR	Present in Park
Bird	Ciconiiformes	Accipitridae	Accipiter striatus	175304	State	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Buteo lineatus	175359	State	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Circus cyaneus	175430	State	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Buteo swainsoni	175367	State	GWCA	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	State	TAPR	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	BUFF	Unconfirmed
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	GWCA	Unconfirmed
Bird	Ciconiiformes	Ardeidae	Ardea herodias	174773	State	WICR	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	GWCA	Unconfirmed
Bird	Ciconiiformes	Laridae	Larus pipixcan	176838	State	PIPE	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	EFMO	Probably Present
Bird	Ciconiiformes	Charadriidae	Charadrius montanus	176522	Federal	ARPO	Historic
Bird	Ciconiiformes	Laridae	Sterna antillarum	176923	Federal	EFMO	Unconfirmed
Bird	Ciconiiformes	Accipitridae	Accipiter cooperii	175309	State	WICR	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	ARPO	Historic
Bird	Ciconiiformes	Accipitridae	Accipiter striatus	175304	State	WICR	Probably Present

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Bird	Ciconiiformes	Accipitridae	Buteo swainsoni	175367	State	WICR	Probably Present
Bird	Ciconiiformes	Accipitridae	Circus cyaneus	175430	State	WICR	Probably Present
Bird	Ciconiiformes	Ardeidae	Nycticorax nycticorax	174832	State	WICR	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	HOME	Unconfirmed
Bird	Ciconiiformes	Laridae	Sterna antillarum	176923	Federal	ARPO	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	CUVA	Present in Park
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	EFMO	Probably Present
Bird	Ciconiiformes	Accipitridae	Haliaeetus leucocephalus	175420	Federal	BUFF	Unconfirmed
Bird	Galliformes	Phasianidae	Bonasa umbellus	175790	State	OZAR	Present in Park
Bird	Gruiformes	Gruidae	Grus canadensis	176177	State	LIBO	Probably Present
Bird	Gruiformes	Rallidae	Rallus limicola	176221	State	CUVA	Present in Park
Bird	Gruiformes	Rallidae	Gallinula chloropus	176284	State	CUVA	Present in Park
Bird	Gruiformes	Rallidae	Porzana carolina	176242	State	CUVA	Present in Park
Bird	Gruiformes	Rallidae	Rallus elegans	176207	State	LIBO	Probably Present
Bird	Gruiformes	Gruidae	Grus americana	176176	Federal	EFMO	Unconfirmed
Bird	Gruiformes	Rallidae	Rallus elegans	176207	State	CUVA	Present in Park
Bird	Gruiformes	Rallidae	Rallus elegans	176207	State	EFMO	Probably Present
Bird	Gruiformes	Rallidae	Porzana carolina	176242	State	GWCA	Present in Park
Bird	Passeriformes	Fringillidae	Vermivora chrysoptera	178852	State	LIBO	Probably Present
Bird	Passeriformes	Fringillidae	Dendroica cerulea	178903	State	LIBO	Present in Park
Bird	Passeriformes	Fringillidae	Mniotilta varia	178844	State	LIBO	Probably Present
Bird	Passeriformes	Fringillidae	Helmitheros vermivorus	178850	State	LIBO	Probably Present
Bird	Passeriformes	Laniidae	Lanius ludovicianus	178515	State	LIBO	Probably Present
Bird	Passeriformes	Fringillidae	Palmeria dolei	179587	Federal	WICR	False Report
Bird	Passeriformes	Fringillidae	Dendroica cerulea	178903	State	CUVA	Present in Park
Bird	Passeriformes	Fringillidae	Wilsonia citrina	178972	State	LIBO	Present in Park
Bird	Passeriformes	Fringillidae	Ammodramus henslowii	179340	State	PIPE	Present in Park
Bird	Passeriformes	Vireonidae	Vireo bellii	179003	State	GWCA	Present in Park
Bird	Passeriformes	Fringillidae	Ammodramus henslowii	179340	State	HEHO	Present in Park
Bird	Passeriformes	Laniidae	Lanius ludovicianus	178515	State	GWCA	Present in Park
Bird	Passeriformes	Fringillidae	Dendroica pensylvanica	178911	State	GWCA	Present in Park
Bird	Passeriformes	Fringillidae	Dendroica cerulea	178903	State	GWCA	Unconfirmed
Bird	Passeriformes	Hirundinidae	Progne subis	178464	State	CUVA	Present in Park
Bird	Passeriformes	Certhiidae	Certhia americana	178803	State	GWCA	Present in Park
Bird	Passeriformes	Certhiidae	Thryomanes bewickii	178562	State	LIBO	Probably Present
Bird	Passeriformes	Muscicapidae	Catharus guttatus	179779	State	CUVA	Present in Park
Bird	Passeriformes	Fringillidae	Vermivora chrysoptera	178852	State	CUVA	Present in Park
Bird	Passeriformes	Laniidae	Lanius ludovicianus	178515	State	CUVA	Historic
Bird	Passeriformes	Fringillidae	Wilsonia canadensis	178977	State	CUVA	Present in Park
Bird	Passeriformes	Certhiidae	Cistothorus palustris	178608	State	LIBO	Probably Present
Bird	Passeriformes	Certhiidae	Cistothorus platensis	178605	State	LIBO	Probably Present
Bird	Passeriformes	Fringillidae	Ammodramus henslowii	179340	State	GWCA	Present in Park

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Bird	Passeriformes	Certhiidae	Certhia americana	178803	State	WICR	Probably Present
Bird	Passeriformes	Vireonidae	Vireo bellii	179003	State	OZAR	Present in Park
Bird	Passeriformes	Laniidae	Lanius ludovicianus	178515	State	OZAR	Unconfirmed
Bird	Passeriformes	Fringillidae	Limnothlypis swainsonii	178848	State	OZAR	Present in Park
Bird	Passeriformes	Fringillidae	Dendroica pensylvanica	178911	State	OZAR	Present in Park
Bird	Passeriformes	Fringillidae	Dendroica cerulea	178903	State	OZAR	Present in Park
Bird	Passeriformes	Certhiidae	Cistothorus palustris	178608	State	OZAR	Unconfirmed
Bird	Passeriformes	Certhiidae	Certhia americana	178803	State	OZAR	Present in Park
Bird	Passeriformes	Laniidae	Lanius ludovicianus	178515	State	WICR	Probably Present
Bird	Passeriformes	Fringillidae	Ammodramus henslowii	179340	State	EFMO	Probably Present
Bird	Passeriformes	Certhiidae	Cistothorus palustris	178608	State	CUVA	Present in Park
Bird	Passeriformes	Certhiidae	Troglodytes troglodytes	178547	State	CUVA	Present in Park
Bird	Passeriformes	Fringillidae	Dendroica magnolia	178886	State	CUVA	Present in Park
Bird	Passeriformes	Fringillidae	Junco hyemalis	179410	State	CUVA	Present in Park
Bird	Passeriformes	Fringillidae	Seiurus noveboracensis	178931	State	CUVA	Present in Park
Bird	Passeriformes	Fringillidae	Ammodramus henslowii	179340	State	CUVA	Present in Park
Bird	Passeriformes	Vireonidae	Vireo bellii	179003	State	WICR	Present in Park
Bird	Passeriformes	Certhiidae	Cistothorus platensis	178605	State	CUVA	Present in Park
Bird	Piciformes	Picidae	Picoides borealis	178257	State	OZAR	Historic
Bird	Piciformes	Picidae	Campephilus principalis	178264	State	OZAR	False Report
Bird	Piciformes	Picidae	Picoides borealis	178257	Federal	OZAR	Historic
Bird	Piciformes	Picidae	Campephilus principalis	178264	Federal	OZAR	False Report
Bird	Piciformes	Picidae	Picoides borealis	178257	State	OZAR	Historic
Bird	Piciformes	Picidae	Sphyrapicus varius	178202	State	CUVA	Present in Park
Bird	Strigiformes	Strigidae	Asio flammeus	177935	State	GWCA	Unconfirmed
Bird	Strigiformes	Strigidae	Asio otus	177932	State	CUVA	Probably Present
Bird	Strigiformes	Strigidae	Aegolius acadicus	177942	State	CUVA	Present in Park
Bird	Strigiformes	Tytonidae	Tyto alba	177851	State	HEHO	Probably Present
Bird	Strigiformes	Tytonidae	Tyto alba	177851	State	OZAR	Unconfirmed
Bird	Strigiformes	Strigidae	Asio flammeus	177935	State	EFMO	Probably Present
Bird	Strigiformes	Strigidae	Asio flammeus	177935	State	OZAR	Unconfirmed
Bird	Strigiformes	Tytonidae	Tyto alba	177851	State	CUVA	Unconfirmed
Bird	Strigiformes	Strigidae	Asio otus	177932	State	EFMO	Probably Present
Bird	Strigiformes	Strigidae	Asio otus	177932	State	OZAR	Unconfirmed
Fish	Acipenseriformes	Acipenseridae	Acipenser fulvescens	161071	State	CUVA	Historic
Fish	Acipenseriformes	Acipenseridae	Acipenser fulvescens	161071	State	HEHO	Probably Present
Fish	Acipenseriformes	Polyodontidae	Polyodon spathula	161088	State	OZAR	Present in Park
Fish	Anguilliformes	Anguillidae	Anguilla rostrata	161127	State	CUVA	Historic
Fish	Cypriniformes	Catostomidae	Cycleptus elongatus	163953	State	OZAR	Present in Park
Fish	Cypriniformes	Catostomidae	Carpiodes velifer	163920	State	OZAR	Present in Park
Fish	Cypriniformes	Cyprinidae	Notropis texanus	163420	State	HEHO	Probably Present
Fish	Cypriniformes	Cyprinidae	Notropis topeka	163471	State	PIPE	Present in Park
Fish	Cypriniformes	Cyprinidae	Notropis ozarcanus	163458	State	OZAR	Present in Park

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Fish	Cypriniformes	Catostomidae	Erimyzon sucetta	163922	State	OZAR	Present in Park
Fish	Cypriniformes	Cyprinidae	Hybognathus nuchalis	163360	State	OZAR	Present in Park
Fish	Cypriniformes	Cyprinidae	Opsopoeodus emiliae	163876	State	OZAR	Present in Park
Fish	Cypriniformes	Cyprinidae	Notropis topeka	163471	Federal	PIPE	Present in Park
Fish	Esociformes	Esocidae	Esox masquinongy	162144	State	CUVA	Present in Park
Fish	Gadiformes	Lotidae	Lota lota	164725	State	CUVA	Historic
Fish	Osteoglossiformes	Hiodontidae	Hiodon tergisus	161906	State	OZAR	Present in Park
Fish	Perciformes	Percidae	Ammocrypta pellucida	168517	State	CUVA	Historic
Fish	Perciformes	Percidae	Percina uranidea	168500	State	OZAR	Present in Park
Fish	Perciformes	Percidae	Stizostedion vitreum glaucum	168507	State	CUVA	Historic
Fish	Perciformes	Centrarchidae	Centrarchus macropterus	168102	State	OZAR	Present in Park
Fish	Perciformes	Percidae	Stizostedion vitreum glaucum	168507	Federal	CUVA	Historic
Fish	Percopsiformes	Amblyopsidae	Typhlichthys subterraneus	164399	State	OZAR	Present in Park
Fish	Percopsiformes	Aphredoderidae	Aphredoderus sayanus	164405	State	HEHO	Probably Present
Fish	Petromyzontiformes	Petromyzontidae	Ichthyomyzon castaneus	159725	State	HEHO	Probably Present
Fish	Petromyzontiformes	Petromyzontidae	Lampetra appendix	159708	State	OZAR	Unconfirmed
Fish	Siluriformes	Ictaluridae	Noturus flavater	164011	State	OZAR	Present in Park
Mammal	Artiodactyla	Bovidae	Bison bison	180706	State	OZAR	Historic
Mammal	Artiodactyla	Cervidae	Cervus elaphus	180695	State	OZAR	Historic
Mammal	Carnivora	Canidae	Canis rufus	180600	Federal	ARPO	Historic
Mammal	Carnivora	Felidae	Lynx rufus	180582	State	EFMO	Present in Park
Mammal	Carnivora	Felidae	Lynx rufus	180582	State	LIBO	Probably Present
Mammal	Carnivora	Canidae	Canis rufus	180600	State	OZAR	Historic
Mammal	Carnivora	Canidae	Canis rufus	180600	Federal	HOSP	Historic
Mammal	Carnivora	Mephitidae	Spilogale putorius	180570	State	HEHO	Probably Present
Mammal	Carnivora	Mustelidae	Mustela frenata	180556	State	OZAR	Present in Park
Mammal	Carnivora	Felidae	Panthera onca	180593	Federal	OZAR	Historic
Mammal	Carnivora	Ursidae	Ursus americanus	180544	State	OZAR	Present in Park
Mammal	Carnivora	Canidae	Canis lupus	180596	State	OZAR	Historic
Mammal	Carnivora	Canidae	Canis lupus	180596	Federal	OZAR	Historic
Mammal	Carnivora	Canidae	Canis rufus	180600	Federal	OZAR	Historic
Mammal	Carnivora	Mustelidae	Lutra canadensis	180572	State	EFMO	Present in Park
Mammal	Chiroptera	Vespertilionidae	Myotis sodalis	180001	State	LIBO	Probably Present
Mammal	Chiroptera	Vespertilionidae	Myotis sodalis	180001	Federal	OZAR	Present in Park
Mammal	Chiroptera	Vespertilionidae	Myotis sodalis	180001	State	OZAR	Present in Park
Mammal	Chiroptera	Vespertilionidae	Myotis leibii	179999	State	OZAR	Probably Present
Mammal	Chiroptera	Vespertilionidae	Myotis sodalis	180001	Federal	LIBO	Probably Present
Mammal	Chiroptera	Vespertilionidae	Myotis grisescens	179997	Federal	BUFF	Present in Park
Mammal	Chiroptera	Vespertilionidae	Myotis grisescens	179997	Federal	OZAR	Present in Park
Mammal	Chiroptera	Vespertilionidae	Myotis grisescens	179997	State	OZAR	Present in Park
Mammal	Insectivora	Talpidae	Condylura cristata	179964	State	CUVA	Present in Park
Mammal	Insectivora	Soricidae	Cryptotis parva	179971	State	EFMO	Present in Park

Category	Order	Family	Latin Name	TSN#	Listing	Park	Park Status
Mammal	Insectivora	Soricidae	Cryptotis parva	179971	State	HEHO	Probably Present
Mammal	Insectivora	Soricidae	Sorex hoyi	179946	State	LIBO	Probably Present
Mammal	Insectivora	Soricidae	Sorex fumeus	179943	State	LIBO	Probably Present
Mammal	Lagomorpha	Leporidae	Sylvilagus aquaticus	180121	State	OZAR	Present in Park
Mammal	Rodentia	Muridae	Synaptomys cooperi	180324	State	HEHO	Probably Present
Mammal	Rodentia	Muridae	Synaptomys cooperi	180324	State	EFMO	Present in Park
Mammal	Rodentia	Muridae	Ochrotomys nuttalli	180379	State	OZAR	Present in Park
Mammal	Rodentia	Muridae	Oryzomys palustris	180336	State	OZAR	Present in Park
Mammal	Rodentia	Muridae	Peromyscus gossypinus	180279	State	OZAR	Unconfirmed
Reptile	Crocodilia	Alligatoridae	Alligator mississippiensis	551771	Federal	ARPO	Present in Park
Reptile	Crocodilia	Alligatoridae	Alligator mississippiensis	551771	Federal	ARPO	Present in Park
Reptile	Squamata	Viperidae	Sistrurus catenatus catenatus	209510	Federal	HEHO	Probably Present
Reptile	Squamata	Colubridae	Pituophis melanoleucus	174263	Federal	GWCA	Unconfirmed
Reptile	Squamata	Colubridae	Opheodrys aestivus	174172	State	LIBO	Present in Park
Reptile	Squamata	Colubridae	Opheodrys vernalis	174173	State	HEHO	Probably Present
Reptile	Squamata	Colubridae	Opheodrys vernalis	174173	State	EFMO	Unconfirmed
Reptile	Squamata	Viperidae	Sistrurus catenatus	174304	State	HOME	Unconfirmed
Reptile	Squamata	Viperidae	Sistrurus catenatus	174304	State	EFMO	Unconfirmed
Reptile	Squamata	Crotaphytidae	Crotaphytus collaris collaris	208788	State	OZAR	Unconfirmed
Reptile	Squamata	Crotaphytidae	Crotaphytus collaris	173912	State	OZAR	Present in Park
Reptile	Testudines	Emydidae	Clemmys insculpta	173772	State	EFMO	Unconfirmed
Reptile	Testudines	Emydidae	Clemmys guttata	173771	State	CUVA	Present in Park
Reptile	Testudines	Emydidae	Emydoidea blandingii	173789	State	CUVA	Present in Park
Reptile	Testudines	Emydidae	Terrapene ornata	173778	State	LIBO	Unconfirmed
Reptile	Testudines	Chelydridae	Chelydra serpentina	173752	State	PIPE	Present in Park
Reptile	Testudines	Chelydridae	Macroclemys temminckii	173755	State	OZAR	Unconfirmed
Vascular Plant	Alismatales	Alismataceae	Sagittaria rigida	38928	State	CUVA	Unknown
Vascular Plant	Apiales	Araliaceae	Aralia hispida	29374	State	CUVA	Unknown
Vascular Plant	Apiales	Apiaceae	Spermolepis inermis	29869	State	GWCA	Unknown
Vascular Plant	Apiales	Apiaceae	Perideridia americana	29797	State	GWCA	Unknown
Vascular Plant	Arales	Lemnaceae	Lemna trisulca	42595	State	OZAR	Unknown
Vascular Plant	Asterales	Asteraceae	Aster dumosus var. strictior	192991	State	OZAR	Unknown
Vascular Plant	Asterales	Asteraceae	Aster furcatus	35575	State	OZAR	Unknown
Vascular Plant	Asterales	Asteraceae	Aster macrophyllus	35608	State	OZAR	Unknown
Vascular Plant	Asterales	Asteraceae	Silphium terebinthinaceum	38411	State	HEHO	Unknown
Vascular Plant	Asterales	Asteraceae	Echinacea purpurea	37281	State	HEHO	Unknown
Vascular Plant	Asterales	Asteraceae	Solidago squarrosa	36314	State	CUVA	Unknown
Vascular Plant	Campanulales	Campanulaceae	Campanula rotundifolia	34497	State	OZAR	Unknown
Vascular Plant	Campanulales	Campanulaceae	Campanula aparinoides	34476	State	OZAR	Unknown
Vascular Plant	Capparales	Brassicaceae	Lesquerella filiformis	23181	State	WICR	Unknown
Vascular Plant	Capparales	Brassicaceae	Lesquerella filiformis	23181	Federal	WICR	Unknown
Vascular Plant	Caryophyllales	Cactaceae	Opuntia macrorhiza	19718	State	PIPE	Unknown
Vascular Plant	Cornales	Cornaceae	Cornus rugosa	27810	State	CUVA	Unknown

Category	Order	Family	Latin Name	TSN#	Listing	Park	Park Status
Vascular Plant	Cyperales	Cyperaceae	Carex cephaloidea	39543	State	CUVA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex arctata	39500	State	CUVA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex argyrantha	39503	State	CUVA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex aurea	39445	State	CUVA	Unknown
Vascular Plant	Cyperales	Poaceae	Bromus latiglumis	40504	State	GWCA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Cyperus acuminatus	39883	State	PIPE	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex cherokeensis	39545	State	OZAR	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex decomposita	39389	State	OZAR	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex straminea	39820	State	OZAR	Unknown
Vascular Plant	Cyperales	Poaceae	Setaria parviflora	505191	State	LIBO	Unknown
Vascular Plant	Cyperales	Poaceae	Setaria geniculata	41235	State	LIBO	Unknown
Vascular Plant	Cyperales	Cyperaceae	Eleocharis lanceolata	40050	State	OZAR	Unknown
Vascular Plant	Cyperales	Poaceae	Oryzopsis racemosa	41991	State	OZAR	Unknown
Vascular Plant	Cyperales	Poaceae	Tridens flavus var. chapmanii	530719	State	OZAR	Unknown
Vascular Plant	Cyperales	Cyperaceae	Eleocharis ovata	40061	State	HOCU	Unknown
Vascular Plant	Cyperales	Poaceae	Calamagrostis stricta ssp. inexpansa	523717	Federal	CUVA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Cyperus retrofractus	39961	State	GWCA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex gracillima	39620	State	GWCA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex crawei	39558	State	CUVA	Unknown
Vascular Plant	Cyperales	Poaceae	Buchloe dactyloides	41533	State	WICR	Unknown
Vascular Plant	Cyperales	Poaceae	Buchloe dactyloides	41533	State	PIPE	Unknown
Vascular Plant	Cyperales	Poaceae	Schedonnardus paniculatus	42063	State	PIPE	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex texensis	39842	State	WICR	Unknown
Vascular Plant	Cyperales	Poaceae	Bouteloua gracilis	41493	State	WICR	Unknown
Vascular Plant	Cyperales	Poaceae	Bromus latiglumis	40504	State	WICR	Unknown
Vascular Plant	Cyperales	Poaceae	Agrostis scabra	40424	State	PIPE	Unknown
Vascular Plant	Cyperales	Poaceae	Oryzopsis asperifolia	41979	State	CUVA	Unknown
Vascular Plant	Cyperales	Cyperaceae	Carex straminea	39820	State	GWCA	Unknown
Vascular Plant	Cyperales	Poaceae	Sphenopholis pensylvanica	41282	State	CUVA	Unknown
Vascular Plant	Cyperales	Poaceae	Poa saltuensis	41157	State	CUVA	Unknown
Vascular Plant	Cyperales	Poaceae	Panicum philadelphicum	504104	State	CUVA	Unknown
Vascular Plant	Dipsacales	Caprifoliaceae	Viburnum lentago	35266	State	GWCA	Unknown
Vascular Plant	Equisetales	Equisetaceae	Equisetum variegatum	17149	State	CUVA	Unknown
Vascular Plant	Ericales	Pyrolaceae	Chimaphila umbellata	23769	State	CUVA	Unknown
Vascular Plant	Fabales	Fabaceae	Desmodium viridiflorum	25833	State	GWCA	Unknown
Vascular Plant	Fagales	Fagaceae	Castanea dentata	19454	State	CUVA	Unknown
Vascular Plant	Fagales	Fagaceae	Quercus nigra	19280	State	GWCA	Unknown
Vascular Plant	Gentianales	Apocynaceae	Apocynum cannabinum	30157	State	CUVA	Unknown
Vascular Plant	Gentianales	Apocynaceae	Apocynum sibiricum	30161	State	CUVA	Unknown
Vascular Plant	Gentianales	Gentianaceae	Gentiana clausa	29974	State	CUVA	Unknown
Vascular Plant	Gentianales	Gentianaceae	Gentianopsis crinita	30080	State	CUVA	Unknown
Vascular Plant	Gentianales	Asclepiadaceae	Matelea obliqua	30375	State	OZAR	Unknown
Vascular Plant	Gentianales	Apocynaceae	Apocynum cannabinum	30157	State	HOCU	Unknown

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Vascular Plant	Hydropteridales	Marsileaceae	Marsilea vestita	17998	State	PIPE	Unknown
Vascular Plant	Juglandales	Juglandaceae	Juglans cinerea	19250	State	CUVA	Unknown
Vascular Plant	Juncales	Juncaceae	Juncus greenei	39273	State	CUVA	Unknown
Vascular Plant	Liliales	Liliaceae	Trillium nivale	43079	State	OZAR	Unknown
Vascular Plant	Liliales	Liliaceae	Zigadenus elegans	43158	State	OZAR	Unknown
Vascular Plant	Myrtales	Lythraceae	Ammannia auriculata	27093	State	GWCA	Unknown
Vascular Plant	Myrtales	Onagraceae	Oenothera triloba	27420	State	WICR	Unknown
Vascular Plant	Myrtales	Lythraceae	Decodon verticillatus	27076	State	EFMO	Unknown
Vascular Plant	Najadales	Najadaceae	Najas gracillima	38997	State	OZAR	Unknown
Vascular Plant	Najadales	Potamogetonaceae	Potamogeton natans	39008	State	CUVA	Unknown
Vascular Plant	Nymphaeales	Ceratophyllaceae	Ceratophyllum echinatum	501366	State	GWCA	Unknown
Vascular Plant	Ophioglossales	Ophioglossaceae	Botrychium multifidum	17187	State	EFMO	Unknown
Vascular Plant	Orchidales	Orchidaceae	Spiranthes lucida	43467	State	CUVA	Unknown
Vascular Plant	Orchidales	Orchidaceae	Platanthera leucophaea	43431	State	OZAR	Unknown
Vascular Plant	Orchidales	Orchidaceae	Platanthera leucophaea	43431	Federal	OZAR	Unknown
Vascular Plant	Orchidales	Orchidaceae	Malaxis unifolia	43647	State	OZAR	Unknown
Vascular Plant	Orchidales	Orchidaceae	Liparis loeselii	43623	State	OZAR	Unknown
Vascular Plant	Orchidales	Orchidaceae	Cypripedium reginae	43538	State	OZAR	Unknown
Vascular Plant	Orchidales	Orchidaceae	Corallorrhiza maculata	43523	State	CUVA	Unknown
Vascular Plant	Orchidales	Orchidaceae	Spiranthes magnicamporum	43468	State	CUVA	Unknown
Vascular Plant	Orchidales	Orchidaceae	Spiranthes ovalis	43451	State	HOCU	Unknown
Vascular Plant	Papaverales	Fumariaceae	Corydalis aurea	18999	State	EFMO	Unknown
Vascular Plant	Papaverales	Fumariaceae	Corydalis sempervirens	19010	State	CUVA	Unknown
Vascular Plant	Pinales	Pinaceae	Abies balsamea	18032	State	EFMO	Unknown
Vascular Plant	Pinales	Taxodiaceae	Taxodium distichum	18041	State	LIBO	Unknown
Vascular Plant	Pinales	Pinaceae	Pinus strobus	183385	State	LIBO	Unknown
Vascular Plant	Pinales	Cupressaceae	Juniperus communis	194820	State	CUVA	Unknown
Vascular Plant	Pinales	Cupressaceae	Thuja occidentalis	505490	State	LIBO	Unknown
Vascular Plant	Pinales	Cupressaceae	Juniperus horizontalis	194846	State	EFMO	Unknown
Vascular Plant	Plantaginales	Plantaginaceae	Plantago elongata	32877	State	PIPE	Unknown
Vascular Plant	Plantaginales	Plantaginaceae	Plantago patagonica	32907	State	GWCA	Unknown
Vascular Plant	Polygonales	Polygonaceae	Polygonum densiflorum	20854	State	OZAR	Unknown
Vascular Plant	Polygonales	Polygonaceae	Polygonum cilinode	20887	State	CUVA	Unknown
Vascular Plant	Polypodiales	Dryopteridaceae	Dryopteris celsa	17528	State	OZAR	Unknown
Vascular Plant	Polypodiales	Dryopteridaceae	Dryopteris intermedia	17538	State	EFMO	Unknown
Vascular Plant	Primulales	Primulaceae	Dodecatheon amethystinum	502105	State	EFMO	Unknown
Vascular Plant	Ranunculales	Ranunculaceae	Delphinium exaltatum	18553	State	OZAR	Unknown
Vascular Plant	Ranunculales	Berberidaceae	Berberis canadensis	18818	State	OZAR	Unknown
Vascular Plant	Ranunculales	Ranunculaceae	Trautvetteria caroliniensis	18803	State	OZAR	Unknown
Vascular Plant	Ranunculales	Ranunculaceae	Thalictrum revolutum	18660	State	EFMO	Unknown
Vascular Plant	Rhamnales	Vitaceae	Vitis aestivalis	28607	State	EFMO	Unknown
Vascular Plant	Rhamnales	Elaeagnaceae	Shepherdia canadensis	27779	State	CUVA	Unknown
Vascular Plant	Rosales	Rosaceae	Geum virginianum	24665	State	OZAR	Unknown

Category	Order	Family	Latin Name	TSN#	Listing	Park	Park Status
Vascular Plant	Rosales	Rosaceae	Crataegus spathulata	24603	State	WICR	Unknown
Vascular Plant	Rosales	Rosaceae	Waldsteinia fragarioides ssp. fragarioides	524829	State	OZAR	Unknown
Vascular Plant	Rosales	Saxifragaceae	Mitella nuda	24410	State	EFMO	Unknown
Vascular Plant	Rubiales	Rubiaceae	Galium boreale ssp. septentrionale	525786	State	OZAR	Unknown
Vascular Plant	Rubiales	Rubiaceae	Galium circaezans var. circaezans	528209	State	OZAR	Unknown
Vascular Plant	Rubiales	Rubiaceae	Galium asprellum	34798	State	EFMO	Unknown
Vascular Plant	Salicales	Salicaceae	Salix discolor	22524	State	GWCA	Unknown
Vascular Plant	Scrophulariales	Bignoniaceae	Catalpa speciosa	34315	State	LIBO	Unknown
Vascular Plant	Scrophulariales	Scrophulariaceae	Agalinis heterophylla	33027	State	GWCA	Unknown
Vascular Plant	Scrophulariales	Scrophulariaceae	Gratiola viscidula	33200	State	OZAR	Unknown
Vascular Plant	Scrophulariales	Scrophulariaceae	Penstemon canescens	33846	State	CUVA	Unknown
Vascular Plant	Scrophulariales	Scrophulariaceae	Limosella aquatica	33207	State	PIPE	Unknown
Vascular Plant	Solanales	Solanaceae	Physalis pubescens	30607	State	EFMO	Unknown
Vascular Plant	Theales	Clusiaceae	Hypericum denticulatum	21434	State	LIBO	Unknown
Vascular Plant	Violales	Cistaceae	Lechea intermedia	22286	State	CUVA	Unknown

2.4 Heartland Network Monitoring Themes

2.4.1 Overview

In the previous section, individual parks' priority issues and management objectives were discussed. While there are differences in the enabling legislations that initially establish the parks, still many of the Heartland Network parks share common environmental concerns about their diverse natural resources. This section combines information from similar park environmental monitoring concerns into 'monitoring themes'. The five identified themes are:

- Plant Communities Monitoring (including forest and prairie ecosystems)
- Aquatic Community Monitoring (including rivers, streams, wetlands, and springs)
- Wildlife Monitoring (including threatened and endangered species, species of concern, exotic species, and overabundant native species)
- Exotic Plant Monitoring (including known infestations and early warning of potential or new arrivals)
- Land Use Change Monitoring (connecting the park with the surrounding landscape)

Table 2.6 lists the themes, parks with environmental concerns in those themes, and a park priority rating from one to four, one reflects the park's highest monitoring concern. The Heartland Network is simultaneously developing a long-term ecological monitoring program, while conducting baseline vascular plant and vertebrate inventories in several parks. As a result, when information from the inventories becomes available additional themes may become evident. Not all monitoring concerns may 'fit' into a theme, as evidenced by ARPO's priority for soil monitoring. However, because it is a high priority that monitoring concern will also be discussed in this section.

The following subsections are divided by theme. The information within each theme is organized within an abbreviated conceptual model context. Figure 2.7 diagrams a hierarchy and groups the parks' identified environmental concerns into ecological effects, stressors, disturbances, or super-disturbances.

- Ecological effects (system responses to stressors),
- Stressors (changes due to some disturbance or driver),
- Disturbances/drivers (forces that have a large scale influence on a system), and
- Super-disturbances (over-riding force).

For all the themes except land use change, each park's environmental concern was either an ecological effect (e.g., species diversity) or a stressor (e.g., point source pollution). For the land use theme the environmental concerns were either a stressor or disturbance/driver.

Most of the long-term ecological monitoring conducted by the I&M Program will focus on monitoring either the ecological effect or stressor or both. Monitoring both the ecological effect and stressor makes it possible to demonstrate possible linkages between them, ultimately providing a clearer understanding. The information presented here in Section 2.4 sets the stage for Section 3 in which stressor-based ecoystem level conceptual models are presented to help identify appropriate long-term montioring indicators.

Park's provided the following information about their environmental concern:

- *Resources at Risk:* Identify specific resources that are vulnerable to impacts.
- *Observations:* What is the current status of the environmental concern and how has that changed in the past.
- *Assumptions:* Assumptions about the environmental concern or responses to potential stressors/disturbances.
- *Predictions*: Predictions of how the environmental concern may change based on various stressors or management actions.
- *Monitoring Objectives*: Specifies what steps should be taken to understand the status of the environmental concern.
- *Monitoring Questions*: Questions about the environmental concerns that would be either fully or at least in part answered by the monitoring data.

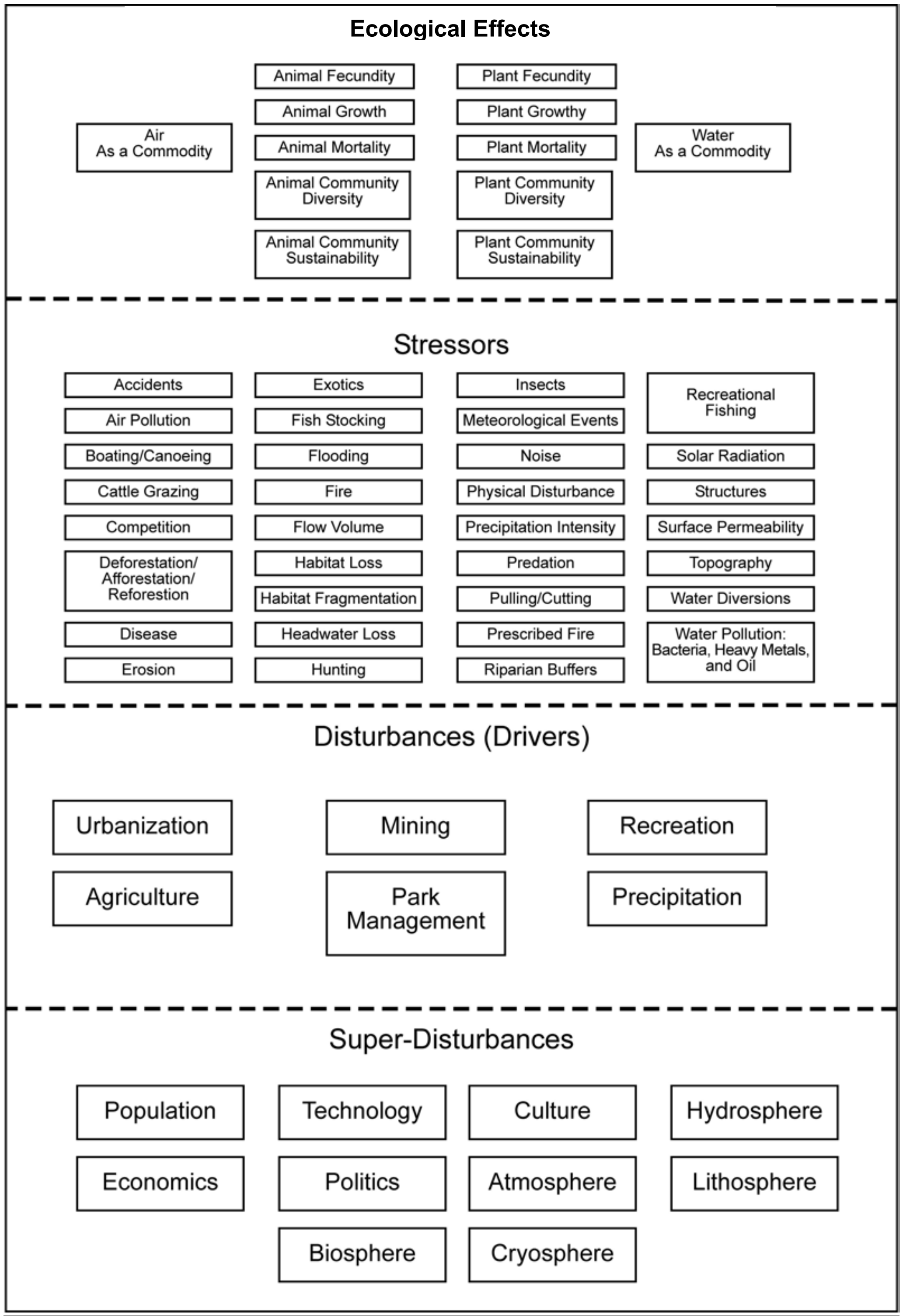
For each theme, except land use change, the information was provided for both the ecological effect and the stressor. For land use change it was provided for the stressor and disturbance. By having both sets of information on hand when initiating Phase II monitoring indicators can be selected that will provide insight into potential linkages.

A-4 through O-4 in Appendix A through O include park-specific monitoring data compiled by each of the Heartland Network parks. Monitoring data for the Prairie Cluster prototype parks included in this plan is for aquatics only. Non-aquatic long term monitoring activities are available from the Prairie Cluster Prototype or the individual prototype parks.

Table 2.6 Heartland Network Parks' Top Four Monitoring Issues per Park Summarized by Monitoring Themes

Plant Community Monitoring		
	#1 park priority	GWCA (prairie), LIBO (forest)
	#2 park priority	GWCA (riparian forest), HEHO (prairie), HOCU (forest)
	#3 park priority	ARPO (forest), PERI (forest)
Aquatic Monitoring		
	#1 park priority	BUFF (river: biological), HEHO (stream: riparian), HOSP (geothermal springs: chemical), OZAR (river: biological)
	#2 park priority	BUFF (river: physical), CUVA (wetlands), EFMO (river: chemical), OZAR (river: physical)
	#3 park priority	BUFF (river: chemical), EFMO (river: biological) HEHO (stream: chemical), HOSP (river: chemical), OZAR (springs: chemical), TAPR (stream: biological), WICR (stream: chemical)
Wildlife Population Monitoring:		
	#1 park priority	PERI (deer)
	#2 park priority	PERI (herpetofauna)
	#3 park priority	HOCU (herpetofauna) CUVA (coyote & deer)
	#4 park priority	BUFF (bats), GWCA (frogs & salamanders), HOCU (birds)
Invasive Exotic Plant Monitoring		
	#1 park priority	CUVA (in rare plant communities and wetlands), HOCU (in forest)
	#2 park priority	LIBO (in forest)
	#3 park priority	GWCA (in prairie and forest)
	#4 park priority	ARPO (in forest), HOSP (in forest)
Soil Erosion		
	#2 park priority	ARPO (soil erosion)
Land Use/Land Cover Change Monitoring		
	#1 park priority	ARPO (land use)
	#2 park priority	HOSP (land use)
	#3 park priority	LIBO (land use)
	#4 park priority	CUVA (land use), HEHO (land use and land cover), OZAR (land use), PERI (land use)

Figure 2.7 Overview of Park's Environmental Concerns, Stressors, Disturbances and Super Disturbances based on background monitoring data from the Heartland Network parks.



2.4.2 Plant Communities Theme

Plant communities found in the Heartland Network are diverse and include a variety of upland and riparian deciduous forest-types (e.g., maple-beech (*Acer-Fagus*), oak-hickory (*Quercus-Carya)*, sycamore (*Platanus occidentalis*); and tallgrass, lowland (wet), and goat prairies. Parks that indicated plant communities as a high priority monitoring concern for their park include ARPO, HOCU, LIBO, and PERI: upland deciduous forest, GWCA and HOCU: riparian forest, and GWCA and HEHO: upland tallgrass prairie.

This section on plant communities provides specific information on the Heartland Network parks' environmental concerns at the 'ecological effects' and 'stressor' levels. Both levels of information are necessary before a linkage can be hypothesized between a stress and effect.

Ecological effects level:

- forest community composition and diversity,
- tree regeneration,
- tree vigor and insect, disease, and pollutant damage,
- tree mortality and downed woody debris, and
- prairie community composition and species diversity.

Stressor level:

- air pollution,
- competition for resources,
- disease,
- flooding,
- insects,
- overstory tree canopy and solar radiation,
- prescribed fire, and
- water diversions.

Also a brief description of disturbance types, both natural and anthropogenic, which result in the stress or impact that in turn produces the park's concern about their natural resources. In Section 3 this information will be expanded within the developed ecosystem conceptual models. This section also includes a list of applicable laws, regulations, and permits that may be at the local, state, or national levels for vegetation monitoring.

2.4.2.1 Parks' Forest and Prairie Vegetation Environmental Concerns at an Ecological Effects Level

2.4.2.1.1 Forest Community Composition and Species Diversity

Forest community composition and diversity is a primary concern for parks. Loss of these features devalues the integrity of each park by affecting both natural and cultural resources. Parks rely on the aesthetics, commemorative nature of sites, and opportunities for resource stewardship, each of these based on species composition and diversity.

Arkansas Post NM

Resources at risk: Forest structure and health.
Observations: Part of the park burned in 1994, because of conditions at the time the fire left 12 and 15-foot flame scars on the trees. Many trees are dead or dying as a direct result of past fire regimes or indirectly due to increased stress and secondary effects of insect damage and disease. It is imperative that a thorough understanding of existing conditions is understood so that if/when prescribed fire is utilized it will not destroy or undesirably alter existing conditions, which are a direct result of past anthropogenic/anthropoligic influences that are linked to the establishment of the park.
Assumptions: Current forest health, as it pertains to dominant tree species vigor, mortality and recruitment rates, is presumed to be low at the park due to past fire regimes and subsequent secondary diseases and insect infestations. Differences are expected to exist between burned and unburned areas of the park.
Predictions: Fire intensity and periodicity will affect extant resources at ARPO.
Monitoring objectives: To determine what effects past fire regimes have had on the forested areas within the park and if a fire regime is needed
Monitoring questions:

- Do differences attributable to fire exist between burned and unburned areas within the park and are they stabilizing over time?

George Washington Carver NM

Resources at risk: Riparian forest community, Carver stream
Observations: May want to open up forest canopy as it has closed in over the years.
Assumptions: The riparian forest provides a buffer from inputs and increases in water temperature for Carver stream.
Predictions:
Monitoring objectives: To maintain in forest cover. To provide riparian buffer for the stream.
Monitoring questions:

- What native species are present in both the overstory and understory?
- What are the relative abundances of native species?

Hopewell Culture NHP

Resources at risk: second growth forest composed of mature hardwood trees and understory vegetation
Observations: Mound City Group was a War Department training camp during World War I. Since the 1960s, 100 acres of forest has re-vegetated through natural succession. Hopewell Mound Group has 75 acres of mature forest. High Bank Works has a wooded area along the Scioto River. Information from the 1960s about the trees in the park is available. Anecdotal data for ages of forested areas available via data mining.

Visitors are allowed to harvest up to nine mushrooms per person per visit, this can be abused especially in the case of morels.

Assumptions: Removal of grazing and farming will result in natural succession in the forest areas. Species composition and population densities should change.

Predictions: Impacts of stressors such as air pollution and herbicide overspray will effect natural succession. Aggressive exotic species will suppress natural succession. Natural succession will eventually suppress less aggressive exotic species.

Monitoring objectives: The park needs to monitor the forest areas to detect trends in species composition, age, and succession.

Monitoring questions:

- What is the species composition - overstory, regeneration, and all understory plants?
- What are the abundance levels of the species?
- What is the age structure for woody?
- Are forested areas changing to a native climax forest?
- What is the change in the depth of the organic matter layer?

Lincoln Boyhood NM

Resources at Risk: Midwestern forest tree species and associated shrubs and forbs.

Observations: Prescribed fire will be used in the upland areas of the Memorial to restore the oak-hickory forests that were present in the early 1800's. Currently, these areas of the Memorial are undergoing succession to more mesic dominant tree species such as tulip poplar and sugar maple. Data was collected in the late 1980's and late 1990's on the trees and forbs of the entire property. Analysis of that data is under way at this time. A lichen inventory in 1990 was conducted to provide a baseline for future studies related to air pollution impacts.

Assumptions: The reforestation projects throughout the history of the Memorial have led to the current vegetation composition. The current vegetation composition can be manipulated to more closely approximate pre-settlement conditions (prior to 1800). The assumptions are that prescribed fire will kill sugar maple and other mesic tree species, reduce hazardous fuels, and reduce the density of exotic forbs and grasses.

Predictions: The current composition of vegetation will change with the re-introduction of fire to the landscape. Exotic, ornamental vegetation in the North Forty will persist for many years unless active management is undertaken to remove or control these species. The predictions are that by 5 years post-treatment, prescribed fire will reduce sugar maple frequency by at least 75%, reduce hazardous fuels by at least 75%, and reduce the density of exotic forbs and grasses by at least 5%.

Monitoring Objectives: Determine (through Fire Effects Monitoring) the composition and densities of tree species and ground layer vegetation following prescribed fire use and manual removal of mesic tree species from the oak-hickory forest surrounding the cemetery. To determine what the dominant tree species are and what type of climax forest can be expected over time.

Monitoring Questions:

- What is the current forest composition?

- How does that composition change over time with and without active management of the vegetation?
- How does prescribed fire affect the native forbs and grasses of LIBO?
- Does floristic diversity change following prescribed fire at LIBO?
- Do pollution sensitive trees and lichens decline in abundance at LIBO?

Pea Ridge NMP

Resources at risk: The park has approximately 3600 acres of primarily deciduous hardwood forests, including post-oak blackjack-oak (*Quercus stellata-marilandica)* woodlands, oak-hickory forests and mixed hardwood forest types. Arkansas State listed Ozark chinquapin (*Castanea ozarkensis)* is in decline throughout the region because of chestnut blight. The Chinquapin occurs at five places in the park.

Observations: Fire-effects monitoring plots are being installed this spring (FY2002). Several hundred acres of forest are dominated by eastern red cedar (*Juniperus virginiana*). These trees invaded the park following agricultural disturbances and became the dominant overstory species due to the absence of fire. Cedar trees were digitized using DOQQs between 1990 and 2001. The park is in the process of cutting and removing cedar trees. This species occurs extensively in the park, therefore this activity will likely continue for many years. Land surveyor notes pre-settlement vegetation mapping - U of AR Monticello Dr Weih has a student working on this for AR and Jim Harland at U of MO Columbia working on MO presettlement. Field areas converted to forests over the past 70+ years around the park. 1862 corn and wheat fields

Assumptions: Eastern red cedar became the dominant overstory species, following agricultural disturbances, due to the absence of fire. The fire-effects monitoring program will answer many of the park's questions on the condition of and changes in the forest. Deer impacts include a reduction in woody regeneration of selected species.

Predictions: Changes in climate, a history of fire suppression, insect invasion as well is human impacts are just a few examples of things that may threaten forests in the Ozark ecoregion in the near future. Pea Ridge NMP has a long history of cattle grazing, fire suppression and other human introduced disturbances. Fire suppression and logging has changed the character of the park's forests significantly since 1862. Agricultural development in the park before the parks establishment has also dramatically changes large areas of the park. Post-Pleistocene lake that became a wet prairie area.

Monitoring objectives Need information regarding native insect outbreaks and fungal outbreaks that are natural disturbances on cyclic intervals. To restore and maintain the forest as it would probably have appeared in 1862, pre extensive fire suppression. To monitor afforestation of fescue fields taken out of production in FY2001.

Monitoring questions:

- What is the composition of the community - overstory, understory?
- What the age structure?
- What is the number of stems/ha of polesize understory?
- What exotics come in? What rate?

- Is deer browse occurring on woody regeneration? At what annual rate?
- Woody regeneration following restoration (cedar removal)?

2.4.2.1.2 Tree Regeneration

Arkansas Post NM

Resources at risk: Dominant overstory composition e.g., oak, hickory, cottonwood, sycamore, and pecan

Observations: Seedling recruitment and success appears to be inadequate within all forested areas at the park due to an overabundance of white-tailed deer, which have been found to be impacting extant vegetation, and the existence of invasive exotics. In 1999 and 2000, vegetation was studied in 20 exclosures and 20 control plots randomly placed within park vegetation types. Another possible reason for low seedling survival may be the spread of exotic invasive plant species in the park.

Assumptions: The dominant tree species mortality rate exceeds seedling recruitment.

Predictions: Seedling recruitment may increase once invasive exotics are eliminated within the forested areas at the park. Conclusive data to determine a predicted response does not exist.

Monitoring objectives: To determine dominant forest seedling recruitment and success on an annual basis within the forested areas, by vegetation type, at the park.

Monitoring questions:

- Does tree mortality match recruitment?
- Does the recruitment and success of dominant tree species seedlings change within forested areas and among vegetation types with the removal of exotics at the park?
- Is the recruitment and success of seedlings similar to that reported in literature?

Lincoln Boyhood NM

Resources at Risk: Midwestern forest tree species and associated shrubs and forbs.

Observations: Oak and hickory reproduction is unsuccessful in the upland forests of LIBO.

Assumptions: The increasing dominance of late successional tree species is inhibiting the reproductive success of oak and hickory tree species.

Predictions: Prescribed fire and manual removal of sugar maple trees from the upland habitats of LIBO will improve the success of oak and hickory reproduction and shift the mixed composition of the upland forests to an oak and hickory dominated habitat.

Monitoring Objectives: To monitor oak regeneration.

Monitoring Questions:

- Is oak reproduction increasing or decreasing in response to fire and mechanical management in the 50 acres of upland forest at LIBO?
- Over time, are oak and hickory reproductive efforts successful?

2.4.2.1.3 Tree Vigor and Insect, Disease, and Pollutant Damage

Arkansas Post NM

Key resources at risk: Dominant overstory composition (e.g., oak, hickory, cottonwood, sycamore, and pecan)

Observations: Many trees have died as a direct result of past park prescribed fire regimes. Forest composition and vegetation type studies were completed in 1977 and 1999. The later study delineated vegetation types by dominant forest species. Additional vegetative components were collected including percentage coverage of downed wood, forbs, grass, vertical structure (0.0-0.5, 0.5-1.0, and 1.5-2.0m) and leaf litter.

Assumptions: Current forest health, as it pertains to dominant tree species vigor, mortality and recruitment rates, is presumed to be low at the park due to past fire regimes and subsequent secondary diseases and insect infestations.

Predictions: Many more trees are slowly succumbing to secondary effects, such as insect damage or disease, and will ultimately die.

Monitoring objectives: To determine dominant tree species vigor by vegetation type within park forested areas on an annual basis.

Monitoring questions:

- Does tree vigor increase or decrease on an annual basis within and among vegetation types and forested areas?
- Does tree vigor match that of healthy forests as reported in literature?

Hopewell Culture NHP

Resources at risk: second growth forest composed of mature hardwood trees

Observations: Mound City Group group has 100 acres of forest that has developed since the 1960s through natural succession. Hopewell Mound Group has 75 acres of mature forest – gypsy moth has been found on this site. High Bank Works has woods along the Scioto River. Ross County has no intense or stable population of or treatment for gypsy moth as of this time. Problems with gypsy moth are found within 50 miles of the park - two counties away. There are isolated patches being treated with BT and monitored by the State about 15 miles from the park. The Ohio State DNR Forestry Division monitors for gypsy moths across the state. They have provided HOCU with 30 insect traps located at three sites. The traps have been in place for 16 years. They are turned in to the Forest Service in Morristown, VA. A report on the monitoring is available. The park is going to request 20 more traps in 2002 so as to have 10 at each site. There is a paper mill in town and the effects of its byproducts on vegetation are not known. Similarly, aerial pesticide applications along power lines (every three years) by South Central Power and/or AEP and nearby agricultural practices may be affecting the forest vegetation.

Assumptions: There is lots of potential for defoliation and mortality of trees because of the tree species present.

Predictions: Estimate that in two years the park will see impacts from gypsy moth.

Monitoring objectives: The park needs to monitor the forest areas to detect trends in forest health.

Monitoring questions:

- Is there evidence of diseases and pests on the overstory?
- Is there a change in the aerial extent of the forest canopy over time?

- Are pollutants from the paper mill affecting the vegetation?
- Are agricultural practices (herbicides specific to broadleaf plants) on the property and adjacent to the park affecting the forest vegetation?
- Are adjacent aerial applications by the power companies affecting the park vegetation?

Lincoln Boyhood NM

Resources at Risk: Midwestern forest tree species and associated shrubs and forbs.
Observations: No *Lymantria dispar* (gypsy moth) have been detected in the park. US Forest Service monitors for gypsy moth in the Hoosier National Forest.
Assumptions: Gypsy moth will eventually be detected at LIBO.
Predictions: Gypsy moth swill impact the forest vegetation of the Memorial if early detection and control measures are not undertaken.
Monitoring Objectives: To detect the presence of *Lymantria dispar* (gypsy moth) should it occur.
Monitoring Questions:

- Are gypsy moths present at LIBO? If so, in what density?
- If present, how are gypsy moths impacting the vegetation of LIBO?
- If employed, how effective are control measures?

Lincoln Boyhood NM

Resources at risk: Forest tree species and associated shrubs and forbs
Observations: Urbanization and industrialization is rapidly spreading across Southern Indiana. Industries include paper manufacturing, power plants, and vehicle manufacturing plants. Many other light industries also operate within 50 miles of the Memorial. Fifty permanent vegetation plots exist, data on trees, understory, and herbaceous layers gathered in 1985, 1997, and 1998. Lichen inventory done in the 1990's. Fire effects monitoring to begin fall, 2002.
Assumption: Land use changes and disturbances may lead to reductions in floristic diversity within the Memorial.
Predictions: As urban air pollutants and population and development of adjacent properties occurs, an increase in the abundance of exotic species will occur in the forests at LIBO. Further, reductions in air quality will lead to decreased floristic diversity. Specifically, lichens and other air pollutant sensitive plant groups and species will be reduced in abundance and occurrence.
Monitoring Objectives: To monitor native forest composition and structure, and understory plant species. To provide an early warning of the potential for impacts to floristic diversity and forest composition from reduced air quality and urbanization.
Monitoring Questions:

- Over time, do pollution sensitive trees and lichens decline in abundance LIBO?
- What are the impacts to native vegetation of increased concentrations of air pollutants?

2.4.2.1.4 Tree Mortality and Downed Woody Debris

Arkansas Post NM

Resources at risk: Employee and visitor safety as it pertains to both direct and indirect effects (e.g., falling snags and probability of fire)

Observations: Because of past fire regimes, trees are diseased and dying thereby providing additional fuel loading in areas that were burned which would not have occurred otherwise.

Assumptions: Fuel loading is presumed to be low in this region due to forest makeup and annual environmental conditions (e.g., significant amounts of rainfall annually, high decomposition rates due to high levels of humidity throughout much of the year, and the seasonal inundation of areas in the park).

Predictions: Due to forest makeup and annual environmental conditions, prescribed fire may not be needed to reduce fuel loading.

Monitoring objectives: To determine snag recruitment and mortality on an annual basis within the forested areas, by vegetation type, at the park. To determine downed woody debris/fuel loading on an annual basis in all vegetation types at the park. To determine the annual rate of decomposition within and among all vegetation types. To determine the changes in downed woody debris/fuel loading and decomposition rates attributable to past fire regimes among vegetation types of similar compositional structure on an annual basis.

Monitoring questions:

- Is snag recruitment increasing on an annual basis?
- Is downed woody debris/fuel loading increasing within and among vegetation types on an annual basis within the park?
- Is downed woody debris/fuel loading within expected parameters, given existing forest composition and geographical area, and is it similar to that reported in literature?
- Are decomposition rates reducing downed woody debris/fuel loading within and among vegetation types at the park on an annual basis?

2.4.2.1.5 Prairie Community Composition and Species Diversity

George Washington Carver NM

Key resources at risk: Specific native prairie grasses and forbs

Observations: Quality of the restored prairies in the park is threatened by invasion of exotic plant species (e.g., Johnson grass, crown vetch, lespedeza (not much now), and encroaching native woody plants (e.g., sumac, blackberry, woody briar, grape vine, and green briar trying to trail in). The park in process of writing a burn plan, however, won’t be able to use prescribed burning until around 2004.

Assumption: Lack of fire results in no way to prevent encroaching of woody vegetation into the prairie.

Prediction: Use of prescribed fires will set back encroachment by woody species. Use of prescribed fires will enhance/maintain native prairie vegetation growth.

Monitoring objectives: To maintain good quality prairie in the park. To monitor native plant species (in terms of abundance, species richness and density), especially in comparison with Diamond Grove Prairie. Monitor status in relation to prescribed fires. Track changes over time from the inventory baseline taken FY2002

Monitoring questions:

- What native species are present compared with the baseline data from the FY2002 Inventory?
- What are the relative abundances of native species?
- What is the abundance of the dominant prairie grasses (big bluestem, little bluestem, Indian grass, side oats, switchgrass)?

Herbert Hoover NHS

Resources at Risk: Community diversity and integrity, soils, water quality, aesthetics, commemorative nature of site, and opportunities for land and water stewardship and interpretation of the resources

Observations: Currently, prairie plants are distributed in bunches without many rhizome producing species covering the soil between bunches. After 30 years, the prairie has not progressed to a self-maintaining community, as hoped. This may be due to the lack of management during some periods. Therefore, management techniques should be re-evaluated periodically. Managers must schedule prescribed fire so that minimal smoke will impact the town and Interstate, soil is not open to long-term erosion, ensure that impact on nesting birds and herpetofauna is limited, and meet the management objectives of the fire.

Assumption: The prairie is a significant landscape for runoff management, reducing the erosion and runoff flow into the flood plain and creek. The prairie promotes natural soil genesis and improves the soil matrix, thus creating a stabile complex. Past management decisions have occasionally resulted in adverse impacts on the prairie that were not immediately detected, because no monitoring was in place.

Prediction: An index of dominance and diversity will provide an indication of health and status of the restored prairie. Changes in dominance/diversity (species composition and relative abundance) over time will indicate the direction of progress. Species composition and percent cover associated with each species will indicate the value of the prairie in protecting soils. Managers wish to see better plant distribution, so as to protect soils and prevent weedy intrusion.

Monitoring objectives: To track the status of the original objectives and alter management practices to meet the needs of the prairie. To evaluate management practices (mowing, haying, fire, herbicide) used in the prairie. To quantify changes in dominance/diversity and relative cover. Early warning detection of new exotic species intruding into the prairie.

Monitoring questions:

- Is species composition changing?
- Is relative abundance changing?

- Is there a correlation between management techniques and plant species composition or dominance/diversity?
- Following fire what are the changes in plant species and relative abundance year after year?

2.4.2.2 Parks' Forest and Prairie Vegetation Environmental Concerns at a Stessor Level

2.4.2.2.1 Air Pollution

Point-source air pollution comes from specific locations include industrial complexes or pesticide sprayers. Non-point air pollution comes from auto emissions. Air pollution may include ozone, acid rain, and pesticides. Air pollution can have various effects e.g., direct damage to plant tissue, it can add toxic substances, or deplete necessary nutrients.

Lincoln Boyhood NM

Resources at Risk: Air
Observations: Significant air pollution sources, both point and non-point, occur within 50 miles of LIBO. Large manufacturing operations such as a paper mill, steel mill, and vehicle manufacturing plants operate locally. A major highway (I-64) is located less than 10 miles from the park. Many smaller industries are also located within 50 miles of the park. The Indiana Department of Environmental Management has listed Spencer County as a County of Concern for toxic air pollutants. Other major air pollutants include; CO, SO_2, and a variety of nitrogen oxides.
Assumptions: Further reductions in air quality are expected as industrial development continues. Re-routing of the state highway to within 3 miles of the Memorial will increase concentrations of vehicular air pollutants within the Memorial.
Predictions: Decreases in air quality will impact the diversity of native vegetation.
Monitoring Objectives: The objective is to provide the Memorial with air quality and impact (vegetation) data sufficient to alert management to the causes of loss of sensitive vegetation species.
Monitoring Questions:

- What are the levels and types of air pollutants effecting LIBO?

Hopewell Culture NHP

Resources at Risk: Air
Observations: There is a paper mill in town. In addition, aerial applications of herbicides occur approximately once every three years to control growth under South Central Power and/or AEP power lines. These herbicides may be specific to broadleaf plants.
Assumptions: Local air pollution and aerial applications of herbicides reduce vigor of forest species. Effects may be hard to detect if mortality from Gypsy moths occurs.
Predictions: Specific damage to tree species will be observed. Broadleaf plants are suppressed in power line right-of-ways.

Monitoring Objectives: Determine if industrial air pollution is affecting the mortality or vigor of native forest species. Determine if the power line vegetation control program is effecting areas outside of the right-of-way.
Monitoring Questions:
- Is there evidence of impacts from air pollution in the forested areas of HOCU?
- Are the herbicides used by the power companies impacting plant communities outside the right-of-way?

2.4.2.2.2 Competition for resources

Interspecies competition/invasive exotic plants stress plant communities. Plants compete for resources including sunlight, water, nutrients, space, or pollinators. Some plants affect soil pH or have allelopathic properties (e.g., secrete poisons) that prohibit the growth of other plants.

Arkansas Post NM

Resources at Risk:
Observations: ARPO has a number of exotic plants
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Herbert Hoover NHS

Resources at Risk: Native prairie plants
Observations: Exotic plants such as European ecotype reed canary grass create localized monotypic stands that exclude all other species. Smooth brome and Kentucky bluegrass encroach on the prairie edges and take advantage of open areas between the warm season bunch grasses. Other weedy plants, some exotic and some native weeds, intrude into the prairie, including dandelion, plantain, Canada thistle, giant ragweed, and assorted woody plants. Tartarian honeysuckle, Siberian elm, and Russian olive are among the exotic woody species.
Assumptions: Unchecked many of these species will spread by self seeding or rhizomes. Catching these problems early is the key to control.
Predictions: Early detection of exotic and intrusive plant competition will allow managers to take steps to reduce populations.
Monitoring Objectives: Monitor changes in relative abundance and locations of exotic and intrusive plants. Monitor the results of control measures taken by managers.
Monitoring Questions:
- Are there any new species intruding into the prairie?
- How is relative abundance changing?
- Are invasive species entering new areas?
- Are problem areas increasing or decreasing in size?
- Are locations and relative abundance changing in response to management actions?

2.4.2.2.3 Disease

Some diseases are fatal to plants, other diseases a plant can live with for years or centuries. Introduced diseases have been especially damaging to native vegetation. Often times diseases are considered a secondary impact on a plant that is already stressed from another impact such as drought or damage to tissues.

Arkansas Post NM

Resources at Risk:
Observations: There are a number of 'secondary' diseases impacting already stressed trees
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.2.2.4 Flooding

Flooding stresses plant communities by removing low lying and/or diseased vegetation. Flooding can be caused by natural meteorological events or may be exacerbated by basinwide changes in surface permeability.

George Washington Carver NM

Resources at Risk:
Observations: Occasional flooding of riparian forest vegetation when Carver Creek overflows.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.2.2.5 Insects

Insects impact plants by in a variety of ways e.g., defoliating, transporting diseases, boring holes, laying eggs in plants. Some very damaging insect species have been introduced into new areas via trade and commerce. Many native insect species have cyclic episodes that erupt every so many years. Plant communities may or may not withstand these events depending in part on other stressors such as weather conditions. Some insect species are host specific and impact only specific host plant species, others are more generalized and impact a variety of plant species.

Arkansas Post NM

Resources at Risk:
Observations: The red oak borer is present.

Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Hopewell Culture NHP

Resources at Risk:

Observations: Lymantria dispar (Gypsy moth) is a concern, although Ross County does not have an epidemic or implemented treatment plan. As of the summer of 2002, the Gypsy moth is a problem two counties away and is expected to be impacting park vegetation within the next two years.

Assumptions: Gypsy moth will become established in the units of the park.

Predictions: The infestation will result in increased mortality of forest species.

Monitoring Objectives: Detect presence of established populations of Gypsy moths as soon as possible. Detect morbidity and mortality of tree species in infested areas. Provide management with information that will help determine appropriate response.

Monitoring Questions:

- When have moth populations reached levels that will damage trees?
- Is the damage causing extensive changes to the composition and succession of forest communities?

Lincoln Boyhood NM

Resources at Risk:

Observations: Lymantria dispar (gypsy moth) has not been detected as of summer 2002, nor have they been detected in Southern Indiana. Based on current estimates, gypsy moth is expected to be present at the Memorial by 2015.

Assumptions: Gypsy moth will populate the Memorial and impact the vegetation.

Predictions: Control measures will be adopted by the Memorial based on NPS Integrated Pest Management protocols for gypsy moth. Impacts to non-target, native invertebrate populations will be a side-effect of any control measures adopted.

Monitoring Objectives: Monitor for presence and population size of gypsy moth. Measure the impacts of gypsy moth on native vegetation (as described previously). Measure the impacts and efficacy of control efforts.

Monitoring Questions:

- When will gypsy moth arrive at LIBO?
- What are the impacts to the native vegetation?
- What are the results of control measures on gypsy moth?
- What are the effects of control measures on non-target invertebrate species?

2.4.2.2.6 Overstory tree canopy and solar radiation

Overstory tree canopy may increase in volume or density through natural regeneration, afforestation or reforestation, or it may decrease through deforestation. Changes in overstory tree canopy influence resources e.g., solar radiation in the lower canopy or on the forest floor, and soil nutrient and water cycling. Canopy closure prevents lower lying plants from receiving much direct radiation which may limit their photosynthetic ability and potentially growth and survivorship. (Conversely it may provide the dense shade necessary for growth.)

George Washington Carver NM

Resources at Risk:
Observations: Forest maturation has resulted in canopy closure over time.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Hopewell Culture NHP

Resources at Risk:
Observations: Mound City Group (120-acres) was a War Department training camp during World War I. Most of the area was in turf grass, the rest allowed to re-vegetate by natural succession. Hopeton Earthworks (292-acres) was farmed prior to NPS acquisition. At Hopewell Mound Group (300 acres) one-quarter of the area is mature forest. The balance was farmed and continues to be mowed for hay. Seip Earthworks (236-acres) has a small area in turf grass, most of the remainder has been farmed. High Bank Works has a wooded area. In all five areas combined there is roughly 100 acres forest. Selective harvesting is going on outside the park boundaries, especially at Hopewell Mound Group.
Assumptions: Removal of grazing and farming will result in natural succession in the forest areas. Species composition and population densities should change. Impacts of stressors such as air pollution and herbicide overspray will affect natural succession. Aggressive exotic species will suppress natural succession. Natural secession will eventually suppress less aggressive exotic species.
Predictions: Forested areas will increase by natural succession.
Monitoring Objectives: Detect changes in forest area and composition.
Monitoring Questions:

- Are forest changes being effected by external stressors such as exotic plants and herbicides?
- Is management of adjacent forest lands affecting the succession of forests areas?

Pea Ridge NMP

Resources at Risk:
Observations: Afforestation of fescue fields taken out of production in FY2001. Field areas were converted to forests over the past 70+ years around the park. 1862 corn and wheat fields and animals in the woodlands.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.2.2.7 Prescribed Fire

Prescribed fires stress plant communities by removing competitive species, particularly exotics that are not adapted to natural cycles of fire. In other instances, fires are important for regeneration. Fire programs are part of park management policies.

Arkansas Post NM:

Resources at Risk:
Observations: The last prescribed fire at the park took place in 1994, only a portion of the park was burned. Because of conditions at the time, the fire left 12 and 15-foot flame scars.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Lincoln Boyhood NM

Resources at Risk: Midwestern forest tree species and associated shrubs and forbs.
Observations: Prescribed fire will be used in the upland areas of LIBO to restore the oak-hickory forests that were present in the early 1800's. Currently, these areas of the Memorial are undergoing succession to more mesic dominant tree species such as tulip poplar and sugar maple. The first prescribed burn is scheduled for October, 2002. Subsequent prescribed fires will be scheduled based on the results of fire effects monitoring and the availability of fire crews.
Assumptions: The assumptions are that prescribed fire will kill sugar maple and other mesic tree species, reduce hazardous fuels, and reduce the density of exotic forbs and grasses. Further, the assumption is that the return interval prescribed will produce the desired results.
Predictions: The planned return interval for prescribed fire at the Memorial is 5-10 years following an initial treatment of annual of biannual fires which may occur in either spring or fall fire seasons. The predictions are that by 5 years post-treatment, prescribed fire will reduce hazardous fuels by at least 75%.
Monitoring Objectives: To determine the results of prescribed fire in meeting Resource Management objectives of fuels reduction, oak and hickory species reproduction, and reduction in the density of late successional tree species. Provide a basis for future vegetation management actions across the entire property, including the young North Forty forests. Fire Effects Monitoring results and analysis will dictate the fire-return interval at the Memorial.
Monitoring Questions:

- What is the annual fuel loading at the Memorial following prescribed fire?
- What is the appropriate return interval for restoration and maintenance of oak-hickory forest at the Memorial? (RESEARCH QUESTION)

George Washington Carver NM

Resources at Risk:

Observations: GWCA has had four prescribed burns since prairie restoration was completed in the mid to late 1980s. In November 1997, Units 2 and 4 were burned. In September 1998, burning rotated to Units 1 and 4. In March 1999, Unit 2, 3 and 6 were burned. Units 1,7W, and 2 were burned in the spring of 2000, although Unit 2 did not burn well.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Herbert Hoover NHS

Resources at Risk:
Observations: Prescribed fire is the principal management technique used for prairie maintenance.
Assumptions: The prairie plant community will respond to prescribed fire with changes in specie composition and relative abundance.
Predictions: A regular fire regime will reduce competition from many exotic and invasive plants. The recycling of nutrients will benefit the plants that survive fire treatment. Big bluestem will dominate the prairie, as it did in eastern Iowa before fire suppression.
Monitoring Objectives: Determine changes in species composition and relative abundance relative to fire treatment.
Monitoring Questions:

- Is fire contributing to the development of a diversified native plant community?

2.4.2.2.8 Water Diversions

Water diversions include any type of damming, pumping, routing and tiling. Water diversions stress plant communities by modifying the amount of water and types of nutrients they receive.

Herbert Hoover NHS

Resources at Risk:
Observations: Tiling is a common practice at HEHO to drain the wetlands. Tiling started as early as 1890, although there was a push in the 1920s. The original tiles were hand dug. Some tiles at HEHO date from 1920s and 1940s, judging by the materials used. The greatest amount of tiling at HEHO was driven by the Soil and Water Conservation Districts cost sharing policies in the late 1960s to 1979. These tiles were sometimes installed in a 66-foot grid system. Many of these tiles still remain in the HEHO prairie and most farms upstream are also tiled.
Assumptions: The tiling of the HEHO prairie while it was agricultural field eliminated the linear slough that existed where the streambed occurs today.
Predictions: Removal of tile in the HEHO prairie would allow infiltration of rainwater and snow melt and slow movement into the low meadow, thus recreating the wetland.
Monitoring Objectives: Determine how removing tile affects species composition and habitat conditions in the wet meadow.
Monitoring Questions:

- Does the tile water contribute to the wet meadow?
- Did breaking tiles reduce stream flow during storm surges.

2.4.2.3 Anthropogenic and Natural Disturbances Impacting Park Forest and Prairie Ecosystems

Present-day disturbance mechanisms potentially impacting Heartland Network parks' forest ecosystems were listed in Figure 2.10. The most common types of disturbance vary, in some cases corresponding with specific forest-types. For example, fire (both suppression and prescribed fire) ranks high in importance in fire-dominated communities such as oak-hickory common to the parks in Missouri and Arkansas. Some disturbance mechanisms are common concerns across forest-types, in particular exotic plant and insect species. The disturbances highlighted in Heartland Network forest and prairie ecosystems are:

- ✓ Agriculture: Agriculture affects plant communities through a number of stressors including afforestation, deforestation, reforestation, exotic plant species, and water diversions.
- ✓ Urbanization: Urbanization is responsible for a number of plant community stressors including deforestation, air pollution, and exotic plant species.
- ✓ Precipitation: Intense precipitation event can lead to flooding.
- ✓ Park Management: Park management actions, including prescribed fires, help influence plant communities.

2.4.2.4 Relevant Laws and Regulations

Local, state, and federal laws, permitting requirements, and so on that will regulate or influence monitoring program decisions and actions were identified by the parks that identified plant community monitoring as a high priority within the I&M program. This information is summarized up in Table 2.7.

Table 2.7. Local, State, and Federal Laws Relevant for Plant Communities Monitoring

Law		ARPO	GWCA	HEHO	HOCU	LIBO	PERI
Local	NPS Cultural Landscape Report	X		X			
	NPS Enabling Legislation	X					
	NPS General Management Plan	X		X			
	NPS Fire Management Plan	X		X			
	Rural Fire Department Cooperative Agreement	X		X			
State	Ohio state regulation 300 ft riparian buffer				X		
Federal	Clean Water Act	X	X	X	X	X	X
	Cultural Landscape Report	X	X	X	X	X	X
	Enabling Legislation	X	X	X	X	X	X
	Farm Act of 2002	X	X	X	X	X	X
	Federally listed T&E plant species	X	X	X	X	X	X
	General Management Plan	X	X	X	X	X	X
	IPM requirements/ herbicide licensing	X	X	X	X	X	X
	National Environmental Policy Act	X	X	X	X	X	X
	Organic Act	X	X	X	X	X	X

2.4.3 Aquatics Theme

Aquatic ecosystems found in the Heartland Network include large rivers, small streams, ponds, cold and geothermal springs, seeps, and wetlands. Eight Heartland Network parks indicated some aspect of an aquatic ecosystem as high priority for monitoring (Table 2.3). BUFF is concerned about biological components, physical parameters, and water quality of the Buffalo River and its tributaries. CUVA is concerned about their existing wetlands, particularly in relation to changing land use within the park. EFMO is concerned about chemical impacts due to meat packing waste-water treatment plants, including a newly proposed plant, on tributaries of the Yellow River. HEHO is concerned about the riparian buffer zone and water quality of Hoover Stream with future potential for an adjacent wetland if or when agricultural tiling is broken on park property. HOSP is concerned about the water quality of the geothermal springs in the park, especially in relation to potential mixing of geothermal waters with surface waters within the same watershed. OZAR is concerned about biological components and physical parameters of the Current River and Jack's Fork River. OZAR is also concerned about the water quality of the springs and tributaries that feed into the two rivers. TAPR is concerned about aquatic biota, including a T&E species, in their prairie streams. WICR is concerned about regular and large episodic inputs of treated and untreated effluent into Wilsons Creek from a sewage treatment plant upstream from the park.

The following information strives to articulate parks' aquatic natural resource concerns and related stressors. Due to the Concerns have been grouped into 'physical', 'biological', and 'water quality' (chemical).

This section on aquatics provides specific information on the Heartland Network parks' environmental concerns at the 'ecological effects' and 'stressor' levels. Both levels of information are necessary before a linkage can be hypothesized between a stress and effect.

Ecological effects level:

- Physical: River Flow,
- Physical: Spring Flow,
- Physical: Prairie Stream Flow,
- Biological: River Communities and Species,
- Biological: Prairie Stream Communities and Species,
- Biological: Prairie Stream Riparian Area Communities and Species, and
- Biological: Wetlands Communities and Species.

Stressor level:

- Physical: Motor Boats and Canoes,
- Physical: Precipitation,
- Physical: Temperature,
- Physical: Tiling,
- Physical: Sedimentation,
- Physical: Soil Erosion,

- Physical: Structures,
- Physical: Surface Permeability,
- Biological: River Habitat,
- Biological: Wetlands Habitat,
- Biological: Riparian Buffer,
- Biological: Recreational Fishing,
- Biological: Stocking of Fish,
- Chemical: Nutrients,
- Chemical: Heavy Metals, and
- Chemical: Pollution.

2.4.3.1 Parks' Aquatic Environmental Concerns at an Ecological Effects Level

2.4.3.1.1 Physical: River Flow

Agricultural water diversions influence aquatic resources through damming, pumping, tiling, and channeling. Either implemented separately or alone, each can have detrimental effects on aquatic resources. Damming reduces stream connectivity and can increase downstream scouring because of upstream sedimentation. Pumping can change the overall water balance by transferring water to other watersheds.

In the Ozark Plateau region karst terrain produces complex pathways of water and energy flow where surface constituents can disappear into the ground only to emerge from springs days or years later. Losing streams, karst windows, and sinkholes provide direct access to spring recharge water from surface activities.

Buffalo NR

Resources at Risk: Changes in run-off are important because they can be long lasting and sometimes have irreversible effects on aquatic communities.

Observations: Construction of a dam on Bear Creek has been proposed. There are numerous little dams to provide drinking water for cattle. Compared to similar sized rivers in most of the U.S., the Buffalo has few dams in its watershed and retains primarily natural flow conditions. The natural flows (especially high flows) transport sediment and do the work required to maintain important physical habitat attributes such as pool depth and volume, spawning reds, riffle-pool spacing, scour pool formation, biological drift and migration, and energy transport, among others.

Assumptions: Physical processes and resultant habitats define the template upon which biological communities evolve and are maintained.

Predictions:

Monitoring Objectives: Within the Buffalo River and its major tributaries, to track the status and trends of major physical habitat indicators, including flow.

Monitoring Questions:

- What are the status and trends of flow in the Buffalo River?
- What are the status and trends of flow in 20 major tributaries where water quality monitoring is currently going on.

Cuyahoga Valley NP

(This ecological effect ties in with the Land Use Change theme)

Resources at Risk:

Observations: The natural flow of the river is affected by water diversion, several storage reservoirs, industrial and municipal wastewater effluent, and power plants. Water is removed from the river upstream from the park at Lake Rockwell for the City of Akron's water supply and is largely returned to the river by Akron's wastewater treatment plant (Cuyahoga Rap Stage One, 1992). Hydro-modification is now the leading source of impairment of Ohio streams and is the origin of habitat degradation and sedimentation problems that are causes of impairment of Ohio's streams. Cumulative effects of such impacts over a large area and over time can be substantial. Park water quality data has not been correlated to the larger landscape level changes that have occurred over the past 25 years.

Assumptions: The effects of urban land use on biological communities in the Cuyahoga River Basin show strong negative correlations between increasingly impervious watersheds and biological health(Yoder et al 1999).

Predictions: The effects of imperviousness and associated cofactors (e.g. urban runoff, altered hydrology) may be offset by land use practices.

Monitoring Objectives: To improve our understanding of land use trends in the region and interpret the indirect influences on aquatic resources from agriculture, urbanization, habitat degradation, channelization of streams and destruction of riparian buffers.

Monitoring Questions:

- Can trends in sediment and nutrient loading, bacteria levels, riparian buffers and hydrology can be correlated to changes in land use changes?

Ozark NSR

Resources at Risk: Outstanding National Resource Waters – Current and Jack's Fork Rivers. Candidate for federally endangered: *Cryptobranchus alleganiensis bishopi* (Ozark hellbender). Missouri species of concern: *Cambarus hubricht*i (Salem cave crayfish), *Allocapnia pygmaea* (winter stonefly), *Ophiogomphus westfalli* (Westfall's snaketail), *Notropis ozarcanus* (Ozark shiner), *Typhlichthys subterraneous* (Southern cavefish), *Cycleptus elongatus* (Blue sucker), *Noturus flavater* (checkered madtom), *Lampetra appendix* (American brook lamprey), *Polydon spathula* (paddlefish), *Alasmidonta marginata* (elktoe), *Ptychobranchus occidentalis* (Ouchita kidneyshell), *Ligumia recta* (black sandshell), and *Lampsilis reeviana* (Arkansas brokenray)

Observations: Flow regimes carve and maintain physical habitat, and also carry energy sources contributing to the rivers' water quality. At OZAR, river flow, and the aquatic habitat environments it produces, receive a relatively constant flow due to the influence of large springs, as opposed to other Ozark streams. A map of channel stable and unstable zones based on historic aerial photography would greatly improve the geomorphic knowledge for park managers. Stream flow is monitored at 6 sites in the park, some since 1916 and 1922. Gaps in the gage network occur in the upper and middle Current River, and on some major springs. USGS Gauging station data - Big Spring 1922-present, Van Buren 1916-present, Two Rivers 1922-1975, Eminence 1922-present, Alley Spring 1929-39 and 1966-79, Round Spring 1929-39 and 1966-79.

Assumptions: Stream flow is the most fundamental variable for understanding physical, chemical, and biological dynamics of rivers. Stream flow carries energy, sediment, and contaminants, and carves out the physical habitats available to river biota.

Predictions: Aquatic physical habitat is apparently undergoing a readjustment from past land and river uses. Stressors will affect flow regime by altering the timing, magnitude, and frequency of peak flows, and altering stream power and erosive capabilities.

Monitoring Objective:

Monitoring Questions:

- Is the river(s) hydrograph changing, particularly the annual and storm hydrographs?

2.4.3.1.2 Physical: Spring Flow

Hot Springs NP

(This environmental concern ties in with the Land Use Change theme)

Resources at Risk: Geo-thermal springs. Recent dating efforts indicate the geo-thermal water is in the ground approximately 4,400 years before rising to the spring field. High temperature of the geothermal springs is approximately 61 deg C (143 deg F) in the collection system. The park is currently capturing 26 point sources of geo-thermal water, some of those are two or three springs.

Observations: The thermal waters of Hot Springs National Park are valued as a unique and healthy water source for local and commercial consumption. This is a closed system and therefore all of it is within the park. All the springs emanate from a small geographic area (relatively small watershed) about 12-15 sq miles. It is the result of a unique combination of stratigraphic and structural trapping. Deformed layers are curvilinear and the aquifers are wavy at depth with thrust faults that transect them. The escape route to the surface is real specific and unique in this region. Recharge surface is higher than were springs come out (200-300 ft). USGS is looking at total flow but not at individual springs. USGS work: recording temperature at some springs, base flow water quantity storm flow water quality, and samples of isotopes for dating water.

Assumptions:

Predictions:

Monitoring Objective: To monitor flow volumes in each of the springs and overall.

Monitoring Questions:

- How is the flow of each spring changing?
- Are there shifts in spring recharge amounts (spatial and/or temporal)?
- Is the water quantity/quality of spring discharge changing?

Ozark NSR

Resources at Risk: Over 300 springs are known from the park, including one of the America's largest, Big Spring. Four of the top-ten largest springs of Missouri are found within the park.

Observations: Using dye-tracing methods, water has been shown to travel underground in this karst terrain as quickly as 3 miles per day. The recharge zones for these springs extend underground as far as 40 miles, and often cross surface watershed divides. Spring recharge zones are individually subject to a suite of lithology, discrete and diffuse discharge patterns, and contamination sources. Alteration of spring flow can results from climatic changes, water withdrawals, or groundwatershed divides caused by complex conduit pathways. Spring monitoring in the park has focused almost exclusively on flow measurements. Available datasets: Automated weather - 2000-present; NWS Weather at Van Buren, Eminence, and Doniphan- 1874-1988; USGS Gauging station data - Big Spring 1922-present, Alley Spring 1929-39 and 1966-79, Round Spring 1929-39 and 1966-79;

Assumptions: Stressors from surface activities affect underground water quality similarly to that of surface streams, yet lack of attenuation of contaminants underground can result in more severe results. Characteristics of the spring recharge zones, including high quantities of flow, connections to surface input, complexity of conduit systems, and lack of filtering underground, makes prediction and preservation of springs a difficult endeavor.

Predictions:

Monitoring Objectives: Assess whether preservation of springs is occurring regarding flow quantity. Refine spatial and temporal delineation of recharge zones of the major park springs. Understanding the genesis and structure of spring conduits and recharge zones to better protect spring water quality.

Monitoring Questions:

- Is the water quantity of spring discharge changing through time?
- What is the relation between stream flow and the karst drainage system? (RESEARCH QUESTION)
- What is the genesis of the spring conduit systems and how does this relate to bedrock geology? (RESEARCH QUESTION)

2.4.3.1.3 Physical: Prairie Stream Flow

Herbert Hoover NHS

(This ecological effect ties in with the Land Use Change theme)

Resources at Risk: Hoover Creek and its associated aquatic community; cultural resources on site, including historic buildings and Library Museum; relationship with city, as flood water from the NHS contributes to downtown flooding; soils, as erosion transports soils; Water quality, as runoff contributes suspended solids and chemicals to the water.

Observations: Water quantity can pose a significant threat to natural and cultural resources on site. A USGS gauging station for flow, rainfall, temperature (water and air) was installed in 1999 and rated in 2001. Therefore, the site has 1 year of data thus far. Gage information is available on USGS website with historic data available from Iowa District, USGS-WRD, Iowa City, IA. Bob Einhellig's report from 1993 flood shows the extent of inundation. Hoover Creek functions as the principle drainage way for an area of the city where land use changes may result in added surface water runoff. It also functions as a drainage way for the hard surfaces in the park. Park staff has noted that the stream is migrating towards the Herbert Hoover Presidential Library-Museum building. Historic structures and many cultural resources are in the 30 – 50 year recurrence flood area. Park buildings are in the floodplain and are vulnerable to flood danger; there has been water in 1st floor of maintenance building many times. The main stem west branch of Wapsinonoc Creek backs up as well, so this is a community problem when town goes under water. Storm downpours of short duration in June of 1967, 5.5 – 8 inches of rain, resulted in a storm surge of 1500 cfs in Hoover Creek. Flows of 1650 cfs during flooding in 1993 exceeded bank full flow, estimated at 650 cfs (Einhellig, 1994), High flows cause flooding of visitor service areas and the historic core. New analysis of 1967 and 1993 data suggests that the 1967 flood was a 20-year recurrence event and the 1993 flood was a 30-year recurrence event. The floods came within inches of floor level in several historic structures. Soil cores, positions of tile outflows, and other observations indicate that the stream continues to entrench at a rate of about one foot per decade.

Assumptions: Surface water runoff presents the greatest potential for flooding the values on site. In 1874, the creek was a small channel on the surface of the land. Land use changes altered the hydrology of the region from a ground water based system to surface water runoff. Surface runoff incises a deep channel and contributes to high sediment loads in the creek. The park must consider major flood abatement or mitigation projects if the trend toward flashy flow continues.

Predictions: Flooding will remain constant or continue to increase as agricultural fields transform to more urbanized uses due to on-going development in the watershed.

Monitoring Objectives: To track maximum flow volume and upstream urbanization and agricultural practices. To monitor functional characteristics of the stream and its riparian area. To find the correlation between precipitation and stream discharge.

Monitoring Questions:

- What is the correlation between rainfall and stream discharge?
- How is park development affecting overland flow?

Pipestone NM

Resources at Risk: Pipestone Creek, Monument facilities, *Notropis topeka*

Observations: Pipestone Creek was channelized in the early 1900's for 13 miles upstream of PIPE. There are an unknown number of tile lines feeding into the creek upstream. As well as the loss of wetlands upstream, the storm runoff from the city of Pipestone occurs in the creek during spring run off and rain events. Pollutants enter the watershed through these avenues. Development is occurring along Pipestone Creek and the south and east boundaries of PIPE.

Assumptions: The creek will remain channelized upstream of PIPE. Development will increase the amount of runoff and flow of Pipestone Creek.
Predictions: Improvements to the watershed upstream of PIPE may decrease the amount of sedimentation and pollutants entering the watershed.
Monitoring Objectives: Monitor flow of Pipestone Creek.
Monitoring Questions:

- How is the flow of Pipestone Creek changing over time?
- Is there a relationship between increased development and flow of Pipestone Creek?
- Do improvements to agricultural stream corridors upstream alter flow and water quality of Pipestone Creek?

2.4.3.1.4 Biological: River Communities and Species

Buffalo NR

Resources at Risk: At least 60 species of native fish, ten found only in the Ozarks region including the Ozark shiner; an even greater number of aquatic macroinvertebrates species; and 23 species of native mussels
Observations: There has been an increase in migration barriers. The Buffalo River is one of the few remaining large undammed river systems in the U.S. It is a State designated "blue-ribbon" smallmouth bass sport fishery, with numerous other sport fishes present as well. It is also considered by the Fish and Wildlife Service to provide a refuge for declining species such as the Ozark shiner and native mussels.
Assumptions: Aquatic communities have been evolving in the Buffalo River for eons and have adapted to the specific chemical, physical, and biological properties naturally present in their environment.
Predictions: Disturbances caused by man's activities will disrupt the natural balance of individual organisms or entire communities in complex ways.
Monitoring Objectives: To track the status and trends of major biological communities (fish, mussels, and macroinvertebrates) within the Buffalo River and major tributaries so that managers can make informed decisions regarding the overall health of the aquatic ecosystem.
Monitoring Questions:

- What are the status and trends of fish community structures?
- What are the status and trends of mussel community structures?
- What are the status and trends of macroinvertebrate community structures?
- What are the status and trends of distribution of habitat types?

Ozark NSR

Resources at Risk: The Ozark Plateau contains the only "relatively intact" temperate headwater streams left in the North American continent (Abell *et al.* 2000). The region is nationally known for its highly distinctive aquatic fauna, especially crayfish (surface and hypogean) and herpetofauna. OZAR protects 2 high-quality examples of these streams systems, the Current River and its major tributary, the Jacks Fork.

These rivers constitute 2 of the 3 rivers designated as Missouri (MO) Outstanding National Resource Waters (ONRWs). The Current River Basin contains 112 of the 270 fish species known to occur in the entire Mississippi River, including six endemics and one subspecies found only in the Current River. The basin also supports 219 benthic invertebrate taxa (Duchrow 1977). Amphibian and reptiles total 73 species, including 13 turtles, 13 salamanders, 13 frogs, and 27 snakes. Candidate for federally endangered: *Cryptobranchus alleganiensis bishopi* (Ozark hellbender). MO species of concern: *Cambarus hubrichti* (Salem cave crayfish), *Allocapnia pygmaea* (winter stonefly), *Ophiogomphus westfalli* (Westfall's snaketail), *Notropis ozarcanus* (Ozark shiner), *Typhlichthys subterraneus* (Southern cavefish), *Cycleptus elongatus* (Blue sucker), *Noturus flavater* (checkered madtom), *Lampetra appendix* (American brook lamprey), *Polydon spathula* (paddlefish), *Alasmidonta marginata* (elktoe), *Ptychobranchus occidentalis* (Ouchita kidneyshell), *Ligumia recta* (black sandshell), and *Lampsilis reeviana* (Arkansas brokenray)

Observations: Park legislation permits harvest activities of fish, mussels, and turtles. Fish stocking of non-natives began prior to park establishment and has continued. Surface and subterranean aquatic biota have been the subject of many inventory/research activities. A full inventory of the aquatic biota within the park has not been completed. Population studies have been conducted on a number of game fish species, but non-game species information is lacking. Invertebrate communities within the park need more comprehensive assessment. Information on Hypogean and hyporheic fauna is particularly lacking. Understanding the variability of aquatic biota communities within an Ozark stream remains to be done. Monitoring has focused on water quality conditions and macroinvertebrates (NPS), stream gauging (USGS/NPS/MODNR), and game fish species (MDC). Macroinvertebrate monitoring data in 21 tributary streams, 1983, 1986, 1989, 1992; Macroinvertebrate collections on Jacks Fork from Global Climate Change Research Program; Chironomids of large springs 1991-present; Fish inventory - 1980's; Small mouth bass YOY - 1985-present;

Assumptions: Aquatic resource conditions in the park are an integrated product of both upstream surface watershed inputs and, due to the karst setting, highly significant subsurface inputs. Aquatic biotic communities integrate and reflect these inputs in their composition and structure, and can imply watershed health through selected indicators. The alteration of energy sources changes the organic matter size distribution and macrophyte distribution.

Predictions: Though river biota have evolved in "dynamic equilibrium" conditions, changing conditions from stressors should start to affect the population dynamics of conservative species first, and then alter community composition through changes in relative abundance and potential addition/increased competition of non-native species due to niche creation.

Monitoring Objectives: To quantify and link impacts of watershed activities and park visitor activities on aquatic habitat and biota.

Monitoring Questions:

- Are there trends in the composition, structure, and function of aquatic biological communities?
- Are conservative species declining?

- Are river biota accumulating metals?
- Are individuals and populations of metal-sensitive river biota being affected by metal exposure?
- Are harvest activities impacting native populations?
- Are aquatic exotic species populations increasing?
- Are there changes in spatial/temporal extent of algal beds?
- Are there changes in aquatic herbivore populations?
- Are there changes in plant populations due to eutrophication?
- Are there changes in primary productivity and community respiration?
- Are changes in flooding regime changing the structure of floodplain plant communities?
- Are spring conduit and spring branch species changing in composition or abundance?
- Are spring conduit and spring branch communities changing in composition or abundance?
- Is the abundance of algae, measured by chlorophyll a in the Current and Jacks Fork Rivers increasing or decreasing (and by how much) over time scales of years to decades?
- Is the composition of the algal community changing over time scales of years to decades?
- Related research questions: Clarify how the living system naturally functions. Identify the main processes or factors that allow a stream to be in good condition and how might they be disrupted by human activities.

2.4.3.1.5 Biological: Prairie Stream Communities ad Species

Pipestone NM

Resources at Risk: Federally endangered *Notropis topeka* (Topeka Shiner), stream biota.

Observations: Thirteen miles upstream from the Monument Pipestone Creek has been channelized to drain agricultural lands and decrease flooding in the city of Pipestone. Below the Monument falls Pipestone Creek takes on more natural stream characteristics such as pools, riffles, and side channels from braiding. These characteristics provide reproductive sites for the *Notropis topeka*. A fish survey in the 1980's identified 25 fish species. A number of these fish species are predators of the Topeka shiner and have been introduced to the ecosystem. Other competitors of the shiner have been introduced through bait fishing. The health of the stream have been altered by the introduction of pollutants and sedimentation from upstream agricultural practices and the altering of native wetland vegetation to non-native reed canary grass. In 2002 water quality was conducted in addition to annual macroinvertebrate sampling.

Assumptions: Increases in pollutants and sedimentation, changes in stream health through the loss of native wetland vegetation, presence of predators, and altered stream flow impact the success of the *Notropis topeka*. Introduced predators will continue to be present although fish stocking will cease.

Predictions: As state implemented programs to improve Pipestone Creek upstream are established sedimentation and pollutants will decrease. Management to control reed canary grass and restore native vegetation will provide a natural community with in the Monument.

Monitoring Objectives: To monitor population of the federally endangered *Notropis topeka* (Topeka Shiner). To monitor stream characteristics and *Notropis topeka* habitat.

Monitoring Questions:

- Is the *Notropis topeka* population stable over time?
- How is the quantity of *Notropis topeka* habitat changing through time?
- How is the quality of the *Notropis topeka* habitat changing through time?

Tallgrass Prairie NP

Resources at Risk: Federally endangered *Notropis topeka* (Topeka Shiner) and state listed *Luxilus cardinalis* (cardinal shiner).

Observations: A rich flora is associated with the margins of prairie springs, seeps and streams. Over time the preserve hopes to reduce stocking rates and add more restricted livestock access to springs and seeps in sensitive areas. First and second order prairie streams within TAPR support at least 25 species of fish, including the federally listed *Notropis topeka* and state listed *Luxilus cardinalis*. Burning of agricultural fields in this region is a common technique to remove dead vegetation and promote vegetation regrowth. Post-burn effects include a potential of increasing erosion, altering aquatic species composition, structure, and abundance, and may lead to long-term detriment to ecosystems.

Assumptions: As of 2002, livestock have unrestricted access to springs and most streams. Once access is more restricted, sensitive aquatic resources and their associated habitats may recover from soil compaction, stream bank erosion and resulting sedimentation/nutrient enrichment. The diversity of native plants associated with springs, seeps and streams may increase.

Predictions: Changes in cattle grazing practices will result in changes in plant diversity and habitat in the riparian areas.

Monitoring Objectives: To monitor population of the federally endangered *Notropis topeka*. To monitor native plant diversity associated with springs and seeps increasing. To monitor the assemblage of native fish in springs and seeps.

Monitoring Questions:

- Is the *Notropis topeka* population stable over time?
- Is the *Luxilus cardinalis* population stable over time?
- Is the native plant diversity associated with springs and seeps increasing over time?
- What is the annual stocking rate in each area of the preserve?
- What is the species composition of the fish in the springs and seeps? Is the diversity changing over time?

2.4.3.1.6 Biological: Prairie Stream Riparian Area Communities and Species

Herbert Hoover NHS

(This environmental concern ties in with the Land Use Change theme)

Resources at Risk: Stream and riparian community; cultural resources affected by erosion and flooding; soils and water quality.

Observations: Currently, no riparian buffer exists on most of the park section of stream, although private landowners maintain buffers. Local interpretation of an aesthetically pleasing landscape pressures the park to maintain extensive, mowed lawns up to and even within the stream banks, contributing to the instability of the banks. Currently, reed canary grass, shrubs, and other invasive species dominate areas of the waterways and stream. Managers recognize that the riparian area of the stream may have potential as an important, under developed habitat. It may serve as a wildlife corridor through town, since riparian buffer exists both upstream and down stream of the park. The riparian area may provide wildlife access to the prairie and is the principle source of water for wildlife on the prairie. It also may provide a rich ecotone between prairie, stream, and cultural portions of the park.

Assumptions: Most streams in the Southern Iowa Drift Plain have potential for listing as 303d impaired streams. The stream is currently in poor condition with a non-functioning riparian area. It provides marginal habitat. Maintaining the status quo is detrimental to all values on site. Riparian rehabilitation will improve water quality, control erosion, improve habitat, and provide an aesthetically appealing feature that will complement the NHS. Successful rehabilitation of the riparian will mitigate flooding. Park maintenance of the stream corridor has often been incompatible with stream and riparian stability and health. Land use in the park (encroachment/development on the riparian zone) and the directing of runoff from hardened surfaces threaten the stream. Development outside the park, on the west side of town, poses the threat of increased hard surface that will contribute to flooding and scouring. Riparian restoration is believed to be a good management technique to slow the rates of entrenchment, erosion, and flood recurrence. The stream channel is also an avenue for invasive species intrusion into the park. Many of the invasives appear to densely populate the stream corridor. A well-established native riparian will compete with exotic intruders.

Predictions: Riparian buffers are one of the best management practices promoted by NRCS and the State for improving water quality and reducing sediment load and runoff. Functional riparian buffers also contribute to flood abatement and erosion prevention by reducing the energy of flow and retaining potential floodwater. The reach of creek within the park does not have a functional riparian area.

*Monitoring Objective*s: To determine accretion/erosion rates in the stream bed and floodplain. To assess the restoration/rehabilitation of a functional riparian condition and improved stability in the geomorphology. To ensure the corridor does not contribute to exotic plant invasions. To assess wildlife habitat and a wildlife corridor quality.

Monitoring Questions:

- What is the dominance and diversity of plants in the riparian area?
- Is the stream a gateway for intrusion by exotic and invasive species?
- What is the total cover by deep rooted native species relative to exposed soil area to determine bank stability and functional geomorphology?
- What is the rate of stream bed accretion, erosion, or meandering within various sections?

2.4.3.1.7 Biological: Wetland Ecosystems Communities and Species

Cuyahoga Valley NP

Resources at Risk: There are 1,217 wetlands totaling 1,669 acres within the park. Thirty-five wetlands are greater than 10 acres in size; 190 are greater than one acre. Other resources: wetland plants, amphibians (frogs and salamanders), turtles, dragonflies, and a federally listed endangered species habitat: *Myotis sodalis* (Indiana bat).

Observations: A Wetlands Inventory and Restoration Assessment, in 2001, identified and mapped all wetlands within the park boundary. Information collected in the larger wetlands includes size, dominant vegetation, source of hydrology, soil types, presence and estimated amount of invasive species, unique features (e.g. endangered bat habitat, vernal pools, rare species), Cowardin classification, accessibility, ownership, human impacts/disturbance, and restoration and enhancement potential. No monitoring of park wetlands currently exists. Invasive plant species were noted for all wetlands. Inventories identified 86 out of 1,214 wetlands were infested with invasive plant species; 43 were either partially or wholly dominated by invasive plants. The 86 wetlands, including all of the largest riparian wetlands in the park, total 1,088 acres of wetlands with invasive plants covering a total of approximately twelve acres.

Assumptions: Surrounding urban and suburban development has impacted the water quality of the Cuyahoga River and its tributaries and may affect park wetlands as well. Potential endangered Indiana bat habitat (roost trees) may be affected by development.

Predictions: Proposed land use changes to convert up to 1,300 acres of parkland to a rural farming landscape are currently being assessed. Park staff is concerned about potential impacts to park wetlands resulting from changes in landscape and land use practices both within the park as well as adjacent to park boundaries.

Monitoring Objectives: To monitor the effects of changes in landscape and land use practices (i.e. agriculture, urbanization) on wetland components to detect early warning indications of ecosystem deterioration.

Monitoring Questions:

- What is net gain/loss in functioning wetlands (plant community structure)?
- What are the changes in wetland fauna populations or community structure?
- Are there trends in stream biological communities?
- What are the changes in exotic wetland plant populations or community structure?
- What are the trends in abundance and distribution of exotic species populations? Are there concomitant declines in native species populations?
- What are trends in contaminant levels in sediment?
- What are the levels of nutrients and sediments?

- Are levels of other contaminants increasing?
- Are there trends in stream morphology?
- What is net gain/loss in functioning wetlands (hydrology)?

2.4.3.2 Parks' Aquatic Ecological Concerns at a Stressor Level

The following information discusses stresses impacting Heartland Network parks' aquatic ecosystems. Where available, information on historic impacts that have shaped the current status is also included. The stresses are presented alphabetically rather than in any order of importance because the importance varies from park to park.

2.4.3.2.1 Physical: Motor boats and canoes

Boating, tubing and canoeing place an outside stress on aquatic environments. Motor boats leave residual pollutants in the stream and churn up the substrate with their rapid movement. Particularly during low water times the use of canoes can also result in disruption of the river or stream channel bottom and sides as the canoe bottom scrapes the channel bottom or as the canoeists disembark and walk through the stream pulling the canoe.

Ozark NSR

Resources at Risk: Current and Jack's Fork Rivers, river biota

Observations: The park has high visitor use levels, with an increase in outboard motor size. To protect novice canoers, OZAR has cut out some in-stream trees resulting in loss of woody habitat.

Assumptions: Though a River Use Management Plan was prepared in the 1980's, more recent changes in watercraft types and use have negatively impacted the quality of experience sought. Tubing activity has had tremendous influence on use levels in the middle and lower Current. Jet motors allow even novice boaters access to a wider swath of the river surface and aquatic habitats.

Predictions: Carrying capacity will be reached and user conflicts will increase. Large motors will continue to increase in horsepower on the Lower Current

Monitoring Objectives: Quantify levels of impact to the physical and biotic components of the aquatic communities from numbers and types of watercraft use. Quantify visitor experience expectations.

- Monitoring Questions:
- Are riverbanks experiencing increased wave action from boats on the Lower Current River?
- Are levels of leaking boat fuel increasing?
- Is the amount of aquatic habitat subject to influences from watercraft increasing?

2.4.3.2.2 Physical: Precipitation

Within a watershed, high levels of precipitation events can cause increased routing along tributaries and changes flood timing and character leading to scoured river beds and changes in channel morphology.

Ozark NSR

Resources at Risk:

Observations: Stationary rain cells can cause precipitation events of 1 " or more per hour within the watershed, and routing along tributaries gives variety to flood timing and character. Flood events occur annually, with an historic maximum rise of 26 ft near Van Buren.

Assumptions: Rain cell activity is highly varied within the park and watershed. Large rain amounts can flush underground contaminants through karst conduit which emerge within the park, or create sediment input from runoff patterns.

Predictions: Modeling cell locations , in combination with hazardous land use practices, and spring recharge areas can be used to develop a priority protection and/or management strategy for the park.

Monitoring Objectives: Track cell patterns through time to develop vulnerability analysis.

Monitoring Questions:

- What are the trends in precipitation cell patterns and precipitation amounts across the Current River watershed and recharge zones?

2.4.3.2.3 Physical: Temperature

Hot Springs NP

(This environmental concern ties in with the Land Use Change theme)

Resources at Risk: Geo-thermal springs. High temperature of the geothermal springs is approximately 61 deg C (143 deg F) in the collection system. Although some individual springs range up to 71 deg C. The park is currently capturing 26 point sources of geo-thermal water, some of those are two or three springs.

Observations: The thermal waters of Hot Springs National Park are valued as a unique and healthy water source for local and commercial consumption. During dry times there is no temperature variation. During intense rain storms more temperature variation occurs. This is a closed system and therefore all of it is within the park. All the springs emanate from a small geographic area (relatively small watershed) about 12-15 sq miles. The escape route to the surface is real specific and unique in this region. USGS is looking at total flow but not at individual springs. USGS work: recording temperature at some springs, base flow water quantity storm flow water quality, and samples of isotopes for dating water.

Assumptions: The very recent mixing of the shallow, near surface, short flow path water with the geo-thermal water is part of the reason there are temperature changes in the geo-thermals.

Predictions: Temperatures over 130 deg F preclude the need to chemically treat the water for human consumption and use. If the thermal water temperature drops below 130 deg F the park will either have to chemically treat the water or stop supplying it to the local hotels, etc.

Monitoring Objective: To determine which spring/spring-box varying temperatures are coming from (there is no impervious layer for water not to get into spring boxes). Monitor temperature trends. Monitor any cold water getting into the geo-thermal springs.

Monitoring Questions:

- How is the temperature of each spring changing?

2.4.3.2.4 Physical: Tiling

Tiling and channeling increases overland flow and steam velocity, which often results in heightened flood peaks.

Herbert Hoover NHS

Resources at Risk:

Observations: Tiling is a common practice at HEHO to drain the wetlands. Tiling started as early as 1890, although there was a big push in the 1920s. The original tiles were hand dug so there was another push in the 1940s when the processes became mechanized. Tiles at HEHO date from 1920s and 1940s, judging by the materials used. The greatest amount of tiling at HEHO was driven by The Soil and Water Conservation Districts cost sharing policies in the late 1960s to 1979. These tiles were installed as a one chain grid system in some cases. Many of these original tiles still remain at HEHO and upstream. In addition, storm drains release flow directly into the creek.

Assumptions: Tiles and storm drains are a significant source of water to the creek. Water volume in the confines of the creek channel correlate to the energy of flow and resulting erosion rates. Suspended solids help transport pollutants. The energy of flow contributes to entrenchment and lateral migration of the creek. Direct input of storm water results in flooding.

Predictions: Without a reduction in storm surge, the creek will continue to erode, entrench, and carry pollutants and suspended solids.

Monitoring Objectives: To guide managers in making the environmentally preferred decision with respect to storm water management.

Monitoring Questions:

- How do management decisions affect water quality in the creek.

2.4.3.2.5 Physical: Sedimentation

Buffalo NR

Resources at Risk: aquatic communities

Observations: Changes in run-off and sediment supply are important because they can be long lasting and sometimes have irreversible effects on aquatic communities. The natural flows (especially high flows) transport sediment and do the work required to maintain such important physical habitat attributes.

Assumptions: Physical processes and resultant habitats define the template upon which biological communities evolve and are maintained. Increased sediment yield is an important consideration for main-stem channels within the parks because it may lead to habitat degradation by changing channel morphology, bed material composition, and the frequency and magnitude of erosion and deposition events, thus altering biotic communities (Panfill and Jacobson, 2001). Aggradation and infilling of pools decreases the area of slow velocity, deep-water habitat available within a channel. Higher sediment yields may lead to changes in the size distribution of sediment on the streambed. Increased sediment yield may lead to channel instability—increased rates of bar and bank migration, destruction of riparian habitat, larger areas of exposed gravel bars, and other responses (which can influence aquatic communities). In-stream activities, deforestation, and increased road densities can add additional fine sediment into streams and degrade spawning grounds and habitat quality. Increased turbidity and suspended sediment can degrade the aesthetic appeal of the river, fish productivity, and habitat.

Predictions:

Monitoring Objectives: Within the Buffalo River and 20 major tributaries, to track the status and trends of major physical habitat indicators, including sediment size and composition.

Monitoring Questions:

- What are the status and trends of sediment size in the Buffalo River?
- What are the status and trends of sediment composition in the Buffalo River?
- What are the status and trends of sediment size in 20 major tributaries in which there is routine water quality monitoring.
- What are the status and trends of sediment composition in 20 major tributaries in which there is routine water quality monitoring.

Herbert Hoover NHS

(This environmental concern ties in with the Land Use Change theme)

Resources at Risk: Hoover Creek and its associated aquatic community (tributary of Wapsinonoc Creek); soils, as erosion transports soils; Water quality, as runoff contributes suspended solids and chemicals to the water.

Observations: USGS gauging station for flow, rainfall, temperature (water and air) was installed in 1999 was rated in 2001. Therefore, the site has 1 year of data thus far. Gage information is available on USGS website with historic data available from Iowa District, USGS-WRD, Iowa City, IA. Soil cores, positions of tile outflows, and other observations indicate that the stream continues to entrench at a rate of about one foot per decade.

Assumptions: Surface water runoff presents the greatest potential for flooding the values on site and decreases water quality in the stream. Surface runoff incises a deep channel and contributes to high sediment loads in the creek. These sediments are capable of ferrying chemical pollutants through the stream and impacting biological integrity in the park and further down stream.

Predictions: The park must consider flood mitigation if the trend toward flashy flow and poor water quality continues. Those flood control techniques must include methods that improve water quality.

Monitoring Objectives: To monitor functional characteristics of the stream and its riparian area. To determine contribution to sediment loading and changes in water quality.

Monitoring Questions:

- What is the level of suspended sediment load entering the park and leaving the park?
- What is the level of suspended sediment over time?

Homestead NMA

Resources at Risk: Cub Creek

Observations: Homestead saw a dramatic change with Cub Creek's stream bank last year. It prompted the staff to solicit technical assistance from the Denver Service Center for bioengineering on the stream banks. Staff has spent a considerable amount of time visiting with upstream farmers promoting USDA's Buffer Strip Program. All this work is to slow the erosion process at Homestead.

Assumptions: Sedimentation and changes in river channel are due to inadequate riparian buffering upstream of park. Land use changes that may affect increased flow are the lack of buffers on upstream fields and burning annual burning of agricultural fields.

Predictions:

Monitoring Objectives:

Monitoring Questions:

- How is inadequate riparian buffering upstream affecting sedimentation rates through time?
- Is sedimentation resulting in altered stream morphology?
- Are sedimentation rates changing?
- Is water clarity changing?

Hot Springs NP

(This environmental concern ties in with the Land Use Change theme)

Resources at Risk: Geo-thermal springs. The park is currently capturing 26 point sources of geo-thermal water, some of those are two or three springs.

Observations: The thermal waters of Hot Springs National Park are valued as a unique and healthy water source for local and commercial consumption. Wittington Springs has a problem with turbidity (function of suspended solids). Several decades ago one spring was taken out of the system (probably a cave spring) because it became problematic due to suspended solids. Recharge surface is higher than were springs come out (200-300 ft). USGS is looking at total flow but not at individual springs. USGS work: recording temperature at some springs, base flow water quantity storm flow water quality, and samples of isotopes for dating water.

Assumptions:

Predictions:

Monitoring Objective: To monitor sedimentation rates.

Monitoring Questions:

- Is sedimentation occurring in any of the springs?
- At what rate in any identified springs?

Ozark NSR

Resources at Risk: Outstanding National Resource Waters – Current and Jack's Fork Rivers. Candidate for federally endangered: *Cryptobranchus alleganiensis bishopi* (Ozark hellbender). Missouri species of concern: Cambarus hubrichti (Salem cave crayfish), Allocapnia pygmaea (winter stonefly), Ophiogomphus westfalli (Westfall's snaketail), Notropis ozarcanus (Ozark shiner), Typhlichthys subterraneous (Southern cavefish), Cycleptus elongatus (Blue sucker), Noturus flavater (checkered madtom), Lampetra appendix (American brook lamprey), Polydon spathula (paddlefish), Alasmidonta marginata (elktoe), Ptychobranchus occidentalis (Ouchita kidneyshell), Ligumia recta (black sandshell), and Lampsilis reeviana (Arkansas brokenray)

Observations: A recent significant increase in road development , ATVs, and horses is contributing to sediment input and channel bed instability. Modeling of gravel routing through the park and its tributaries is a unique dataset for the park. Available datasets: Water quality for 8 parameters at 16 park sites (pH, fecal coliform, fecal strep, alkalinity, conductivity, DO, nitrate, chlorophyll) - 1983-present; Automated weather - 2000-present; NWS Weather at Van Buren, Eminence, and Doniphan- 1874-1988; USGS Gauging station data - Big Spring 1922-present, Van Buren 1916-present, Two Rivers 1922-1975, Eminence 1922-present, Alley Spring 1929-39 and 1966-79, Round Spring 1929-39 and 1966-79; MORAP Landcover Phase I and II.

Assumptions: Stream flow carries energy, sediment, and contaminants, and carves out the physical habitats available to river biota. Stressors to the physical habitat such as gravel roads, recreation, and fords, increase fine sediment and habitat homogeneity. Changing agricultural practices, particularly grazing, are causing the movement of gravel bars in the river channels through increased erosion rates.

Predictions: Both upstream activities and park management actions have the ability to increase sediment deposition and runoff patterns to the mainstem rivers, causing an increase in habitat homogeneity within the park aquatic habitats, and subsequent decrease in biodiversity.

Monitoring Objective: Monitor turbidity and fine sediment deposition in areas associated with visitor use activities, including boating, horse use, and ford crossings. Track gravel bar routing.

Monitoring Questions:

- What is the status and trends of sediment influx, storage, and load within the Current and Jacks Fork Rivers?

2.4.3.2.6 Physical: Soil Erosion

Erosion stresses aquatic environment through the release of nutrients and sediment loading. Erosion is attributed to a number of activities and factors. Riparian vegetation removal can increase surface runoff and erosion rates. Surface mining results in the displacement of soils and the removal of vegetation. Urbanization often results in the removal and displacement of soil. Combined with decreases in surface permeability, urbanization can lead to more overland flow and increased erosion rates.

Hot Spring NP

Resources at Risk: Geothermal springs and rivers in the park

Observations: The narrow valleys surrounding HOSP have seen significant development and the toes of mountains have often been removed for the creation of new structures and parking lots. Gravel mining is found within the watershed.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.3.2.7 Physical: Structures

Structures in the aquatic environment can act as important stressors. In some cases, they may change channel morphology. Gravel roads and fords through streams can contribute to sediment influx and loss of bed armoring.

Buffalo NR

Resources at Risk:
Observations: This park has launch pads and the supporting fill material.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Ozark NSR

Resources at Risk:
Observations: Launch ramps, riverbank developed sites, gravel roads and fords within the park contribute to sediment influx and loss of bed armoring.
Assumptions: There are historically stable and unstable reaches of the Current and Jacks Fork River, that is sections of channel which shift frequently or not at all. To minimize conflicts between channel movement and park facilities, developed sites should be carefully sited in stable river reaches.
Predictions: Poor site selection of some park facilities in unstable zones will lead to conflicts in park management between facility protection vs resource preservation.
Monitoring Objectives: Assess channel change rate at developed sites in unstable reaches to support management decision making.
Monitoring Questions:

- What is the rate of change of channel migration at park developed sites along the riverbanks?
- What is the rate of head-cutting in the river bed at ford sites?

2.4.3.2.8 Physical: Surface Permeability

Agriculture, recreation, and urbanization can modify infiltration rates through the removal/alteration of vegetation and the compaction/removal of soils. Lowered surface permeability reduces infiltration and increases overland flow and erosion rates.

Buffalo NR

Resources at Risk:
Observations: Agricultural practices have lowered surface permeability. Numerous access roads have been constructed within the park boundaries.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Herbert Hoover NHS

Resources at Risk:
Observations: Changes in land use have affected surface permeability. Hard surface causes storm water to runoff 10 times faster than vegetated landscape. Agricultural and residential land also soil permeability, the result of removing tallgrass prairie and the compaction of soils through the use of heavy machinery.
Assumptions: Permeable soil retains water and supports soil genesis better than non-permeable surfaces.
Predictions: Permeability of soil will relate to amount of water retained in soils and ground water recharge. Permeability has an inverse relation to rate of runoff and consequent stream discharge.
Monitoring Objectives: To predict how land use changes will affect flooding and water quality.
Monitoring Questions:

- What is the result of land use change on water retention and flooding?

Hot Springs NP

Resources at Risk:
Observations: The increased presence of residential and commercial structures and new roads has changed surface permeability. Through land acquisition, the process of urban sprawl is also being reversed at HOSP. Houses identified as standing over sensitive aquifer recharge areas are being purchased and have or are in the process of being removed. Following removal of the homes and roads, sites are recontoured and allowed to revegetate naturally. Arkansas novaculite, a rock that is mined in Hot Springs, is frequently purchased by tourists.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Pipestone NM

Resources at Risk: Pipestone Creek, PIPE facilities, *Notropis Topeka,*
Observations: Impermeable surfaces resulting from urban encroachment is a concern.
Assumptions: Impermeable surfaces cause impacts the water quality and quantity of Pipestone Creek within PIPE's boundaries. This has altered the characteristics of the creek.
Predictions: As development occurs along Pipestone Creek and PIPE's eastern and southern boundaries runoff and pollutants from urban areas into the Creek will increase.
Monitoring Objectives: Monitor urban pollutants in Pipestone Creek. Monitor changes in flow of Pipestone Creek.
Monitoring Questions:

- Are urban pollutants increasing in Pipestone Creek overtime?
- Is the flow of Pipestone Creek changing due to urbanization along the corridor?
- Is there an increased threat to PIPE facilities due to increased runoff from urbanization?

Wilson's Creek NB

Resources at Risk:
Observations: Impermeable surfaces resulting from urban encroachment is a concern.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.3.2.9 Biological: River Habitat

Buffalo NR

Resources at Risk: Outstanding Natural Resource Waters: all of the Buffalo River and Richland Creek (major tributary, within park boundaries, of the Buffalo River)
Observations: Changes in run-off and sediment supply are important because they can be long lasting and sometimes have irreversible effects on aquatic communities. Degradation and loss of physical aquatic habitat have been cited as causes for declines in populations of many freshwater invertebrate and fish species (Jefferies and Mills, 1990). Compared to similar sized rivers in most of the U.S., the Buffalo has few dams in its watershed and retains primarily natural flow conditions. The natural flows (especially high flows) transport sediment and do the work required to maintain such important physical habitat attributes as pool depth and volume, spawning reds, riffle-pool spacing, scour pool formation, biological drift and migration, and energy transport, among others. Land use changes and stream channel alterations are affecting streams in much of the mid-west, and the Buffalo River provides a typically more protected natural environment where native communities and natural processes may be perpetuated given adequate management practices.
Assumptions: Physical processes and resultant habitats define the template upon which biological communities evolve and are maintained. Increased sediment yield is an important consideration for main-stem channels within the parks because it may lead

to habitat degradation by changing channel morphology, bed material composition, and the frequency and magnitude of erosion and deposition events, thus altering biotic communities (Panfill and Jacobson, 2001). Aggradation and infilling of pools decreases the area of slow velocity, deep-water habitat available within a channel. Higher sediment yields may lead to changes in the size distribution of sediment on the streambed. Increased sediment yield may lead to channel instability—increased rates of bar and bank migration, destruction of riparian habitat, larger areas of exposed gravel bars, and other responses (which can influence aquatic communities). Removal of riparian vegetation can increase stream temperatures and promote increased primary production. In-stream activities, deforestation, and increased road densities can add additional fine sediment into streams and degrade spawning grounds, general habitat quality, and increase turbidity. Habitat quantification is also important in assessing observed changes in biological communities. Increased turbidity and suspended sediment can degrade the aesthetic appeal of the river, fish productivity, and habitat.

Predictions:

Monitoring Objectives: Within the Buffalo River and its major tributaries, to track the status and trends of major physical habitat indicators, including bank full parameters, sediment size and composition, pool volume, distribution of habitat types, channel cross-sections, and flow.

Monitoring Questions:

- What are the status and trends of bank full parameters in the Buffalo River?
- What are the status and trends of pool volume in the Buffalo River?
- What are the status and trends of distribution of habitat types in the Buffalo River?
- What are the status and trends of channel cross-sections in the Buffalo River?
- The major ones, for example the 20 we currently monitor for routine WQ.
- What are the status and trends of bank full parameters in the major tributaries which tributaries?
- What are the status and trends of pool volume in the major tributaries which tributaries?
- What are the status and trends of distribution of habitat types in the major tributaries which tributaries?
- What are the status and trends of channel cross-sections in the major tributaries which tributaries?

Ozark NSR

Resources at Risk: Candidate for federally endangered: *Cryptobranchus alleganiensis bishopi* (Ozark hellbender). Missouri species of concern: *Cambarus hubrichti* (Salem cave crayfish), *Allocapnia pygmaea* (winter stonefly), *Ophiogomphus westfalli* (Westfall's snaketail), *Notropis ozarcanus* (Ozark shiner), *Typhlichthys subterraneous* (Southern cavefish), *Cycleptus elongatus* (Blue sucker), *Noturus flavater* (checkered madtom), *Lampetra appendix* (American brook lamprey), *Polydon spathula* (paddlefish), *Alasmidonta marginata* (elktoe), *Ptychobranchus occidentalis* (Ouchita kidneyshell), *Ligumia recta* (black sandshell), and *Lampsilis reeviana* (Arkansas brokenray)

Observations: Abiotic factors (flow, physical habitat, water quality, and energy sources) provide the template for the overall biological integrity of park river systems. Flow regimes carve and maintain physical habitat, and also carry energy sources contributing to the rivers' water quality. At OZAR, river flow, and the aquatic habitat environments it produces, receive a relatively constant flow due to the influence of large springs, as opposed to other Ozark streams. A map of channel stable and unstable zones based on historic aerial photography would greatly improve the geomorphic knowledge for park managers. Karst terrain produces impressively complex pathways of water and energy flow, where surface constituents can disappear into the ground only to emerge from springs within the park days or years later. Some water emerging from the park's largest spring is thought to be thousands of years old. Stream flow is monitored at 6 sites in the park, some since 1916 and 1922. Gaps in the gage network occur in the upper and middle Current River, and on some major springs. Physical habitat change along selected transects on the Jacks Fork has been assessed and monitored by use of cross-sections. Modeling of gravel routing through the park and its tributaries is a unique dataset for the park. Dye tracing activities have delineated spring recharge zone and shown flow direction variability depending on time of year. Available datasets: Water quality for 8 parameters at 16 park sites (pH, fecal coliform, fecal strep, alkalinity, conductivity, DO, nitrate, chlorophyll) - 1983-present; Automated weather - 2000-present; NWS Weather at Van Buren, Eminence, and Doniphan- 1874-1988; USGS Gauging station data - Big Spring 1922-present, Van Buren 1916-present, Two Rivers 1922-1975, Eminence 1922-present, Alley Spring 1929-39 and 1966-79, Round Spring 1929-39 and 1966-79; MORAP Landcover Phase I and II.

Assumptions: Stream flow is the most fundamental variable for understanding physical, chemical, and biological dynamics of rivers. Stream flow carries energy, sediment, and contaminants, and carves out the physical habitats available to river biota. Aquatic physical habitat is apparently undergoing a readjustment from past land and river uses. Stressors will affect flow regime by altering the timing, magnitude, and frequency of peak flows, and altering stream power and erosive capabilities. Stressors to the physical habitat such as gravel roads, recreation, and fords increase fine sediment and habitat homogeneity. Water quality stressors usually increase turbidity, contaminants, and nutrients, altering pH and DO. Changing agricultural practices, particularly grazing, are causing the movement of gravel bars in the river channels through increased erosion rates.

Predictions:

Monitoring Objective: Monitor turbidity and fine sediment deposition in areas associated with visitor use activities, including boating, horse use, and ford crossings. Track cattle grazing and gravel bar locations

Monitoring Questions:

- Is river morphology/channel form changing?
- Are park aquatic hydraulic habitat units (HHUs) becoming homogenized?
- Are spring conduit and spring branch habitats changing in composition or abundance?

- Potential research question: What level/type of flood is most effective at creating and maintaining these habitats?
- What aspects of "underground island biogeography" can be applied to the physical habitat and biota of spring conduit systems?

2.4.3.2.10 Biological: Wetlands Habitat

Loss of important aquatic habitats is a major concern throughout the Americas since these habitats contain an abundance of species and are a factor in water filtration. These losses have occurred either directly (draining or conversion of land for urban use) or indirectly (change in hydrology).

Cuyahoga Valley NP

Resources at Risk:

Observations: Agricultural practices and urbanization surrounding CUVA continue to threaten the remaining wetlands habitats in and around the park. Natural resources issues of concern include: 1) land use changes inside and outside the park boundary including urbanization, fragmentation, impervious surfaces and loss of habitat; 2) removal or inadequate riparian and wetland buffers in developments and the affects thereof on park resources; 3) non-point source pollution; 4) erosion and sedimentation caused by development; 5) modification or elimination of headwater streams. Future monitoring will include wetlands and primary headwater habitat streams. These issues cause a number of resource impacts, but to date CUVA has not been able to make the connection between ongoing monitoring and the overall ecosystem health of the park. Overall, the integrity of aquatic and terrestrial ecosystems within CUVA is a direct manifestation of land use in the watershed area. What is needed is more detailed and timely data for long-term ecological monitoring at CUVA

Assumptions: Surrounding land use changes, such as increased development and agriculture, increases in impervious surfaces, removal of trees and changes in hydrologic regime could be correlated to changes in amphibian and bird abundance and diversity using current land cover and land use maps.

Predictions: Impacts to aquatic resources via land use changes such as agriculture and urban/suburban development can result in habitat degradation such as channelization and removal of riparian buffers By improving our understanding of land cover and land use trends in the region, we will be better able to interpret their indirect influences on each of the resources monitored.

Monitoring Objectives: Produce land cover maps and indices of land use change to enable researchers and resource managers at CUVA to better understand the influence of land use and land cover on populations of all monitored wildlife including white-tailed deer, beaver, coyote, songbirds, owls, raptors, great blue heron, amphibians, and lepidopterans. Model and predict affects of development, park management activities, and other disturbances on the population, reproduction, distribution and diversity of aquatic and terrestrial wildlife and associated habitats. Overall goals are to develop comprehensive data sets of the land cover within the Cuyahoga River watershed

Monitoring Questions:

- What are the quantity, characteristics and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed animal population trends and habitat value?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?

2.4.3.2.11 Biological: Riparian Buffers

Riparian buffers along agricultural fields, while serving as refuge for several plant and animal species, are used to prevent runoff and erosion.

Buffalo NR

Resources at Risk:
Observations: Few of the upstream fields have adequate stream buffers.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Herbert Hoover NHS

Resources at Risk:
Observations: Most stream sections within the park do not have protective buffers. Private landowners upstream of HEHO generally have adequate buffers. Tiles from the park areas that were agricultural fields still drain directly into the creek.
Assumptions: Buffers improve water quality by filtering runoff, retaining runoff, and improving infiltration. A riparian buffer would help stabilize the creek banks by providing a root mass that would retain soil. The buffer would prevent vehicles and mowers from driving along the edge of the bank. A buffer would provide habitat and enhance a wildlife corridor.
Predictions: Local residents will resent the fact that they are encouraged to take land out of production to provide riparian buffers, while the park has none. Vehicular traffic and mowing along the creek bank will continue to fracture the fragile banks. Runoff draining through tiles, storm drains, and overland will continue to degrade the waterquality and increase stream flow after storms. A riparian buffer will encourage wildlife movement through safe habitat.
Monitoring Objectives: To assist managers in making the environmentally preferred decisions in managing the NHS.
Monitoring Questions:

- How much does a riparian buffer affect water quality?
- Does a riparian buffer improve wildlife habitat?

Pipestone NM

Resources at Risk: Pipestone Creek, biotic communities, *Notropis topeka*
Observations: Few of the upstream fields have adequate stream buffers. There is a loss of native vegetation to non-native reed canary grass along the stream banks.
Assumptions: The lack of stream buffers upstream increase pollutant and sedimentation loading into Pipestone Creek. There will be a continual loss of native vegetation due to the encroachment of non-native reed canary grass.
Predictions: Implementation of state run programs to place buffers along Pipestone Creek will help to decrease pollutant and sedimentation run off.
Monitoring Objectives: Monitor changes in riparian buffers.
Monitoring Questions:

- Are riparian buffers increasing over time?
- Does an increase of riparian buffers improve water quality?

Tallgrass Prairie NP

Resources at Risk:
Observations: Few of the upstream fields have adequate stream buffers.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.3.2.12 Biological: Recreational fishing

Fishing activities can stress aquatic systems through the trampling of the stream banks and the unintended disturbance of sensitive species.

Buffalo NR

Resources at Risk:
Observations: Fishing is a popular recreation activity.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Ozark NSR

Resources at Risk:
Observations: Park legislation permits the harvesting of fish, mussels, and turtles.
Assumptions: The biotic integrity of the Current and Jacks Fork Rivers is influenced by the levels of harvest of the various species. Harvest activities may negatively affect non-game species as well.

Predictions: More influence on aquatic communities is occurring due to harvest than is known. In particular, mussel species are distributed in sparse beds, and harvest is generally unobserved, so harvest of these invertebrates could negatively influence sustainable populations.
Monitoring Objectives: Assess whether harvest activities of fish , mussels, or turtles are causing population declines.
Monitoring Questions:

- What are the status and trends of harvested fish species within the Current and Jacks Fork Rivers?
- What are the status and trends of harvested mussel species within the Current and Jacks Fork Rivers?
- What are the status and trends of harvested turtle species within the Current and Jacks Fork Rivers?

2.4.3.2.13 Biological: Stocking of Fish

Non-native fish species can modify fish populations and the demand for food.

Buffalo NR
Resources at Risk:
Observations: Exotic species are sometimes introduced through recreational activities.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Ozark NSR

Resources at Risk:
Observations: The practice of stocking of non-native fish species, which began prior to the park's establishment, continues to this day.
Assumptions: Non-native fish can serve as predators or niche fillers of native species, resulting in alteration of the native species distribution, abundance, and vigor.
Predictions: Non-native fish will alter the community structure in coldwater reaches of the Current and Jacks Fork Rivers.
Monitoring Objectives: Quantify the influence of non-native fish species on both native fish and their communities.
Monitoring Questions:

What is the status and trend of Brown Trout and Rainbow Trout distribution and abundance in "trout waters" within the Ozark NSR?

How are these populations affecting the diversity, distribution, and abundance of native fishes?

Pipestone NM

Resources at Risk: Natural fish communities, federally endangered *Notropis topeka*.
Observations: Historic fish stocking occurred in Pipestone Creek. The most recent was in 2000 just downstream in a lake outside the Monument. Stocking is supposed to be stopped because of the presence of the *Notropis Topeka.*
Assumptions: Introduced fish compete for resources with native fish. Some introduced fish are predators of native fish.
Predictions: With out removal of introduced fish species competition will continue with native species. Some native species may be loss.
Monitoring Objectives: Monitor species composition during *Notropis Topeka monitoring.*
Monitoring Questions:

- How is the ratio of introduced fish species to native fish species changing overtime?
- *Are introduced species increasing over time*?
- *Are new species found with in the creek*?

Tallgrass Prairie NP

Resources at Risk:
Observations: Fish stocking occurs within streams.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.3.2.14 Chemical: Bacteria, Especially E. coli and Fecal Coliform

Sources of bacteria include upstream waste water treatment plants, as is the case near WICR and EFMO, cattle along riparian areas which occurs at BUFF and OZAR.

Buffalo NR

Resources at Risk: Outstanding Natural Resource Waters: all of the Buffalo River and Richland Creek (major tributary, within park boundaries, of the Buffalo River)
Observations: Although the Buffalo River has a designation as an Outstanding Natural Resource Water, portions of the river have been designated by State agencies as impaired because of non-point pollution (Arkansas Department of Pollution Control and Ecology, 1992).
Assumptions: High bacteria levels represent a public health concern and could result in swimming beach closures. Water quality is rapidly declining in rivers throughout northern Arkansas and southern Missouri as regional development increases at some of the fastest rates in the nation
Predictions: Water quality can decline as development pressures increase.
Monitoring Objectives: To track the status and trends of E coli and fecal coliform in the Buffalo River and 20 of its major tributaries.
Monitoring Questions:

- What are the seasonal & annual trends in fecal coliform levels as related to public safety and State regulations?

Effigy Mounds NM

Resources at Risk: Yellow River watershed includes several tributaries, one of which has a reproducing native trout population. The Yellow River is a popular recreational feature, including boating, swimming, and fishing. The Yellow River flows into the Mississippi at the park boundary.

Observations: Water quality is a growing issue for the park because of industries coming into the Yellow River watershed. There are two animal meat packing plants (sewage treatment) on tributaries of the Yellow River. A couple time a year one of the plants dumps raw untreated sewage directly into the tributary. The result is a pulse of organic matter, an increase in bacterial growth, decrease in oxygen supply, and fish kills in the area due to lack of oxygen in the water. There is a current proposal to add another meat packing plant on one of the tributaries of the Yellow River. The new plant is requesting a variance to permit dumping of up to six times the recommended guideline levels for fecal coliform and sodium into the tributary. (The variance to exceeds discharge levels of EPA and state.) Available datasets: Ten years of data on 12 water quality parameters for Syn Magill and Yellow River. Sny Magill data was collected weekly and Yellow River data was collected monthly. Iowa DNR did chemical analysis at State Hygenics lab. Macroinvertebrate data also available for Sny Magill. Study was conducted by the IA Geologic Survey. USGS had a remote staging station. IA DNR did the data analysis. EPA funded the project and US F&W also involved. Lots of past data on the river, printouts of water analysis.

Assumptions: River looks in pretty good shape. The fish kills that happen as a result of influx of sewage near the plants do not happen further down stream near the park. This is due to the oxygen levels. Oxygen is used up by bacteria breaking down the sewage near the plant but further down stream as there is less and less sewage there are less bacteria and the impact on oxygen decreases. The sewage inputs are like 'pulse' events that happen only a couple times each year. Animal meat-packing plant and agricultural practices are increasing bacteria loading in stream.

Predictions: Current standards for discharge used by the EPA may be based on a constantly flowing stream with lots of dilution. However, the water in the Yellow River in the area of the park has a long residence time because it is backed up there where it flows into the Mississippi River. The slow movement through this area may result in more intense impacts on the Yellow River. At the location where the Yellow River meets the Mississippi the water is more stagnant and less diluted than in a constantly flowing river. Since pollutant levels are held over longer in slow moving streams there may be there more accumulation/impact to the system in these slow moving areas

Monitoring Objectives: Monitoring water chemistry is the key. What does the historic data tell us about the 12 parameters that were measured? The park needs information on established 'thresholds' for various bacteria (e.g., fecal coliform) in order to compare samples taken from the Yellow River and its tributaries with standardized acceptable levels. Long-term objective is to continue monitoring. Short-term objective is to do high power analysis to determine results from the existing data. Find out pollution guidelines. Find out thresholds for the 12 water quality parameters that were measured. Possibly develop a long-term relationship with USGS. USGS does 50/50 cost share. (Linking the following stressors to the effects in the park will require additional monitoring of the stressors themselves – essentially a landscape scale of monitoring. Collect any available data upstream and downstream from the treatment plants within the Yellow River watershed. The plants may have to sample for compliance information or the state may do regulatory sampling. How is packing plant effluent affecting fecal coliform and sodium chloride levels through time? How are agri-chemical inputs affecting nutrient levels through time? How is inadequate riparian buffering upstream affecting abiotic water integrity through time?)

*Monitoring Question*s:

- What is the level of fecal coliform in the Yellow River within the park boundaries?
- Is the level of fecal coliform increasing or decreasing over time? At what rate is the change occurring?
- How does the level of fecal coliform in the Yellow River within the park boundaries compare with EPA and state standards/guidelines/thresholds?

Herbert Hoover NHS

Resources at Risk: Hoover Creek and its associated aquatic community (tributary of Wapsinonoc Creek). Water quality, as runoff contributes suspended solids and chemicals to the water.

Observations: Water quality has become an issue in many local streams as surveys indicate that many qualify as 303d streams. Managers know that nitrate and *E. coli* levels exceed levels allowable for close human contact (swimming and drinking). *E. coli* concentrations have been examined where the stream enters the park and where it leaves. The concentration appears to be lower as the stream leaves the park. Mechanisms for this reduction in *E. coli* concentration should be explored. Turbidity is very high after storms. Datasets available: Datasets: Informal water monitoring using LaMotte water chemistry kits and one coliform test result.

Assumptions: Iowa currently has 157 streams listed as impaired. Experts expect that this number will increase to 2000 once small streams are surveyed for water quality, under the Clean Water Act. Hoover Creek is not listed as a 303D stream because the state has not tested it, but its levels of pollution exceed the standards that determine listing. Farmers upstream have riparian buffers and there are no feedlots in the watershed. Therefore, the high *E. coli* (2000 colonies) and Nitrate-Nitrogen levels are more likely from septic systems. The USGS can test for septic issues. High turbidity indicates soil erosion upstream or in the park.

Predictions: Changes in the riparian area geomorphology and vegetative cover will affect sediment loads in the creek. The longer creek water resides on the NHS, the higher the quality of the water that leaves the site.

Monitoring Objectives: To determine if source of pollutants is in park or above the park. To determine if management techniques affect water quality. To determine if prescribed fire affects water quality.

Monitoring Questions:

- What is the level of *E. coli* coming into the park and exiting the park?
- Is that level of *E coli* increasing or decreasing over the length of the stream (with a time factor)? At what rate is it changing?
- Does the park contribute to sediment load of the creek, or any other pollution levels?
- Can stream management affect water quality?

Ozark NSR

Resources at Risk Status as an Outstanding National Resource Water. Visitor health

Observations: A five-mile reach of the Jacks' Fork is on the 303(d) list of impaired waters due to consistent violations of state standards for fecal coliform. Point source possibilities include a large cross-country horse trail ride, leaking septic tanks, and resuspension of bottom sediments Surface water quality monitoring by the NPS began in earnest in 1983 and has continued to present. A recent trend analysis of basic physiochemical and biological parameters shows continued good surface water quality, with the primary exception of fecal coliform bacteria levels.. Available datasets for: Water quality for 8 parameters at 16 park sites (pH, fecal coliform, fecal strep, alkalinity, conductivity, DO, nitrate, chlorophyll) from 1983 to present; USGS Bacteriological Study database for Jacks Fork. Water quality within the park has received the most consistent resource monitoring, but a recent review of the data trends highlight gaps in parameters selected, as well as the temporal and spatial monitoring framework, particularly during winter and flood conditions.

Assumptions: The smaller river sections within the park have reached a carrying capacity for fecal coliform sources. Fecal coliform contamination is coming from both surface point sources near the rivers, and from higher in the watershed through the spring systems. Karst systems competently transport pollutants and contaminants unchanged through underground pathways to emerge in surface waters. Recent monitoring of pathogens on the Jacks Fork has pointed to Alley Spring as a point-source input for fecal coliform.

Predictions: Without effective regulation fecal coliform levels will continue to be out of compliance.

Monitoring Objectives: Monitor status of bacteria in surface water and bed sediments.

Monitoring Questions:

- What is the status and trend of fecal coliform levels in surface and bed sediments at selected sites within the Current and Jacks Fork Rivers at a representative suite of flow levels through time?

Pipestone NM

Resources at Risk: Pipestone Creek, human health, wildlife, and river biota

Observations: Pipestone Creek is listed through the Clean Water Act as a 303d impaired water body. Pipestone Creek was channelized for 13 miles upstream of PIPE. Agricultural activities including feedlots and animal confinements occur through out the channelized portion of the creek. Uncontrolled runoff from the city of Pipestone occur as well. Water quality testing conducted in 2002 for fecal coliforms have shown levels above the EPA recommended levels. Annual monitoring for macroinvertebrates as indicators for water quality has occurred since 1997.

Assumptions: More animal confinements placed along the channelized portion of the creek will result in increased fecal coliform.

Predictions: State implemented actions to reduce runoff from agricultural fields should improve fecal coliform levels introduced through fertilizer from animal waste.

Monitoring Objectives: Monitor levels of fecal coliform. To monitor macroinvertebrates (as an indicator of water quality) in order to tie impacts of pollutants to stream biota.

Monitoring Questions:

- Is Pipestone Creek meeting the Minnesota State water quality parameters?
- Can Pipestone Creek be removed from the 303d impaired waters list?
- Are fecal coliform levels increasing in Pipestone Creek?
- Is the composition of macroinvertebrates changing?
- How are levels of pollutants changing over time?

Wilson's Creek NB

Resources at Risk: Wilson's Creek and Shuyler Creek, human health, wildlife and river biota

Observations: Wilson's Creek is listed through the Clean Water Act as a 303d impaired water body. The Springfield Sewage Treatment Facility is upstream of the park. On average, 70-80 percent of the water in Wilson's Creek is treated effluent. The treatment facility occasionally spills raw sewage into Wilson's Creek. Increasing residential development is happening adjacent to or nearing the park boundaries.

Assumptions: Increased residential development is responsible for higher levels of fecal Coliform/*E. coli* in Wilson's Creek.

Predictions:

Monitoring Objectives:

Monitoring Questions:

- Is Wilson's Creek meeting the established Missouri State water quality parameters (especially in relation to the wastewater treatment plant)?
- Is Shuyler Creek meeting the established Missouri State water quality parameters (especially in relation to the wastewater treatment plant)?
- Are *E. coli* and fecal coliform levels increasing in Wilson's Creek?
- Are *E. coli* and fecal coliform levels increasing in Shuyler Creek?
- How are levels of pollution (nutrients and pathogens) changing through time?

2.4.3.2.15 Chemical: Nutrients, Especially Nitrogen, Sodium chloride, and Atrozene

Chemical inputs into aquatic systems come from sources such as agricultural runoff, livestock, waste water treatment plants, and so on. Agricultural runoff is particularly common following rainfall events. Cattle along waterways are sources of nutrient input, bacteria, and soil disruption.

Buffalo NR

Resources at Risk: Outstanding Natural Resource Waters: all of the Buffalo River and Richland Creek (major tributary, within park boundaries, of the Buffalo River)

Observations: Principal concerns at this time include the effect on aquatic ecosystems of increasing nutrients, originating from non-point sources as a result of external land use. Agricultural development and forest clearing has increased non-point source pollution, which represents the most significant long-term threat. Studies that focused on the dynamics between nutrients and biotic communities in Ozark streams suggest that nutrient concentrations are not directly toxic to individual organisms. USGS-NAWQA studies in the Ozarks found the increased nutrient concentrations and less shaded conditions at agricultural reaches probably result in increased periphyton production, and therefore, a more abundant food source for herbivores (Petersen, 1998). Ongoing analysis of periphyton, water-quality, and habitat data indicate increases in periphyton biovolume and shifts in taxonomic composition at agricultural reaches compared to forest reaches. In other regional investigations, environmental factors such as substrate size, embeddedness, canopy angle, drainage area, gradient, and basic water chemistry also affected community composition at a given site. However, increased nutrient concentration exhibited the most consistent change in biologic communities in both site comparison and before and after studies (Smart et. al., 1985; Stewart, 1987; Arkansas Department of Pollution Control and Ecology, 1995). Water-quality monitoring has shown a correlation between agricultural non-point source chemical pollution (nitrates, for example) and stream water-quality (Mott, 1997; U.S. Department of Agriculture, 1995). Portions of the Buffalo River have been designated by State agencies as impaired because of non-point pollution (Arkansas Department of Pollution Control and Ecology, 1992).

Assumptions: A combination of agricultural practices, urbanization and recreation are increasing nutrient loadings within the Buffalo Watershed. Agricultural development and forest clearing has increased non-point source pollution, which represents the most significant long-term threat.

Predictions: Water quality, as defined by nutrient levels in the water, can decline as development pressures increase.

Monitoring Objectives: To track the status and trends of nutrients in the river and 20 major tributaries.

Monitoring Questions:

- What are the levels and trends of nutrients within the river?
- What are the levels and trends of nutrients within the 20 major tributaries?
- What are the spatial patterns of nutrients within the river?
- What are the spatial patterns of nutrients within the 20 major tributaries?

Effigy Mounds NM

Resources at Risk: Yellow River watershed includes several tributaries, one of which has a reproducing native trout population. The Yellow River is a popular recreational feature, including boating, swimming, and fishing. The Yellow River flows into the Mississippi at the park boundary.

Observations: Water quality is a growing issue for the park because of industries coming into the Yellow River watershed. There are two animal meat-packing plants (sewage treatment) on tributaries of the Yellow River. A couple time a year one of the plants dumps raw untreated sewage directly into the tributary. The result is a pulse of organic matter, an increase in bacterial growth, decrease in oxygen supply, and fish kills in the area due to lack of oxygen in the water. The second plant is a 'kosher kill' facility that inputs six times the normal salt load into the river system There is a current proposal to add another meat-packing plant on one of the tributaries of the Yellow River. The new plant is requesting a variance to permit dumping of up to six times the recommended guideline levels for fecal coliform and sodium into the tributary. (The variance to exceeds discharge levels of EPA and state.) Upstream from the park is a lot of agricultural land. One of the products used by farmers, atrozene, is of high concern for water tables because of the long residence time in system. Other compounds of concern include tryzenes, nitrates, and ammonium. Available datasets: Ten years of data on 12 water quality parameters for Sny Magill and Yellow River. Sny Magill data was collected weekly and Yellow River data was collected monthly. Iowa DNR did chemical analysis at State Hygenics lab. Macroinvertebrate data also available for Sny Magill. Study was conducted by the IA Geologic Survey. USGS had a remote staging station. IA DNR did the data analysis. EPA funded the project and US F&W also involved. Lots of past data on the river, printouts of water analysis.

Assumptions: River looks in pretty good shape. The fish kills that happen as a result of influx of sewage near the plants do not happen further down stream near the park. This is due to the oxygen levels. Oxygen is used up by bacteria breaking down the sewage near the plant but further down stream as there is less and less sewage there are less bacteria and the impact on oxygen decreases. The sewage inputs are like 'pulse' events that happen only a couple times each year. Agricultural chemicals enter the river from farms within the watershed, in part because of inadequate riparian buffers upstream of the park.

Predictions: Current standards for discharge used by the EPA may be based on a constantly flowing stream with lots of dilution. However, the water in the Yellow River in the area of the park has a long residence time because it is backed up there where it flows into the Mississippi River. The slow movement through this area may result in more intense impacts on the Yellow River. At the location where the Yellow River meets the Mississippi the water is more stagnant and less diluted than in a constantly flowing river. Since pollutant levels are held over longer in slow moving streams there may be there more accumulation/impact to the system in these slow moving areas.

Monitoring Objectives: Monitoring water chemistry is the key. What are the critical chemical components to monitor? Is it necessary to monitor all 12 that were monitored in the previous 10 years? What does the historic data tell us about the 12 parameters that were measured? The park needs information on established 'thresholds' for various compounds (e.g., sodium chloride, atrozene, trizene) and elements (e.g., nitrogen) in order to compare samples taken from the Yellow River and its tributaries with standardized acceptable levels. Long-term objective is to continue monitoring. Short-term objective is to do high power analysis to determine results from the existing data. Find out pollution guidelines. Find out thresholds for the 12 water quality parameters that were measured. Possibly develop a long-term relationship with USGS. USGS does 50/50 cost share. (Linking the following stressors to the effects in the park will require additional monitoring of the stressors themselves – essentially a landscape scale of monitoring. Collect any available data upstream and downstream from the treatment plants within the Yellow River watershed. The plants may have to sample for compliance information or the state may do regulatory sampling. How is packing plant effluent affecting fecal coliform and sodium chloride levels through time? How are agri-chemical inputs affecting nutrient levels through time? How is inadequate riparian buffering upstream affecting abiotic water integrity through time?)

Monitoring Questions:

- What is the level of sodium chloride in the Yellow River within park boundaries?
- Is the level of sodium chloride increasing or decreasing over time? At what rate is the change occurring?
- How does the level of sodium chloride in the Yellow River within the park boundaries compare with EPA and state standards/guidelines/thresholds?
- What is the level of nitrogen (and other nutrients of concern) in the Yellow River within park boundaries?
- Is the level of nitrogen increasing or decreasing over time? At what rate is the change occurring?
- How does the level of nitrogen in the Yellow River within the park boundaries compare with EPA and state standards/guidelines/thresholds?
- What level of trireme in the system is detrimental to wildlife?

Herbert Hoover NHS

Resources at Risk: Hoover Creek and its associated aquatic community (tributary of Wapsinonoc Creek). Water quality, as runoff contributes suspended solids and chemicals to the water.

Observations: Storm water drains directly into the creek both on the NHS and off site. During storm events the nitrate levels decrease - a possible dilution factor – suggesting that the source is not agricultural. The NHS does not use best management techniques for storm water runoff. Deviations from best management practices include no riparian buffer and direct input of runoff from storm drains. Water quality has become an issue in many local streams as surveys indicate that many qualify as 303d streams. Managers know that nitrate and *E. coli* levels exceed levels allowable for close human contact (swimming and drinking). Methods for reducing nitrate levels, should also receive attention. Storm drains from hard surfaces on site carry chemicals from roadways (road-salt, oil and fuel) directly into the stream.

Assumptions: Iowa currently has 157 streams listed as impaired. Experts expect that this number will increase to 2000 once small streams are surveyed for water quality, under the Clean Water Act. Hoover Creek is not listed as a 303D stream because the state has not tested it, but its levels of pollution exceed the standards that determine listing. Farmers upstream have riparian buffers and there are no feedlots in the watershed. Therefore, the high *E. coli* (2000 colonies) and Nitrate-Nitrogen levels are more likely from septic systems. If the source is septic tanks, as suggested by *E. coli* levels, then phosphate and household chemical input will be high, also. Other organic pollutants, such as pesticides are entering the water from residential or agricultural sources and the park. USGS can test for septic issues. The lack of best management practices on the NHS may contribute to poor water quality.

Predictions: Nutrient levels will increase as more septic systems are constructed within the watershed, providing more non-point source pollution. Chemical applications on the NHS may result in chemical laden runoff entering the stream. Pollutants associated with fossil fuel powered vehicles will continue to be washed directly into the stream.

Monitoring Objectives: To monitor water quality constituents, such as nitrate-nitrogen, sodium chloride and potassium chloride, and carbon based chemicals. To determine the effectiveness of mitigation measures for pollution input from NHS runoff.

Monitoring Questions:

- What are the current levels of agricultural and residential produced nitrates and pesticides as water enters the park? What are those levels as water leaves the park?
- How is park development and management practices affecting water quality?

Hot Springs NP

(This environmental concern ties in with Land Use Change theme)

Resources at Risk: Geo-thermal springs. Preservation of the health and safety of the public using the thermal water provided by the park. The park is mandated to provide water to the public in unending supply for bathing.

Observations: The geo-thermal waters in the park are valued as a unique and healthy drinking water source for local and commercial consumption, and for recreational and therapeutic value as thermal water baths. People come from other states as well as the local region to collect the water and take it home to use. There is a perception that taste is unique. Economic impact on the local area and state would be great if the springs were not useable. Closing down the springs would result in loss of business, etc. This has happened in short term circumstances in the past. Bedinger *et al.* (1979) conducted a broad spectrum of analyses on thermal water samples collected during spring base-flow periods and determined that water from the thermal springs is a mixture of a small amount of water less than 20 years old (including contemporary water - very recent component) and a preponderance of water about 4,400 years old. Samples collected from cold water sources showed evidence of contamination with elevated concentrations of nitrate and chloride as compared to thermal water samples. During and after storm events, the contribution of young, proximal recharge area water to the thermal springs appears to be greater than during base-flow conditions.

Assumptions: Mixing of the thermal- and cold-water components of flow probably occurs as the thermal waters emerge from deep portion of the flow path into the shallow ground-water zone. Time elements involved in the thermal dynamics of the system could make any subsequent mitigation strategies, should pollution of the water occur, take decades and/or even centuries to be effective. Such an occurrence would virtually destroy the park. Impacts from pollutant sources occurring within the near surface, short flow water path would have a rapid and detrimental effect on water quality within the system. Potential effects on ground-water recharge occurring in an urban setting include contaminants leaking from sewer systems, leaking underground storage tanks, contaminants from chemical-intensive commercial activities where spills or improper disposal may occur, and chemical-charged non-point source runoff from lawns, parking lots, roads, etc. Characterizing the extent and location of the recharge area and approximate time of travel for constituents moving from the recharge area to the thermal springs would enable development of plans to protect the recharge area from contamination related to intense urban land use in the area and response to acute impacts such as spills.

Predictions: The introduction of pollutants into the aquifer from any source or medium could force the park to chemically treat the geothermal water or to terminate its delivery to the hotels, etc. Shallow ground-water systems predominated by fracture or conduit flow can be extremely problematic in areas of intense urban or agricultural land use; these systems are subject to rapid input of surface contaminants and rapid transport of these contaminants to wells and springs with little opportunity for natural attenuation processes to occur.

Monitoring Objectives: Monitor water quality trends in terms of change in mineral content and pH for taste.

Monitoring Questions:

- How are E coli changing through time?
- How are fecal coliform changing through time?

Ozark NSR

Resources at Risk: Outstanding National Resource Waters status for the Current and Jacks Fork Rivers. Potential effects to riverine biota from drop in DO.

Observations: The park rivers are typically oligotrophic and can absorb small levels of phosphorus and nitrogen without negative effects. However, during certain flow levels, and light conditions, algal blooms can occur, which then dislodge and float downstream , primarily causing nuisances for park fishermen, and reducing the aesthetic quality of the river experience. Surface water quality monitoring by the NPS began in earnest in 1983 and has continued to present. A trend analysis for this data has been conducted, highlighted overall good water quality, with the exceptions of possible pathogen and nutrient increases. Available datasets for: Water quality for 8 parameters at 16 park sites (pH, fecal coliform, fecal strep, alkalinity, conductivity, DO, nitrate, chlorophyll) - 1983-present. Water quality within the park has received the most consistent resource monitoring, but a recent review of the data trends highlight gaps in parameters selected, as well as the temporal and spatial monitoring framework, particularly during winter and flood conditions.

Assumptions: Recent increases in the frequency of algal blooms point to an oligotrophic system with a low tolerance for increases in nutrients. Water quality stressors usually increase turbidity, contaminants, and nutrients, altering pH and DO.

Predictions: Increases in nutrient point source inputs to the surface streams or spring systems feeding the river will cause and increase in nuisance algal blooms. A catastrophic spill may result in fish kills.

Monitoring Objectives: Monitor status of nutrients and other contaminants in surface water and bed sediments.

Monitoring Questions:

- Is the total nutrient loading (N, P) to the Current and Jacks Fork Rivers increasing or decreasing (and by how much) over time scales of years to decades?

2.4.3.2.16 Chemical: Heavy Metals, Especially Lead, Copper, Cadmium, and Zinc

Runoff from mines often contains toxic leachates, including various heavy metals. Point-source pollution can enter waterways via overland runoff or through underground karst drainage systems. Industries operate within the watershed area of several of the parks. A CERCLA Superfund site has recently been listed within the recharge zone of Big Spring at OZAR. Lead mines are found in Ozark NSR's spring recharge zones watershed. Illegal dumping in sinkholes and hollows is a widespread problem throughout the Ozark Plateau region.

Buffalo NR

Resources at Risk: Outstanding Natural Resource Waters: all of the Buffalo River and Richland Creek (major tributary, within park boundaries, of the Buffalo River)

Observations: Principal concerns at this time include the effect on aquatic ecosystems of metal concentrations that are above EPA freshwater criteria, originating from external land use. The Ozarks, including the Buffalo River basin, contains mineralized belts that have been extensively mined. Leachate of heavy metals from mine tailings, areas of natural occurring metals, and possibly from copper-chromium-arsenic wood treatment facilities, have caused EPA freshwater criteria for copper, cadmium, lead, and zinc to be exceeded on a number of occasions at BUFF (NPS, 1997).

Assumptions: Heavy metals can interfere with aquatic community reproduction and growth.

Predictions: Water quality can decline as development pressures increase.

Monitoring Objectives: To track the status and trends of major water quality parameters in the river and major tributaries.

Monitoring Questions:

- Are heavy metal concentrations a concern for biological communities?

Ozark NSR

Resources at Risk: Bioaccumulation of lead and other heavy metals within the park aquatic biota, reducing species vigor and posing a human health threat for consumptive harvest.

Observations: The park is surrounded by one of the largest lead belts in the world. Lead processing activities, particularly tailings ponds, produce wastes for which containment is an uncertain thing, particularly during heavy rains. Failure of a tailings pond dam within another surface watershed resulted in contamination of a losing stream which emerged at Blue Spring within the park. There has been sediment sampling for lead levels conducted in the branch of Blue Spring (Current River) following significant (discharge Q10, Q25) floods.

Assumptions: Heavy metals, once released freely into the environment, are impossible to clean up, particularly in aquatic or karst systems. Bioaccumulation will continue for decades and beyond.

Predictions: Without stringent monitoring of current or lead mining activities in the recharge zones for the Current and Jacks Fork recharge, any lead contamination will eventually reach the Current and Jacks Fork rivers.

Monitoring Objectives: Monitor status of heavy metals in surface water and bed sediments.

Monitoring Questions:

- Are heavy metal levels increasing in river water, sediments, or biota at selected sites throughout the park?

2.4.3.2.17 Chemical: Pollution

Agricultural practices introduce a variety of chemicals into the aquatic environment when fertilizers, pesticides, and herbicides runoff following rainfall events. Agricultural practices can produce point-source air pollution when chemicals become airborne during application. These chemicals may eventually settle in water. Urbanized areas are a source of pollution. External inputs include sediment, contaminants, pathogens, oils, and nutrient runoff from lawns, parking lots, and roads. This contaminated water can flows directly into river channels and also enters the shallow groundwater following rainfall events.

Buffalo NR

Resources at Risk: Outstanding Natural Resource Waters: all of the Buffalo River and Richland Creek (major tributary, within park boundaries, of the Buffalo River)

Observations: Principal concerns at this time include groundwater degradation in a karst terrain. The mountainous nature of the region combined with the numerous highways that transect the watershed have resulted in a number of hazardous materials spills from truck transport accidents. Illegal dumping in sinkholes and hollows is a widespread problem that brings trash and hazardous materials to the river through underground karst drainages or surface tributaries.

Assumptions: Heavy metals can interfere with aquatic community reproduction and growth.

Predictions:

Monitoring Objectives: To track the status and trends of major water quality parameters in the river and major tributaries.

Monitoring Questions:

- Are levels of other contaminants increasing?

Cuyahoga Valley NP

Resources at Risk:

Observations: The Cuyahoga River has a complex set of influences causing water quality impairment. Point sources of water pollution associated with municipal wastewater treatment plants, storm sewer overflows, and industrial dischargers. Studies by the Ohio Environmental Protection Agency (OEPA) on the Cuyahoga River suggest that the Cuyahoga has shown significant improvement since the days of the burning river. Existing problems that still plague the section of the river within the park are pollutant loadings for heavy metals and fecal coliform bacteria associated with combined sewer overflows, urban runoff and waste-water treatment plant bypasses and numerous short term instances of low dissolved oxygen. Rain induced "shock loadings" of pollutants from sewer overflows and urban runoff contribute to chemical and biological impacts (Ohio EPA1999).

Assumptions: Impacts to aquatic resources via land use changes and non-point and point source pollution can result in impairment of water resources and aquatic habitat. The Ohio EPA is currently preparing a TMDL (Total Maximum Daily Load) program , established under Section 303(d) of the Clean Water Act for the Cuyahoga that will focus on identifying and restoring polluted rivers, streams lakes and other surface water bodies. The goalis to bring impaired sections of the river and streams into compliance with Ohio water quality standards.

Predictions: Impairment of water resources for recreation and aquatic life as a result of the non-point and point source discharges of nutrients, pesticides, trace elements, synthetic organic compounds, and pathogens to streams and the river will continue with current land use practices until an approved TMDL program is implemented.

Monitoring Objectives: The park's objectives for a long term aquatic monitoring program reflect the overall management policies of the agency. National Park Service Management Policies 2001states that the fundamental purpose of the National Park System established by the Organic Act begins with a mandate to conserve park resources and values (1.4.3) and that impairment of these resources (impact that would harm the integrity of the park resources or values) may not be allowed. (1.4.4). Furthermore, the NPS will perpetuate surface waters and groundwaters as integral components of park aquatic and terrestrial ecosystems (4.6.1) and will work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for the protection of park waters (4.6.3).

Monitoring Questions:

- How do changes in land use and additional point source discharges correlate to observed aquatic community population trends, water quality trends and riparian habitat value?

Cuyahoga Valley NP

Observations: Pollution problems, particularly non-point source, remain in portions of the Cuyahoga River watershed. For this reason, the Environmental Protection Agency classified portions of the river as one of the 43 Great Lakes Areas of Concern, warranting development of a Remedial Action Plan. Although much progress has been made to control and mitigate contamination and improve water quality since the early 1970's water quality is greatly influenced by land use and human activities. Pesticide concentrations, phosphorus, and nutrient levels are often high. Storm runoff, land use and chemical releases affect surface water quality and aquatic biota (NAWQA 2000).

Assumptions: Impacts to aquatic resources via land use changes and non-point source pollution can result in impairment of water resources and aquatic habitat . By improving our understanding of land cover and land use trends in the region, we will be better able to interpret the impact of non point source pollution on aquatic resources. The Ohio EPA is currently preparing a TMDL (Total Maximum Daily Load) program , established under Section 303(d) of the Clean Water Act for the Cuyahoga that will focus on identifying and restoring polluted rivers, streams lakes and other surface water bodies. The goal is to bring impaired sections of the river and streams into compliance with Ohio water quality standards

Predictions: Impairment of water resources for recreation and aquatic life as a result of the non-point source discharges of nutrients, pesticides, trace elements, synthetic organic compounds, and pathogens to streams and the river will continue with current land use practices until an approved TMDL program is implemented

Monitoring Objectives: The park's objectives for a long term aquatic monitoring program reflect the overall management policies of the agency. National Park Service Management Policies 2001states that the fundamental purpose of the National Park System established by the Organic Act begins with a mandate to conserve park resources and values (2.1.3.1) and that impairment of these resources (impact that would harm the integrity of the park resources or values) may not be allowed. (1.4.4). Furthermore, the NPS will perpetuate surface waters and groundwaters as integral components of park aquatic and terrestrial ecosystems (4.6.1) and will work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for the protection of park waters (4.6.3). Additional objectives include:1)Produce land cover maps and indices of land use change to enable researchers and resource managers at CUVA to better understand the influence of land use and land cover on aquatic resources and water quality. 2)Model and predict affects of development, park management activities, and other disturbances on the population, reproduction, distribution and diversity of aquatic wildlife and associated habitats. Overall goals are to develop comprehensive data sets of the land cover within the Cuyahoga River watershed.

Monitoring Questions:

- What are the quantity, characteristics and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed aquatic community population trends, water quality trends and riparian habitat value?
- What are the impacts of NPS management and development in the watershed on aquatic resources given a broader regional and temporal context?

Herbert Hoover NHS

Resources at Risk: Hoover Creek and its associated aquatic community (tributary of Wapsinonoc Creek). Water quality, as runoff contributes suspended solids and chemicals to the water.

Observations: Storm water drains directly into the creek both on the NHS and off. The NHS wishes to improve its storm water management, since best management techniques are not being used. Oil and other solvents are seen on paved surfaces. These chemicals are washed away during storms. Dumping of grass clippings in stream and other on site practices.

Assumptions: Surface water runoff may decrease water quality in the stream. Storm drains are a source of pollution in the creek. Management actions in the park impact water quality.

Predictions: Input of pollutants from paved surfaces will continue as long as the storm drains open directly into the creek. Once the response of the resource is understood, managers can make better decisions about preferred alternatives

Monitoring Objectives: To observe how management activities affect the water quality. Quantify impacts of management actions on the resource.

Monitoring Questions:

- How much grease, oil, and other pollutants is going into the stream from parking lots in the park (park generated pollution)?
- How is park development affecting water quality?
- How are management actions impacting the overall health of the aquatic system?

Hot Springs NP

Resources at Risk: Hot Springs Creek, Gulpha Creek, Wittington Creek, and Bull Bayou

Observations: Major industrial complexes now exist south and east of the city of Hot Springs. Leaky transformers at older industrial sites are known to have left pools of oil that may contain PCBs. HOSP also has problems with leaking sewer systems, leaking underground storage tanks and improper disposal. Gulpha Gorge Road, or Highway 70b, is one of the two highways accessing the city of Hot Springs and trucks carry hazardous materials that have in the past there have been accidents and spills into the creek. Meth labs are another potential problem at HOSP, where dumping piles have been found along the creek bed. Historically, fish kills have occurred due to dumping in Hot Springs Creek. Other impacts to Hot Springs Creek include agricultural runoff importing nutrient loads into the system and residential use of Cloradain transported to the creek by over land flow during storm events.

Assumptions: Human health will be adversely affected by toxins or bacteria. Areas would have to be closed if the situation warrants - hot spot Bull Bayou and Gulpha Creek in the area south of the land fill and north of the Black Snake bridge. Impacts to fauna in the creek, which can be a food source for humans and wildlife, pose a potential health threat

Predictions: Continued development surrounding Hot Springs will cause a decline in spring water quality due to increased pollution levels.

Monitoring Objectives: To monitor water quality as it affects biological aspects, e.g., people that swim in it. Monitor base flow and run off effects during heavy rain storm events. Monitor flow (need stream gages on each site).

Monitoring Questions:

- How are trace elements changing through time?
- How are volatile organic compounds (VOCs) changing through time?

Pipestone NM

Resources at Risk: Watershed biota, riparian corridor

Observations: Urban and agricultural runoff is common following rainfall events. It is unkown what pollutants enter the watershed during these events or how long they remain in the watershed.

Assumptions: Non-point pollutants enter Pipestone Creek during rainfall events.

Predictions: As urbanization occurs along Pipestone Creek there will be an increase in the quantity and types of non point pollutions entering the creek during rainfall events.

Monitoring Objectives: Monitor key non point pollutants during rainfall events.

Monitoring Questions:

Are non point pollutants increasing with the expansion of urban areas?

2.4.3.3 Anthropogenic and Natural Disturbances Impacting Park Aquatic Ecosystems

Figure 2.10 lists the present-day disturbance mechanisms potentially impacting the Heartland Network parks' aquatic resources. These large-scale disturbances include:

- ✓ Agriculture: Agricultural practices are important causes of point and non-point water pollution, modify surface permeability, frequently channel and divert water, modify and destroy habitats, and disturb the surface and river channels in a variety of ways, including grazing and prescribed fires.
- ✓ Forestry: Legal and illegal logging practices can remove forest cover and be an important cause of surface erosion.
- ✓ Mining: Mining impacts water resources through point-source pollution, changes in surface permeability and erosion.
- ✓ Recreation: Park visitation and recreation activities influence aquatic resources through the stocking of native and non-native fish, boating and canoeing, improper waste disposal, the construction of structures, and changes in surface permeability associated with access roads.
- ✓ Urbanization: Urbanization has been linked to a variety of environmental stressors. Stressors include point and non-point pollution sources, changes in surface permeability, erosion, habitat loss and modification, water diversions, and water consumption.

These disturbances will not be monitored specifically for the aquatic effects, although it is important to understand that the stressors, which will be monitored, are controlled by these larger-scale drivers.

2.4.3.4 Relevant Laws and Regulations

Local, state, and federal laws, permitting requirements, and so on that will regulate or influence monitoring program decisions and actions were identified by the parks that identified aquatic monitoring as a high priority within the I&M program. This information is summarized up in Table 2.8. The Heartland Network has contracted with the U of KS to provide information on all state aquatics regulations and protocols for the states in which the network has parks. This information will be available for use in indicator selection in Phase II and incorporated in subsequent drafts of Phase I.

Table 2.8 Local, State, and Federal Laws Relevant for Aquatic Monitoring

Laws		HEHO	HOME	HOSP	OZAR	CUVA	BUFF	PIPE	TAPR	EFMO	WICR
State	Missouri Statutes 10 CSR 20-7.031				X						X
	Iowa Water Quality Standards IAC 567: Chapter 61	X								X	
	Arkansas State Laws - Regulation #2			X			X				
	State of Ohio Water Quality Standards OAC 3745-1					X					
	Total Daily Maximum Load program					X					
	Water Quality Standards for Minnesota-7050, 7052							X			
Federal	Clean Water Act	X	X	X	X	X	X	X	X	X	X
	Enabling Legislation	X	X	X	X	X	X		X	X	X
	Endangered Species Act	X	X	X	X	X	X	X	X	X	X
	Federal Cave Protection Act of 1988	X	X	X	X	X	X	X	X	X	X
	Federal Mining Laws	X	X	X	X	X	X	X	X	X	X
	Flood Disaster Protection Act of 1973	X	X	X	X	X	X	X	X	X	X
	Floodplain Management - Executive Order 11988	X	X	X	X	X	X	X	X	X	X
	National Environmental Policy Act	X	X	X	X	X	X	X	X	X	X
	National Park Service Director's Order 77-1; NPS-77	X	X	X	X	X	X	X	X	X	X
	National Park Service Management Policies 2001 - Section 4.6.1	X	X	X	X	X	X	X	X	X	X
	National Parks Omnibus Management Act	X	X	X	X	X	X	X	X	X	X
	Organic Act	X	X	X	X	X	X	X	X	X	X
	Protection of Wetlands; Rivers and Harbors Act - E.O. 11990	X	X	X	X	X	X	X	X	X	X
	Watershed Protection and Prevention Act	X	X	X	X	X	X	X	X	X	X

2.4.4 Wildlife Theme

Wildlife, both native and exotic, in the Heartland Network parks is diverse, in part because of the diversity of habitats within and adjacent to the parks. Five Heartland Network parks indicated a particular wildlife group or individual species as a high priority for monitoring (Table 2.3). CUVA and PERI are concerned about high population densities of *Odocoileus virginianus* (white-tailed deer) within their parks. CUVA is also concerned about increasing population densities of *Canis latrans* (coyotes). HOCU and PERI are concerned about herpetofauna diversity, as is GWCA with a particular focus on frogs and salamanders. BUFF is concerned for the bat diversity in their park, including three federally listed threatened or endangered species. HOCU is concerned about the bird communities utilizing the forest and/or open grassland areas of their park.

This section on wildlife provides specific information on the Heartland Network parks' environmental concerns at the 'ecological effects' and 'stressor' levels. Both levels of information are necessary before a linkage can be hypothesized between a stress and effect.

Ecological effects level:

- Federal or State listed species, or species of special concern,
- overabundance of native wildlife populations, and
- species diversity on a population level.

Stressor level:

- accidents;
- air pollution;
- deer food supply;
- habitat fragmentation/loss;
- physical disturbance;
- predation and hunting;
- sound and air quality degradation; and
- water pollution (point source).

In Section 3.1 this information will be expanded upon within the developed ecosystem conceptual models. This section also includes a list of applicable laws, regulations, and permitting that apply to wildlife and wildlife monitoring at the local, state, or national levels.Parks' Environmental Concerns Related to Wildlife

2.4.4.1 Parks' Wildlife Environmental Concerns at an Ecological Effect level

2.4.4.1.1 Federal or State listed Species, or Species of Special Concern

Several listed species or species of concern exist within the boundaries of Heartland Network parks. Sustainable and/or increased populations are the primary focus for such species, a focus that will ensure continuity of species genetic pools.

Buffalo NR

Resources at Risk: Bat populations, including three federally listed endangered bat species: *Myotis grisescens* (Gray bat), *Myotis sodalis* (Indiana bat), and *Corynorhinus townsendii ingens* (Ozark Big-Ear bat).

Observations: Over 300 caves are currently documented in the park. Hibernating, bachelor and maternity colonies are known to exist in several park caves and abandoned mines. The caves provide critical habitat for bats, including three federally endangered bat species: *M. grisescens*, *M. sodalis*, and *C. townsendii ingens*. There are also reports of *Myotis leibii* (Eastern Small Footed bat), a G3 N3 S1 ranked species, in at least one cave inside the park. *M. sodalis* is declining in Arkansas; *M. grisescens* is improving in most of its range, and may soon be down listed to threatened; and *C. townsendii ingens* is declining over its entire range. The genetic pool for the latter species is very small and in danger of extinction. Current estimates of the population are 2,000 to 2,500 individuals. *C. townsendii ingens* has very specific roost requirements and is intolerant to disturbance. There are two apparently distinct groups: members of the eastern group are known to use caves within the park. Bat roost knowledge in the Lower Buffalo Wilderness (LBW) is poor. The LBW is approximately 21,500 acres. A systematic study of the caves and abandoned mines in this area has never been undertaken. All three federally listed bat species are known to utilize caves and mines within two miles of the LBW boundary. Arkansas' largest hibernaculum for the *M. grisescens* is located just outside this area. There are two known *M. grisescens* caves in the LBW, one is a maternity cave with a population of ten to fifteen thousand bats.

Assumptions: The bats are vulnerable to intentional and unintentional disturbance when people enter cave roosting areas. Alteration of foraging areas outside park boundaries, mainly in the form of increased development and loss of forest cover, has the potential to negatively influence bat populations within the park.

Predictions:

Monitoring Objectives: To monitor populations.

Monitoring Questions:

- What are the status and trends of the endangered bat populations at Buffalo National River?
- What are the status and trends of the bat's critical habitat?

Pea Ridge NMP

Resources at Risk: Herpetofanua community, in particular a species of wood frog

Observations: An inventory of the reptiles and amphibians of Pea Ridge was conducted in 2000. Most amphibians found during the survey were associated with small ponds, while reptiles were found throughout the park. This inventory probably reached its goal of documenting 90% of the species occurring in the park. None of the species found are federally threatened or listed species. One species of frog, the wood frog, (identified in the FY2002 inventory) has been in serious decline in the area for some time. While these animals are still fairly common in central and southern Arkansas, the population at Pea Ridge is one of the only ones in the nearby area. Once common in Missouri, it is now rare and is tracked by the state department of natural resources.

This decline in amphibians mirrors a similar nationwide decline. Many areas deal with invasive cedar trees by cutting and burning. The change in reptile and amphibian populations following this treatment has never been documented. Cover boards have been placed in areas where cedar trees will be removed, and the abundance and species composition of reptiles and amphibians before and after treatment will be measured.

Assumptions: Filling in ponds on park property was being done prior to 1999, resulting in a loss of habitat. Filling in ponds was supposed to continue.

Predictions:

Monitoring Objectives: To monitor response of reptiles and amphibians populations following the removal of cedar trees.

Monitoring Questions:

- Are populations stable, increasing or declining?
- How do reptile/amphibian populations change following management actions like restoration of cedar dominated areas?

2.4.4.1.2 Overabundance of Native Wildlife Populations

Overabundance of various native wildlife populations is a concern for parks. For example at HOME, the local public views deer as 'belonging to the park' and attributes increases in car collisions with deer as a result of the 'parks deer population'. Park property does provide some habitat value, however the park acreage is small hence this problem includes a much larger area than is controlled by the park. At CUVA, increased populations of coyote are a concern both for public safety and for safety of small pets potentially killed by coyotes.

Cuyahoga Valley NP

Resources at Risk: Native and rare plant populations, regeneration of native woody species, small mammals, and forest understory birds.

Observations: While the overabundance of *Odocoileus virginianus* (white-tailed deer) is a major issue at Cuyahoga Valley, the park has numerous long term monitoring programs in place to monitor both population trends as well as impacts on other natural resources. White-tailed deer populations have been monitored in CUVA since 1988 using roadside spotlight surveys. Results of those surveys have demonstrated a population increase of approximately 9% annually over the past 12 years, with the population doubling in that period of time. Rapid increase (15% annual) of white-tailed deer populations between 1990-1996, along with a concurrent rise in deer-vehicle collisions and apparent impacts to vegetation. Since 1997, the rate of population increase has slowed and numbers detected during spotlight surveys appear to be stable. Current estimates of deer densities range between 47-89 deer per square mile, approximately 2-4 times higher than densities shown elsewhere (Marquis 1974, Alverson et al. 1988, Tilghman 1989).

Assumptions: Deer have flourished since habitat conditions are favorable, no predators exist, and hunting is prohibited on parklands and in many adjacent communities. Overabundance of deer is related to elimination of plant species, reduction of forest regeneration, changes in habitats, and visitor safety. Because of the fragmented nature of the park due to agriculture and other land development, there is potential for deer to drive populations of frequently browsed species to local extinction.

Predictions: Impairments to park resources caused by deer overabundance will continue until population numbers decrease.

Monitoring Objectives: As the park progresses towards an active deer management plan, additional monitoring of the deer population and their impacts on natural resources may be needed to compliment or enhance the current monitoring. Monitoring the effect of deer overpopulation on the herbaceous plant community and the woody species regeneration remains a high priority objective.

Monitoring Questions:

- At what density level do deer negatively impact the herbaceous plant community and regeneration of woody species?
- What deer density levels negatively impact ground nesting birds?
- What effects does the overpopulation of deer have on the herbaceous plant community, the regeneration of woody species?
- What effects does the overpopulation of deer have on small mammals?

Cuyahoga Valley NP

Resources at Risk: *Vulpes fulva* (red fox) and *Urocyon cinereoargenteus* (gray fox); Park visitor and neighbor safety.

Observations: Specific goals were established in the park's Resources Management Plan (1999) to produce a coyote management plan and gain basic information on the ecological role of the species in the park. No coyote management plan has yet been produced because of a lack of basic ecological information on the species. *Canis latrans* (coyotes) expanded into southwestern Ohio in 1919 (Weeks et al. 1990) and now occupy all counties in the state. The species was first detected in CUVA in the late 1980's. Population trends are increasing, and have doubled since the park began monitoring coyotes in 1993. A vocal response survey was initiated in 1993 to monitor population trends in the park (NPS 1993). Since that time, the population index has increased by 14% annually, suggesting that the coyote population within park boundaries have more than doubled. Accurate population estimates are not available, but estimates generated from the howling survey suggest a minimum of 60 individuals present, with a possible density of 0.4 animals per square mile. Two local area metroparks have repeated the NPS auditory survey in their parks. The State of Ohio, Department of Natural Resources asks deer bow hunters to report coyote sightings. More human/coyote interactions are occurring in the park. Coyotes have become a species of concern both because of their potential to become overabundant and have an adverse impact on other wildlife (such as fox), and from increased negative interactions with park visitors and residents who fear for the safety of themselves and their pets. Within the last 6 years, human-coyote interactions have increased within CUVA and elsewhere in the region as evidenced by higher frequencies of visitor and landowner complaints to park staff as well as a dramatic increase in local media attention.

Assumptions: Coyote populations are high because of a lack of natural predators and current laws prohibiting hunting. As the top mammalian predator in the park, coyotes represent one of the most important wildlife resources in the park ecosystem.

Predictions: Coyote populations will continue to increase within the park and surrounding area and become a nuisance to park visitors. Coyote may also affect a decrease in the fox population by competing for similar habitat and food sources.

Monitoring Objectives: Objectives include: understand the role of coyotes in the ecosystem; identify coyote population impacts on fox populations; and maintain population levels and reduce human/coyote incidents.

Monitoring Questions:

- Does the frequency of human-coyote conflicts increase with estimated coyote population levels?
- What is the population level at which coyote-human contact frequency is unacceptable?
- What is the population level at which impacts to other wildlife are unacceptable?

Pea Ridge NMP

Resources at Risk: Flora and understory tree regeneration

Observations: Several attempts have been made to estimate *Odocoileus virginianus* (white-tailed deer) density at Pea Ridge in the last decade. An aerial infrared survey conducted in 1995 counted 312 deer on the parks 4300 acres. An undergraduate research project conducted in 1996 using Kings method (King, 1943) estimated that 350 deer occurred on the park. Subsequent counts using Kings method conducted in 1998 and 1999 estimated that 417 and 700 deer occupied the park respectively. Deer spotlight surveys, initiated in 2000 give density estimates ranging from 40-70 deer per square mile. This technique is still being evaluated for its efficacy at Pea Ridge. Overall, deer density estimates range from 45-85 deer/sq. miles. A herd health study conducted in 2000 concluded that the park has an overabundant deer population that has been living beyond the carrying capacity of the park's vegetation for a significant period of time (Davidson, 2000). Davidson (2000) implicated high deer densities as the primary cause of high abomasal parasite counts (APC's), parasite loads, low weights and poor nutritional health in the park's deer. In a 2002 meeting with the NPS National white-tailed deer management team, several additional monitoring indicators were identified. These include finding and monitoring of indicator plant species and continued monitoring of deer impacts on vegetation using exclosures.

Assumptions: Lack of natural predators and prohibition of hunting have resulted in an increase in white-tailed deer. The area around the park is developing rapidly, with more people moving to rural areas. Development and fragmentation promotes deer population growth within the park. Impacts on the park will only increase as the park's deer population continues to grow. Noise from the increased development is affecting the wildlife within the park. Preliminary research suggests that deer in the park are overabundant and that deer negatively impact the park's vegetation.

Predictions: In the absence of predators and with current laws, white-tailed deer will become more abundant. Increased development around the park will increase the number of connecting trails (and visitors) in PERI. More visitation will result in more automobile noise, as well as noise from hikers. Increasing noise levels with further development will negatively affect wildlife populations.

Monitoring Objective:

Monitoring Questions:

- What is the density of deer in the park?
- Is deer browsing significantly impacting plant communities or regeneration of hardwood tree species?

2.4.4.1.3 Species Biodiversity and Abundance

Species diversity and abundance is a concern for parks. Diversity and abundance offers an insight into species interactions, interactions that ultimately guides natural resource management.

George Washington Carver NM

Resources at Risk: Frogs and salamanders in the streams, spring, and pond.
Observations: A herpetofauna inventory was conducted in 2002 by Dr. Stan Trauth of the University of Arkansas.
Assumptions: Water quality in the streams may be adversely affecting herpetofauna and amphibian populations.
Predictions:
Monitoring Objective: To track species and populations, especially frogs and salamanders.
Monitoring Questions:

- Are species population increasing or decreasing over time?
- At what rate are the changes occurring for any given species or overall?
- What species are present along the stream or in pond or spring?

Hopewell Culture NHP

Resources at Risk: Bird populations and species, especially Dickcissel and Savannah sparrow
Observations: Eagles have moved into the area.
Assumptions: The park owns 800+ acres of grassland that may be good habitat for grassland birds.
Predictions: Removal of grazing, agriculture, and trees along old fence lines to create larger, unbroken grasslands will increase the numbers and diversity of nesting birds.
Monitoring Objectives: Determine the effect of landscape management on bird populations.
Monitoring Questions:

- What is the diversity and abundance of nesting bird?
- What is the nesting success?

Hopewell Culture NHP

Resources at Risk: Herpetofauna populations, particularly turtles
Observations: The ongoing herpetofauna survey has recorded several species previously unknown to occur in the park.
Assumptions: Flooding along the Scioto River has increased the migration of turtles
*Prediction*s: Removal of grazing and agriculture, and the resulting increase in forest and grassland areas will cause an increase in the diversity and numbers of herpetofauna.
Monitoring Objectives: Determine if landscape management is having an effect on herpetofauna populations.
Monitoring Questions:

- How are population abundances changing? (specific species will not be available until the current inventory project is completed)
- At what rate are populations changing?
- What impact are the management practices of changing vegetation (especially in the grasslands) having on herps/amphibians (i.e. snakes)?

2.4.4.2 Parks' Wildlife Environmental Concerns at a Stressor Level

2.4.4.2.1 Accidents

Accidents stress wildlife because it is not a normal form of natural selection. Accidents would include auto collisions and electrocution.

Cuyahoga Valley NP

Observations: The annual number of reported deer/vehicle accidents has more than doubled in the past ten years in and around the park. Summit county, which includes park land, is one of the counties with the highest number of deer/vehicle accidents in the state of Ohio. Most of the accidents occur during the breeding season (October-December).

Assumptions: Deer/vehicle accidents will continue to occur and perhaps increase as the deer population and suburbanization surrounding the park increase. However, deer mortality from vehicles is not a significant reduction to the overall herd.

Predictions: Deer/vehicle accidents will continue to increase in the park and surrounding county as the deer population increases.

Monitoring Objectives: To provide for the safety and protection of visitors, residents and employees; to reduce the number of deer/vehicle accidents; to reduce the threats of Lyme Disease and ehrlichiosis infections.

Monitoring Questions:

- How do we establish forest species composition goals that consider: historic vegetation patterns, succession, forest health, and overall aesthetics?
- How do we establish herbaceous plant species composition goals that consider: wildlife needs (food, nests, shelter, etc.), soil protection, water quality, aesthetics, and other factors?
- How do we establish a deer population level which, if maintained, will be compatible with other natural resources and not cause unacceptable changes in other components?

2.4.4.2.2 Air Pollution

Air pollution can stress wildlife through respiratory and/or skin contact. Aerial spray can linger and enter respiratory systems of wildlife whereas direct contact can occur if wildlife is exposed to the pollutant. Either way, the result is a decrease in the ability of wildlife to function, grow, and reproduce in their respective ecosystems.

Arkansas Post NM

(This stress relates to the land use concern of aerial over-spraying)

Observations: The Mississippi bayou region surrounding ARPO is primarily large-scale agriculture. Because the land is wet and unstable for much of the growing season, most of the chemicals are applied by aerial broadcasting.

Assumptions:

Predictions:

Monitoring Objectives:

Monitoring Questions:

2.4.4.2.3 Food Supply

Agricultural practices can affect food supplies for animal species. Natural systems regulate deer populations with food but when the food supply is abundant and available year round, populations get out of control.

Buffalo NR

Observations: Deer populations have access to hay fields within and outside of park boundaries.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Cuyahoga Valley NP

Observations: Increases in year-round food resources have contributed to deer population growth. When continuous blocks of forested land are fragmented by agricultural fields, open or old fields, landscaped industrial or residential development, or transportation or utility corridors the amount of edge habitat increases. Development of suburban residential areas has also provided increased deer forage in the form of landscape vegetation, fruit trees, and vegetable gardens. Park residents, neighbors and visitors often feed the deer during the winter months by supplementing their natural diets with feed corn and salt blocks.
Assumptions: Agricultural fields located on park lands will continue to suffer increased damage due to deer overbrowsing. The practice of residents providing deer feeding stations continues to increase year-round food forage that may contribute to deer population growth.
Predictions: If deer densities continue to increase at the present rate, agricultural fields and cultural landscapes will continue to suffer damage.
Monitoring Objectives: To reduce or eliminate damage to landscape vegetation; to reduce damage to agricultural crops.
Monitoring Questions:

- How do we establish forest species composition goals that consider: historic vegetation patterns, succession, forest health, and overall aesthetics?
- How do we establish herbaceous plant species composition goals that consider: wildlife needs (food, nests, shelter, etc.), soil protection, water quality, aesthetics, and other factors?
- How do we establish a deer population level which, if maintained, will be compatible with other natural resources and not cause unacceptable changes in other components?

2.4.4.2.4 Flooding

Flooding stresses wildlife by killing healthy members, relocating populations, modifying habitats, and creating barriers. This adversely affects population structure and composition, interaction with the local habitat, and that areas' gene pool.

Hopewell Culture NHP

Observations: The Scioto River and its tributaries flood in spring, during periods of snow melt and high rainfall.
Assumptions: Flooding will increase mortality of less mobile species. Larger species, such as deer, may become concentrated in the park units when floods drive them from bedding areas in riparian forest.
Predictions: Annual flooding will have little impact on larger wildlife populations and their movements.
Monitoring Objectives: Determine if flooding is having an adverse effect on species of concern. Determine if the units of the park are becoming refuges for deer during high floods. Determine if deer concentrated in park units during floods have long-term impacts on park vegetation.
Monitoring Questions:

- Are species of concern, such as the false map turtle, impacted by flood events?
- Do floods displace deer from riparian forests?
- Do deer concentrate in the park units during severe floods?
- If so, do the deer cause long-term impacts to vegetation?

2.4.4.2.5 Habitat Fragmentation/Loss

A fragmented landscape stresses wildlife communities because it increases the edge effect and prevents immigration and/or emigration. Fragmentation, often associated with agriculture and urbanization, is the cause for widespread declines in species numbers and assemblages. Loss of habitat stresses wildlife populations by reducing available resources such as space, water, and food. Each are needed for species growth and reproduction and a lack thereof will lead to species extirpation or extinction.

Buffalo NR

Observations: Agricultural practices, including haying have reduced the amount of forest cover
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Cuyahoga Valley NP

Observations: The CUVA forests are heavily fragmented by roads, suburban development, recreational areas (ski areas, sledding hills, picnic areas, golf courses, events sites), a railroad, utility corridors, and agricultural lands throughout the park. The largest and oldest semi-contiguous tracts of mature forest are between approximately 750 and 1,800 acres in size. These are located in reservations managed by Cleveland Metroparks in the northern half of CUVA and in the Virginia Kendall, Blossom Music Center, and Oak Hill areas in the southern half of the park. Even these tracts, however, are internally fragmented and dissected, with correspondingly large amounts of habitat edge, which reduces their habitat value for forest interior species.

Assumptions: Fragmentation of habitat can be a concern for populations of some native plant communities. The effects of continued fragmentation on plant communities, factors such as increased light penetration, smaller patch size, and lower soil moisture, can alter the habitat enough to make the affected area unsuitable for the plants growing there. When this happens, plants more adapted to the new conditions move in. This results in a gradual change in the species composition in the affected area. Fragmentation will cause additional moderate adverse impacts on forest interior wildlife species, particularly birds, which require larger tracts of habitat for successful breeding. Increased amounts of distinct edge habitat will continue to enhance populations of generalist species such as raccoons, crows, and brown-headed cowbirds.

Predictions: As areas outside of CUVA in surrounding counties become more developed and lose forests and other greenspace, forest and other natural habitats within CUVA will become increasingly isolated. Amplified fragmentation effects on habitats within CUVA will further degrade the quality of forest habitats for forest dependent species. Continued overabundance of deer and related overbrowsing of forest would exacerbate this condition.

Monitoring Objectives: To monitor ecosystem health which may be affected by changes in land use within the park and adjacent to park boundaries.

Monitoring Questions:

- Is adjacent land use and habitat fragmentation acting as a barrier for colonization, migration, or decreasing the effective size of habitat areas?
- Does fragmentation of habitat affect dispersal corridors and animal distribution?

Herbert Hoover NHS

Resources at Risk: Community diversity and integrity, soils, water quality, aesthetics, commemorative nature of site, and opportunities for land and water stewardship and interpretation of the resources

Observations: The prairie and prairie ecotone provide a rich environment for wildlife species. This island of habitat stands in the midst of developed land and can provide habitat diversity for wildlife or its diversity may be limited because of stressors from outside the park. Although obvious connectivity is limited between this native habitat and others in eastern Iowa, many species, particularly birds, flying insects, and species compatible with human activities, have successfully re-colonized the prairie and stream.

Assumptions: The restored prairie is too small to successfully provide habitat for many obligate grassland species. However, it can provide a small island of habitat for many prairie flora and fauna. Agriculture and urbanization surrounding the park will impact wildlife movement and colonization of natural areas. Further agricultural or urban changes could alter these nearby habitats or corridors, although it is unknown whether the impacts would be negative or positive. The wildlife and insect populations in the prairie and stream habitats rely on limited corridors through which they access nearby habitat.

Predictions: A healthy plant community will attract wildlife in its vicinity. This structure-based approach to ecosystem management relies on persistence of or re-colonization by native animal species (Noss 1991).

Monitoring Objectives: To understand impacts of management actions on the health of the plant community.

Monitoring Questions:

- How do management techniques affect plant community diversity and integrity?

- Does prescribed fire improve the vigor of the prairie community? When and where should fire be used?

Hopewell Culture NHP

Observations: Bird and amphibian habitats are fragmented
Assumptions: The units of the park will continue to be surrounded by agriculture and/or suburban developments.
Predictions: Habitat fragmentation within the park units will be decreased by removal of trees along old fence lines and the increase of forest areas due to natural succession. The units of the park will not have habitat connections to other similar habitats.
Monitoring Objectives: Determine if bird and amphibian populations are impacted by habitat fragmentation in the vicinity of the park. Determine if bird and amphibian populations are effected by landscape management in the park.
Monitoring Questions:

- Are bird and amphibian populations and diversity changing as a result of NPS management actions within the park?
- Are bird and amphibian populations and diversity changing as a result of land use outside of the park?

Hopewell Culture NHP

Resources at Risk:
Observations: Chillicothe's growth I don't think urban growth is the only culprit here. Most of the areas around the park units are farmed which impacts forest bird species. In effect virtually the entire bird habitat in the valleys has been modified since the 1780s. If anything, the change to a large lot suburban landscape has increased the number of trees and shrubs in the valley. has removed [Amount?] of bird habitat. I guess I don't know where we are going with this. The relatively small size of the park units in a "sea" of agriculture and suburban developments means that the impacts have already occurred. It would seem logical to me that the controlling factors in bird populations are regional factors such as the interactions between the forested ridges and agricultural valley floors and the edge of Appalachia and the (mostly farmed) glacial plains. This is well outside of the scope of the park's purpose.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Lincoln Boyhood NM

Resources at Risk: Midwestern deciduous forest faunal diversity and abundance
Observations: Faunal inventories at LIBO have detected less diversity and abundance than expected. Adjacent to LIBO is Lincoln State Park with 1700 acres of forest. It has not undergone the same disturbance history as LIBO. The state park has high visitation, with use confined primarily to areas around the forest and very little within it.

Assumptions: Land use changes and disturbances over time have presumably led to reductions in wildlife diversity at LIBO, as has a lack of active and aggressive vegetation management. Direct management of wildlife is not feasible in an area the size of LIBO (200 acres). Improvements in diversity will depend on local land use and actions on adjacent properties. Providing high quality habitat within LIBO is possible. Management actions are best directed towards improving the quality of the plant communities.
Predictions: Improvements in the quality of the forest plant community diversity and ecological functioning will lead to improvements in faunal diversity and abundance.
Monitoring Objectives: Monitor forest health, defined as plant community diversity and ecological functioning, to determine if management actions are improving forest health. Detect the results of outside influences on LIBO's forests.
Monitoring Questions:

- What are the effects to forest health (defined as plant community diversity and ecological functioning) of adjacent development, increased vehicular traffic, management actions, and increased visitation?

Pea Ridge NMP

Observations: The suburban development around the park is quickly fragmenting the remaining forest habitat.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

Pea Ridge NMP

Observations: In-filling of ponds prior to 1999 has resulted in the loss of wetland habitats.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.4.2.6 Physical Disturbance

People entering sensitive habitats stresses wildlife. Entering a sensitive area may affect timed responses of wildlife (bats emerging from roost) or interfere with the presence of integral species (pollinators). Many areas have been devoid of any human disturbance and rely on that continued absence.

Buffalo NR

Observations: People entering the roosting area of the caves which are important bat habitats.
Assumptions:

Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.4.2.7 Predation and Hunting

Predation is an important stressor of wildlife populations. Predation can be both natural and anthropogenic. Natural predation has evolved over several eons and tended to keep populations "in check". Due to human disturbance, anthropogenic means have been integrated into the population controls for many areas.

Cuyahoga Valley NP

Observations: Since European settlement, natural deer (and coyote) predators such as wolves and mountain lion have been exterminated from the area thereby eliminating an effective natural population control factor. Mortality by predation can have major impacts on deer populations: 1) they reduce the long term average of deer populations, 2) they reduce the peaks in deer population fluctuations, and 3) they reduce the annual number of fawns that survive to maturity and thereby lengthen the time for the herd to recover from a low point in the population. Additionally, there is no hunting or trapping permitted in CUVA and many adjacent communities.
Assumptions: With the elimination of natural predators and hunting, the overabundance of native animals may continue.
Predictions: Park staff will continue to study alternatives to reduce the overabundance of native animals due in part to lack of natural predation.
Monitoring Objectives: To maintain population levels which will be compatible with other natural resources and not cause unacceptable changes in other components.
Monitoring Questions:

- When is it appropriate to manage population levels to reduce human/coyote incidents?
- How do we identify coyote population impacts on fox populations?
- What is the ecological role of the coyote in the ecosystem?
- What effects does the overpopulation of deer have on the herbaceous plant community, the regeneration of woody species, forest understory birds and small mammals?

Pea Ridge NMP

Observations: Many of the natural predators have been eliminated Hunting is not permitted in the park and as more people move around the park, the hunting pressure is likely to decrease.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.4.2.8 Sound and Air Quality Degradation

Noise stresses wildlife communities by changing the natural "sound" of habitats and degrading species interactions. Urbanized areas have higher noise levels as a result of more traffic and a decrease in total vegetation (a natural noise buffer).

Lincoln Boyhood NM

Resources at Risk: Faunal diversity and abundance

Observations: The state is widening and re-aligning Highway 231 to within a mile of the park boundary. In addition, railroad traffic has increased along lines that pass through LIBO. Truck, auto and rail traffic is expected to mirror further development within southern Indiana. No air quality monitoring is being accomplished by federal or state agencies within the county.

Assumptions: Degraded air quality and noise from traffic negatively affects fauna within the park. The air quality of the Memorial is at risk due to the industrialization within Spencer and surrounding counties. The impacts of current land use trends and development within and surrounding Spencer County are expected to be increased visitation, increased air pollution, and increased traffic and noise.

Predictions: The health of the animal communities will decline as traffic levels increase surrounding the parks. Noise levels are projected to increase upon completion of the proposed freeway and other surrounding development.

Monitoring Objectives: To provide an early warning of the potential for impacts to natural resources presumed to be affected by reduced air quality/urbanization

Monitoring Questions:

- Does the current faunal diversity change over time given the expected land use changes surrounding LIBO?

Pea Ridge NMP

Observations: PERI is located next to a major truck route, Highway 62, which connects the Wal-Mart headquarters in Bentonville, AR with eastern markets. In addition, a proposed freeway will connect Kansas City to Shreveport.

Assumptions:

Predictions:

Monitoring Objectives:

Monitoring Questions:

2.4.4.2.9 Water Pollution (point source)

Water pollution is an important stressor because of its affect on water quality. Species exist within defined water quality parameters and once those parameters are polluted, tend to decline in numbers or die.

George Washington Carver NM

Observations: Lead and zinc mines, located just south of the GWCA boundary, were in operation from approximately the 1900s to the 1950s appear to be responsible for degraded water quality. Lead is prominent in the water and the pH is low.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.4.3 Anthropogenic and Natural Disturbances Impacting Park Wildlife

Several anthropogenic and natural disturbances provide the driving force behind the stresses and park concerns previously discussed (Figure 2.10). The primary disturbances highlighted in the Heartland Network parks are:

- ✓ Agriculture – Agriculture changes the natural food supply, fragments habitats, removes habitats, and is a source of pollution.
- ✓ Mining – Mining is an important source of pollution.
- ✓ Precipitation – Intense precipitation events are often responsible for flooding.
- ✓ Recreation – While park visitation and recreation is generally considered positive because it demonstrates the public's interest in the park, visitation can have negative consequences to wildlife. Some of the parks identified recreation and park visitation as potential stressors to wildlife populations. Recreation physically disturbs habitats and creates noise.
- ✓ Urbanization – Urbanization fragments habitats, removes habitats, reduces natural and anthropogenic predators, changes the natural food supply, creates noise, and increases the rate of automobile collisions with animals.

2.4.4.4 Relevant Laws and Regulations

Local, state, and federal laws, permitting requirements, and so on that will regulate or influence monitoring program decisions and actions were identified by the parks that identified wildlife monitoring as a high priority within the I&M program. This information is summarized up in Table 2.9.

Table 2.9. Local, State, and Federal Laws Relevant for Wildlife Monitoring

Law		BUFF	CUVA	PERI	HOCU	GWCA
Local	Enabling Legislation (BUFF, CUVA)	X	X			
	Hunting Ban (PERI)			X		
Federal	Endangered Species Act	X	X	X	X	X
	General Authorities Act	X	X	X	X	X
	Organic Act	X	X	X	X	X

2.4.5 Exotics Plants Theme

Exotic plants are a concern in parks because of their potential as a 'stressor' to readily invade new areas and negatively impact the native plant and wildlife communities. Six Heartland Network parks listed exotic species as a high priority monitoring concern: ARPO, CUVA, GWCA, HOSP, HOCU, and LIBO. The Heartland Network exotic plant monitoring program will track (1) the status of known exotics/infestation areas and (2) incoming exotics/new infestation areas. Tracking known exotics and infestation areas will also incorporate information on ongoing park management control/eradication activities. Table 2.10 lists the most critical invasive exotic plant species identified by the Heartland Network parks.

Different exotic plant species react differently to herbicide applications or other control methods. Each exotic plant species must be viewed individually to find the best control method for that species. Climate, dispersal methods (i.e., wind, animals), and surrounding vegetation types also determine how exotic species thrive. For these reasons the following section addresses the parks' concerns in the context of individual exotic plant species.

This theme section on exotic plants also includes information on control methods being used in the park (Table 2.11), a brief description of natural and anthropogenic disturbances that impact exotic plants, and a list of relevant laws, regulations, and permitting that apply to exotic plants and monitoring at the local, state, or national levels.

Table 2.10 Exotic plant species identified as the most critical for some of the Heartland Network parks[1] and the relative level of concern for each species

Category	Scientific Name	Common Name	ARPO	CUVA	GWCA	HOSP	HOCU	LIBO
Trees and Shrubs	*Ailanthus altissima*	Tree-of-heaven		O			H	L
	Elaegnus umbellata	Autumn olive		H			O	O
	Ligustrum japonica	Common privet		L			M	O
	Ligustrum sinense	Chinese privet		O			O	O
	Lonicera tartarica	Tartarian honeysuckle		O			M	O
	Poncirus trifoliate	Trifoliate orange		O			O	O
	Prunus laurocerasus	Cherry laurel		O			O	O
	Rhamnus frangula	European buckthorn		H			O	O
	Rosa multiflora	Multiflora rose		H			H	M
Herbaceous	*Alliaria petiolata*	Garlic mustard		H			H	L
	Lespedeza cuneata	Chinese lesepdeza		O			O	O
	Lythrum salicaria	Purple loosestrife		H			O	O
	Phalaris arundinacea	Reed canary grass		H			O	O
	Phragmites australis	Giant reed grass		H			O	O
	Polygonum cuspidatum	Japanese knotweed		H			O	O
	Sorghum halepense	Johnson grass		O			M	O
Vines	*Dioscorea oppositifolia*	Chinese yam		O			O	H
	Lonicera japonica	Japanese honeysuckle		H			M	H
	Pueraria lobata	Kudzu		O			O	O
	Vinca minor	Periwinkle		O			M	M
	Vitis aestivalis	Summer grape		O			M	O

L = low concern
M = moderate concern
H = high concern
O = no/minimal concern

1 The parks included in this table are those that prioritized exotic plant monitoring within their park's top four priorities

2.4.5.1 Parks' Exotic Tree and Shrub Species Environmental Concerns at a Stressor Level

2.4.5.1.1 Ailanthus altissima (Tree-of-Heaven)

Hopewell Culture NHP

Resources at Risk: Archeologically significant mounds; native plant regeneration; natural plant succession.

Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks all lack spatial data. *A. altissima* has become established and is inhibiting native plant reproduction.

Assumptions: *A. altissima* will spread unless controlled.

Predictions: Public trails and other facilities will be an avenue of introduction of new species and extending other species distributions.

Monitoring objectives: A monitoring program needs to be established to track the presence and spread of known species on park lands and to identify locations of new points of colonization.

Monitoring questions:

- How do exotics modify habitat for other species?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect archaeology?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs?
- To what extent are new and old pest species invading?
- What is the distribution of selected exotic species?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- What is the extent before and after development and how does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If exotics are removed what plants replaces them?

2.4.5.1.2 Elaeagnus umbellata (Autumn-olive)

Cuyahoga Valley NP

Key resources at risk: Threatened and endangered rare plant species; native species, forest understory.

Observations: *E. umbellata* are fast-growing shrubs or small trees that grow up to 20 feet tall. *E. umbellata* can survive in very poor soils because of its nitrogen-fixing root nodules. It grows in disturbed areas, roadsides, pastures and fields throughout the park. It is an aggressive, invasive non-native plant that threaten native plant species.

Assumptions: Control of *E. umbellata* have not attempted yet.

Predictions: Without natural predators or controls, invasive non-native plants are able to spread quickly and force out native plants. Some invasive species may have progressed so far that controlling or elimination of the species will be difficult, time consuming and expensive.

Monitoring objectives: To control/minimize exotics in rare plant communities and wetlands. Overlay maps of invasives and native plant communities and determine overlap; plan removals in potentially sensitive areas. Assess impact of invasive removals on native plant community.

Monitoring questions:

- At what rate is the number and distribution *of E. umbellata* populations changing?

- Is *E. umbellata* displacing native species?
- Do increasing amounts of *E. umbellata* correspond to decreasing occurrence of rare/sensitive species?
- If *E. umbellata* is removed, will rare species increase in number or reproduction?

2.4.5.1.3 Prunus laurocerasus (cherry laurel)

Hot Springs NP

Resources at Risk: Trees
Observations: As residential lots are reclaimed by the park and buildings removed, *P. laurocerasus* begins rapid encroachment and then spreads to adjacent forest.
Assumptions: Cutting *P. laurocerasus* does not destroy it. In the past, Garlon was somewhat successful, but a cut stump application has to be used persistently to be effective.
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.5.1.4 Ligustrum japonica (common privet)

Arkansas Post NM

Resources at risk: Understory and forest regeneration.
Observations: *L. japonica* was mapped throughout all vegetation types and their ecotones at the park.
Assumptions: *L. japonica* is present in all units of the park.
Predictions: *L. japonica* will spread and displace native habitat unless controlled.
Monitoring Objectives: The monitoring objective of the park is to track the presence/absence and abundance of *L. japonica* within the park in all vegetation types biannually to determine the effectiveness of herbicidal eradication efforts. A biannual presence/absence-monitoring regime would delineate those plants missed from the initial attack and identify those areas that require another treatment. In addition, a two-year regime would detect exotic recruitment therefore allowing management to eliminate those plants prior to fruit dissemination.
Monitoring Questions:

- Did the removal of *L. japonica* and the subsequent application of herbicides effectively reduce/eliminate invasive exotic plant presence within the park?
- What is the biannual distribution/abundance over time?
- Is recruitment of the exotics being effectively controlled?
- Is *L. japonica* encroaching from adjacent private land, if so in which areas and at what rate of spread?
- Is recruitment of native flora increasing, decreasing, the same?

Hopewell Culture NHP

Resources at risk: Archeologically significant mounds, native plant regeneration, natural plant succession.
Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all data.
Assumptions: *L. japonica* is present in all units of the park.
Predictions: *L. japonica* will spread and displace native habitat unless controlled.
Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *L. japonica* on park lands and to identify locations of new points of colonization. The program also needs to be able to detect new species.
Monitoring questions:

- How do exotics modify habitat (e.g., bird species)?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect arch?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs in park?
- To what extent are pest species invading?
- What is the distribution of selected exotic species on park land?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- Are there new pest species showing up?
- What is the extent prior to public use development and following development? How does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If the exotics are removed what comes up in the exposed area?

2.4.5.1.5 Ligustrum sinense (Chinese Privet)

Arkansas Post NM

Resources at risk: Understory and forest regeneration.
Observations: *L. sinense* was mapped throughout all vegetation types and their ecotones at the park.
Assumptions:
Predictions:
Monitoring Objectives: The monitoring objective of the park is to track the presence/absence and abundance of *L. sinense* within the park in all vegetation types biannually to determine the effectiveness of herbicidal eradication efforts. A biannual presence/absence-monitoring regime would delineate those plants missed from the initial attack and identify those areas that require another treatment. In addition, a two-year regime would detect exotic recruitment therefore allowing management to eliminate those plants prior to fruit dissemination.
Monitoring Questions:

- Did the removal of privet and the subsequent application of herbicides effectively reduce/eliminate invasive exotic plant presence within the park?

- What is the biannual distribution/abundance over time?
- Is recruitment of the exotics being effectively controlled?
- Are invasive exotics encroaching from adjacent private land, if so in which areas and at what rate of spread?
- Is recruitment of native flora increasing, decreasing, the same?
- Boundaries: Biannual recruitment and regeneration of exotics by vegetation type at the park.

2.4.5.1.6 Lonicera tartarica (Tartarian Honeysuckle)

George Washington Carver NM

Resources at risk:
Observations:
Assumptions:
Predictions:
Monitoring objective:
Monitoring questions:

Hopewell Culture NHP

Resources at risk: Archeologically significant mounds; native plant regeneration; natural plant succession.
Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all data.
Assumptions: *L. tartarica* is very likely present in all units of the park.
Predictions: This species will continue to spread and displace native habitat unless controlled. Closure of overstory canopy will limit *L. tartarica* and reduce the extent.
Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *L. tartarica* on park lands and to identify locations of new points of colonization. The program also needs to be able to detect new species and allow the park to control new invasions in a timely and cost-effective manner.
Monitoring questions:

- How do exotics modify habitat (e.g., bird species)?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect arch?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs in park?
- To what extent are pest species invading?
- What is the distribution of selected exotic species on park land?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- Are there new species?

- What is the extent prior to public use development and following development? How does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If the exotics are removed what comes up in the exposed area?

Lincoln Boyhood NM

Resources at Risk:
Observations:
Assumptions:
Predictions:
Monitoring Objective:
Monitoring Questions:

2.4.5.1.7 Rhamnus frangula (European Buckthorn)

Cuyahoga Valley NP

Resources at risk: Threatened and endangered rare plant species; native species, forest understory.
Observations: *R. frangula* are fast-growing shrubs or small trees that grow up to 20 feet tall. *R. frangula* occurs in park wetlands, but it is also found in forests, edges, and old fields. This tree is aggressive, invasive non-native plants that threaten native plant species.
Assumptions: Chemical and mechanical treatments of *R. frangula* have temporarily slowed the spread of these plants.
Predictions: Without natural predators or controls, invasive non-native plants are able to spread quickly and force out native plants. Some invasive species may have progressed so far that controlling or elimination of the species will be difficult, time consuming and expensive.
Monitoring Objectives: To control/minimize exotics in rare plant communities and wetlands. Overlay maps of invasives and native plant communities and determine overlap; plan removals in potentially sensitive areas. Assess impact of invasive removals on native plant community.
Monitoring Questions:
- At what rate is the number and distribution of *R. frangula* populations changing?
- Is *R. frangula* displacing native species?
- Do increasing amounts of *R. frangula* correspond to decreasing occurrence of rare/sensitive species?
- If *R. frangula* are removed, do rare species increase in number or reproduction?

2.4.5.1.8 Poncirus trifoliate (trifoliate orange)

Arkansas Post NM

Key resources at risk: Understory and forest regeneration.

Observations: *P. trifoliate* was mapped throughout all vegetation types and their ecotones at the park.
Assumptions:
Predictions:
Monitoring Objective: The monitoring objective of the park is to track the presence/absence and abundance of *P. trifoliate* within the park in all vegetation types biannually to determine the effectiveness of herbicidal eradication efforts. A biannual presence/absence-monitoring regime would delineate *P. trifoliate* missed from the initial attack and identify those areas that require another treatment. In addition, a two-year regime would detect *P. trifoliate* recruitment therefore allowing management to eliminate those plants prior to fruit dissemination.
Monitoring Questions:

- Did the removal of *P. trifoliate* and the subsequent application of herbicides effectively reduce/eliminate invasive exotic plant presence within the park?
- What is the biannual distribution/abundance of *P. trifoliate* over time?
- Is recruitment of *P. trifoliate* being effectively controlled?
- Is *P. trifoliate* encroaching from adjacent private land, if so in which areas and at what rate of spread?
- Is recruitment of native flora increasing, decreasing, the same?

2.4.5.1.9 Rosa multiflora (Multiflora Rose)

Cuyahoga Valley NP

Key resources at risk: Threatened and endangered plant species; native species.
Observations: *R. multiflora* is a dense spreading shrub with widely arching canes and stiff, curved thorns. This shrub grows up to 15 feet tall and has numerous flowers that produces clusters of small, red fruits that are eaten by birds and mammals which help disperse the seeds. An individual plant can produce up to 500,000 seeds per year. *R. multiflora* was formerly planted as a "living fence" to control livestock, stabilize soil and create barriers for roadways. It has also been planted in the past as a wildlife cover and food source. This rose occurs in a wide range of habitats throughout the park, but prefers sunny areas and well drained soils.
Assumptions: Chemical and mechanical treatments of *R. multiflora* have not been attempted.
Predictions: Without natural predators or controls, invasive non-native plants are able to spread quickly and force out native plants. Some invasive species may have progressed so far that controlling or elimination of the species will be difficult, time consuming and expensive.
Monitoring Objectives: To control/minimize exotics in rare plant communities and wetlands. Overlay maps of invasives and native plant communities and determine overlap; plan removals in potentially sensitive areas. Assess impact of invasive removals on native plant community.
Monitoring Questions:

- At what rate is the number and distribution of *R. multiflora* populations changing?
- Is *R. multiflora* displacing native species?

- Has *R. multiflora* become naturalized?
- Do increasing amounts of *R. multiflora* correspond to decreasing occurrence of rare/sensitive species?
- If *R. multiflora* is removed, will rare species increase in number or reproduction?

Hopewell Culture NHP

Resources at risk: Archeologically significant mounds; native plant regeneration; natural plant succession.

Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all data.

Assumptions: *R. multiflora* is present at all units of the park.

Predictions: R. multiflora will continue to spread and displace native habitat unless controlled.

Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *R. multiflora* on park lands and to identify locations of new points of colonization.

Monitoring questions:

- How do exotics modify habitat (e.g., bird species)?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect arch?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs in park?
- To what extent are exotic species invading?
- What is the distribution of selected exotic species on park land? How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- Are there new exotic species?
- What is the extent prior to public use development and following development? How does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If the exotics are removed what comes up in the exposed area?

2.4.5.2 Parks' Exotic Herbaceous Species Environmental Concerns at a Stressor Level

2.4.5.2.1 Alliaria petiolata (garlic mustard)

Cuyahoga Valley NP

Resources at Risk: Threatened and endangered rare plant species; native species, forest understory.

Observations: *A. petiolata* is a biennial herb that can grow up to 4 feet tall. It produces large quantities of seed which can remain viable for seven years or more. It invades upland

and floodplain forests, yards, streams, trails and roadsides throughout the park. Maps of invasives in rare plant communities will be completed in 2003.

Assumptions: No chemical or mechanical treatments of *A. petiolata* have been attempted.

Predictions: Without natural predators or controls, invasive non-native plants are able to spread quickly and force out native plants. Some invasive species may have progressed so far that controlling or elimination of the species will be difficult, time consuming and expensive

Monitoring Objective: To control/minimize *A. petiolata* in plant communities. Overlay maps of *A. petiolata* and native plant communities and determine overlap; plan removals in potentially sensitive areas. Assess impact of *A. petiolata* removal on native plant community.

Monitoring Questions:

- At what rate is the number and distribution of *A. petiolata* populations changing?
- Is *A. petiolata* displacing native species?
- Do increasing amounts of *A. petiolata* correspond to decreasing occurrence of rare/sensitive species?
- If *A. petiolata* is removed, do rare species increase in number or reproduction?

Hopewell Culture NHP

Key resources at risk: Archeologically significant mounds; native plant regeneration; natural plant succession.

Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all data. The invasive status of *A. petiolata* makes it difficult to establish and maintain the preferred vegetation cover.

Assumptions: *A. petiolata* is present in all units of the park.

Predictions: *A. petiolata* will continue to spread and modify native habitat unless controlled.

Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *A. petiolata* on park lands and to identify locations of new points of colonization.

Monitoring questions:

- How do exotics modify habitat for other species?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect archaeology?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs?
- To what extent are new and old pest species invading?
- What is the distribution of selected exotic species?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- What is the extent before and after development and how does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If exotics are removed, what plants replaces them?

2.4.5.2.2 Lespedeza cuneata (Chinese lespedeza)

Hot Springs NP

Resources at Risk:
Observations:
Assumption:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.5.2.3 Lythrum salicaria (Purple Loosestrife)

Cuyahoga Valley NP

Resources at Risk: Threatened and endangered plant species; native species, wetlands.

Observations: *L. salicaria* is a popular garden flower that grows 3-7 feet tall and has a dense bushy growth of 1-50 stems. It spreads aggressively by underground rhizomes and can produce a million seeds per plant. It grows in a variety of wetland habitats including marshes, river banks, ditches, wet meadows, and edges of water bodies throughout the park. Loosestrife can invade both natural and disturbed wetlands, replacing native vegetation with nearly pure stands of loosestrife. It is of little habitat value. Maps of invasives in rare plant communities will be completed in 2003. Maps of invasives, including *L. salicaria* in wetlands has been completed.

Assumptions: Chemical and mechanical treatments of *L. salicaria* have temporarily slowed the spread of these plants. However, it is apparent that inconsistent, small-scale invasive plant control has not been able to keep pace with the spread of *L. salicaria*.

Predictions: Without natural predators or controls, invasive non-native plants are able to spread quickly and force out native plants. Some invasive species may have progressed so far that controlling or elimination of the species will be difficult, time consuming and expensive

Monitoring Objectives: To control/minimize *L. salicaria* in rare plant communities and wetlands. Overlay maps of *L. salicaria* and native plant communities and determine overlap. Plan removals in potentially sensitive areas. Assess impact of *L. salicaria* removals on native plant community.

Monitoring Questions:

- At what rate is the number and distribution of *L. salicaria* populations changing?
- Is *L. salicaria* displacing native species?
- Do increasing amounts of *L. salicaria* correspond to decreasing occurrence of rare/sensitive species?
- If *L. salicaria* is removed, will rare species increase in number or reproduction?

2.4.5.2.4 Phalaris arundinacea (Reed Canary Grass)

Cuyahoga Valley NP:

Resources at Risk: Threatened and endangered plant species; native species.

Observations: P. arundinacea is a large, coarse grass that reaches 2-5 feet in height and spreads by sprouting new shoots through underground rhizomes and by seed. It grows in wetlands, marshes, and streambanks throughout the park. Native strains possibly occur. Maps of invasives in rare plant communities will be completed in 2003. Maps of invasives in wetlands has been completed.

Assumptions: Chemical and mechanical treatments of *P. arundinacea* have temporarily slowed the spread of these plants. However, it is apparent that inconsistent, small-scale invasive plant control has not been able to keep pace with *P. arundinacea*.

Predictions: Without natural predators or controls, invasive non-native plants are able to spread quickly and force out native plants. Some invasive species may have progressed so far that controlling or elimination of the species will be difficult, time consuming and expensive

Monitoring Objectives: To control/minimize *P. arundinacea* in rare plant communities and wetlands. Overlay maps of *P. arundinacea* and native plant communities and determine overlap. Remove *P. arundinacea* in potentially sensitive areas. Assess impact of *P. arundinacea* removals on native plant community.

Monitoring Questions:

- At what rate is the number and distribution of *P. arundinacea* populations changing?
- Is *P. arundinacea* displacing native species?
- Do increasing amounts of *P. arundinacea* correspond to decreasing occurrence of rare/sensitive species?
- If *P.arundinacea is* removed, will rare species increase in number or reproduction?

2.4.5.2.5 Phragmites australis (Giant Reed Grass)

Cuyahoga Valley NP

Key resources at risk: Threatened and endangered plant species; native species.

Observations: P. australis, is a grass that reaches up to 15 feet in height and spreads forming huge colonies by sprouting new shoots through underground rhizomes. It grows in water areas of marshes, riverbanks and disturbed or polluted soils, often creating pure stands. It is possible that both native and non-native strains occur. Long term management is necessary for control of this persistent plant. Maps of invasives in rare plant communities will be completed in 2003. Maps of invasives in wetlands has been completed.

Assumptions: Chemical and mechanical treatments of *P. australis* have temporarily slowed the spread of these plants. However, it is apparent that inconsistent, small-scale invasive plant control has not been able to keep pace with *P. australis*.

Predictions: Without natural predators or controls, invasive non-native plants are able to spread quickly and force out native plants. Some invasive species may have progressed so far that controlling or elimination of the species will be difficult, time consuming and expensive

Monitoring Objectives: To control/minimize *P. australis* in rare plant communities and wetlands. Overlay maps of *P. australis* and native plant communities and determine overlap. Remove *P. australis* in potentially sensitive areas. Assess impact of *P. australis* removals on native plant community.

Monitoring Questions:

- At what rate is the number and distribution of *P. australis* populations changing?
- Is *P. australis* displacing native species?
- Do increasing amounts of *P. australis* correspond to decreasing occurrence of rare/sensitive species?
- If *P. australis is* removed, will rare species increase in number or reproduction?

2.4.5.2.6 Polygonum cuspidatum (Japanese knotweed)

Cuyahoga Valley NP

Key resources at risk: Threatened and endangered plant species; native species.

*Observation*s: *P. cuspidatum* is a shrub like herb that grows up to 10 feet tall. Once established it is spread by a system of underground rhizomes reaching 60 feet. It is found in open areas, such as roadsides, streambanks and woodland edges. It spreads quickly and forms dense thickets. It is very difficult to control. Maps of invasives in rare plant communities will be completed in 2003.. Maps of invasives in wetlands is completed. An inventory of *P. cuspidatum* along the Cuyahoga River and it's tributaries will be completed in 2003.

*Assumption*s: *P. cuspidatum* is known to invade riverbanks and other bare areas in the park. Since the species occurs mostly along the river, the impacts of large populations remaining established in the park are likely to be great on downstream areas.

Predictions: Completed inventories will provide a means to track the spread of the *P. cuspidatum* and determine efficacy of mitigation/control projects in the future.

Monitoring objectives: To control/minimize *P. cuspidatum* in rare plant communities and wetlands. Overlay maps of *P. cuspidatum* and native plant communities and determine overlap. Remove *P. cuspidatum* in potentially sensitive areas. Assess impact of *P. cuspidatum* removals on native plant community.

Monitoring questions:

- At what rate is the number and distribution of *P. cuspidatum* populations changing?
- Is *P. cuspidatum* displacing native species?
- Do increasing amounts of *P. cuspidatum* correspond to decreasing occurrence of rare/sensitive species?
- If *P. cuspidatum is* removed, will rare species increase in number or reproduction?

2.4.5.2.7 Sorghum halepense (Johnson grass)

Hopewell Culture NHP

Resources at risk: Archeologically significant mounds; native plant regeneration; natural plant succession.

Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all spatial data.

Assumptions: S. halepense is present in all units of the park.

Predictions: S. halepense will continue to spread and impact grassland restoration efforts.

Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *S. halepense* on park lands and to identify locations of new points of colonization.

Monitoring questions:

- How do exotics modify habitat for other species?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect archaeology?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs?
- To what extent are new and old pest species invading?
- What is the distribution of selected exotic species?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- What is the extent before and after development and how does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If exotics are removed what plants replaces them?

2.4.5.3 Parks' Exotic Vine Species Environmental Concerns at a Stressor Level

2.4.5.3.1 Dioscorea oppositifolia (Chinese yam)

Lincoln Boyhood NM

Resources at Risk: Midwestern forest tree species and associated shrubs and forbs. Other resources include faunal diversity and abundance that are dependent upon the composition, condition, and diversity of the forest vegetation.

Observations: *D. oppositifolia* is present only along the eastern edge of the North Forty area of the Memorial. Present extent is 1-2 acres horizontally and at the top of the current forest canopy vertically. The vine covers all vegetation and structures where present. The vine spreads rapidly via asexual reproductive bodies called bulbils which resemble tiny potatoes. Roots readily sprout from the bulbils.

Assumptions: The ground level and understory vegetation is out competed by *D. oppositifolia*.

Predictions: Without treatment, *D. oppositifolia* will continue to spread.

Monitoring Objectives: To detect the presence and spatial abundance *D. oppositifolia*. To provide data on the effectiveness of *D. oppositifolia* treatments. To utilize monitoring data to allow for adaptive management in the treatment of this species.

Monitoring Questions:

- What is the percent cover of *D. oppositifolia* at LIBO?
- What is the status of *D. oppositifolia* over time (increasing/decreasing abundance)?
- Are control efforts successful over time?
- What species will re-establish the affected area following treatment of *D. oppositifolia*?

2.4.5.3.2 Lonicera japonica (Japanese honeysuckle)

Cuyahoga Valley NP

Resources at risk: Threatened and endangered plant species; native plants.
Observations: *L. japonica* is a woody semi-evergreen vine that climbs and drapes over native vegetation, forming dense patches. It thrives in disturbed habitats, such as roadsides, trails, fencerows, abandoned fields and forest edges throughout the park. Disturbances such as road building, flooding and windstorms create an opportunity for this vine to invade native plant communities
Monitoring Objectives: To control/minimize *L. japonica* in rare plant communities and wetlands. Overlay maps of *L. japonica* and native plant communities and determine overlap. Remove *L. japonica* in potentially sensitive areas. Assess impact of *L. japonica* removals on native plant community.
Monitoring Questions:

- At what rate is the number and distribution of *L. japonica* populations changing?
- Is *L. japonica* displacing native species?
- Do increasing amounts of *L. japonica* correspond to decreasing occurrence of rare/sensitive species?
- If *L. japonica is* removed, will rare species increase in number or reproduction

Hopewell Culture NHP

Resources at risk: Archeologically significant mounds, native plant regeneration, natural plant succession.
Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all spatial data.
Assumptions: *L. japonica* is present in the Mound City Group unit of the park. Natural succession in forest areas may suppress the plant.
Predictions: Public trails and other facilities will be an avenue of introduction of new species and extending other species distributions.
Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *L. japonica* on park lands and to identify locations of new points of colonization.
Monitoring questions:

- How do exotics modify habitat for other species?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?

- What invasives attract nuisance animals that affect archaeology?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs?
- To what extent are new and old pest species invading?
- What is the distribution of selected exotic species?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- What is the extent before and after development and how does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If exotics are removed what plants replaces them?

George Washington Carver NM

Key resources at risk:
Observations:
Assumptions:
Predictions:
Monitoring objectives: Track *L. japonica* encroaching into the prairie. Determine where 'hot spots' or invasion corridors are located.
Monitoring questions:

- What is the rate of encroachment of *L. japonica* (time and place specific i.e. annual and which unit)?
- At what rate is *L. japonica* expanding or contracting?

Lincoln Boyhood NM

Resources at Risk: Midwest forest species of forbs, grasses, and trees.
Observations: L. japonica is an aggressive invader and a prolific reproducer. It persists in canopy gaps and is reduced in extent and presence under closed canopy conditions.
Assumptions: L. japonica cannot be completely eradicated from the Memorial.
Predictions: The initiation of prescribed fire in the fall of 2002 within the upland forests of the Memorial may actually increase the occurrence and density of *L. japonica* in the short term (2-5 years). Manual or chemical treatments will reduce *L. japonica* density.
Monitoring Objectives: Monitor the density and distribution of *L. japonica* over time. Determine if management actions are effecting the density and distribution of *L. japonica*.
Monitoring Questions:

- What is the density and distribution of *L. japonica* within LIBO over time?
- What are the effects of resource management actions on the density and distribution of *L. japonica* over time?

Arkansas Post NM

Resources at Risk: Understory and forest regeneration.
Observations:

Assumptions:
Predictions:
Monitoring Objective: To track the presence/absence and abundance of *L. japonica* within the park in all vegetation types biannually to determine the effectiveness of herbicidal eradication efforts.
Monitoring Questions:

- What is the biannual distribution/abundance of *L. japonica* over time?
- Is recruitment of *L. japonica* being effectively controlled?
- Is *L. japonica* encroaching from adjacent private land, if so in which areas and at what rate of spread?
- Is recruitment of native flora increasing, decreasing, the same?

2.4.5.3.3 Pueraria lobata (kudzu)

Hot Springs NP

Resources at Risk:
Observations: P. lobata rapidly encroaches reclaimed residential lots and buildings. It is destructive (kills other vegetation, especially trees) and obscures the landscape. Cutting does not eliminate *P. lobata*, however, chemical applications are somewhat successful. *P. lobata* is found in areas of disturbance.
Assumptions:
Predictions:
Monitoring Objectives:
Monitoring Questions:

2.4.5.3.4 Vinca minor (periwinkle)

Hopewell Culture NHP

Resources at Risk: Archeologically significant mounds; native plant regeneration; natural plant succession.
Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all spatial data.
Assumptions: V. minor is present in all units of the park.
Predictions: V. minor will continue to spread and modify natural habitat unless controlled.
Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *V. minor* and to identify locations of new points of colonization.
Monitoring Questions:

- How do exotics modify habitat for other species?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect archaeology?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs?

- To what extent are new and old pest species invading?
- What is the distribution of selected exotic species?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- What is the extent before and after development and how does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If exotics are removed what plants replaces them?

2.4.5.3.5 Vitis aestivalis (summer grape)

Hopewell Culture NHP

Key resources at risk: Archeologically significant mounds; native plant regeneration; natural plant succession

Observations: At Mound City Group and Hopewell Mound Group physical maps of exotics (size, location, # of plants) exist, but spatial data is lacking. Hopeton Earthworks, High Bank Works, and Seip Earthworks lack all spatial data.

Assumptions: *V. aestivalis* is present in all units of the park.

Predictions: *V. aestivalis* will continue to spread and modify native habitat unless controlled.

Monitoring objectives: A monitoring program needs to be established to track the presence and spread of *V. aestivalis* and to identify locations of new points of colonization.

Monitoring questions:

- How do exotics modify habitat for other species?
- What are the various mechanisms of dispersal?
- Which plants have the greatest impact on archaeology?
- What invasives attract nuisance animals that affect archaeology?
- What is the rate of spread of invasive species as visitor use increases?
- How to control invasives as restoration occurs?
- To what extent are new and old pest species invading?
- What is the distribution of selected exotic species?
- How does that change over time?
- What is the effectiveness of the control in the revegetation programs?
- What is the extent before and after development and how does it change?
- What is the regeneration (type and amount) in areas of exotics?
- If exotics are removed what plants replaces them?

2.4.5.4 Anthropogenic and Natural Disturbances Impacting Exotic Plants

Several anthropogenic and natural disturbances provide the driving force behind the stresses and park concerns previously discussed (Figure 2.10). The primary disturbances include:

- ✓ Park Management Decisions: Parks decide when, where and how to treat exotic plant species. Some treatments include mechanical removal, chemical applications, biological controls and fire.
- ✓ Precipitation: Drought and flood events both act as stressors on exotic plants.

2.4.5.5 Exotic Plant Control Methods used by the Heartland Network Parks

Natural stresses on exotic plants can be similar to other plants, including drought, flooding, excessively hot or cold temperatures, and so on. Common anthropogenic stresses involve management 'control' methods, including mechanical, chemical, biological, and prescribed fire. Each control method can be applied in various timing, frequency, and intensity. The results of which provide various success rates. One aspect of exotic plant monitoring in the Heartland Network will provide long-term information on the success rates of park management control activities. Table 2.11 includes a summary of current management practices and outcomes.

Table 2.11 Exotic plants control methods used by park managment in the Heartland Network parks

Scientific Name	Common Name	Mechanical (Removal)	Chemical Application	Prescribed Burning	Results
		Methods/Timing	Methods/Timing	Methods/Timing	
Elaegnus umbellate	Autumn olive				
Ligustrum japonica	Common privet		HOCU; Round-up		
Ligustrum sinense	Chinese privet				
Lonicera tartarica	Tartarian honeysuckle		HOCU; Round-up		
Poncirus trifoliate	Trifoliate orange				
Prunus laurocerasus	Cherry laurel				
Rhamnus frangula	European buckthorn	CUVA	CUVA		
Rosa multiflora	Multiflora rose	HOCU; Pulling			
Alliaria petiolata	Garlic mustard	HOCU; Pulling			
Lespedeza cuneata	Chinese lesepdeza				
Lythrum salicaria	Purple loosestrife	CUVA	CUVA		

Phalaris arundinacea	Reed canary grass				
Phragmites australis	Giant reed grass	CUVA	CUVA		
Polygonum cuspidatum	Japanese knotweed				
Sorghum halepense	Johnson grass				
Dioscorea oppositifolia	Chinese yam				
Lonicera japonica	Japanese honeysuckle				

Scientific Name	Common Name	Mechanical (Removal)	Chemical Application	Prescribed Burning	Results
		Methods/Timing	Methods/Timing	Methods/Timing	
Pueraria lobata	Kudzu				
Vinca minor	Periwinkle				
Vitis aestivalis	Summer Grape				

2.4.5.6 Relevant Laws and Regulations

Local, state, and federal laws, permitting requirements, and so on that will regulate or influence monitoring program decisions and actions were identified by the parks that identified plant community monitoring as a high priority within the I&M program. This information is summarized up in Table 2.12.

Table 2.12 Local, State, and Federal Laws Relevant for Exotic Plant Monitoring

Laws		CUVA	GWCA	HOCU	LIBO
Local	Burning permits				X
State	State listed T&E or special concern	X	X	X	X
	State exotic species laws	X	X	X	X
Federal	Herbicide and protocol; Safety requirements	X	X	X	X
	Invasive Species Executive Order - 1999	X	X	X	X
	IPM requirements/ approval	X	X	X	X
	National Environmental Policy Act	X	X	X	X
	Natural Resources Management Guidelines	X	X	X	X
	NPS Management Policies (2001) section 4.4.4	X	X	X	X

2.4.6 Other Monitoring Concerns Not Within a Theme

The Heartland Network spans a large area of the central USA. As such, it includes a large diversity of soil types and soil related issues. ARPO is concerned about soil erosion because some of the park's historical artifacts are comprised of soil materials, most notably the Civil War Rifle Pits and Indian Mounds. This section on soils provides specific information on the Heartland Network parks' environmental concerns at the 'ecological effects' and 'stressor' levels. Both levels of information are necessary before a linkage can be hypothesized between a stress and effect.

Ecological effects level:

- loss of soil.

Stressor level:

- recreation and
- vegetation.

2.4.6.1 Park's Soil Environmental Concerns at an Ecological Effect Level

2.4.6.1.1 Soil loss

Exposed soil resources can be transported away from their original site via wind or water. The amount and rate of soil loss varies and can be measured. Or the loss can generally be ameliorated with replacement of vegetative cover over the soil.

Arkansas Post NM

Resources at Risk: Civil War Rifle Pits, Indian Mounds, and archeological resources

Observations: Cultural resources at the park such as the Civil War Rifle Pits and Indian mounds are currently forested. Several fishing areas also exist at the Memorial Unit and are heavily utilized; significant footpaths have resulted from this use. Consequently, park management is concerned that erosion may be occurring in these areas. Datasets: Arkansas Post National Memorial's classified base map, which includes both park units, will be able to provide extant conditions of landscapes within the park thereby providing a baseline for monitoring efforts.

Assumptions: The Indian mounds and Civil War Rifle Pits are presumed to be eroding. Because of this, archeological resources can be destroyed.

Predictions: Erosion of both cultural and natural resources is a well-documented fact at Arkansas Post National Memorial. It has the potential to destroy and/or degrade the significance of the site as well as extant landscapes thereby altering other resources such as the flora and fauna.

Monitoring Objectives: Monitoring objectives are to track erosion in specified areas (e.g., Fishing areas, Visitor Center Pond, Civil War Rifle Pits and Indian Mounds) on an annual basis.

Monitoring Questions:

2.4.6.2 Park's Soil Environmental Concerns at a Stressor Level

2.4.6.2.1 Recreation

Recreational fishing can result in trampling of vegetation both along shoreline areas and trails leading to and from aquatic areas. Ultimately creation of trails leads to reduction in vegetation cover that protects the underlying soil resource.

Arkansas Post NM

Resources at Risk: Archeological resources

Observations: Several fishing areas exist at the Memorial Unit. These are heavily utilized and significant footpaths have resulted from this use. Park management is concerned that erosion may be occurring in these areas due to visitor use.

Assumptions Fishing areas at the Memorial Unit are heavily utilized. If semi-permanent accommodations are made, utilization is expected to increase possibly further affecting the resources in those areas. Determination of use areas as well as the amount and type of use for each designated area will need to be decided upon. Designated areas may need to be addressed differently depending upon soil type, topography, and other factors.

Predictions: Erosion of both cultural and natural resources is a well-documented fact at Arkansas Post National Memorial. It has the potential to destroy and/or degrade the significance of the site as well as extant landscapes thereby altering other resources such as the flora and fauna.

Monitoring Objectives: Monitoring objectives are to track erosion in specified areas (e.g., Fishing areas, Visitor Center Pond) and determine the cause of the soil loss/erosion.

Monitoring Questions:

2.4.6.2.2 Vegetation

Roots of vegetation reach down into the soil substrate for nutrients and water. The depth of penetration depends on the type of vegetation. For most tree species the majority of roots are in the top 18 inches of the soil and extend out to the width of the tree crown. Dead trees underground roots may uplift soil when the above ground biomass tips over. The result is a disruption to the soil substrate. Grass root systems generate extensive underground biomass.

Arkansas Post NM

Resources at Risk: Civil War Rifle Pits and Indian Mounds

Observations: Cultural resources at the park such as the Civil War Rifle Pits and Indian mounds are currently forested. Park management is concerned that erosion may be occurring in these areas due to the existence of trees.

Assumptions The Indian mounds and Civil War Rifle Pits are presumed to be eroding due to the existence of trees. As these trees age, or because of extreme climatic events, they become susceptible to disease and uprooting. Because of this, archeological resources can be destroyed. A covering of grass may better protect these areas by decreasing root damage and by eliminating the possibility of trees root wadding.

Designated areas may need to be addressed differently depending upon soil type, topography, and other factors. Appropriate grass species will also need to be selected for some areas as determined by soil, elevation, shade, etc.

Predictions: Erosion of both cultural and natural resources is a well-documented fact at Arkansas Post National Memorial. It has the potential to destroy and/or degrade the significance of the site as well as extant landscapes thereby altering other resources such as the flora and fauna.

Monitoring Objectives: Monitoring objectives are to track erosion in specified areas (e.g., Civil War Rifle Pits and Indian Mounds), determine the cause of the soil loss/erosion, and track erosion in grassy areas of similar structure and makeup on an annual basis.

Monitoring Questions:

- Are trees causing cultural resources to erode at the park over time?
- Is grass a better soil protector than trees?
- Given geographical location, soil makeup, and climatic conditions, is erosion significantly slowed or deterred over time in an area covered with grass versus one covered with trees?

2.4.7 Land Use Change Theme

Land use change is a common theme among many parks and seven – ARPO, CUVA, HEHO, HOSP, LIBO, OZAR and PERI – have identified it as one of their top four monitoring issues. ARPO is concerned primarily about the influence of agricultural practices on the park, particularly in relation to pesticide spraying. CUVA is located adjacent to Cleveland and Akron and faces many issues related to urban sprawl. HEHO's environment is dominated primarily by agriculture; shifts in these practices show a concurrent change in the landscape. HOSP is focused on maintaining water quality of the springs – current changes in land use threaten this on multiple fronts. LIBO is located in a region that is quickly changing from a rural to urbanized/industrialized setting. OZAR's problems individually are small – some mining, logging, agriculture, tourism and urbanization– but cumulatively threaten its aquatic resources. PERI, as are many of the southern parks, is found in a rapidly growing region of Arkansas and is only beginning to manage many of the issues that parks on the urban front already face.

Land use change is unique among the monitoring themes because it places local park concerns within the context of a larger landscape, thereby discussing outside influences on park natural resources. Instead of focusing on concern-stressor relationships, this section focuses on stressor-disturbance connections. By taking a larger view, it is possible to link environmental concerns to the driver, thus making the monitoring program more comprehensive and meaningful.

Therefore, section 2.4.7 moves up one step from previous sections. Instead of focusing on natural resource concerns (effects), section 2.4.7.2 focuses on the identified stressors. In addition to the parks' stressors, this section includes a summary of disturbances impacting the parks with park-specific information related to the stress. In addition, a brief description of the 'super-disturbances', which ultimately explain changes in the disturbances, are outlined. Section 3.1 will expand on this information through the development of ecosystem conceptual models.

This section addresses the following stressors:

- Air Pollution (Point and Non-Point Sources)
- Exotic Plant Species
- Noise
- Habitat Loss
- Headwater Stream Removal
- Riparian Buffers
- Soil Destabilization and Erosion
- Urban Structures
- Water Consumption
- Water Pollution (Point and Non-Point Sources)

These stressors are influenced by a number of disturbances, including:

- Agriculture
- Forestry
- Mining
- Recreation
- Urbanization

This section concludes with a list of applicable relevant laws, regulations, and permitting that apply to land use at the local and state levels.

2.4.7.1 Park's Land Use Change Ecological Concerns at a Stressor Level

Each of these stressors is outlined in more detail for each of the parks.

2.4.7.1.1 Air Pollution - Non-Point Source

Non-point source air pollution is an important stress on plant and animal communities. Non-point sources most frequently are from automobile emissions, although other miscellaneous machinery might be included as potential sources. High ozone levels can damage plant foliage and oxidize lung tissues of animals. Lowered pH from SO_x emissions can lower water pH levels of precipitation.

Lincoln Boyhood NM

Resources at Risk: Midwestern forest tree species and associated shrubs and forbs (Section 2.4.4). Other resources are faunal diversity (not identified for monitoring as an environmental concern) and abundance that are dependent upon forest vegetation.

Observations: LIBO has 110 acres of forest containing diverse flora and fauna assemblages. Urbanization and industrialization is rapidly occurring within southern Indiana and there is increased traffic from automobiles and rail use. Currently, plans exist to expand and re-align Highway 231. No air quality monitoring of the county is being done by federal or state agencies.

Assumptions: Increases of non-point air pollution is often a result of increased urbanization. This may be from increased traffic, utilities, and/or industries. These increases may be a detriment to forest flora and fauna.

Predictions: At LIBO, the impacts of current land use trends and development within and surrounding Spencer County are expected to increase air pollution beyond already high concentrations from existing industries. This pollution will be a detriment to park flora and fauna.

Monitoring Objectives: Monitor air pollution associated with point and non-point sources.

Monitoring Questions:

- How much and what type of land use changes are occurring with the surrounding area?
- What are the levels and composition of air pollutants at LIBO?
- Are levels of air pollutants increasing at LIBO?

2.4.7.1.2 Air Pollution - Point Source

Point-sources of pollution can release similar constituents found in the non-point sources, although heavy metals, including lead and mercury, may be more pronounced. Air pollution from factories and power utilities may affect animal populations though lead and mercuric poisoning.

Arkansas Post NM

Resources at Risk: Human health; plant (Section 2.4.4) and animal communities (not identified for monitoring as environmental concern).

Observations: Agricultural aerial overspray occurs at ARPO. Agriculture is an important point-source of air pollution.

Assumptions:

Predictions: Changes are expected to occur seasonally and by year, due to crop rotation and types of chemicals used.

Monitoring Objectives: Monitor air pollution levels associated with chemicals

Monitoring Questions:

- Does overspray of pesticides, herbicides, and fertilizer occur within the park on a seasonal and annual basis?
- What amounts of each type of over spray occurs seasonally and annually?
- Do pesticides and fertilizers pose health risks to visitors and employees?
- What is the seasonal and annual presence/absence and amounts of pesticides, herbicides and fertilizers within all vegetation types at the park?

Lincoln Boyhood NM

Resources at Risk: Midwestern forest tree species and associated shrubs and forbs (Section 2.4.4). Other resources are faunal diversity (not identified for monitoring as an environmental concern) and abundance that are dependent upon the composition, condition, and diversity of forest vegetation.

Observations: LIBO has 110 acres of forest containing diverse flora and fauna assemblages. Urbanization and industrialization is rapidly occurring within southern Indiana and there is increased traffic from automobiles and rail use. Currently, plans exist to expand and re-align Highway 231. No air quality monitoring of the county is being done by federal or state agencies. A lichen inventory in 1990 was conducted to provide a baseline for future studies.

Assumptions: Increases of non-point air pollution is often a result of increased urbanization. This may be from increased traffic, utilities, and/or industries. These increases may be a detriment to forest flora and fauna.

Predictions: At LIBO, the impacts of current land use trends and development within and surrounding Spencer County are expected to increase air pollution beyond already high concentrations from existing industries. This pollution will be a detriment to park flora and fauna.

Monitoring Objectives: Monitor air pollution associated with point and non-point sources

Monitoring Questions:

- How much and what type of land use changes are occurring with the surrounding area?
- What are the levels and composition of air pollutants at LIBO?
- Are levels of air pollutants increasing at LIBO?

2.4.7.1.3 Exotic Plant Species

Exotic plant species stress both plant and animal communities. Exotics compete for water, space, nutrients and solar radiation, thereby disrupting native communities. Changes in plant communities can disrupt food supplies and habitats for various native fauna. Exotic plant species are often introduced by urban landscaping, although agricultural practices are important sources as well.

Cuyahoga Valley NP

Resources at Risk: Riparian corridors, wetlands (Section 2.4.2) and rare plant communities

Observations: CVNP protects 32,943 acres along the Cuyahoga River between Cleveland and Akron, Ohio. The park is surrounded by a fragmented, rapidly developing landscape, which in the past was largely agricultural. The landscape is a mosaic of second growth forests, fields and urban developments. It is one of the largest remaining tracts of forested area in northeastern Ohio. Internally, there is park development, agricultural use, mixed land ownership and road maintenance. Externally, there are utility corridors, suburban development, and agricultural practices. Over the last 27 years, the landscape surrounding the park has become increasingly urbanized while the park has evolved to more natural conditions, remaining a relatively undeveloped, pastoral valley. LTEM vegetation monitoring found that the top three most encountered plants in the herbaceous layer are exotic species.…

Assumptions: Increased urbanization is introducing more exotic plant species to CUVA.

Predictions: It is reasonable to expect that the park will always be exposed to a variety of pressures from non-native plant species, both from within and outside of our boundary. Eight hundred and twenty seven species of vascular plants, of which 18% are non-native, have been documented as occurring in CUVA (Andreas 1986).

Monitoring Objective: Monitor exotic plant species associated with urbanization

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- Is adjacent land use acting as a barrier for colonization/migration, or decreasing the effective size of habitat areas?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed animal population trends and vegetation community structure and age?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?

- How does the land use change inside and outside the park compare to the region as a whole?
- What are the relative ages of forests in CUVA and how does that relate to long term monitoring data collected in those areas?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

Herbert Hoover NHS

Resources at Risk: Native plant communities (Section 2.4.4)

Observations: Tartarian honeysuckle (*Lonicera tatarica*) has spread from ornamental park plantings and nearby residential yards. Exotic plant species are encroaching onto the park prairie and within the stream riparian area. Notable exotic species were introduced, including smooth brome (*Bromus inermis*) and other cool season exotic grasses in waterways between agricultural fields. Smooth brome is now spreading into the prairie from neighboring fencerows. Exotic species are concentrated in rills and the creek, which drain agricultural land.

Assumptions: Neighboring land can provide the seed bank for exotic species invasion into the park. Cultural landscape plantings on the park are also a source of invasive species.

Predictions: Land use outside of the park will continue to impact the natural areas of the park. Limiting the use of non-native cultural landscape species in the park will reduce the threat of intrusion into natural areas.

Monitoring Objective: Monitor exotic species associated with agricultural practices and cultural landscape.

Monitoring Questions:

- Is there a change in relative abundance of cool season waterway vs. warm season waterway cover?
- How does change in land use affect the rate and type of exotic intrusion?
- What are the trends for growth and development? Do the land use change trends pose additional threats from invasive plants, increased runoff, and pesticide drift?
- Will changes in land use curtail the use of prescribed fire or other management practices in the park?
- Will replacement of cultural landscape species, particularly those known to be invasive, with native or non-invasive species reduce the rate and composition of exotic intrusion?

Lincoln Boyhood NM

Resources at Risk: Native plant communities (Section 2.4.4).

Observations: Non-native plantings from adjacent properties can spread to LIBO.

Assumptions*:* The urbanization around LIBO could introduce more exotic species through nurseries or the immigration of people who bring with them non-native species.

Predictions: If urbanization occurs directly adjacent to the park, more exotic species will become established within the Memorial.

Monitoring Objectives: Monitor park boundaries for the establishment of exotic species.

Monitoring Questions:

- Are new exotic species becoming established in the park?
- What are the sources of new exotic species establishments within the park?

Pea Ridge NMP

Key Resources at Risk: Native plant communities (Section 2.4.4).
Observations: The urbanization around PERI is introducing more exotic species through nurseries or the immigration of people who bring with them non-native species for use in their garden.
Assumptions: The recent urbanization within northwest Arkansas is bringing more exotic species that are introduced through nurseries or the immigration of people who bring with them foreign species.
Predictions:
Monitoring Objective: Monitor exotic species associated with urbanization
Monitoring Questions:

- What is the rate of change of urban areas?
- How is the adjacent land use changing?
- What is the change in land use over 20 year periods?
- Historically, what was the overstory composition and extent?

2.4.7.1.4 Noise

Noise comes from various machinery, including automobiles, all-terrain vehicles, farm machinery, factories, and airplanes. Noise can scare and chronically agitate animals, thereby disrupting breeding and eating patterns.

Lincoln Boyhood NM

Resources at Risk: Native wildlife populations (not identified for monitoring as environmental concern).
Observations: The industrial boom near LIBO is forcing the state to widen and re-align Highway 231 to within a mile of the park boundary. In addition, railroad traffic has increased along lines that pass through LIBO.
Assumptions: Urbanized areas have increased noise levels associated with increased traffic and a decrease in total vegetation (i.e. vegetation noise buffers).
Predictions: Vehicular and rail traffic is expected to mirror any further development within southern Indiana. Noise levels are projected to increase upon completion of the proposed freeway and other surrounding development. The impacts of current land use trends and development within and surrounding Spencer County are expected to be increased visitation, traffic and noise. The potential impacts to the natural resources of LIBO are unknown but could include reductions in the natural quiet and increased resource destruction from visitation/use.
Monitoring Objective: Measure the effectiveness of the current vegetative buffers and provide an indication of how much buffer is needed to maintain quiet.
Monitoring Questions:

- How much and what type of land use changes are occurring with the surrounding area?
- What changes occur in the noise levels at LIBO over time?

Pea Ridge NMP

Resources at Risk: Wildlife communities (Section 2.4.4), visitor enjoyment (not identified for monitoring as environmental concern).

Observations: PERI is located next to a major truck route, Highway 62, which connects the Wal-Mart headquarters in Bentonville, AR with eastern markets. Thousands of people visit the park on an annual basis. Urbanized areas have higher noise levels as a result of more traffic and a decrease in total vegetation, which serves as a noise buffer.

Assumptions :

Predictions: A proposed freeway will connect Kansas City to Shreveport. This freeway will increase the presence of automobile noise and lead to further economic development of northwest Arkansas. Increased development around the park will increase the number of connecting trails (and visitors) in PERI, which will also increase noise levels.

Monitoring Objective: Monitor noise levels in sensitive wildlife locations

Monitoring Questions:

- What is the rate of change of urban areas?
- How is the adjacent land use changing?
- Where and how many and what type of roads are being built?
- What is the change in land use over 20 year periods?

2.4.7.1.5 Habitat Loss

A loss of habitat is a large-scale stress that affects both plant and animal communities. Habitat loss can remove important migration corridors, restrict access to food supplies, and separate breeding populations. In some cases, predation and parasitism increases from a change in boundaries (e.g., cowbirds).

Cuyahoga Valley NP

Resources at Risk: Migration corridors (not identified for monitoring as environmental concern).

Observations: Internally, there is park development, agricultural use, mixed land ownership and road maintenance. External to CUVA, there are utility corridors, suburban development, agricultural practices and mineral extraction. The park is surrounded by a fragmented, rapidly developing landscape, which in the past was largely agricultural. The landscape is a mosaic of second growth forests, fields and urban developments. It is one of the largest remaining tracts of forested area in northeastern Ohio. Land cover maps and indices of land use change derived from a 2003-4 project, "Assessing Land Use Cover Change and it's Affects on the Natural and Cultural Resources of CVNP" would enable researchers and resource managers at CUVA to better understand the influence of land use and land cover on populations of all monitored wildlife including white-tailed deer, beaver, coyote, songbirds, owls, raptors, great blue heron, amphibians, and lepidopterans. This knowledge would be helpful in modeling and predicting affects of development around the park, of park management activities, and other disturbances on the population, reproduction, distribution and diversity of wildlife. Datasets: cover classification using 1994, infrared transparencies taken in 2000 by the USFS, and color digital orthophotography covering two-thirds of the park (Summit County) created from 1:500 scale photography at 6 inch pixel are being digitized and examined to determine indices of land use changes in the park.

Assumptions: Habitat corridor loss may be a result from increased urbanization and changes in land use surrounding the park

Predictions: Land use changes adjacent to park boundaries may continue until the impacts resulting from it can be identified and analyzed using a regional context and watershed approach.

Monitoring Objective: Monitor changes in land use that result in loss of important habitat corridors.

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- Is adjacent land use acting as a barrier for colonization/migration, or decreasing the effective size of habitat areas?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed animal population trends and vegetation community structure and age?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- What are the relative ages of forests in CUVA and how does that relate to long term monitoring data collected in those areas?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

2.4.7.1.6 Headwater Stream Removal

A loss of headwater streams can significantly alter stream hydrology, there by affecting river flow volume and aquatic habitat. Headwater streams are frequently lost through urbanization and agricultural practices.

Cuyahoga Valley NP

Resources at Risk: Watersheds, headwater streams, riparian corridors, and wetlands (Section 2.4.2).

Observations: CUVA is surrounded by a fragmented, rapidly developing landscape, which in the past was largely agricultural. The landscape is a mosaic of second growth forests, fields and urban developments. Internally, there is high visitor use, park development, agricultural use, mixed land ownership and road maintenance. External to the park are utility corridors, suburban development, agricultural practices and mineral extraction. Over the last 27 years, the landscape surrounding the park has become increasingly urbanized while the park has devolved to more natural conditions, remaining a relatively undeveloped, pastoral valley. The preservation of watershed, riparian, and associated stream ecosystems is a fundamental part of CUVA's enabling legislation (PL 93-555), to preserve and protect "…for public use and enjoyment, the historic, scenic, natural and recreational values of the Cuyahoga River and the adjacent lands of the Cuyahoga Valley…." Water resources are the most significant natural resource in CUVA and are fundamental to the park's ecosystem. One main goal of the park's Resources Management Plant (RMP 1999) is to maintain or improve water quality in the river, streams and other surface waters so that healthy aquatic ecosystems are restored, human health is protected, and visitor experiences enhanced. These headwater streams are the origins of the many tributaries to the Cuyahoga and the condition of them is unknown. Primary headwater streams should be inventoried, monitored and afforded protection as important components of the ecosystem Long term monitoring of chemical, physical and biological parameters have been in place for the Cuyahoga River, streams and ponds since the mid 1980's. Future monitoring will include wetlands and primary headwater habitat streams

Assumptions: Impacts to aquatic resources via land use changes such as agriculture and urban/suburban development can result in habitat degradation such as channelization of streams and destruction of riparian buffers. Hydro-modification is now the leading source of impairment of Ohio streams and is the origin of habitat degradation and sedimentation problems that are causes of impairment of Ohio's streams. Cumulative effects of such impacts over a large area and over time can be substantial. Park water quality data has not been correlated to the larger landscape level changes that have occurred over the past 25 years. This Land Use Cover project would provide a vital layer of needed information to relate the changes in water quality to changes in land cover over time.

Predictions: This inventory and subsequent long term monitoring of headwater streams will provide information that can be used to detect early signs of watershed degradation or sources of degradation. The park should make every effort to identify, monitor and protect high quality, primary headwater streams and to educate neighbors and partners in the importance of this aquatic resource. Land use and land cover maps will give us a broader understanding of cumulative changes in the watershed and sub-watersheds in and surrounding park boundaries

Monitoring Objective: Inventory and Monitor headwater streams

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- Is adjacent land use acting as a barrier for colonization/migration, or decreasing the effective size of habitat areas?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?

- How does this change correlate to observed animal population trends, vegetation community structure and age, and water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

2.4.7.1.7 Riparian Buffers

Riparian buffers are important stressors for aquatic and terrestrial systems. Riparian buffers help prevent erosion, filter nutrients and pollutants, and protect waterways from direct sunlight. In addition, riparian buffers offer important habitat for various riparian flora and fauna.

Cuyahoga Valley NP

Resources at Risk: Watersheds, headwater streams, riparian corridors and wetlands (Section 2.4.2).

Observations: CUVA is surrounded by a fragmented, rapidly developing landscape, which in the past was largely agricultural. The landscape is a mosaic of second growth forests, fields and urban developments. It is one of the largest remaining tracts of forested area in northeastern Ohio. Internally, there is high visitor use, park development, agricultural use, mixed land ownership and road maintenance. External to CUVA are utility corridors, suburban development, agricultural practices and mineral extraction. Over the last 27 years, the landscape surrounding the park has become increasingly urbanized. The objective of most ecological monitoring is to determine whether long-term changes are occurring in various ecosystem components. Because all ecosystems are dynamic and change through time in the absence of human intervention, managers are particularly interested in whether observed changes are in a "negative" direction (e.g., implying degradation), and can be attributed to specific management activities.

Assumptions: There is removal or inadequate riparian and wetland buffers within the park as well as in surrounding urban developments.

Predictions:

Monitoring Objective: Monitor the ecological conditions in wetlands and riparian areas to determine if established buffer zones are deteriorating, and deteriorating conditions are due to park management practices (e.g., agriculture and inadequate buffers) rather than some park-wide (e.g., regional) phenomenon.

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- Is adjacent land use acting as a barrier for colonization/migration, or decreasing the effective size of habitat areas?

- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed animal population trends, vegetation community structure and age, and water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

2.4.7.1.8 Soil Destabilization and Erosion

Unstable soils are important stressors on aquatic and terrestrial systems. Sediment loading can increase turbidity, change stream morphology, and increase nutrients. A loss of nutrient-rich soils also diminishes the quality of the growing environment for terrestrial flora.

Cuyahoga Valley NP

Resources at Risk: Watersheds, headwater streams, riparian corridors, and wetlands (Section 2.4.2).

Observations: The river basin is a broad, flat floodplain subject to inundation at varied frequencies. The basin width varies from 500 feet to 5000 feet and is composed of glacial and post-glacial deposits. The majority of the slopes in the park are 25% or steeper, and occur mostly in the northern portion of the park and all the tributaries (McCormick 1975). In addition to human-induced erosion in the basin, there is a large natural, or background, erosion problem within the Cuyahoga watershed. Accelerated in-filling of lakes and reservoirs presents an ongoing problem. The average annual sediment load passing one of the river gauging stations is estimated to be 381,000 tons, of which 235,000 tons are in suspension and 146,000 tons are in the form of bedload. Dredging of the navigation channel at the mouth of the river occurs annually (Cuyahoga RAP Stage One 1991). Internally, there is high visitor use, park development, agricultural use, mixed land ownership and road maintenance. *Assumptions*: Increased rates of erosion are resulting from urbanization and land use changes in the watershed.

Predictions: Erosion and sedimentation will continue to increase as impervious surfaces increase.

Monitoring Objective: Monitor land use changes to provide early signs of watershed degradation caused by accelerated erosion rates.

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed water quality?

- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

Hot Springs NP

Resources at Risk: Physical and chemical water quality of springs and rivers (Section 2.4.2).

Observation: Mining has resulted in the excavation of soils and increased erosion from the lack of roots to stabilize the soils and increased erosivity by direct rainfall. The narrow valleys surrounding HOSP have seen significant development and the toes of mountains have often been removed for the creation of new structures and parking lots. These locations have shown signs of erosion and have occasionally failed. Urbanization often results in the removal of soil, which can destabilize soils and make them more prone to erosion.

Assumptions:

Predictions:

Monitoring Objective: Monitor soil stability and erosion rates in areas where urbanization and mining are occurring.

Monitoring Questions:

Ozark NSR

Resources at Risk: Physical habitat quality of the rivers.; biota that are dependent upon these habitats

Observations: Panfil and Jacobson 2001 note that tributary sedimentation effects to larger streams in the Current River region of the Ozarks are positively correlated with the slope of the watershed, and negatively correlated to the amount of cleared land in the riparian corridor.

Assumptions: Land use clearing on the steeper eastern watersheds of the Current River would result in the highest potential input of gravel.

Predictions: Portions of the mainstem river downstream from these tributaries will receive more gravel input, which if large enough, could serve to increase lateral migration of the riverbanks, widen the river channel, and increase water temperatures.

Monitoring Objective: Monitor channel cross sections and tributary mouths to track gravel loading.

Monitoring Questions:

Are there changes in catchment land use practices by tributary through time?

How fast is the gravel wave migrating down river?

2.4.7.1.9 Surface Permeability

Surface permeability is a leading stressor on aquatic systems. Changes in surface permeability influence both the amount and timing of overland storm runoff. Because precipitation is partitioned between runoff and infiltration, higher runoff rates result in less infiltration and lowered groundwater levels. Overland runoff, which moves through a hydrologic system at a faster rate than subsurface flow, can overwhelm drainage networks with heightened flood peaks. Changing flood regimes can scour and erode aquatic and terrestrial habitats.

Cuyahoga Valley NP

Resources at Risk: Watersheds, headwater streams, riparian corridors, and wetlands (Section 2.4.2)

Observations: The Ohio EPA reports that the analysis of the effects of urban land use on biological communities in the Cuyahoga River basin showed strong negative correlations between increasingly impervious watersheds and biological health (Yoder et al 1999). The effects of imperviousness and associated cofactors (e.g., urban runoff, altered hydrology) may be offset by land use practices. Biological impacts were exacerbated in basins subject to additional stressors such as CSOs, SSOs, concentrated urban/industrial land usage or habitat alterations. Conversely, sub-basins with estate-type residential watersheds and intact physical habitats maintained comparatively good biological quality, even at higher levels of urbanization thus emphasizing the importance of maintaining natural features within a watershed including in-stream habitat, wooded riparian buffers and green space. CUVA is surrounded by a multitude of land uses such as utility corridors, suburban development, agricultural practices and mineral extraction.

Assumptions: Impervious surfaces will continue to increase surrounding the park unless urban sprawl is examined on a regional or watershed level.

Predictions: Impacts to biological health will continue to be exacerbated until stressors are mitigated or eliminated.

Monitoring Objective: Measure land use changes and how they affect surface permeability within the watershed.

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

Herbert Hoover NHS

Resources at Risk: Historic buildings adjacent to Hoover Creek; riparian zone (Section 2.4.2).

Observations: Within Hoover Creek watershed there are a variety of agricultural practices including the use of tiles to channel water off fields, the removal of the tallgrass prairie, and heavy machinery that increase the rate of storm water runoff. Development on the north and west sides of the city also significantly increase runoff. Flood magnitudes have changed through time. The historic resources of the park lie within the 100-year flood plain (FEMA map, 1982), probably within the 50-year flood plain (Einhellig, 1994). More recent calculations based on Hoover Creek's flow suggest that some structures, including the library, are now within the 30-year floodplain (Eash, 2000). While shifts in the flood recurrence estimates are expected as rainfall records and modeling techniques improve the shift of land from agricultural to residential and businesses expected to be the dominant rationale for hydrologic changes. Within the park, Hoover Creek, which was once a series of linear sloughs, has now cut a 10-foot incision and has destabilized the river bank.

Assumptions: Agricultural practices and development of residential housing and businesses are reducing surface permeability within the Hoover Creek watershed.

Predictions: The trend towards development in the watershed will continue.

Monitoring Objective: To estimate changes in surface permeability within the Hoover Creek watershed and determine impacts on storm surges.

Monitoring Questions:

- What are changes in surface permeability (e.g., paved areas, etc.)?
- What is the relative abundance of different land uses?
- What are the trends for growth and development?

Hot Springs NP

Resources at Risk: The springs and old structures within the flood plain; the consistent ratio of warm and cold water components of the springs (Section 2.4.2).

Observations: There is an increased presence of residential and commercial structures within the watershed. Through land acquisition and structure removal, the process of urban sprawl is also being reversed at specific locations. Houses identified as standing over sensitive aquifer recharge areas are being purchased and have or are in the process of being removed. Following removal, sites are recontoured and allowed to revegetate naturally. Gravel mining is occurring within the watershed. Arkansas novaculite, a rock that is mined in Hot Springs, is frequently purchased by tourists. The increases in structures, the construction of drainage systems, and roads have all led to a change in surface permeability.

Assumptions: Development has resulted with an overall decrease of surface permeability.

Predictions:

Monitoring Objective: Monitor surface permeability for the entire watershed. If possible, monitor entire sub-surface watershed.

Monitoring Questions:

- How has surface permeability changed?

2.4.7.1.10 Urban Structures

Urban structures can stress wildlife communities, particularly birds. Cell phone towers and power lines have been linked to unusually high bird mortalities through electrocution and disorientation. If a person comes to the park to view birds this can be in direct conflict. More often urban structures are associated with impaired viewsheds of natural resources.

Pea Ridge MP

Resources at Risk: Visual aesthetics (not identified for monitoring as environmental concern).
Observations: Urban structures, including water towers, cell phone towers, and power line towers, are a result of rapid urbanization. Throughout much of northwest Arkansas, many of these urban structures are now visible from various vantage points at PERI.
Assumptions: Urbanization is diminishing the visual resources of PERI.
Predictions:
Monitoring Objective: Monitor visual aesthetics
Monitoring Questions:

2.4.7.1.11 Water Consumption

Water consumption stresses aquatic resources. Pumping reduces groundwater levels and changes baseflow conditions during extended dry periods. Reduced baseflow may also alter stream temperatures and affect aquatic habitats.

Pea Ridge NMP

Resources at Risk: Physical water quality and aquatic habitat (not identified for monitoring as environmental concern).
Observations: There has been a recent development of neighborhoods around PERI. These neighborhoods are not part of a municipal water system and must acquire water through wells.
Assumptions: Urbanization places a greater demand for water. Recent residential development adjacent to PERI is responsible for the drilling of new wells.
Predictions:
Monitoring Objective: Monitor groundwater levels
Monitoring Questions:

- What is the rate of change of urban areas?
- How is the adjacent land use changing?
- What is the change in land use over 20 year periods?

2.4.7.1.12 Water Pollution (Non-Point Source)

Non-point water pollution sources stress aquatics resources in a number of ways. High phosphorous levels, for instance, can accelerate algeal growth, while runoff from agricultural fields may be high in pesticides. Storm runoff funneled from roadways can stress aquatic systems with oils and elevated sodium chloride levels.

Arkansas Post NM

Resources at Risk: Aquatic life and habitat (not identified for monitoring as environmental concern).
Observations: There have been a number of fish kills following rainfall events. High levels of fertilizers and pesticides are applied annually to surrounding fields. The general biodiversity of the region, particularly bird populations, appears to have declined over the last 30 years.

Assumptions: Agricultural runoff is a major non-point source pollutant in the water. Levels are particularly high following rainfall events.
Monitoring Objective: Monitor groundwater for non-point pollution sources
Monitoring Questions:

Cuyahoga Valley NP

Resources at Risk: Watersheds, headwater streams, riparian corridors, and wetlands (Section 2.4.2).
Observations: The park is surrounded by a fragmented, rapidly developing landscape, which in the past was largely agricultural. The landscape is a mosaic of second growth forests, fields and urban developments. It is one of the largest remaining tracts of forested area in northeastern Ohio. Internally, there is high visitor use, park development, agricultural use, mixed land ownership and road maintenance. Externally, there are utility corridors, suburban development, agricultural practices and mineral extraction. Over the last 27 years, the landscape surrounding the park has become increasingly urbanized while the park has devolved to more natural conditions, remaining a relatively undeveloped, pastoral valley. . Impacts to aquatic resources via land use changes such as agriculture and urban/suburban development can result in habitat degradation such as channelization of streams and destruction of riparian buffers. Hydro-modification is now the leading source of impairment of Ohio streams and is the origin of habitat degradation and sedimentation problems that are causes of impairment of Ohio's streams. Cumulative effects of such impacts over a large area and over time can be substantial. Park water quality data has not been correlated to the larger landscape level changes that have occurred over the past 25 years. The current Land Use Cover project will provide a vital layer of needed information to relate the changes in water quality to changes in land cover over time
Assumptions: Urbanization, tourism, storm water runoff, mining and agriculture are the major non-point pollution sources.
Predictions: Producing land cover maps and indices of land use change will enable researchers and resource managers at CUVA to better understand the influence of land use and land cover. Predicting affects of development, park management activities, and other disturbances on the population, reproduction, distribution and diversity of aquatic and terrestrial wildlife and associated habitats will be a direct result of the land cover maps.
Monitoring Objective: Monitor land use changes and how they affect water quality parameters (i.e. nutrients, sediments, bacteria) related to non-point pollution sources.
Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?

- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

Hot Springs NP

Resources at Risk: Chemical water quality of springs (Section 2.4.2).
Observation: Urbanized areas are a source of non-point source pollution. At HOSP surface runoff during rainfall events collects oils deposited on the roads by vehicles. This contaminated water flows directly into river channels and also enters the shallow groundwater.
Prediction:
Monitoring Objective: Monitor water parameters related to non-point sources of pollution.
Monitoring Questions:

- How does land use change affect water quality?
- What is the percent change from forest to urban?
- What type of things are going on the landscapes?
- What types of vegetation is there?

2.4.7.1.13 Water Pollution (Point-Source)

In addition to chemical constituents found in the non-point sources of water pollution, other chemical elements are more often introduced with point-sources. For instance, acid mine drainage and factory effluent can be high in heavy metals or other chemicals related to manufacturing or sewage treatment.

Hot Spring NP

Resources at Risk: Chemical water quality of hot springs and river (Section 2.4.2).
Observations: There are numerous old and abandoned industries and generators. There have been some truck accidents (i.e., overturns, spills).
Assumptions: The increase in urbanization surrounding HOSP is creating more sources of point source water pollution
Predictions: The increased urbanization of HOSP will result in more point sources of water pollution.
Monitoring Objective: Monitor water parameters related to point-source pollution
Monitoring Questions:

Ozark NSR

Resources at Risk: Chemical and biological water quality of rivers and springs (Section 2.4.2).
Observations: There are lead mines throughout the watershed. There is also some industrial development surrounding the park.

Assumptions: Urbanization, specifically industrial development, and mining are responsible for point-sources of water pollution.
Predictions:
Monitoring Objective: Monitor water quality parameters related to industries and mining
Monitoring Questions :

- Are there changes in catchment land use practices?

2.4.7.2 Park's Land Use Change Ecological Concerns at a Disturbance Level

The eleven identified stressors are the due to various drivers. These drivers are discussed for each of the parks that identified land use change as an issue.

2.4.7.2.1 Agriculture

A number of stressors are frequently associated with agriculture, including point and non-point sources of water and air pollution, changes in surface permeability, and the introduction of exotics.

Arkansas Post NM

Resources at Risk:
Observations: The Mississippi bayou region surrounding ARPO is primarily large-scale agriculture. Because the land is wet and unstable for much of the growing season, most of the chemicals are applied by aerial broadcasting.
Assumptions:
Predictions:
Monitoring Objectives
Monitoring Questions:

Cuyahoga Valley NP

Resources at Risk:
Observations: Agricultural abandonment has allowed some areas in and around the park to return to succession. Also, CUVA's demolition program has removed more than 100 structures from the park. After removal, the park policy has been to let the surrounding landscape return to natural succession. As mandated by the park's enabling legislation, CUVA has attempted to preserve the rural cultural landscape by encouraging continued agricultural uses. While this attempt has not been fully effective to date, a new initiative is being developed which has the potential to convert over 1500 acres of parkland back to agricultural use over the next ten years. Natural resources issues of concern include: 1) land use changes inside and outside the park boundary including urbanization, fragmentation, impervious surfaces and loss of habitat; 2) removal or inadequate riparian and wetland buffers in developments and the affects thereof on park resources; 3) non-point source pollution; 4) erosion and sedimentation caused by development; 5) modification or elimination of headwater streams; 6) barriers to habitat corridors; and 7) introduction

and dispersion of invasive plant species a land cover and land use study would be beneficial to our understanding of the context in which existing natural resources and cultural landscapes are situated

Assumptions: Agriculture will continue to be an active land use within and around the park.

Predictions: Land cover maps and indices of land use change derived from the Land Use and Land Cover project will enable researchers and resource managers at CUVA to better understand the influence of land use and land cover on populations of all monitored wildlife including white-tailed deer, beaver, coyote, songbirds, owls, raptors, great blue heron, amphibians, and lepidopterans. This knowledge will be helpful in modeling and predicting affects of development around the park, of park management activities, and other disturbances on the population, reproduction, distribution and diversity of wildlife

Monitoring Objectives: To monitor land use changes such as agriculture and it's affects on other natural resources (i.e. habitat, wetlands, water quality) within the park and surrounding watershed.

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

Herbert Hoover NHS

Resources at Risk:

Observations: HEHO has a long history of agriculture that has changed dramatically over the past 60 years. In the early part of the century, farmers grew various row crops, raised animals, and devoted land to pasture creating a diverse mosaic of introduced plants and land uses. By 1990, the diversity had been replaced by monocropping. Farms in the early part of this century were small-scale operations (150 acres average) and animals provided the power for cultivation. By 1990, however, the typical farm was 2000 plus acres with most, if not all, of farming being done with large-scale, fossil-fuel-powered machinery.

Assumptions: Agriculture will continue to impact natural resources on site.

Predictions: Depending on the impact of the new farm bill, agriculture may prove to be a more benign neighbor than in residential and business development.

Monitoring Objectives To relate land use changes to local impacts on resources.

Monitoring Questions:

- How are land use changes affecting resources on site?

2.4.7.2.2 Mining

Mining can have a number of potential stressors including point-source pollution, erosion, and changes in surface permeability.

Cuyahoga Valley NP

Resources at Risk:

Observations: CUVA has 97 active oil and gas wells within park boundaries and many miles of underground pipelines. Similar petroleum activities surround the park. Topsoil removal, sand and gravel operations, and sandstone quarries were once activities within the park. There is great potential for leaks and spills from such activities to impact the park's natural resources, especially waterways and plant communities.

Assumptions: Stressors related to mining activities will remain, and most likely increase as the nation's interest on locating sources of domestic energy increase.

Predictions: Oil and gas extraction activities will increase in the park and surrounding region.

Monitoring Objectives: To identify, monitor and mitigate potential impacts of petroleum mining activities on the park's natural resources, especially water quality and plant communities.

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change?

Hot Springs NP

Resources at Risk:

Observations: Prehistoric, historic, and current rock and gravel mining operations dot the landscape to the east of HOSP.

Assumptions:

Predictions:

Monitoring Objectives

Monitoring Questions:

2.4.7.2.3 Recreation

Recreation introduces a number of stressors including noise, non-point sources of pollution, exotic species, and increases erosion rates.

Cuyahoga Valley NP

Resources at Risk:

Observations: A primary attribute of the park is the preservation of some 33,000 acres of relatively undeveloped and scenic open space in a pastoral valley lying less than 30 miles from the approximately four million residents of the Cleveland and Akron metropolitan areas. The significance of the area is not limited to its potential to serve the recreational needs of the regional population. The river and valley contain important remnants of our national natural and cultural heritage. Public Law 93-555 states that the area is to be managed "in a manner which will preserve its scenic, natural, and historic setting while providing for the recreational and educational needs of the visiting public." Visitor-use patterns defined by the long-established public or quasi-public facilities in the recreation area have been expanded and enhanced. Emphasis is on recreational uses that harmonize with the natural and cultural landscape.

Assumptions: The goal of resource planning for the CUVA area is to provide a recreational and scenic attraction that serves as a model for restoration and maintenance of a quality environment.

Predictions: The park will plan accordingly to provide recreation for visitors with minimum impact to the natural resources.

Monitoring Objectives: To identify and monitor any land use changes or impacts to natural resources caused by park development or increased visitation/recreational needs.

Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change

Ozark NSR

Resources at Risk:

Observations: While OZAR is remote in location, it has high levels of visitation…

Assumptions:

Predictions:

Monitoring Objectives

Monitoring Questions:

Pea Ridge NMP

Resources at Risk:

Observations: The large population influx into northwestern Arkansas is likely to increase the number of day visitors wishing to recreate at PERI. Adjacent neighborhood will likely bring in more hikers.
Assumptions:
Predictions:
Monitoring Objectives
Monitoring Questions:

2.4.7.2.4 Urbanization

Urbanization is a general term that refers to industrial, commercial, and residential development. Urbanization is an important driver of various stressors including point and non-point sources of water and air pollution, exotic plant species, erosion, and changes in surface permeability.

Cuyahoga Valley NP

Resources at Risk:
Observations: A primary attribute of the park is the preservation of some 33,000 acres of relatively undeveloped and scenic open space in a pastoral valley lying less than 30 miles from the approximately four million residents of the Cleveland and Akron metropolitan areas. The Cuyahoga Valley provides a sharp contrast to the Cleveland and Akron urban spheres that surround the recreation area. Recognition of this contrast serves as the basis for the emphasis on open-space preservation and recreational settings, rather than facility construction and formalized developments. The cooperation of the various landowners is encouraged to protect park resources and develop complimentary uses for the surrounding lands.
Assumptions: Degradation of natural resources will continue as a result of urbanization.
Predictions: Urbanization will continue to accelerate within the rural and open areas surrounding the park as the suburban population increases. Impacts on natural resources from a variety of land uses will always be a problem for the park as it becomes more isolated due to fragmentation and urbanization.
Monitoring Objectives: To monitor land use changes inside and outside the park boundary including urbanization, fragmentation, impervious surfaces and loss of habitat
Monitoring Questions:

- How do we monitor ecosystem health that may be affected by changes in adjacent land use changes outside park boundaries?
- What are the quantity, characteristics, and trajectory of change in land cover and land use in the park and surrounding region?
- How does this change correlate to observed water quality?
- What are the impacts of NPS management and development on resources given a broader regional and temporal context?
- How does the land use change inside and outside the park compare to the region as a whole?
- Are there land cover or land use changes which would help us determine where to monitor for the effects of that change

Hot Springs NP

Resources at Risk:
Observations: Garland County, which includes the City of Hot Springs and HOSP, has increased in population size to 140,000 people.
Assumptions:
Predictions:
Monitoring Objectives
Monitoring Questions:

Lincoln Boyhood NM

Resources at Risk:
Observations: The region surrounding LIBO is rapidly shifting from small farms and rural communities to larger urbanized residential areas and industrial land uses.
Assumptions: The trend will continue and eventually impact the Memorial's resources.
Predictions: The impacts expected are loss of forest health and increased exotics.
Monitoring Objectives: Monitor the proximity of developments to the Memorial to provide early warning and allow for preventative measures to be taken in protecting the resources.
Monitoring Questions:

- What are the regional trends in development and industrial uses?

Pea Ridge NMP

Resources at Risk:
Observations: The urban interface around PERI is also growing rapidly.
Assumptions:
Predictions: In northwest Arkansas, a region that includes Pea Ridge, the population is expected to grow to 500,000 within the next 20 years.
Monitoring Objectives
Monitoring Questions:

2.4.7.3 Super-Disturbances Impacting Land Use Change

This section places each of the anthropogenic disturbances – agriculture, urbanization, logging, mining, and recreation –within a context, using super-disturbances. These large scale super-disturbances help explain the historical development, current status, and future changes of each of the natural and anthropogenic drivers. While these super-disturbances are far beyond the scope of this monitoring program, it is nevertheless important to recognize that future changes in the driver-stressor-effect relationship is ultimately controlled by this level of national and global processes.

Stern *et al.* (1992) define five major social driving forces – population growth, economic growth, technological change, political-economic institutions, and attitudes and beliefs. There are also five major natural drivers that define Earth's environmental system.

Anthropogenic super-disturbances include:

- ✓ Population Growth- Each person in a population makes a certain demand on resources, including the consumption of food, energy and space. All things being equal, the more people found in one area, the more demands they will make on the areas' natural resources.
- ✓ Economic Growth – The wealthier a community is, the more resources they will consume. Likewise, strong economic growth consumes more energy and resources and produces more products and waste.
- ✓ Technological Change – Technology changes the way a society utilizes their resources, how efficiently they consume their resources, and what types of wastes are produced in the process.
- ✓ Political-Economic Institutions – Social and legal institutions influence the structure of decision-making and ultimately the types of laws and regulations - from local to national - that influence how a society functions.
- ✓ Attitudes and Beliefs- Cultural beliefs and attitudes determine how individuals and groups perceive, interact with, and value their environment.

Natural super-disturbances include:

- ✓ Atmosphere – Includes all atmospheric processes and matter, including gases, the transfer of mass, energy and momentum.
- ✓ Hydrosphere – The hydrosphere includes all water bodies. The hydrosphere is the main reservoir of water and is an important transporter of heat.
- ✓ Lithosphere – The lithosphere includes all of soils and geologic layers. This layer can serve as a minor reservoir for water (i.e., groundwater) and is component of the carbon cycle.
- ✓ Biosphere – The biosphere includes all living plants, animals, and fungi.
- ✓ Cryosphere- The cryosphere includes glaciers and snow. Ice caps and snow are important reservoir of water and exerts a strong influence on surface albedo.

2.4.7.4 Relevant Laws and Regulations

Local, state, and federal laws, permitting requirements, and so on that will regulate or influence monitoring program decisions and actions were identified by the parks that identified land use change as a high priority within the I&M program. This information is summarized up in Table 2.13.

Table 2.13 Local, State, and Federal Laws Relevant for Land Use Change Monitoring

Laws		ARPO	CUVA	HEHO	LIBO	OZAR	PERI
Local	Local zoning			X			
	Local ordinances on riparian buffers		X				
State	State air quality laws and standards	X	X	X	X	X	X
	Missouri Statutes 10 CSR 20-7.031 (OZAR)					X	
Federal	CFR 29 & 36	X	X	X	X	X	X
	Clean Air Act	X	X	X	X	X	X

2.5 Current or Historic Natural Resource Studies

2.5.1 Monitoring within the Park and by Other Agencies within the Area

Current and past data mining activities and the Nature BIB results provide documentation about past studies related to the monitoring concerns described previously in this plan. Table 2.14 provides a summary of the number of data sets, maps, and reports pertinent to each of the monitoring themes for each park. The information includes documents that can be found both at and outside of the park. These documents, once completely reviewed, will provide constructive information for development of the I&M program. Due to the large number of documents reflected in Table 2.14, the parks were asked to identify the references they were aware of as the most critical for review in relation to the I&M monitoring program. Annotated bibliographies of those specific documents are included in the following section (2.5.2).

Table 2.14 The number of data sets, maps and reports relevant to park's priority issues as posted on the NPS database NatureBIB as of May 2002

Park	Aquatics	Invasive Exotic Plants	Land Cover/Use Change	Plant Communities	Wildlife Populations
ARPO	6	5	3	14	10
BUFF	156	18	84	130	200
CUVA	107	20	23	72	116
EFMO	32	21	4	76	61
GWCA	47	12	5	132	90
HEHO	3	0	0	25	2
HOCU	0	0	0	3	1
HOME	26	22	25	69	31
HOSP	75	5	128	148	62
LIBO	3	1	2	28	11
OZAR	299	33	28	122	231
PERI	2	1	12	57	21
PIPE	10	35	12	70	44
TAPR	0	0	0	1	1
WICR	52	31	10	116	67

An annotated bibliography of these resources is found in Tables A.1 through O.1in Appendices A through O.

Table 2.15 lists important GIS coverages that will be used during the monitoring development and fieldwork. Some themes, including DRGs (digitized topographic maps) and ozone levels are complete for all parks. Other coverages, including soils, land cover, and geology, will require significant work before all parks have complete information.

Parks that have identified land use change as an issue will likely be using satellite imagery and aerial photography for some of their analyses. Table 2.16 indicates the time period and platform where information is available for each park.

Table 2.15 Summary of existing GIS coverages found on the GIS Clearinghouse that are relevant to monitoring

GIS Layer	ARPO	BUFF	CUVA	GWCA	HEHO	HOCU	HOSP	LIBO	OZAR	PERI
Park Boundary										
Soils										
Land Cover										X
DRG										
DEM										
Rivers		X			X			X	X	
Geology										
Roads	X				X	X			X	
DOQQ										
Trails										X
Hydrologic Unit	X	X	X	X	X	X	X	X	X	X
Ozone levels										

	Useful information with full documentation (metadata) at NPS GIS Clearinghouse
X	Information available but requires posting on the GIS Clearinghouse
	Insufficient metadata or lack of useful information

Table 2.16 Summary of satellite imagery and aerial photography for parks that have identified land use change as one of their top four monitoring priority

Decade	Aerial Photography	Landsat TM-7	Landsat TM-5	Ikonos
1940	HOSP, LIBO, HEHO, GWCA, PERI			NA
1960	ARPO, BUFF, HOSP, PERI, GWCA, OZAR, HEHO, LIBO, HOCU, CUVA			NA
1980	ARPO, BUFF, HOSP, PERI, GWCA, OZAR, HEHO, LIBO, HOCU, CUVA			NA
1990	ARPO, BUFF, HOSP, PERI, GWCA, OZAR, HEHO, LIBO, HOCU, CUVA		BUFF, HOSP	NA
2000	ARPO, BUFF, HOSP, PERI	BUFF, OZAR, PERI, HOSP, ARPO, CUVA, LIBO, HEHO		PERI, HOSP, GWCA, HEHO, LIBO, HOCU

This imagery was all purchased through the Heartland Network I&M program

2.5.2 Park Natural Resource Data Sets Relevant to Park Priority Issues

This section highlights data sets and references that have been identified by park staff as being key resources for future monitoring activities. References are organized by the five monitoring themes identified – Aquatics, Exotic Plants, Land Use Change, Plant Communities, and Wildlife Populations. Included with each reference is a brief annotated bibliography. The summary of existing information was made possible through the data mining efforts conducting in the spring and summer of 2002. Appendixes A-O (Tables A.1-O.1) provide a complete annotated bibliography of all of the resources for each of the monitoring issues.

2.5.2.1 Plant Communities

2.5.2.1.1 GWCA – Prairie and Forest

Walker, Mark Swartz, Sarah Place, Nick Jones, Barry Davis, Jay Covarrubias, Higinio (1995). Tree survey, Harkins Area, George Washington Carver National Monument, 1995, Report of methods and results (ID # 127521). *This report documents a tree survey conducted in the summer of 1995 of the Harkins Area of George Washington Carver National Monument in order to divide the Harkins woodland into plots, determine species composition of the woodland, tree identification, site description, construction of a species distribution map, notation of any surface anomalies of suspected cultural origin and determination of approximate size of the Harkins woodland. A discussion on the background and purpose of the study is included. Methods used during the survey are identified to include site inspections and measurements, transect line selection, plot marking and numbering, tree identification and measurement, and data collection. Conclusions and recommendations based on the survey are also included. Maps illustrate the Harkins tree survey areas and an overview of archaeological sites of George Washington Carver National Monument. A sample of the woody vegetation sampling form and plot map/graph are included. Table data provides the four letter code assigned for each species identified in the survey. Additional table data identifies a summary of the size class breakdowns for each species, relative densities within each size class, and number of trees in the subject in order of abundance. A map illustrating the plots where no trees of measurable size were found and the total number of trees and species per plot is also included. Graphical data illustrates the overall percentages for the tree species breakdown, percentages of size class breakdown of all trees over 1 inch and percentages of species breakdown of size class 1-2 inches, 5-10 inches, and 25-50 inches. The appendices includes graphical data on the size class breakdown of each species and dominant species maps.*

Jones, Barry (1995). Tree survey, Persimmon Grove, George Washington Carver National Monument, 1994, Report of methods and results (ID # 127524). *This report documents a tree survey conducted in June of 1994 of the Persimmon Grove located along the Carver trail, between the trail boardwalk and the cemetery, of George Washington Carver National Monument in order to provide adequate baseline data. The survey describes the dividing of the sampling area into plots, determination of the actual population of persimmon trees in the grove, species composition of the grove, tree identification, site description, and determination of test sampling methods for future surveys. A discussion on the background and purpose of the study is included. Methods used during the survey are identified to include site inspections and measurements, transect line selection, plot marking and numbering, tree identification and measurement, and data collection. Conclusions and recommendations based on the survey are also included. Maps and graphs illustrate the Persimmon Grove tree sampling plots. Total number of trees, for all identified species, counted in each size class within the sampling area is included as well percentages of total counted. A map showing the spatial arrangement of the plots is included to show the abundant species in each plot and how they were arranged spatially. A list of most abundant species in each plot is included as well as an example of the woody vegetation sampling form used. The appendix includes species plot maps for each species.*

Jones, Barry (1994). An annotated flora of George Washington Carver National Monument (ID # 8940). *This report, written in January, 1994 by Biological Science Technician Barry Jones, provides a baseline data list of all flora identified in George Washington Carver National Monument. This list is based on all available field lists, specimens, and research reports from 1953 through 1993. It includes a brief one page description of the habitats found and previous studies conducted by Ernest J. Palmer as well as a brief summary of problems encountered due to changes in taxonomic nomenclature over the last 30 years. The 38 page primary list identifies the species alphabetically by Latin name followed by a common name or names, specimen information (dates and location of each), and any other general or specific information about the distribution or status of the species in the park. It also annotates whether the species was included on Palmer's 1964 list and/or on the 1983 revised Palmer list. A secondary list of records of species considered to be of marginal importance to the park's flora due to their uses as ornamentals and/or crops is also included.*

Wilson, Louise Jackson, James R. (1994). Prairie Management Baseline and Monitoring Program, George Washington Carver National Monument (ID # 95631). *This report documents the prairie management baseline and monitoring program established for George Washington Carver National Monument based on data collection and analysis conducted in 1984. The introduction discusses the need for a prairie monitoring program and the research objectives. Methods used during the analysis addresses the management units, species list, quantitative vegetational analysis, sample plots locations, data collection and analysis, importance values, species diversity and evenness and management unit similarity. The results for each of these areas are also included. A discussion is included of individual management units, similarity between units, comparison with Diamond Grove Prairie, coefficients of similarity and importance value, and monitoring protocol. Figures illustrate the location of management units, cluster analysis dendrogram, and summer and autumn diversity and evenness. Additionally, figures identify the distribution of each species for each plot as determined by plot sampling. Table data include plant species identified in the summer and autumn of 1993 for each unit and a comparison of importance values with the 1982 analysis for each unit. A table identifies the coefficients of similarity and importance values.*

Cox, Erica (1993). A blooming calendar of wildflowers and woody plants at George Washington Carver National Monument (ID # 18008). *This study, by Missouri Southern State College students, was conducted to formulate a wildflower and woody plant species list for George Washington Carver National Monument and to note the blooming times for each species starting May 16, 1992 until November 13, 1992. A discussion on previous studies by E.J. Palmer (1950's and 1960s) and D. Detzer(1970) conducted at the park is included. The four different habitat areas within the park are described and includes climate, temperature, rainfall, and soil composition. The study describes route and data collection. Conclusions and recommendations based on study findings are also included. Maps illustrating the collection routes and soil types within the park are included. Also included is a sample log sheet used in the research. Graphical data identifies the concentrations of wildflowers and woody plants in each area. Table data identifies the temperature and rainfall amounts measured and the genus and species of those wildflowers and woody plants found during the study period. The list identifies the scientific name, common name and location found within the prairie management unit area. A list of all flora known to be at George Washington Carver National Monument is included and a list of those not previously recorded at the park. Log sheets kept during the research are included and identify the species and week number A table identifies the forb species needed for prairie restoration which identifies the species name and seed rate (ounces/acre). A spiral notebook containing field notes used during the study is also found in the file.*

Unknown author (1992). List of Genus and Species Names of Wildflowers at George Washington Carver National Monument, (Beginning May 16, 1992 through November 6, 1992) (ID # 72232). *This is a list of genus and species names of wildflowers at George Washington Carver National Monument beginning May 16, 1992 through November 6, 1992. Rare or endangered species are annotated.*

Vinyard, Timothy Jackson, James R. (1984). George Washington Carver National Monument, Prairie Monitoring Summer Report, Vegetational analysis and photographic record of the six prairie management units (ID # 55517). *This report contains a table that list the photographs, color slides on file which were taken, from the air and on the ground, June 10, 1983 and June 14-28, 1983 of the vegetation in each of the prairie management units one through six at George Washington Carver National Monument. It also contains a list of the vegetative sampling results of the ten most important species in the front portion of each unit which identifies the species by scientific name, importance* value, frequency, average cover and relative density for each species. Black and white photographs are included showing an aerial view of prairie management units one through five.*

Palmer, Ernest J. (1983). The flora and natural history of George Washington Carver National Monument (ID # 48649). *This report is the National Park Service, Midwest Region Research/Resources Management Report that includes portions of Ernest J. Palmer's original 1964 manuscript on the flora and natural history of George Washington Carver National Monument from Carver's childhood up to the time of report. The report is an overview of the natural history of the park and includes the results of flora studies, conducted over several seasons. The preface discusses Mr. Palmer's interest in the park as well as references Mr. Palmer's original work. This report includes a brief history of the park's creation and Carver's contributions of economic and scientific value. It also includes a summary of Carver's life spanning from his birth, through his studies and travels, to his work at Tuskegee Normal and Industrial Institute. A summary of the physical characteristics of the area is given which includes acreage, topography, geology, erosion effects, and soil origins as well as the waterways, flora, woody plants, wild animal life, birds, reptiles, terrapins, fish, and insects found on the property. A list of flora*

Palmer, Ernest J. (1964). The flora and natural history of George Washington Carver National Monument (ID # 48648). *This report provides an overview of natural history of George Washington Carver National Monument from Carver's childhood up to the time of report. The results of flora studies, conducted over several seasons, is also included in this report. It includes a brief history of the park's creation and Carver's contributions of economic and scientific value. It also includes a summary of Carver's life spanning from his birth, through his studies and travels, to his work at Tuskegee Normal and Industrial Institute. A summary of the physical characteristics of the area is given which includes acreage, topography, geology, erosion effects, and soil origins as well as the waterways, flora, woody plants, wild animal life, birds, reptiles, terrapins, fish, and insects found on the property. In addition, more detailed information is provided on the botany, mosses and cryptogams, birds, geology, geological specimens of the subject area. A letter from Mr. Palmer to the superintendent of the park is included regarding his appointment as a Collaborator of the park and his review of a revised version of his paper. The addendum includes a cross reference between Mr. Palmer's plant common names and the standardized plant names.*

2.5.2.1.2   HEHO – Prairie

Christiansen, Paul (1996). Prairie Inventory, Herbert Hoover National Historic Site, 1995 (ID # 95625). *This report on the inventory of 1995 highlights the development of prairie domination in recently seeded plots, the continued domination of established prairie vegetation, and the emerging information on strategies of various forb species to maintain viable populations on the*

Snyder & Associates Inc. Land and Community Associates John Milner Associates Dunbar/Jones Partnership Andropogon Associates, Ltd. (1995). Herbert Hoover National Historic Site Cultural Landscape Report (ID # 60433). *The Report discusses the natural resources of the park such as the Wapsinonoc creek. The report surmises several hydrologic solutions for the existing flood plain: Off stream limited detention in a built wetland; swale overflow spillway around bridges; replacement of bank soil with more permeable material. The report discusses the vegetation of the park along with diagrams and photos of the 1850- forward era of*

U.S. Biological Science (1995). Vascular Plant Survey of Herbert Hoover NHS, IA. (ID # 152147). *438 species identified and vouchered in the park's collection. The park's flora is now considered to be 92% complete.*

Christiansen, Paul (1995). Prairie Inventory, Herbert Hoover National Historic Site, 1994 (ID # 95624). *Permanent and walking transects and forb transects were sampled at the Herbert Hoover National Historic Site reconstructed prairie in August, 1994. This marks the 12th inventory since 1982 on the site providing information for use in prairie management and interpretation. Over the years prescribed burning has brought about significant changes in the prairie vegetation including decreases in the density of Canada thistle and the dominance of big bluestem mostly at the expense of switchgrass.*

U.S. Biological Science (1995). Vascular Plant Survey of Herbert Hoover NHS, IA. (ID # 152147). *438 species identified and vouchered in the park's collection. The park's flora is now considered to be 92% complete.*

Christiansen, Paul (1994). Prairie Inventory, Herbert Hoover National Historic Site, 1993 (ID # 95623). *The format for this inventory is much the same as in previous year's with added emphasis on forb population dynamics and evaluation of the new prairie seedings directly south of the presidents grave site. Analysis of the vegetation as of August, 1993, as well as management suggestions are included*

Osowski, Sharon (1993). Herbert Hoover NHS Inventory and Monitoring Program 1993 Report (ID # 60435). *A Prairie Monitoring Program (PMP) was established at Herbert Hoover National Historic Site (HEHO). The purpose of the 1993 program was to establish and implement inventory and monitoring methods for all taxa (plants, invertebrates, vertebrates) in the Hoover Prairie. This annual report summarizes the process from the monitoring program through recommendations for future inventory and monitoring. Osowski goes on to explain that in her opinion the park needs a bio-tech along with another ranger to assist in gathering data. She had to assume the duties of a ranger which conflicted with weather dependent data collecting.*

Osowski, Sharon (1993). Osowski folder (ID # 88513). *This folder contains numerous handwritten notes and compilations used in completing several reports and studies done at the Herbert Hoover National Historic Site.*

Osowski, Sharon (1993). Species Checklists (ID # 116564). *This checklist provides a detailed listing of family/species/habitat and characteristics on the following concerns: Mushrooms, Plants, Insects, Butterflies, Fish, Reptiles & Amphibians, Birds and Mammals.*

Christiansen, Paul (1992). 1991 Prairie inventory, Herbert Hoover National Historic Site (ID # 3705). *An inventory of the vegetation on the reconstructed prairie at Herbert Hoover National Historic Site in West Branch, Iowa. The effects of controlled spring burning on the species dynamics of the dominant prairie grasses were of special interest.*

Christiansen, Paul (1992). Distribution Maps of Iowa Prairie Plants (ID # 33210). *This is a collection of distribution maps for prairie species in Iowa. This book was written to answer many of the questions about range and site suitability for Iowa prairie species. In addition, information is given on size, flower color, flowering, and fruiting date as well as notes on many species.*

Christiansen, Paul (1992). Prairie Inventory: Herbert Hoover National Historic Site, 1992 (ID # 95622). *The inventory has detailed tables of the sampling of walking and permanent plots. Species dynamics and establishment of marked individual plant longevity are followed rigorously. The study plots are measured with Daubenmire techniques.*

Christiansen, Paul (1990). 1989 Prairie Inventory, Herbert Hoover National Historic Site (ID # 3519). *This body of information is very revealing in overall vegetation dynamics, the vegetative response to prescribed burning. This report concentrates on the 1989 inventory as well as comparisons with previous reports on overall vegetational cover, response after seeding, prairie forb dynamics, and some remarks on Canada Thistle control.*

Christiansen, Paul (1990). 1990 Prairie Inventory, Herbert Hoover National Historic Site (ID # 3608). *Walking transects and permanent plots were surveyed as well as permanent transects monitoring the dynamics of establishment and migration of prairie forbs. Controlled burning was carried out in the spring of 1990 and effects on the vegetation were noted. The level of dominance of prairie and alien species is of special concern.*

Christiansen, Paul (1988). 1988 Prairie Inventory, Herbert Hoover National Historic Site (ID # 3427). *The reconstructed tallgrass prairie at the Herbert Hoover National Historic Site was established in 1971. Several time management regimens have been used including haying, burning and rest. Enhancement of the forb (non-grassy herbaceous plants) population was investigated by Landers, by establishment of a demonstration plot on the south prairie margin near the Library, and by informal seeding and transplanting staff personnel. Inventorying of the vegetation of the reconstructed prairie began in 1982 and was continued in 1984, 1985, and 1987. This report is a continuation of that effort.*

Willson, James Stubbendieck, James/Willson, James Stubbendieck, James (1986). An Identification of Prairie in National Park units in the Great Plains (ID # 60434). *The section gives a brief history of the park along with some schematics as to the altitudes and layouts of the land features. Present vegetation and Prairie Management Histories are given along with surrounding land usages.*

Christiansen, Paul (1985). Prairie Inventory, Herbert Hoover National Historic Site, 1985 (ID # 95621). *This report includes data and analysis of the vegetation of the prairie at the Herbert Hoover National Historic site for the summer of 1985. Comparisons are made with data from 1982 and 1984 and implications and recommendations for future management are discussed. Tables and maps in the* *appendix give locations and results of cover determinations for the five walking transects and ten permanent plots.*

Christiansen, Paul (1984). Prairie Inventory, Herbert Hoover National Historic Site, 1984 (ID # 95620). *This report includes an inventory of the vegetation of the restored prairie at the Herbert Hoover National Historic Site, West Branch, Iowa. Walking transects established in 1982 were reevaluated. The permanent plots established in 1982 were reevaluated where possible, and are also included in this report. In addition comments on prairie management and establishment are discussed. Tables in the appendix contain locations and results of cover determinations for five walking transects and ten permanent plots. Conclusions are that the weed problems will be completely eliminated after a couple more seasons with controlled burning.*

Midcap, James T. (1982). ISU Maintenance recommendations Herbert Hoover N.H.S.West Branch, IA (ID # 67666). *The recommendations cover hedge replacement along with the need to diversify the white pines that outline the park in case they become susceptible to disease and die off at the same time. A list of alternatives is provided. There are recommendations for grass plantings along the stream banks to control erosion.*

Christiansen, Paul (1982). Prairie Inventory: Herbert Hoover National Historic Site, 1982 (ID # 95619). *This report includes an inventory of the vegetation of the reconstructed prairie at the Herbert Hoover National Historic Site at West Branch, Iowa. Also included is a discussion on the status of Canada Thistle, several native grasses and management options to encourage native grasses while discouraging aggressive weeds. Several hand drawn plot sites show the managed sections of the park.*

Schramm, Peter (1978). The 'Do's and Don'ts' of Prairie Restoration (ID # 33728). *The Knox College Biological Field Station located in Knox County, West Central Illinois, this paper reviews the various procedures used to plant and establish prairie. The two most important variables affecting restoration are weed seeds present, and prompt germination of a high percentage of the grass and forb seeds planted. Suggestions on how to control these variables are presented. A variety of successful planting methods may be used.*

Landers, Roger Q. (1977). A Report to the National Park Service on Reestablishment and Management of Native Prairie Areas (ID # 105076). *Report describes the early prairie as containing more forbs than grasses. A study is done at several sites in Iowa including Herbert Hoover. The plots are broken down to No burn-spring-No Herbicide and No burn-spring-with herbicide. Tables go on to describe germination rates of different species and population counts along with resistance to weed varieties. Conclusions are mixed because of an extremely dry year*

Holden, Max W. (1975). The importance of fire in maintaining native prairie vegetation in the north central United States (ID # 64212). *This manuscript describes in detail the symbiotic relationship that fire has on the growing patterns and populations of various north central midwestern prairie vegetation. Includes data on burning and nitrogen increases in selected plots.*

Landers, Roger Q. (1975). A Report on the status and Management of Native Prairie Areas in National Parks and Monuments in the Midwest Region (ID # 104889). *This report simplistically outlines the recent history of settler migration and the moldboard plows effect on the prairie grasses decline. There is a small description of the historical aspect along with a comprehensive listing of prairie grasses. Included is a management system for reestablishing the prairie grasses: Andropogon gerardi (Big bluestem), Sorghastrum nutans (Indian grass) etc.*

Landers, Roger Q. Glenn-Lewin, David C. (). Fifth Midwest Prairie Conference (ID # 95662). *The proceedings have a wide ranging background starting with the arrival of the prairie plants about 9000 years ago until the present day. Every park in the midwest is described along with management and species descriptions. A short description of Herbert Hoover National Historic Site is provided, but the wealth of information on various restoration methods and procedures makes this a must read for any natural resource manager contemplating a prairie restoration.*

Author unknown (). Incomplete listing of trees located in the historic core and Library-Museum Area 198_ (ID # 151622). *Listing of trees in the historic core and around the entrances to the Herbert Hoover Presidential Library-MuseuM. The listing was made as an aid for interpreters, and not as a comprehensive inventory.*

2.5.2.1.3 HOCU – Forest

National Park Service (1996). Flora of the Mound City Unit (ID # 48867). *This is a plant checklist and is based on plants collected during 1995 by the National Biological Service and on specimens collected and observations made prior to that study. Collected plants are preserved as herbarium specimens and stored at Hopewell Culture. All identifications have been verified at the Herbarium of The Ohio State University.*

Course, Jennifer E.J. Bennett, James P. (1996). The Vascular Flora of Hopewell Culture National Historical Park, Ross County, Ohio (ID # 132212). *During the spring and summer of 1995, over 700 plant specimens were collected from all units of the park. The specimens were identified, pressed and are stored in the park herbariuM. Checklist of all plant species is included in this document.*

National Park Service (). Herbarium Collection (ID # 60384). *Herbarium specimen collection was started in 1995. The collection contains approximately 650 species (May, 1995).*

2.5.2.1.4 LIBO – Forest

Pavlovic, Noel (1997). Vegetation Mapping (ID # 152155). *Study done to sample spring flora, update species lists and prepare a plot map.*

Wagner, Gia (1996). Vegetation/Tree Survey (ID # 152164). *Survey done to document changes to previously designated plots.*

White, Mark Pavlovic, Noel B. (1989). Forest Regeneration of Lincoln Boyhood National Memorial: Presettlement, Existing Vegetation, and Restoration Management Recommendations (ID # 50008). *Research and recommendations of how to proceed with approximating the Presettlement forest at Lincoln Boyhood National Memorial. This report describes the presettlement vegetation, current vegetation and management experiments to eliminate exotic plant species. Management recommendations for vegetation restoration are given along with restoration priorities.*

Unknown author (). Herbarium collection (ID # 60386). Lincoln Boyhood National Memorial has an extensive herbarium located on the grounds. Specimens are collected and preserved for future

2.5.2.1.5 PERI – Forest

Author unknown? (no author included in original record) (1994). 1994 Split Cedar Rail Contract (ID # 4018). *A contract specifying the cutting and removal of Eastern Red Cedar (Juniperus virginiana), and detailing specific requirements of the*

Pea Ridge National Military Park (1994). Pest Management Program Report (ID # 91201). *Lists specifications for using Arsenal to control shrubs and trees beneath utility lines.*

Pea Ridge National Military Park (1994). Resources Management Plan (ID # 106429). *Describes and evaluates current park programs. Natural resources issues for 1994 included: possible degradation of park resource due to a large herd of white-tail deer; invasion of musk and bull thistles; accelerated erosion due to the horse trail; over-population of juniper trees; impacts of external refuse dumping; and trees that are hazardous to visitors and staff.*

Author unknown? (no author included in original record) (1993). Field sheets (ID # 44723). *Spreadsheets shoing results of the fall and spring sampling of plots established in 1978.*

Author unknown? (no author included in original record) (1992). Corrected sheets for the 1976 plots sampled in 1992 (ID # 27856). *Lists of grasses sampled in 1992 from plots planted in 1976.*

Dale, Edward E.= Jr. (1992). Prairie Restoration at Pea Ridge National Military Park, Benton County, Arkansas: Report of Research for 1992 (ID # 95654). *Vegetation cover measurements were taken in June and September on plots established in 1975, 1976, 1978, and 1991. It was recommended that all prairie plots be burned around April of 1993 to reduce mulch, inhibit woody species, and return mineral nutrients to the soil.*

Pea Ridge National Military Park (1991). Pest Control Program Report (ID # 91133). *Lists specifications for using Dithane M-45, Manzate 200, and Mancozeb to control cedar apple rust and scab.*

Pea Ridge National Military Park (1991). Pest Control Program Report (ID # 91135). *Lists specifications for using Thuricide to control eastern tent caterpillar, fall webworm, and bagworm infestations.*

Author unknown? (no author included in original record) (1991). Sheets for 1975, 1976, and 1978 plots sampled in 1991 (ID # 112216). *Lists of grasses sampled in 1991 from plots planted in 1975, 1976, and 1978.*

2.5.2.2 Aquatics

2.5.2.2.1 BUFF - River Biotic

US Department of Agriculture, Natural Resources Conservation Service (1995). Buffalo River Tributaries; Final Watershed Plan Environmental Assessment (ID # 19538). *The report addresses both existing and potential water quality problems in the middle segment of the Buffalo River and in six tributaries that flow into the middle reach of the Buffalo River. Recommended solutions, opportunities, and environmental impacts are included. Land treatment measures and conservation easements are included in these recommendations.*

Sagers, Cynthia L. (1995). Inventory and Characterization of the Riparian Zone (Wetands) at Buffalo National River (ID # 151640). *Thirty-five tree species and 323 herbaceous plant species were described within Buffalo River's riparian community.*

Robison, Henry J. (1995). Survey of the Ozark Shiner, Notropis ozarcanus, in the Buffalo National River. Unpublished report for Buffalo National River. (ID # 152068). *The Buffalo River may contain the best known opoulations of Ozark shiner according to this survey by the author of the Fishes of Arkansas.*

Siegwarth, Gary L. Johnson, James E. (1994). Pre-spawning migration of Channel Catfish into three warmwater tributaries-Effects of a cold trailwater (ID # 95722). *Spring migrations of channel catfish (Ictalurus punctatus) into the Kings, Mulberry and Buffalo Rivers, Arkansas, were compared to determine adult catfish migration into a warmater river that flows into a cold tailwater. The Buffalo River flows into a cold tailwater reach of the White River and supports a sparse channel catfish population compared to similar rivers in the region that do not flow into cold tailwaters. To assess channel catfish migration, hoop nets were deployed at the confluence of the three rivers and fished continuously from 29 March to 22 April 1992, with total catches used as an index of the relative number of fish migrating into each river. Movements of channel catfish into the three rivers were observed throughout April; however the relative number migrating into the Buffalo River (n=33) was significantly less than the Kings (n=169) or Mulberry (n=263) Rivers. Water temperatures differ significantly between the White and the Buffalo Rivers during the sampling period, but did not differ between the Kings and Mulberry, and their respective confluence. Although cold, White River tailwaters do not totally inhibit overwintering and migration of adult channel catfish into the Buffalo River, reduced numbers of migratory catfish may partially account for the river's low reproductive output and sparse adult population.*

Buffalo National River (1991). Water Quality Report, 1985-1990 (ID # 135204). *Results of the water quality monitoring program showed that the only area adjacent to the river contributing measurable amounts of pollutants was Boxley Valley. Most other water quality impairment resulted from the confluencing of tributaries with the river.*

Whisenant, Keith Avis Maughan, O. Eugene (1989). Technical Report No. 28: Smallmouth Bass and Ozark Bass in Buffalo National River (ID # 124342). *This study set out to determine whether increased recreational use was having a negative impact on the principal sport fishes in Buffalo River; to provide baseline data on habitat use and population characteristics of Ozark bass; and to determine how smallmouth bass habitats in Buffalo River compared to those in other areas.*

Harvey, Michael J. (1985). Status of Endangered Bat Populations at Buffalo National River, Arkansas (ID # 118308). *A study to monitor the status of endangered bat taxa inhabiting the Buffalo National River. Six caves were found to house bachelor or transient gray bat (Myotis grisescens) colonies in summer. Another cave houses a gray bat maternity colony. Additional caves were found to be hibernacula for gray bats. Indiana bats (M. sodalis) were found in three caves. Includes maps of caves and trapping sites and tables of*

Schnell, Gary D. Johnson, Forrest L. (1985). Wildland Fire History and the Effects of Fire on Vegetative Communities at Buffalo National River, Arkansas (ID # 137983). *This study established that fuel loadings are light to moderate in the area; that the mean fire-return interval has changed from 11 years or less before 1973 to approximately 100 years since 1973; that vegetation at the time of the study was at least fire-tolerant if not fire-dependent; and that the species composition in upland forests has not changed since 1841.*

Aley, Thomas (1982). Characterization of Groundwater Movement and Contamination Hazards on the Buffalo National River, Arkansas (ID # 22669). *'The purpose of this report is to provide a useful characterization of the groundwater hydrology in the Buffalo National River area.' Describes the geology and groundwater of the area (geologic formations, groundwater recharge, movement, water quality). Then discusses threats to water quality for development current human use and grazing. Notes that some contamination from human sewage is already present. Refers to related maps which are not included.*

Harvey, Michael J. (1980). Distribution, Status, and Ecology of Endangered Bats of Buffalo National River, Arkansas (ID # 33547). *Estimates of populations of endangered bats in all caves known to house them were made during May and June of 1980. Report details findings, broken down by cave.*

Springer, M. D. Smith, E. G. Parker, David G. Meyer, R. L. Dale, Edward E. (1978). Final Report, Buffalo National River Ecosystems, Part IV (ID # 46065). *Presents the results of studies in water quality and phycological studies (graphs and tables showing seasonal variation in water quality values and algae); rare, threatened, and endangered vascular plants (includes a list of species and tables with information on distribution and habitats, drawings of species and a few maps showing distribution); human carrying capacity study on camping areas (rating system for human impact); vegetation map and natural areas surveys (describes forest types); recreational river stress using time-lapse photography (canoeing); and effects of cattle grazing on water quality.*

Cashner, Robert C. Brown, James D. (1977). Longitudinal Distribution of the Fishes of the Buffalo River in Northwestern Arkansas (ID # 73222). *A survey of the fishes of the Buffalo River was conducted over seven years. 59 species were recorded based on 135 collections and literature records. 'The general pattern of distribution for the river was one of species addition rather than replacement from headwaters to the mouth.' Includes a list of species with an indication of where they are found in the river.*

Buffalo National River (1975). Final Master Plan (ID # 45999). *Describes the area of the Buffalo National River and presents a plan for land classification, visitor use, circulation, and zoning.*

Steele, Kenneth F. Southwest Region, National Park Service (1974). Heavy Metal Geochemistry of Bottom Sediments from the Buffalo River (ID # 60176). *Heavy metals in sediments of the Buffalo River. Procedure, variation along the river, chemistry, and environmental implications. Includes a table giving the amount of 11 metals in shale, sandstone and carbonates.*

Meek, S. E. Clark, H. Walton (1912). Bureau of Fisheries Document No. 759 (ID # 81251). *A study of three sites along the river, detailing types of mussels found at each.*

Author unknown? (no author included in original record) (). Biology of the Caves at Buffalo National River (ID # 16656). *Cave fauna of the caves at Buffalo National River were represented by 60 arthropods, two mollusks, one annelid, and 18 vertebrates.*

Steele, K.F., Mott, D.N., 1998, Storm and Base Flow Water Quality for Bear, Calf, and Tomahawk Creeks, Arkansas Water Resources Center, University of Arkansas.

Scott, D.H., Hofer, K.R., 1995, Spatial and Temporal Analysis of the Morphologic and Land use Characteristics of the Buffalo River WaterShed, Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas, 52pp.

Brynt, C.T., 1997, An Assessment of the Macroinvertebrate Community of the Buffalo National River, Masters Thesis, University of Central Arkansas, Conway, Arkansas, 99pp.

Petersen, J.C., 1998, Water Quality Assessment of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma—Fish Communities in Streams of the Ozark Plateaus and their Relations to Selected Environmental Factors, U.S.G.S., Water Resources Investigations Report 98-4155, 32pp.

Mathis, M.L., 2001, Development of a multimetric system of biological water-quality monitoring for the Buffalo National River: Contract Report for National Park Service, Buffalo National River, Harrison, AR, 59 pp.

Panfil M.S., and Jacobson, R.B., 2001, Relations Among Geology, Physiography, Land Use, and Stream Habitat Conditions in the Buffalo and Current River Systems, Missouri and Arkansas: Biological Science Report USGS/BRD/BSR-2001-0005, U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO, 110 pp.

Jacobson, R.B. and Primm, A.T., 1997. Historical land use changes and potential effects on stream disturance in the Ozark Plateaus, MIssouri: USGS Water-Supply paper 2428.

2.5.2.2.2 CUVA - Aquatics

Davey Resource Group (2001). Wetlands GIS Inventory and Restoration Assessment (ID #:29171). *The project's purpose was to locate, assess, and map the wetlands, with special emphasis for those appropriate for restoration or enhancement. This goal was accomplished through the use of state-of-the-art, pen tablet computer data gathering techniques that enable accurate and efficient information collection and processing. The results have been presented in a custom-designed digital map book that provides NPS resource managers information about wetlands location, quality and restoration potential in an easy-to-use computerized database. The custom software was created with the assistance of advanced geographic information system (GIS) technology. A total of 1,214 wetlands were found in Cuyahoga Valley NP, ranging from very small vernal pools and seeps to large wetland systems along the Cuyahoga River. Attribute data includes dominant vegetation, hydrology, soil, invasive species, unique features, ownership, Cowardin classification, water quality ,digital photos, impacts and restoration potential.*

Wilder, George J., McCombs, Martha R. (1999). A Floristic Study of Fawn Pond and Surrounding Territory (Cuyahoga Valley National Recreation Area and Brecksville, Ohio). (ID #: 49064). *Report on an inventory of vascular plants in and around Fawn Pond in Cuyahoga Valley National Recreation Area. This is a first step in an effort by the park to study wetland plants distributed throughout the park. Found 310 plant species and hybrids (including 43 not formerly documented in the park's flora, one of which is a state record for Ohio).*

Walton, B. Michael, Varhegyi, Geza, Mavroidis, Spiro M., Gibson, A. Ralph, Conaway, Cynthia A. (1996). Amphibian Surveys in the Cuyahoga Valley National Recreation Area. ((ID #:7825). *Report on the first two years (1994 and 1995) of a long-term amphibian monitoring program in the Cuyahoga Valley National Recreation Area (CVNRA) in northeast Ohio. Surveys of terrestrial and stream-side salamanders were conducted using transects; surveys of calling anurans were accomplished with an automated call recorder. The study identified six salamander species (Desmognathus fuscus, Eurycea bislineata, Notophthalmus viridescens, Plethodon cinereus, Plethodon glutinosus, and Pseudotriton ruber) and nine species of anurans (Bufo americanus, Hyla versicolor, Pseudacris crucifer, Pseudacris triseriata, Rana catesbeiana, Rana clamitans, Rana palustris, Rana*

National Park Service, Water Resources Division (1995). Baseline Water Quality Data Inventory and Analysis - Cuyahoga Valley National Recreation Area - Volumes I &II (ID #:13715). *The results of surface water quality data retrievals for the Cuyahoga Valley National Recreation Area (CVNRA) from six of the United States Environmental Protection Agency's (EPA) national databases: (1) Storage and Retrieval (STORET) water quality database management system; (2) River Reach File (RF3); (3) Industrial Facilities Discharge (IFD); (4) Drinking Water Supplies (DRINKS); (5) Flow Gages (GAGES); and (6) Water Impoundments (DAMS). This document is one product resulting from a cooperative contractual endeavor between the National Park Service's Servicewide Inventory and Monitoring Program, the National Park Service's Water Resources Division (WRD), and Horizon Systems Corporation to retrieve, format, and analyze water quality data for all units of the National Park System containing significant water resources. The primary goal of this project is to provide descriptive water quality information in a manner and format that is both consistent with the goals of the Servicewide Inventory and Monitoring Program and useable by park resource managers. The document provides: (1) a complete inventory of all retrieved water quality parameter data, water quality stations, and the entities responsible for the data collection; (2) descriptive statistics and appropriate graphical plots of water quality data characterizing annual and seasonal central tendencies and trends; (3) a comparison of the park's water quality data to relevant EPA and WRD water quality screening criteria; and (4) an Inventory Data Evaluation and Analysis (IDEA) to determine what Servicewide Inventory and Monitoring Program "Level I" water quality parameters*

have been measured within the study area. Accompanying the report are disks containing digital copies of all data used in the report, as well as all components of the report (tables, figures, etc.).

State of Ohio Environmental Protection Agency (1994) Appendices to Biological and Water Quality Study of the Cuyahoga River and Selected Tributaries - Geauga, Portage, Summit, and Cuyahoga Counties (Ohio) Volume 2 (ID #: 10101). *This document is the appendices to Biological and Water Quality Study of the Cuyahoga River - Volume 1. It contains the following information: (1) chemical, sediment and datasonde continuous monitor sampling data, (2) Cuyahoga RAP fish tissue sampling data, (3) macroinvertebrate sampling data, and (4) fish sampling data.*

State of Ohio Environmental Protection Agency (1994). Biological and Water Quality Study of the Cuyahoga River (ID #: 16170). *This is a report of a 1991 Cuyahoga River mainstem monitoring study that extended upstream of Tare Creek, in Geauga County, to its confluence with Lake Erie. Biological and water quality sampling were conducted in selected Cuyahoga River tributaries including; Tare Creek, Fish Creek, Little Cuyahoga River, Furnace Run, Yellow Creek, North Fork Yellow Creek, Brandywine Creek, the Tinkers Creek subbasin (mainstem, Pond Brook, Beaver Meadow Run, Hawthorne Creek), Mill Creek, Big Creek, Morgan Run (water quality sampling only), the old section of river channel near the mouth (water quality and sediment sampling only), and Breakneck Creek and Kingsbury Run (sediment sampling only). This monitoring study: (1) assesses the chemical/physical water quality, biological communities, fish tissue, and habitat quality in the study area to determine the magnitude and extent of impacts from point and non-point sources of pollution and habitat alteration, (2) evaluates potential impacts associated with major municipal wastewater treatment plants (WWTPs) and industrial discharges within the study area in support of the water quality based effluent limitations (WQBEL) report process, (3) evaluates impacts associated with combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), and urban runoff in the Akron and Cleveland metropolitan areas, (4) assesses aquatic life use attainment potential in the study including the Cuyahoga River navigation channel, (5) determines attainment status of existing and recommended designated uses (aquatic life, recreation, water supply, etc.), and (6) examines trends in chemical water quality and biological condition through time for portions of the Cuyahoga River mainstem, Tinkers Creek, and the Little Cuyahoga River where sufficient historical data is available. Report includes color plates of the Cuyahoga River mainstem and its tributaries. Volume 2 of this report contains appendices of data collected during the study.*

Tillman, Danielle C. (1992). Rapid Bioassessment of Fourteen Perennial Streams Using Benthic Macroinvertebrates (ID #: 100733). *In 1987, a rapid bioassessment conducted of twenty-one tributaries of the Cuyahoga River was conducted (Pfenninger, 1987). This study is an effort to repeat the work done in 1987 in order to assess if any improvements in water quality are indicated in the macroinvertebrate populations. Along with the macroinvertebrate collection and identification, an Ohio Environmental Protection Agency Qualitative Habitat Evaluation Index Field Sheet (QHEI) was completed for each stream studied. The QHEI was developed to measure habitat factors which are generally important to aquatic life. This study examined the correlation between biotic index and the habitat quality indicated by the QHEI.*

Pfenninger, Deborah W. (1987). A Biological Monitoring Program for the Perennial Streams of the Cuyahoga Valley National Recreation Area (ID #: 16392). *A proposed biological monitoring program for the perennial streams within the Cuyahoga Valley National Recreation Area (CVNRA). Macroinvertebrate analysis is recommended as a complement to the ongoing chemical and physical water quality being done in the CVNRA. The proposal includes methodology, specimen identification procedures, and analysis. Included with the proposal is a completed biological stream monitoring data summary.*

Savisky, Timothy, Olive, John H., Jackson, Jim L., Holland, Lynda, Bass, Joanna (1986). Benthic Macroinvertebrates as Indexes of Water Quality in the Upper Cuyahoga River (ID #: 15073). *The results of a 1986 benthic macroinvertebrate assessment of water quality from nine areas along the upper Cuyahoga River. Water samples for selected chemical-physical analyses (hydrogen ion activity (pH), conductivity, and total hardness) were collected to provide an index of potential biological productivity. Approximately 146 taxa of macroinvertebrates were collected from the upper Cuyahoga*

River. The study measures benthic macroinvertebrates in terms of: density of organisms, ratio of scraper-grazers to detritivores, ratio of amphipods to isopods, and the proportion of organisms that are intolerant, facultative, and tolerant of organic pollution. These measures of benthic community structure were selected for their usefulness as indexes of water quality.

Huryn, A.D., Foote, B.A. (1980). Genera of Stream-Inhabiting Insects Occurring in the Cuyahoga Valley National Recreation Area (CVNRA), with a Biological Classification of the Flowing Water Habitats (ID #: 51685). *This study generates a biological classification of the streams within the Cuyahoga Valley National Recreation Area that is based on the aquatic insect fauna and determines the genera and distribution of stream insects occurring within the Park boundaries. It includes a map of stream insect survey collection sites and a list of species collected.*

Orr, Lowell P., Kleeberger, Steven R., Davic, Robert D. (1980). A Survey of the Fish and Rare and Endangered Amphibians and Reptiles of the Cuyahoga River Tributaries in the Cuyahoga Valley National Recreation Area (ID #: 123367). *This purpose of this study is twofold: (1) to inventory the fishes of the tributaries of the Cuyahoga River and ponds within the boundaries of the Cuyahoga Valley National Recreation Area (CVNRA) and (2) to continue an inventory of the reptiles and amphibians within the CVNRA that was initiated in 1978, emphasizing a search for rare and endangered species (particularly the Four-toed Salamander and the Spotted Turtle) that may be found in the vicinity of Phase II of the proposed Cuyahoga Valley Interceptor Sewer.*

Orr, Lowell P. (1978). A Survey of the Amphibians and Reptiles of the Cuyahoga Valley National Recreation Area (ID #: 123319). *The purpose of this research was to survey the amphibians and reptiles of the Cuyahoga Valley National Recreation Area (CVNRA) through field collecting and by examining area museum collections and the literature. Twenty three species of amphibians and fifteen species of reptiles were found within the CVNRA.*

U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services for the National Wetlands Inventory (1977) National Wetlands Inventory (ID #: 82127). *Topographic maps identifying wetland resources within the Cuyahoga Valley National Recreation Area. Maps were prepared primarily by stereoscopic analysis of high altitude aerial photographs. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with Classification of Wetlands and Deep Water Habitats of the United States (Cowardin, et al, 1977).*

National Biological Survey (No Date). Benthic Macroinvertebrate and Polycyclic Aromatic Hydrocarbon Inventory in Tributaries of the Cuyahoga River at the Cuyahoga Valley National Recreation Area (ID #: 15053). *Cuyahoga Valley National Recreation Area (CVNRA) has over 190 miles of perennial and ephemeral streams (excluding the Cuyahoga River) within its boundaries. Oil extraction and transportation activities in and around the park potentially jeopardize the water quality of these streams. Over thirty-five miles of major and secondary gas and oil pipelines traverse the park including many of the 21 park streams. Additionally, there are 97 active oil and gas wells within park boundaries and many more adjacent. Oil spills could adversely impact both terrestrial and aquatic resources since most spill material eventually reaches park waters directly or by runoff. Oil pollution has been shown to affect organisms in two fundamental ways. It tends to coat or smother organisms (Laws, 1981), and oil associated hydrocarbons bioaccumulate in body tissues causing toxic responses. The purpose of this research is to establish baseline data on benthic macroinvertebrate communities and to perform polycyclic aromatic hydrocarbons (PAH) scans of stream sediments.*

2.5.2.2.3 EFMO - Aquatics

Seigley, L. S. (1996). Results of Water Sampling Of Yellow River (ID # 107223). *Results of water sampling project on Yellow River which runs through Effigy Mounds National Monument. Results for this ongoing project are frequently updated.*

Schueller, Michael D. Kennedy, Jack O. Birmingham, Michael W. (1995). Sny Magill Creek Non-point Source Pollution Monitoring Project: 1994 Benthic Biomonitoring Results (ID # 114113). *Report of water quality surveys of Sny Magill Creek which runs through Effigy Mounds National Monument. The studies are part of an effort to document the effectiveness of non-point source pollution controls in restoring water quality. Detailed results from samples taken from six testing sites and progress graphs are included.*

Grau, Thomas L. Brown, Leroy Anderson, Robert M. (1994). Sny Magill Creek Cold Water Stream Water Quality Improvement (ID # 114110). *Report of efforts to improve water quality of Sny Magill Creek which runs through Effigy Mounds National Monument. The studies are part of an effort to document the effectiveness of non-point source pollution controls in restoring water quality. Efforts to reduce and measure pollution from agricultural activities are documented and plans for future efforts laid out.*

Schueller, Michael D. Kennedy, Jack O. Birmingham, Michael W. (1994). Sny Magill Creek Non-point Source Pollution Monitoring Project: 1993 Benthic Biomonitoring Results (ID # 114112). *Report of water quality surveys of Sny Magill Creek which runs through Effigy Mounds National Monument. The studies are part of an effort to document the effectiveness of non-point source pollution controls in restoring water quality. Detailed results from samples taken from six testing sites and progress graphs are included.*

Various authors Seigley, L.S. (1994). Sny Magill Non-point Source Pollution Monitoring Project, Clayton County, Iowa: Water Years 1992 And 1993 (ID # 114114). *Report of water quality studies of Sny Magill Creek which runs through Effigy Mounds National Monument. The studies are part of an effort to document the effectiveness of non-point source pollution controls in restoring water quality. Topics addressed include farming practices, geology, precipitation, fish assessments, habitat assessments, sediment discharge, and water quality.*

Various authors Seigley, L.S. (1994). Sny Magill Watershed Monitoring Project: Baseline Data (ID # 114115). *Compilation of results of several studies the Sny Magill Watershed which runs through Effigy Mounds National Monument. Geology, water quality, habitat evaluation, historical data, and fish assessments are all discussed and baseline data recorded. The studies are part of an effort to document the effectiveness of non-point source pollution controls in restoring water quality.*

Sanchini, Paula, Ph.D. (1994). Assessment of Wetland Habitats near Ponds at Effigy Mounds National Monument. (ID # 151125). *Wetland vascular plant surveys for the monument. the 120-acre Sny Magill Unit has been surveyed for forest vegetation but is still lacking in wetland plant data.*

Schueller, Michael D. Kennedy Jack O. Hausler, Mark C. (1992). *Sny Magill Creek Non-point Source Pollution Monitoring Project: 1991 Benthic Biomonitoring Pilot Study Results (ID # 114111). Results of a 1991 water sampling project on Sny Magill Creek which runs through Effigy Mounds National Monument. Six sampling sites were used in this survey. Annual results for this ongoing project are located in the same file.*

2.5.2.2.4 GWCA - River: Biotic

2.5.2.2.5 HEHO - Stream: Physical

Snyder & Associates Inc. Land and Community Associates John Milner Associates Dunbar/Jones Partnership Andropogon Associates, Ltd. (1995). Herbert Hoover National Historic Site Cultural Landscape Report (ID # 60433). *The Report discusses the natural resources of the park such as the Wapsinonoc creek. The report surmises several hydrologic solutions for the existing flood plain: Off stream limited detention in a built wetland; swale overflow spillway around bridges; replacement of bank soil with more permeable material. The report discusses the vegetation of the park along with diagrams and photos of the 1850- forward era.*

Osowski, Sharon (1993). Species Checklists (ID # 116564). *This checklist provides a detailed listing of family/species/habitat and characteristics on the following concerns: Mushrooms, Plants, Insects, Butterflies, Fish, Reptiles & Amphibians, Birds and Mammals.*

Kondratieff, Boris Harris, Mitchell Boyle, Terence (). Manual for Implementation and Development of Aquatic resource inventory and monitoring methodology in prairie parks Herbert Hoover (ID # 75156). *A well done manual speaking specifically on the implementation and monitoring methodologies used in the aquatic resource inventory process. A permanent sampling site has been established on West Branch Wapsinonoc Creek in HEHO for benthic macroinvertebrate sampling and water chemistry monitoring. The Surber bottom sampler is employed to gather the benthic macroinvertebrates.(bottom dwelling worms, mollusks and anthropods, large enough to be seen with the unaided eye.*

2.5.2.2.6 HOME - Aquatics

Homestead National Monument (1992). Cub Creek Water Quality Statistics (ID # 28775). *Each sample date contains a report on conditions at sample site and methods used. Contains chemical and macroinvertebrate analysis of samples by independent labs.*

Schandt, C.Warden, R. (1991). Distribution of Nitrate in Vadose Soils of Gage Counties, Lower Big Blue Natural Resources District (ID # 33368). *This paper contains information from deep soil tests done at 13 Gage County Nebraska test sites including HOME (Homestead National Monument) specifically looking at nitrate levels throughout the strata sampled (to 19 feet at HOME).*

Kondratieff, Boris C. Harris, M.A. Boyle, Terence (1991). Water Quality Work Plan for Homestead National Monument (ID # 135313). *This report provides an inventory of the aquatic macroinvertebrates and baseline information about the aquatic ecosystem of Cub Creek through Homestead National Monument, and outlines a program for monitoring the aquatic resources using biological criteria. See also N1617 "Management of Natural Resources: Water Quality-Cub Creek" in general park files.*

Homestead National Monument (1989). Resource Management Plan with Environmental Assessment (superceded) (ID # 106232). *A resource planning document that addresses both cultural and natural resources at Homestead National Monument. Refers to baseline natural resource data from 1984 prairie vegetation study by the University of Nebraska, history of restoration and management of tall grass prairie at HOME (Homestead National Monument), management of gallery forest and other current problems and recommended actions.*

Baynes, Randall K. (1988). General Management Plan for Homestead National Monument of America (ID # 51964). *The 1970 addition of the detached Freeman School unit, expanded visitor center and school interpretive themes/treatments, and several park infrastructure, resource management and land condition concerns are issues not addressed by Homestead's 1964 Master Plan. Guidance to resolve these issues required the preparation of a new General Management Plan. This plan will describe current management concepts as they have evolved from the 1964 Master Plan. A Development Concept Plan for the Freeman School will be included. Proposals for the updating of an Interpretive Prospectus will be developed. The General Management Plan will develop alternatives for interpretation at the visitor center and the Freeman School, sewage treatment and equipment storage in the developed area, parking at and access to the Freeman School, land protection for parcels adjoining the Freeman School, and a state-owned parcel contiguous with the monument's restored native tallgrass prairie, and mitigation of erosion, and related problems caused by the periodic flooding of Cub Creek.*

Homestead National Monument (1983). Erosion control; Cub Creek Stabilization (ID # 41297). *This file contains request for bids, job specifications, blue-line plans and photos of work being performed to fix erosion on Cub Creek.*

Unknown author (1966). Cub Creek Watershed: Gage and Jefferson Counties, Nebraska (ID # 28777). *This informational brochure details a plan to build flood and grade control dams and structures within the Cub Creek watershed. HOME (Homestead National Monument) is located at the base of the 92,000 acre watershed.*

Unknown author (). Cub Creek (ID # 28773). *A series of photo slides of Cub Creek which runs through HOME (Homestead National Monument). There is no information with this slide*

Unknown author (). Cub Creek Watershed: Gage and Jefferson Counties (ID # 28776). *Show the Cub Creek drainage area with tributaries and section lines.*

Kondratieff, Boris C. Harris, M. A. Boyle, Terence (). Manual for Implementation and Development of Aquatic Resource Inventory and Monitoring Methodology in Prairie Parks: Homestead National Monument (ID # 75157). *This manual states rationale and methodology for the inventory and*

monitoring of aquatic resources in the prairie parks and analysis of data collected with the assistance of NAPSAC and BSTRAP programs.

2.5.2.2.7 HOSP - Geothermal Springs

Noguchi, Kimio (1982). Geochemical Nature of Hot Spring Waters in Hot Springs National Park of Arkansas (ID # 52513). *Found correlations between various chemical characteristics of the hot springs water (e.g. calcium and bicarbonate contents). Discusses the implications for the origin of the water. Also measured nitrogen, and carbon dioxide in gases emitted from the hot springs.*

Swann, Sandra Kay (1981). The Hot Springs of Hot Springs National Park, Arkansas: An Overview (ID # 62125). *Description of the geologic events that created the hot springs, written in non-technical language. Section titles: Geology of the Area; Age, Source & Movement of Waters; Flow, Temperature & Composition of Waters.*

Stone, C. G. Sniegocki, R. T. Reed, J. E. Pearson, F. J. Bedinger, M. S. (1979). Geohydrology of Geothermal Systems. Geological Survey Professional Paper 1044-C (ID # 136213). *Table of contents: Geologic Setting; Character of the spring and well waters in the hot-springs area (physical quality - flow, temperature and silica concentration, and chemical quality - hydrogen and oxygen isotopes, carbonates, radioactivity); The Hot-Spring Flow SysteM. Includes tables and graphs of data. In the back pocket is a geological map (1:24,000 scale). This was a three year plus research project and is the most thorough investigation to date regarding the nature and origin of the park's thermal water resources and their geohydrologic framework. Provides management recommandations. Open U.S.G.S. file report.*

Sniegocki, Richard T. Reed, Joe E. Pearson, Frederick J. =Jr. Bedinger, Marion S. (1974). Abstracts with Programs. Geological Society of America (ID # 125278). *Hot springs at Hot Springs National Park issue from a large overturned anticline along the southern margin of the Ouachita anticlinorium in the Zigzag Mountains. Combined flow of the hot springs ranges from 750,000 to 950,000 gallons per day. Data supports the concept that the water that flows from the springs is from infiltration of precipitation on an outcrop of the Bigfork Chert and the Arkansas Novaculite about 10 miles away.*

Stone, C. G. Sniegocki, R. T. Reed, J. E. Pearson, F. J. Bedinger, M. S. (1974). Open-file report to the National Park Service, Southwest Region, Santa Fe, New Mexico (ID # 136215). *Table of contents: Geologic Setting; Character of the spring and well waters in the hot-springs area (physical quality - flow, temperature and silica concentration, and chemical quality - hydrogen and oxygen isotopes, carbonates, radioactivity); The Hot-Spring Flow SysteM. Includes tables and graphs of data. In the back pocket is a geological map, a land cover map, and a map showing locations of cold springs and wells.*

Pearson, F. J. Jones, B. F. Bedinger, M. S. (1972). Carbon-14 Ages of Water from the Arkansas Hot Springs (ID # 20701). *Results of analysis of carbon in the hot springs water. Describes the carbon-related water chemistry and the age of the water determined by carbon isotope analysis.*

Sniegocki, R. T. Poole, J. L. Bedinger, M. S. (1970). The Thermal Springs of Hot Springs National Park, Arkansas--Factors Affecting Their Environment and Management (ID # 125279). *Summary of the hydrogeology of the hot springs based upon best current information (as of 1970). Discusses the flow of water from the surface into the ground and out at the hot springs, the nature of the water (minerals, gases, temperature, and radioactivity), the impact of human activities, and management issues (flooding pollution, park development). Includes tables of data gathered from previous reports.*

Waring, Gerald A. Stearns, Norah D. Stearns, Harold T. (1937). Geological Survey Water-Supply Paper 679-B (ID # 125275). *An index in the back lists references to Arkansas Hot springs on p. 78-80, 117. P. 78-80 includes a description of the hot springs. P. 117 is part of a table which gives name, location, geology, temperature, discharge rate and remarks for each spring.*

Hazlett, Donald C. (1935). The geology of the vicinity of the Hot Springs National Park, Arkansas (ID # 55142). *Description of the geology of the Hot Springs National Park area - topography, drainage, stratigraphy, structural features, sedimentary and igneous rocks, geologic history and economic geology.*

Schlundt, Herman (1935). American Journal of Science (ID # 104857). *Measured radioactivity of water from 45 springs. Found radon in all in widely varying amounts. Radium was found in some tufa deposits. Also measured pH. Includes 3 brief tables giving radon, radium and pH data.*

Weed, Walter Harvey Haywood, J. K. Department of the Interior (1912). Analyses of the Waters of the Hot Springs of Arkansas and Geological Sketch of Hot Springs Arkansas (ID # 8044). *Describes methods of examination for different compounds and water quality measures, medicinal value of substances usually found in mineral waters. Followed by charts of data for each of the springs. At the end is a separate, brief report on the geology of the area - topography, rocks, hot springs, tufa deposits, sources of water in hot springs, sources of mineral content of waters, constancy of spring temperatures and discharge and source of heat. Includes several historical black and white photographs of the area.*

2.5.2.2.8   HOSP – Rivers

Wagner, George H. Steele, Kenneth F. (1985). Metal concentrations in the ground water of Ouachita Mountains, Arkansas, U.S.A. (ID # 77328). *Ground water samples from mineralized areas of the Ouachita Mountains were analyzed for Fe, Mn, Zn, Cu, Co, Ni, Pb, Hg, Sb, Sr, Ba, Ca, Li. The sampled area included Hot Springs National Park. Sampling techniques followed EPA and American Public Health Association guidelines. EPA criteria for Fe and Mn in drinking water were exceeded in many of the areas tested. One spring exceeded the EPA Hg criterion, and 3 springs exceeded the Pb criterion. Studies pf this sort are useful in establishing anthropological effects. Table I: Median concentrations, ranges, threshold concentrations, average anomalous concentrations and percent of springs exceeding the EPA drinking water limits for various metals in spring water of areas studied. Table II: Detection of known mineral deposits by anomalous concentrations of metals in springs less than 1.7 km from deposits compared with anomalous concentrations of metals in springs more than 1.7 km from mineral deposits.*

Schmitz, Eugene H. Nix, Joe F. Meyer, Richard L. Houston, James Buchanan, Tom M. (1978). A Limnological Study of Ricks Pond and the Gulpha Creek Drainage in Garland County, Arkansas an interdisciplinary study conducted for the National Park Service (ID # 72056). *Sections on water quality (water temperature, dissolved oxygen, specific conductance, pH, alkalinity, chemistry, coliform, turbidity), phytoplankton & periphyton (includes a list of species and density of organisms), aquatic vegetation (brief description of aquatic plant species), zooplankton (list of species and density of species), benthos (list of species and number of organisms), fishes (list of species with comments and distribution maps) and recommendations for the establishment of a put-and-take fishery in Ricks pond.*

Sims, A. C. Ogra, M. S. (1976). Aquatic Resources of Gulpha Gorge Creek Hot Springs National Park, Arkansas: Final Report on Chemical and Microbiological Analysis (ID # 10682). *Analysis of water quality of Gulpha Gorge creek. Found good quality and no indication of contamination from human campers or hikers. Parameters measured were color, conductivity, dissolved oxygen, pH, temperature, turbidity, acidity, alkalinity, chloride, chromium hexavalent, copper, fluoride, hardness, iron, lead, manganese, mercury, nitrogen, phosphate, silica, sulfate & sulfide, suspended solids, and coliform bacteria. At the end is a list of plant species found along the creek and recommendations for future research.*

Southwest Region, National Park Service Ogra, M. S. (1974). Aquatic Resources of Gulpha Gorge Creek Hot Springs National Park - Arkansas (ID # 10681). *Description of analysis of water resources in Gulpha Gorge Creek watershed (within and adjacent to Hot Springs National Park).Includes table of water analysis results from 7 stations (temperature, pH, chemistry).*

US Army Corps of Engineers, Vicksburg District (1974). Flood Plain Information Ouachita River Hot Springs Creek - Stokes Creek, Molly Creek - Gulpha Creek City of Hot Springs, Arkansas (ID # 48504). *The Army Corps of Engineers has generated two documents dealing with the flood plains in and adjacent to the park. One, 'Flood Plain Information - City of Hot Springs addresses the Ouachita River, Hot Springs Creek, and Gulpha Creek among others' was released June l974. The second, 'Flood Insurance Study', was released February, l974. Both have narrative detailed maps and aerial photographs with flood plain overlays. Report on the flooding of the Ouachita River and its tributaries - past floods, flood factors, future floods. Maps show flooding areas (lines and shading on black and white aerial photographs at a scale of 1:10,000).*

2.5.2.2.9   OZAR – Springs

Dreiss, Shirley J. (1989). Regional Scale Transport in a Karst Aquifer. 1. Component Separation of Spring Flow Hydrographs (ID # 102964). *This paper describes chemical fluctuations in the discharge of three large karst springs in southeastern Missouri. The chemical history from one of the springs is then used to compute the storm-derived component of the spring discharge. This discharge component is a time series that represents the arrival of rapidly introduced and transported infiltration at the spring outlet. In a companion paper [Dreiss, this issue] a method is presented for describing regional scale transport in the karst conduit network by treating this component as the output response of the aquifer to a series of naturally occurring, regional scale tracer events.*

Vineyard, Jerry D. Pflieger, William L. Lipscomb, Robert G. Feder, Gerald, L. (1974). Springs of Missouri with sections on Fauna and Flora (ID # 117154). *It is the purpose of this report to present available quantitative and qualitative information about springflow in Missouri and to illustrate and describe the physical and cultural changes in the spring environs. This additional information will be of interest to those charged with the management of the state's water resources (particularly in the recreation field) and to homeowners, farmers and those city dwellers seeking country retreats. Information and records collected for this report, which are expected to stimulate further contributions to karst hydrology, also will be used for an interpretive study of the movement of water in the limestone and dolomite that underlie the Ozarks.*

Aley, Thomas J (1973). Groundwater Tracing and Recharge Basin Delineations for Big Spring, Alley Spring and Round Spring (ID # 58294). *This document is a report on successful groundwater tracings for Big Spring, Alley Spring and Round Spring.*

Aley, Catherine L. and Aley, Thomas J. (1987). Groundwater Study, Ozark National Scenic Riverways - Volume 1. Vol 1 ed.. Protem, Missouri: Ozark Underground Laboratory.

Aley, Catherine L. and Aley, Thomas J. (1987). Groundwater Study, Ozark National Scenic Riverways - Volume 2. Vol 2 ed.. Protem, Missouri: Ozark Underground Laboratory.

Imes, Jeffrey L. and Kleeschulte, Michael J. (1995). Seasonal Ground-Water Level Changes (1990-1993) and Flow Patterns in the Fristoe Unit of the Mark Twain National Forest, Southern Missouri. Washington D.C.: United States Printing Office; 1995; Water-Resources Investigations Report 95-4096.

2.5.2.2.10 OZAR – Abiotic

Bobbitt, Karen (1996). Drainage Basin Control on Gravel Distribution in the Current River, Missouri (ID # 34654). *This study evaluates drainage basin controls on channel instabilities in the Current River, a typical Ozarks river with a drainage area of about 6000 km2. Basin size, relief, drainage density, shape factors, bedrock geology, and land use characteristics of thirteen third- through fifth- order tributary watersheds were examined using readily available digital data sets in a Geographic Information System (GIS) platforM. The impact each basin has on channel characteristics was determined within the main channel as mapped off of 1:24,000-scale aerial photographs. Results from gravel mapping and field observations indicate that a drainage area threshold exists. Basins at least forty times smaller than the area drained by the Current River upstream from each tributary basins, high relief and bedrock lithology (channel downcutting through the Eminence-Potosi Dolomites) correlate with a high amount of impact on the Current River. Drainage basin controls on main channel instabilities vary throughout the basin. The strongest controls are found in the east central portion of the Current River watershed, the location of all high impact tributary basins. The lowermost part of the basin is fed mainly by small tributaries, making drainage basin controls less effective in this part of the watershed.*

Joseph, Robert L. Friewald, David A. Bell, Richard W. (1996). Water-Quality Assessment Of The Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma-Summary of Information of Pesticides, 1970-1990 (ID # 134898). *Historical pesticide data from 1970-90 were compiled for 140 surface-water, 92 groundwater, 55 streambed-sediment, and 120 biological-tissue sampling sites within the Ozark Plateaus National Water Quality Assessment Program study unit. Surface water, bed-sediment, and biological-tissue sites have drainage basins predominantly in the Springfield and Salem Plateaus; groundwater sites are predominantly located in the Osage Plains and Mississippi Alluvial Plain. Many sites were sampled only once or twice during this period. A large percentage of the samples were collected in the mid-1970's and early 1980's for surface water, 1990 for ground water, the late 1980's for bed sediment, and the early 1980's for biological tissue. Quality criteria or* *standards have been established for 15 of the pesticides detected in the study unit. For surface water samples, the drinking water maximum contaminant level for alachlor was exceeded in one sample from one site in 1982. For groundwater samples, the drinking water maximum contaminant level for atrazine was exceeded in four samples from four wells in 1990. For biological-tissue samples collected during the years 1982-89, the fish tissue action levels for chlordane (19 sites; 26 samples), heptachlor epoxide (3 sites; 3 samples), p,p'-DDE (2 sites; 2 samples), dieldrin (2 sites, 2 samples), and mirex (1 site, 1 sample) were exceeded. For bed-sediment samples, quality criteria or standards were not exceeded for any pesticide. Pesticides do not pose any widespread or persistent problems in the study unit, based on the limited number of samples that exceeded quality criteria and standards.*

National Park Service (1995). Baseline Water Quality Data Inventory and Analysis, Ozark National Scenic Riverways, Vol. I & II (ID # 13794). *This document presents the results of surface-water-quality data retrievals for Ozark National Scenic Riverways (OZAR) from six of the United States Environmental Protection Agency's (EPA) national databases: (1) Storage and Retrieval (STORET) water quality database management system: (2) River Reach File (RF3); (3) Industrial Facilities Discharge (IFD); (4) Drinking Water Supplies (DRINKS); (5) Water Gages (GAGES); and (6) Water Impoundments (DAMS). This document is one product resulting from a cooperative contractual endeavor between the National Park Service's Servicewide Inventory and Monitoring Program, the National Park Service's Water Resource Division (WRD), and Horizon System Corporation to retrieve, format, and analyze water quality data for all units of the National Park System containing significant water resources. The primary goal of the project is to provide descriptive water quality information in a manner and format that is both consistent with the goals of the Servicewide Inventory and Monitoring Program and useable by park resource managers. The document provides: (1) a complete inventory of all retrieved water quality parameter data, water quality stations, and the entities responsible for the data collection; (2) descriptive statistics and appropriate graphical plots of water quality data characterizing annual and seasonal central tendencies and trends; (3) a comparison of the park's water quality data to relevant EPA and WRD water quality screening criteria; and (4) an Inventory Data Evaluation and Analysis (IDEA) to determine what Servicewide Inventory and Monitoring Program "Level I" water quality parameters have been measured within the study area. Accompanying the report are disks containing digital copies of all data used in the report, as well as components of the report (tables, figures, etc.).*

Petersen, James C. Friewald, David A. Davis, Jerri V. Adamski, James, C. (1995). Water-Quality Assessment of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma-Analysis of Information on Nutrients, Suspended Sediment, and Suspended Solids, 1970-92 (ID # 134896). *Water-Quality data collected during water years 1970-90 (October 1 to September 30) for 83 surface-water sites in the 48,000 square mile Ozark Plateaus study unit of the National Water-Quality Assessment Program were analyzed using selected descriptive and statistical methods. The water-quality data include nutrient (nitrogen and phosphorus), suspended-sediment, and suspended-solids data; and ancillary information on fertilizer use, animal waste, sewage-treatment plants, and land use.*

Saucier, Roger T. (1983). Historic Changes in Current River Meander Regime (ID # 60865). *The Current River in the Salem Plateau of Missouri flows in a several thousand-foot wide valley bordered by several hundred-foot high rock bluffs. It is a gravel bed stream of moderate gradient (bed rock-controlled) with a straight to slightly sinuous pattern. Three well-developed alluvial terraces of late Pleistocene age flank the river and modern floodplain and provide an indication of the rate and extent of lateral channel shifting. Despite probable major regional climatic changes associated with glacial-interglacial cycles, the river pattern did not change and the channel was exceptionally stable until several thousand years ago. More rapid lateral channel migration began during the late Holocene and dramatically increased in the early 19th century due to a huge influx of gravel. This was triggered by extensive hillside erosion attributable to several decades of timber clear-cutting followed by open range grazing. Geomorphic response of the fluvial system to the gravel load includes a characteristic form of meandering involving increased sinuosity, rapid bar growth, sharp channel bends, and repetitive chute cutoffs within discrete sedimentation zones. A positive feedback mechanism facilitates continued cutoffs within these zones. As a consequence of this process, the net amount of floodplain and terrace reworking in the last 100 years has exceeded that of the previous 5,000 to 10,000 years.*

Barks, James H. (1978). Water Quality in the Ozark National Scenic Riverways, Missouri (ID # 134997). *Water quality analysis was conducted and reported in this document for the streams and rivers located in the Ozarks National Scenic Riverways. The Current River and its principal tributary, Jack's Fork,* *are the Ozark National Scenic Riverway's primary natural features. About 60 % of the baseflow in the two streams is derived from the seven largest springs in the basin. Because the streams and springs are the primary attractions to the park, preservation of the physical, chemical, and biological quality and aesthetic appeal of the waters is important. From April 1973 to May 1975, water samples were collected from 19 wells, 7 large springs, 14 sites on the Jacks Fork, and 5 tributaries to the Current River and Jacks Fork.*

Duchrow, Richard M. (1976). Water Quality of the Current, Jack's Fork, Eleven Point, Little Black and Warm Fork of Spring River Basins of Missouri (ID # 135145). *Aquatic invertebrates were collected from the Current, Jack's Fork, Little Black and Warm Fork of Spring River basins to determine the water quality in these streams. Fifty-one sampling stations were established on these streams and their major tributaries. Invertebrate collections, and water samples at selected stations, were taken quarterly during 1974. The water quality conditions were evaluated by examining the invertebrate communities at each station both qualitatively and quantitatively. Qualitatively, the total number of taxa, found throughout the year, and the number of mayfly and stonefly taxa found on a seasonal and annual basis were compared to established standards for unpolluted streams in Missouri. The invertebrate community structure and presence or absence of pollution sensitive taxa were also used as indicators of water quality. Quantitatively, the diversity of the invertebrate community was evaluated by calculating species diversity index values and comparing these values to standards established for unpolluted Missouri streams. Invertebrate community structure between stations was compared by calculating coefficients of similarity for pairs of stations. Point sources of pollution which actually or potentially discharged into these rivers and their tributaries were identified.*

Harvey, Edward .J. Gann, E.E. (1969). Hydrology and Water Resources of the Current River Basin (ID # 63233). *The purpose of this report is to provide background information on the hydrology and water resources of the Current River basin as related to the development of the Ozark National Scenic Riverways. The material presented is to be incorporated by the National Park Service in a comprehensive report covering the ecosystem of the Current River basin. Final results are to be used by the National Park Service in planning the development of the Scenic Riverways.*

Clifford, Hugh F (1966). Some Limnological Characteristics of Six Ozark Streams (ID # 115467). *Physical, chemical and biological conditions were studied in six Ozark streams, Current, Jacks Fork, Gasconade and Big Piney rivers and Huzzah and Courtois creeks. Water chemistry characteristics of various streams illustrated the degree of influence due to geochemical and human activity factors. Biologically, the streams exhibited distinct floral and faunal characteristics normally associated with unpolluted waters. Statistical comparisons of certain chemical and biological parameters were made between stations. From these it was possible to demonstrate the degree of chemical and aquatic invertebrates differences in stations, rivers and drainage areas.*

Adamski, James C.; Petersen, James C.; Friewald, David A., and Davis, Jerri V. (1995). Environmental and Hydrologic Setting of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma. Little Rock, AR: U.S. Geological Survey; 1995; U.S. Geological Survey Water-Resources Investigations Report 94-4022. 69 p.

Bobbit, Karenet.=al. (1995). A Physiographic/Geomorphic Classification of the Current River Valley. National Park Service-ONSR; 1995 Oct 339+

Jacobson, Robert B. and Pugh, Aaron L. (1997). Riparian-Vegetation Controls on the Spatial Pattern of Stream-Channel Instability, Little Piney Creek, Missouri. 1997; U.S. Geological Survey Water-supply Paper 2494. 33 p.

McKenney, Rose A. and Jacobson, Robert B. (1996). Erosion and Deposition at the Riffle-Pool Scale in Gravel-bed Streams, Ozark Plateaus, Missouri and Arkansas, 1990-95. Rolla, MO: U.S. Geological Survey; 1996; Open-file Report 96-655A. 171 p.U.S. Geological Survey, Branch of Information Services, Box 25286, Denver, CO 80225-0286.

McKenney, Rose A.; Jacobson, Robert B., and Wertheimer, Robert C. (!995). Woody Vegetation and Channel Morphogenesis in Low-gradient, Gravel-bed Streams in the Ozark Plate Missouri and Arkansas. Geomorphology. 1995; 13:175-198.

Rabeni, Charles F. and Jacobson, Robert B. (1993). The Importance of Fluvial Hydraulics To Fish-Habitat Restoration in Low-Gradient Alluvial Streams. Freshwater Biology. 1993; 29:211-22

United States Geological Survey. (1996). Summary of Data for USGS Streamflow Gauging Stations within the Ozark National Scenic Riverways. Rolla, Missouri: United States Geological Survey; 19996 spiral-bound reports. Water Resources Division, 1400 Independence Rd., Mail Stop 100, Rolla, MO 6540

2.5.2.2.11 OZAR – Biotic

Gardner, James E. Auckley, Jim (1984). Invertebrate Fauna from Missouri Caves and Springs (ID # 66768). *A biological inventory of 436 caves and 10 springs, found in 38 counties in Missouri, was conducted from September, 1978 through August, 1984. Records presented in this study were based on collections of more than 4,500 invertebrate specimens, combined with taxonomic determinations and contributions from some 60 invertebrate systematists. Some 414 invertebrate species have been identified as a result of these collections. Data provided for each species include systematice, occurrence and natural history notes. Known geographic distribution and records from previously published materials are included for most species. Each species was classified according to its probable ecological role in the subterranean environment (troglobite, troglophile, trogloxene or acidental).*

Larson, James W. (1969). Natural Resources Basic Data for Ozark National Scenic Riverways (ID # 82854). *This document is a series of reports relating to the natural resources of Ozark National Scenic Riverways. The purpose of this report is to provide a basic understanding of the natural components, ecosystem dynamics, and man's influence in the Riverways and adjacent areas. The report is based on reconnaissance field trips and discussions held in the area on February 11, 12 and 13, 1969. A number of suggestions are presented by the team members for consideration by National Park Service planners and managers.*

Doisy, Kathy and Rabeni, Charles (1995). A Biological Monitoring Program for the Ozark National Scenic Riverways (Draft). Columbia, Missouri. Missouri Cooperative Fish and Wildlife Research Unit, Biological Resources Division, USGS, 302 Anheuser Busch Natural Resources Bldg, Columbia, Missouri 65211.

Doisy, Kathy E. and Rabeni, Charles F. (2001). Flow Conditions, Benthic Food Resources, and Invertebrate Community Composition in a Low-Gradient Stream in Missouri. Journal of the North American Benthological Society; 20(1):17-32.

Doisy, Kathy E.; Rabeni, Charles F., and Galat, David L. (1997). The Benthic Insect Community of the Lower Jacks Fork River. Transactions Missouri Academy of Sciences; 31:19-36 pp.

2.5.2.2.12 PIPE - Aquatics

Faaborg, K (2001). History of Pipestone Creek. Edited by K. Legg. *Internal document for Pipestone National Monument, National Park Service.*

NPS. 1999. Baseline water quality data inventory and analysis, Pipestone National Monument. National Park Service, Water Resources Division, Fort Collins, CO 80525. Technical Report NPS/NRWRD/NRTR-98/198.

Peterson, James T. (1997). Annual Status Report, 1996 Stream Macroinvertebrate Biomonitoring for Pipestone National Monument. (ID #:9733). *The family biotic index scores suggested that the "good" water quality in Pipestone Creek had changed little since 1992. In addition, two indices for upper Pipestone Creek and all of the indices for lower Pipestone Creek indicated increased water quality form the reference year of 1989. However, these indices may not accurately depict the "true water quality of Pipestone Creek and should be considered as rough estimates, due to the number of sample periods and the time.*

Schmidt, Konrad (1989). Vegetation Survey and Prairie Management Plan for PIPE, Pipestone National Monument Fishes List (ID #:151814). *An inventory of the fish found in PIPE streams.*

Peterson, J.T., W.M. Rizzo, E.D. Schneider, and G.D. Willson. 1999. Macroinvertebrate Biomonitoring Protocol for Four Prairie Streams. U.S. Department of the Interior, U.S. Geological Survey. Prepared for the Great Plains Prairie Cluster Long-Term Ecological Monitoring Program, National Park Service.

Rabold, James S. (1995 and 1996). Pipestone National Monument Macroinvertebrate Survey. Survey completed by the company Equatics.

Becker, D.A., T.B. Bragg, and D.M. Sutherland. 1986. Vegetation Survey and Prairie Management Plan for Pipestone National Monument.

2.5.2.2.13 TAPR - Aquatics

No articles have been identified at this time.

2.5.2.3 Exotics

2.5.2.3.1 ARPO

Arkansas Post National Memorial (1995). Arkansas Post National Memorial Resource Management Plan [DRAFT] (ID # 11365). *Draft Resource Management Plan. Includes project statements which describe proposed work. Natural resource projects are: Armadillo Management Program; Exotic Plants - Japanese Honeysuckle; Boundary Survey/Marking; Resource Inventory - Flora/Fauna (vegetation mapping, small mammal inventory, fisheries inventory); Management Ignited Prescribed Fire; Water Quality Assessment; Environmental compliance (NEPA); Fisheries Management Plan; Geographical Information SysteM.*

Arkansas Post National Memorial (1994). Statement for Management: Arkansas Post National Monument (ID # 117708). *Document identifying management issues at Arkansas Post National Memorial, with brief discussion of natural resources management. Areas requiring study include fauna; invertebrates; updated bird, mammal, reptile, and amphibian species lists; endangered species; ticks and mosquitos; river erosion; and exotic plant species.*

Arkansas Post National Memorial (1987). Resources Management Plan for Arkansas Post National Memorial, Arkansas County, Arkansas (ID # 106542). *Natural Resource projects include Natural Resources-Basic Inventory; Wildlife Protection; Prescribed Burning; Insect and Arachnid control; Hazardous Reptiles; Exotic Species; Vegetation Management.*

Arkansas Post National Memorial (1981). Resources Management Plan: Arkansas Post National Memorial: Natural Resources, Cultural Resources (ID # 106490). *Resource Management planning document for Arkansas Post National Memorial, AR, includes the following natural resource considerations: Natural Resources-Basic Inventory; Wildlife Protection; Prescribed Burning; Insect and Arachnid Control; Hazardous Reptiles; Exotic Species; Vegetation Management; Environmental Assessment; and Water Resources Management Profile.*

Arkansas Post National Memorial (1977). Resources Management Plan for Arkansas Post National Memorial, Arkansas County, Arkansas (ID # 106540). *On p. 27-34 are project statements: Natural Resources Basic Inventory (plants and animals); Insect Control - Mosquitoes (spray Malathion); Other Insect and Arachnid Control (problems in buildings); Wildlife Protection (controlling poaching); Exotic Species (Japanese honeysuckle); Prescribed Burning; Hazardous Reptiles (those found near visitor areas will be killed).*

2.5.2.3.2 CUVA

National Park Service (1999). Rare Plant Monitoring Plan (ID #:100961). *In 1986, Barbara Andreas completed an inventory of vascular plants (Andreas, 1986). The inventory included 51 state-listed rare taxa, whose status was based on the 1986-87 Ohio Department of Natural Resources rare plant list. A five year rare plant monitoring cycle is recommended by Andreas. Based on this recommendation rare taxa populations were re-inspected in 1992-93 by Moranz (VIP), and Tillman (SCA volunteer). This plan is meant as an extension of previous monitoring efforts.*

Revlock, Philip (1993). Alien Species Inventory CVNRA (ID #:3840). *A 1993 reinventory of the Cuyahoga Valley National Recreation Area (CVNRA) based on 1989 and 1990 inventories of Giant Reed Grass and Purple Loosestrife.*

National Park Service, Cuyahoga Valley National Recreation Area (1991). Plant Community Study Methodology (ID #: 93272). *Outlines the procedures to be used for study to characterize the species composition of various plant associations within the boundaries of the Cuyahoga Valley National Recreation Area. The procedures outlined are based primarily on those described in the Long-term Ecological Monitoring System Users Manuals for Shenandoah National Park. Some changes have been made to accommodate conditions at Cuyahoga Valley and to better address park goals. Topics*

covered include: site selection criteria, data collection, site description and data forms, and dominance and abundance determination.

National Park Service, Cuyahoga Valley National Recreation Area (1990). Control Plan for Alien Plant Species (ID #:27495). *Outlines a plan to control alien plant species within the Cuyahoga Valley National Recreation Area (CVNRA) specifically: Fortune's Wild Strawberry Bush (Euonymus fortunei), Japanese Honeysuckle (Lonicera japonica), Purple Loosestrife (Lythrum salicaria), Reed Canary Grass (Phalaris arundinacea), Giant Reed Grass (Phragmites australis), Japanese Knotweed (Polygonum cuspidatum), and European Alder Buckthorn (Rhamnus frangula). Includes National Park Service policies for control of alien species, plan objectives, inventory methodology, monitoring procedures, alternative controls, and management actions.*

Ruch, Daniel (1989). Wetland Inventory of Threatening Alien Plant Species in the Cuyahoga Valley National Recreation Area (ID #: 3553). *A draft report of an inventory conducted on seven species of alien plants that are potentially threatening the native flora of the Cuyahoga Valley National Recreation Area. The alien species inventoried include: Purple Loosestrife (Lythrum salicaria), Japanese Knotweed (Polygonum cuspidatum), Tall Reed Grass (Phragmites australis), European Alder Buckthorn (Rhamnus frangula), Japanese Honeysuckle (Lonicera japonica), Fortune's Wild Strawberry (Euonymus fortunei), and Reed Canary Grass (Phalaris anundinacea). Information on sightings includes species name, location, a site map and the size of infestation as visually estimated.*

Andreas, Barbara K. (1986). Botanical Surveys on the Cuyahoga Valley National Recreation Area with Special Emphasis on State-listed Rare Species (ID #: 18425). *The U.S. Fish and Wildlife Service and the National Park service provided funds for a floristic survey of the portion of the Cuyahoga Valley National Recreation Area (CVNRA) owned by the U.S. government. Occurring in the Glaciated Allegheny Plateau Physiographic Region of Ohio, in northern Summit and southern Cuyahoga counties, the study area encompassed 14,000 (5600 hectares) located primarily along steep-sided, narrow tributary ravines and the floodplain of the Cuyahoga River. Eight hundred and twenty-seven species of vascular plants, of which 18% are non-indigenous, have been documented as occurring in the CVNRA. Compilation of the vascular flora is based on field surveys, a survey of several Ohio herbaria, and a survey of pertinent floristic literature. The catalogue of the vascular flora includes information on flowering time, habitat, frequency, successional stage and management recommendations. The flora is listed alphabetically by genus and common name. Fifty-one state-listed rare taxa, whose status is based on the 1986-1987 Ohio rare plant list, have been documented from the CVNRA. Flowering period, location, source of record, population size, potential impacts and management recommendations for these rare taxa are provided. U.S.G.S. topographic quadrangles indicating the locations of rare taxa are indicated. Community types identified within the CVNRA include swamp forests, bottomland floodplain woods, beech-maple woodlands, mixed mesophytic woodlands, hemlock ravines, oak-hickory woodlands, eroding bluffs, wetlands (ponds, lakes, rivers, streams, marshes) and two types of communities of disturbance, waste places and old fields. In addition to general descriptions of the above community types, four unique natural areas, Furnace Run, the Narrows Slopes, Stumpy Basin and Virginiaa Kendall Ledges are discussed. Management recommendations for the maintenance of these communities are provided for consideration. Those taxa non-native to Ohio are indicated in the catalogue as well as in the alphabetical list by genus. Management recommendations for seven aggressive non-native taxa, Euonymus fortunei, Lonicera japonica, Lythrum salicaria, Phalaris arundinacea, Phragmites australis, Polygonum cuspidatum, and Rhamnus frangula are presented.*

2.5.2.3.3 GWCA

Arbogast, Renee (1989). Germination/Viability rates of Sorghastrum nutans and Festuca elatier (also identification of: Petalostemon purpureum, Petalostemon candidum, Amorpha canescens and Echinacae purpurea (ID # 55657). *This report, written by a Missouri Southern State College student, documents a study conducted to determine the germination and viability rates of Sorghastrum nutans (Indian grass) and Festuca elatier (tall Kentucky fescue) and also the identification of the Petalostemon purpureum (purple prairie clover), Petalostemon candidum (white prairie clover), Amorpha canescens (lead plant) and Echinacae purpurea (pale purple coneflower) as native prairie flora seedlings at George Washington Carver National Monument. The report discusses the concern by the park in regards to germination rates as well as the need for identification of native prairie flora*

seedlings. It also includes a discussion on the environmental conditions needed to germinate and potential problems encountered during germination and seedling identification. The study was conducted using established methods for seed purchase and storage, germination process, identification, viability, planting, sampling, and data analysis (Chi-square test). Graphical data identifies the relationship of milliliters of water to the number of days and the number of seeds germinated to the number of days for each type of seed. Conclusions of the study are included.

Palmer, Ernest J. (1983). The flora and natural history of George Washington Carver National Monument (ID # 48649). *This report is the National Park Service, Midwest Region Research/Resources Management Report that includes portions of Ernest J. Palmer's original 1964 manuscript on the flora and natural history of George Washington Carver National Monument from Carver's childhood up to the time of report. The report is an overview of the natural history of the park and includes the results of flora studies, conducted over several seasons. The preface discusses Mr. Palmer's interest in the park as well as references Mr. Palmer's original work. This report includes a brief history of the park's creation and Carver's contributions of economic and scientific value. It also includes a summary of Carver's life spanning from his birth, through his studies and travels, to his work at Tuskegee Normal and Industrial Institute. A summary of the physical characteristics of the area is given which includes acreage, topography, geology, erosion effects, and soil origins as well as the waterways, flora, woody plants, wild animal life, birds, reptiles, terrapins, fish, and insects found on the property. A list of flora*

Palmer, Ernest J. (1964). The flora and natural history of George Washington Carver National Monument (ID # 48648). *This report provides an overview of natural history of George Washington Carver National Monument from Carver's childhood up to the time of report. The results of flora studies, conducted over several seasons, is also included in this report. It includes a brief history of the park's creation and Carver's contributions of economic and scientific value. It also includes a summary of Carver's life spanning from his birth, through his studies and travels, to his work at Tuskegee Normal and Industrial Institute. A summary of the physical characteristics of the area is given which includes acreage, topography, geology, erosion effects, and soil origins as well as the waterways, flora, woody plants, wild animal life, birds, reptiles, terrapins, fish, and insects found on the property. In addition, more detailed information is provided on the botany, mosses and cryptogams, birds, geology, geological specimens of the subject area. A letter from Mr. Palmer to the superintendent of the park is included regarding his appointment as a Collaborator of the park and his review of a revised version of his paper. The addendum includes a cross reference between Mr. Palmer's plant common names and the standardized plant names.*

Unknown author (). George Washington Carver National Monument, Exotic Species List (ID # 55512). *This is a list of exotic species found at George Washington Carver National Monument. It identifies the scientific and common name or names for each species.*

2.5.2.3.4 LIBO

Pavlovic, Noel (1997). Vegetation Mapping (ID # 152155). *Study done to sample spring flora, update species lists and prepare a plot map.*

Wagner, Gia (1996). Vegetation/Tree Survey (ID # 152164). *Survey done to document changes to previously designated plots.*

White, Mark Pavlovic, Noel B. (1989). Forest Regeneration of Lincoln Boyhood National Memorial: Presettlement, Existing Vegetation, and Restoration Management Recommendations (ID # 50008). *Research and recommendations of how to proceed with approximating the Presettlement forest at Lincoln Boyhood National Memorial. This report describes the presettlement vegetation, current vegetation and management experiments to eliminate exotic plant species. Management recommendations for vegetation restoration are given along with restoration priorities.*

Unknown author (). Herbarium collection (ID # 60386). *Lincoln Boyhood National Memorial has an extensive herbarium located on the grounds. Specimens are collected and preserved for future*

2.5.2.3.5 HOCU

2.5.2.4 Wildlife Populations

2.5.2.4.1 CUVA

National Park Service (1999) 1999 Coyote Monitoring Report; Cuyahoga Valley National Recreation Area. (ID #: 4250). *Annual coyote monitoring report for Cuyahoga Valley National Recreation Area*

National Park Service (1999). Demonstration Deer Exclosures Summary Report 1991-1999, Cuyahoga Valley National Recreation Area (ID #: 30699). *In 1991 three deer exclosures were constructed in the park in order to evaluate and demonstrate the affect of deer browsing on vegetation over time. Declines in vegetation characteristics (i.e. woody seedling regeneration, sapling growth, etc.) in unfenced plots without a corresponding decline in fenced (exclosed) areas may indicate that factors other than deer are influencing vegetation. This report examines the data from 1991-1999 for these demonstration exclosures.*

Creekmore, Terry E., Creekmore, Lynn H. (1999). Health Assessment of White-Tailed Deer of the Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999 (ID #: 60094). *Data from 10 white-tailed deer (Odocoileus virginianus) collected in Cuyahoga Valley National Recreation Area in February 1999 by the National Wildlife Health Center as part of a herd health assessment prograM. In 1999 moderate to high body fat indices indicated that the deer herd was in better nutritional condition than observed in previous years. The deer are presently causing damage to urban landscapes, agricultural crops and to motor vehicles as a result of collisions on roads and highways. The deer herd is considered potentially vulnerable to adverse environmental factors in years where they are nutritionally stressed and in the future may experience population declines due to*

Underwood, H. Brian (1999). Monitoring Report for Distance Method Sampling (ID #: 79657). *This report analyzes a representative data set from a full implementation of distance sampling at Cuyahoga Valley. Objectives are to estimate deer density for several survey units, test the relative merits of classifying observations of deer groups in distance categories; and explore potential bias in distance estimation by analyzing a subset of distances measured exactly with a hand held laser-rangefinder.*

Benke, Meg (1998 and 1997). Deer Spotlight Survey Report. (ID #: 4208). A*nnual report*

Stout, Susan L. (1998). Assessing the Adequacy of Tree Regeneration on the Cuyahoga Valley National Recreation Area (ID #: 11701). *This report assesses the variation in tree regeneration abundance and recommends three aspects in its long term monitoring efforts for forest regeneration. These include fenced exclosures, the concept of stocked plots and a vegetation monitoring scheme.*

DiPietro, Teresa (1998). CVNRA Long Term Ecological Monitoring (Vegetation) Plan ID #: 29183 *The objectives of this plan are to establish a permanent, quantitative, vegetation monitoring system on a broad spatial scale. Data will be collected to monitor changes in the composition, structure, and regeneration of plant communities. Data analysis may identify and interpret changes that may occur as a result of natural succession, management activities, or perturbations such as gypsy moths, migration of exotic species, and grazing pressure.*

Cepek, Jonathan (1998). Determining the Biological Status of Coyotes in the Cuyahoga Valley National Recreation Area (ID #: 31649). *This report is a proposal for Master's Degree Research to compare the various methods of canid study in an urban encroached area; investigate possible trends revealed by these methods; gather baseline data on the coyote population in the CVNRA to include general distribution, diet, and any population estimates that can be made.*

deCalesta, David S. 1998 Implications of Feeding Preferences for Management of White-tailed Deer on Cuyahoga Valley National Recreation Area (ID #: 64177). *Observations of plants browsed upon by white-tailed deer within CVNRA was compared with a comprehensive review of white-tailed deer forage preferences. Recommended actions include developing a system of fenced exclosures to verify deer impacts on vegetation, and initiating a study of deer movements and habitat use within and adjacent to CVNRA.*

Redding, Jim (1998). A Qualitative Assessment of Current Deer Impact on the Cuyahoga Valley National Recreation Area Forested Stands (ID #: 99818). *This paper describes an assessment made on the impact deer are having on the woody and herbaceous vegetation in forested stands within Cuyahoga Valley National Recreation Area.*

National Park Service (1997). Cuyahoga Valley National Recreation Area White-tailed Deer Population Distribution Monitoring Report ID #: 29180 *annual report*

National Park Service (1997). Environmental Assessment and Management Plan for White-tailed Deer (ID #: 39724) *Environmental assessment for the management of white-tailed deer in Cuyahoga Valley National Recreation Area.*

National Park Service, Cuyahoga Valley National Recreation Area (1996) Coyote Howling Survey Results, Cuyahoga Valley National Recreation Area, 1996 (ID #: 28176) *Results of a coyote inventory and monitoring effort to collect baseline population data and to determine geographic distribution of coyotes within the boundaries of the Cuyahoga Valley National Recreation Area. An auditory count method was conducted to collect data on coyote population. This howling survey was used to estimate approximate numbers of coyote in an area by using repeatable listening stations and identifying number, distance and direction of responding coyotes.*

National Park Service, Cuyahoga Valley National Recreation Area (1995). Deer Exclosures Summary Report 1991-1995 (ID #: 30022). *Results of a five year study (1991-1995) to determine the impacts of white-tailed deer on vegetative resources within the Cuyahoga Valley National Recreation Area.*

National Park Service, Cuyahoga Valley National Recreation Area (1995). White-Tailed Deer Population Distribution Monitoring Plan (ID #: 137260). *Detailed plan for conducting a deer fecal pellet group survey in the Cuyahoga Valley National Recreation Area. The objectives of this study are to: (1) determine the geographic distribution of deer throughout the Area of Concern (AOC) and identify areas of high deer concentrations, (2) provide a map which graphically displays the concentrations and distribution of deer throughout the AOC, (3) provide an indirect estimate of deer density which may be calibrated with future aerial survey counts to provide a valid and reliable estimate of the entire deer population within the AOC, and (4) provide an additional index of trend in relative deer density and distribution. Correlation of the pellet group data with spotlight counts and aerial surveys would provide a valid and reliable estimate of the trend of deer density and distribution. Includes sample plot selection criteria, methodology, literature review, random number tables, and a map of fecal pellet group*

Helmer, Joel W. (1994). Spatial Distribution of Deer-Vehicle Accidents in Summit County, Ohio 1988-1992: Implications for Urban Deer Management (ID #: 116204). *Analyzes the spatial distribution of deer-vehicle collisions in Summit County, Ohio from 1988-1992. The distribution is examined to determine patterns in both time and space. This distribution is mapped to show areas of the county experiencing increasing numbers of deer vehicle collisions. The distribution of deer-vehicle collisions is also discussed as a possible white-tailed deer population index and management tool for Summit County and similar urban ecosystems. Suggestions are made on how the distribution pattern could be used to implement site specific as well as general management options in Summit County.*

Huml, Joseph W. (1992). Feeding Preferences of White-Tailed Deer in the Cuyahoga Valley National Recreation Area (ID #: 44206). *Results of a study conducted to determine the forage species preferred by white-tailed deer in the Cuyahoga Valley. A preference ranking for both woody and herbaceous species was established by calculating the percentage of individuals within each species that were browsed and weighting these percentages according to the intensity of browsing. Rankings are based on foraging preferences seen from May through early August. A map indicating the locations of the 21 study sites is included.*

Waller, David W. Orr, Lowell P. Mazzer, Samuel J. (1984). Wildlife Survey of the Cuyahoga Valley National Recreation Area (ID #: 138498). *An inventory of the amphibians, reptiles, birds, and mammals of the Cuyahoga Valley National Recreation Area (CVNRA) in northeastern Ohio prepared through field studies from the summer of 1982 to the fall of 1983 and from CVNRA an literature records. Extensive collecting efforts were directed toward habitats thought to support rare and endangered species. Species names, habitats, and distribution maps are included for all amphibians, reptiles, and mammals collected or observed within the CVNRA.*

National Park Service (1999). CVNRA Deer Exclosure Monitoring (ID #: 4251). *Trends in white-tailed deer population growth have led to an increased interest in the impact of the deer on vegetation at Cuyahoga Valley National Recreation Area (CVNRA). In spring of 1998 and extensive park-wide vegetation system (Long term ecological monitoring system) was initiated. It was observed that environmental conditions (soil types, aspect, slope, past history of disturbance, etc.) varied considerably from one site to another. This information led to the conclusion that a system of deer exclosures with paired unfenced plots would greatly enhance our understanding of the influence of deer on vegetation versus other environmental factors.*

National Park Service (1999). Cuyahoga Valley National Recreation Area Long Term Ecological Monitoring (vegetation), 1998-1999 (ID #: 29173). *During the summer of 1998, 92 permanent long-term ecological monitoring sites (LTEMS) were installed throughout Cuyahoga Valley National Recreation Area (CVNRA)and the Cleveland Metroparks (CM). The LTEMS study was implemented primarily in an attempt to assess the effects of deer grazing on plant resources. Additional objectives included: (1) Establishment of quantitative baseline vegetation information on a broad spatial scale, representing plant communities that occur at CVNRA. (2) Monitoring for changes in composition, structure, and regeneration of CVNRA plant communities over time (3) Utilization of data collected over time to identify and interpret changes that may occur as a result of natural succession, management activities, or perturbations such as gypsy moths, weather events, migration of exotic species, and grazing pressure. (4) Provision of a general framework and baseline data to support future experimental*

2.5.2.4.2 GWCA

Overdeer, Danny (2000). Amphibians of GWCNM.

Overdeer, Danny (2000). Reptiles of GWCNM.

Fuller, Stephen James (1987). Population densities of turtle species in Williams Pond, George Washington Carver National Monument (ID # 94578). *This study, conducted by a Missouri Southern State College student, documents the determination of the different types of turtles found in Williams Spring Pond at George Washington National Monument. A discussion is included on the ecosystem generally associated with this species as well as the one of Williams Spring Pond. Capture/recapture, identification, data recording, and population estimation methods, based on established methods, are discussed. Diagrams identifying the trap placement in Williams Spring Pond and the marking system utilized are included. A table, for each species captured, lists the specimen number, carapace length, carapace width, weight, capture date, capture location, recapture dates, and recapture location, is included. Also included is population estimates graphical data which include date, marked animals in population, captured, total marked captures, recaptures, sum recaptures, newly marked and released, population estimate, standard error of estimate, and the 95% confidence limit for each species captured. Conclusions and recommendations based on the survey are included.*

Szot, Sandra Ann Fuller, Stephen James Ellis, Russell G. (1986). Snake species survey of George Washington Carver National Monument prairie management unit number five (ID # 113988). *This study, conducted by Missouri Southern State College students, documents the determination of the snake species identified on Prairie Management Unit Number Five at George Washington Carver National Monument. Trapping methods, based on established methods, are discussed. A table, listing the common and scientific names of the species identified, the length and sex of species captured, the trap number and date of capture, is included. Also included is a trap layout diagraM. A description of each of the species obtained in the study, based on reference material, is given. Conclusions and recommendations based on*

Angle, Bret (1985). Survey of the reptilian populations at George Washington Carver National Monument, Diamond, Missouri (ID # 123431). *This study, conducted by a Missouri Southern State College student, documents the determination of the different types of reptilians, specifically lizards, snakes and turtles, found at George Washington National Monument. A discussion is included on the reptilian classifications, previous studies, predator habits, food consumption, and potential threat to man. Observation and capture/recapture methods, based on established protocol, are discussed. A table, listing the common and scientific names of the species identified and the number of species observed, is included. Also included are maps identifying the locations of where the lizards, snakes, and turtles were found in the subject area. Conclusions and recommendations based on the survey are included.* Unknown author (). Reptiles and amphibians of George Washington Carver National Monument (ID # 105366). *This is a list of reptiles and amphibians of George Washington Carver National Monument. It lists the common name of each species sighted within categories of "To Be Found", "Strong Possibility", "Possible", and "Close."*

2.5.2.4.3 PERI

Author unknown? (no author included in original record) (1994). Project Statement Sheet: Management of Deer Herd (ID # 98586). *Description of proposed aerial infrared population survey to locate and count deer within the park in order to yield base data on population and habitat.*
Author unknown? (no author included in original record) (1994). Project Statement Sheet: Re-Establish Wild Turkey (ID # 98587). *Description of proposed aerial infrared population survey to locate and count wild turkeys within the park.*
Pea Ridge National Military Park (1994). Resources Management Plan (ID # 106429). *Describes and evaluates current park programs. Natural resources issues for 1994 included: possible degradation of park resource due to a large herd of white-tail deer; invasion of musk and bull thistles; accelerated erosion due to the horse trail; over-population of juniper trees; impacts of external refuse dumping; and trees that are hazardous to visitors and staff.*

Pea Ridge National Military Park (1992). Pest Control Program Report (ID # 91136). *Lists specifications for using Diazinon to control ticks, chiggers, and wasps.*
Author unknown? (no author included in original record) (1987). Resources Management Plan for Pea Ridge National Military Park (ID # 106580). *Natural resource section includes descriptions of issues and actions - Basic Inventory, Management of Deer Herd, Vegetative Management Plan, Reestablishment of Wild Turkey, Quantification of Federal Water Rights, Reestablishment of Tall Grass Prairie, Forest and Ornamental Tree Pest Control, Feral and Diseased Animals, Soil Erosion, Hazardous Trees in High Visitor Use Areas.*
Dale, Edward E.= Jr. (1983). Plant Communities and Rare or Endangered Plant Species of Pea Ridge National Military Park, Benton County, Arkansas [Final Report] (ID # 93205). *'The purposes of this study were to verify the types and species composition of vegetation communities previously reported as present, prepare an updated vegetation map of the area on a 7 1/2 minute (1/24,000) U.S.G.S. quadrangle, make a systematic search for the presence of rare or endangered plant species and to prepare a check-list of plants that occur in the park.' Much of the report consists of tables of plant species with data on density per acre, importance value and percent cover. Includes check list of plants at Pea Ridge National Military Park and a small, black & white vegetation map.*
National Park Service, Southwest Regional Office (1982). Resources Management Plan, Pea Ridge National Military Park (ID # 106631). *Natural resource section includes descriptions of issues and actions - Basic Inventory, Management of Deer Herd, Vegetative Management Plan, Reestablishment of Wild Turkey, Quantification of Federal Water Rights, Reestablishment of Tall Grass Prairie, Forest and Ornamental Tree Pest Control, Feral and Diseased Animals, Soil Erosion, Hazardous Trees in High Visitor Use Areas.*
Author unknown? (no author included in original record) (1976). Resources Management Plan, Pea Ridge National Military Park (ID # 106630). *Describes problems with the natural and cultural resources in the park and suggests action to solve theM. Natural resources issues in 1976 included completing a natural resource basic inventory; completing a soils inventory and analysis; studying faunal populations; completing an ecosystem analysis; continued maintenance on trees and other vegetation; forest and ornamental tree pest control; control of feral and diseased animals; maintenance and repair of erosion sites; introduction of wild turkeys; reestablishment of a tall-grass prairie; management of the deer population; implementation of a vegetative management plan; and reforestation by transplanting and planting of*

2.5.2.5 Soil Erosion

2.5.2.5.1 ARPO

2.5.2.6 Land Use/Cover Change

2.5.2.6.1 ARPO

Folsom, Christopher Paul Barnes, Alton Anthony= Jr. (1965). Master Plan: Arkansas Post National Memorial, Arkansas County, Arkansas; A terminal problem presented for   the degree of Bachelor of Landscape Architecutre, University of Georgia (ID # 76238). *Master plan, prepared as a student project, addressing landscaping issues at Arkansas Post National Memorial, AR. Discussion includes characteristics of the floor plain and the movement of the Arkansas River, climate, and land management.*

Cartographer unknown (). Untitled: Aerial photographs (ID # 128994). *The following descriptions were taken from the park's 'map files' binder (the numbers refer to roll numbers in the map cabinet): 'A17 1969 aerial photograph; A25 aerial photograph around Lake Dumond, showing old river courses; A57 preflood aerial photographs; A86, B13 -   aerial photograph.'*

Cartographer unknown (). Untitled: Aerial photographs (ID # 128995). *2 sets of 9' x 9' black and white aerial photographs taken in 1974. Some have sites marked and labeled with number/letter codes, but there is no accompanying explanation of codes.One set of photographs is in one photo box, the other in another. It's unclear why they're separated.*

2.5.2.6.2   CUVA

2.5.2.6.3   HEHO

None Available

2.5.2.6.4   HOSP

Hot Springs National Park (1985). Land Protection Plan Hot Springs National Park (ID # 69767). *Land protection plan for the park. Describes land use (compatible and incompatible with the goals of the park), protection alternatives (zoning, acquisition...) and recommendations. Includes land status maps and a Natural Resources map (shows thermal water discharge zone, recharge zone, flood plain and park boundary). A boundary map is tucked in the back pocket.*

Watts, Michael R. Dale, Edward E. (1980). Purchase Order CX 70299001 (ID # 132906). *Describes 4 vegetation types (Upland Hardwood, Pine-Oak Hickory, Oak Hickory-Pine, Mixed Forest) and relation of environmental factors to vegetation types. Appendix I gives the results of a soil analysis (organic matter, pH, phosphorus, nitrogen, potassium, calcium, sodium, magnesium, conductivity). Tables give data on species density, basal area, importance value, percent cover, and the geology & exposure associated with various vegetation types. Refers to a map which is not included with this copy of the document.*

Holmes, B. V. (1977). Land Classification Map (ID # 69533). *Map of the park with sections hand colored to indicate natural zone, historical zone, development zone, private development and landscape management.*

National Park Service, W.P.A. (1937). The Vegetation Type Survey of Hot Springs National Park (ID # 133237). *Description of fieldwork followed by map keys (symbols representing species, color codes for vegetation types, acreage covered by various species, and the maps themselves (2 maps, folded and bound into the book. One is 'Hot Springs National Park Arkansas Vegetation types Map', scale is 1 inch=400 feet. 5 vegetation types are colored in and smaller areas are delineated with symbols for dominant species. The other map is 'Reference Map for Vegetation Type map of Hot Springs National Park Arkansas'. This map has the same plant species designations, but no colored areas for vegetation types. Blue and orange circles give locations of sample plots and photograph sites. A description of this report in the park's Resource Management Plan reads ' Covers the traditional park area of that date and a considerable portion of the present acquisition zone west of the traditional park. Scientific accuracy probably somewhat lacking and several fires since then have caused some changes. Covers major overstory species only. Not published, file copy in the park.'*

US Geological Survey (). Figure 4. - Land cover in the vicinity of the Hot Springs, Arkansas (ID # 44870). *Map showing areas which are forested, deforested, quarry, or urban land cover (with percentage covered by roofs, roads, parking lots...). No indication of the larger work this is part of.*

Various photographers (). AERIAL PHOTOGRAPHY (ID # 129054). *1. Aerial photos by CA Aaero topo, March, 1974. Scale varies. No index. 2. Aerial photographs - Arlington lawn by Ron Warner, February & April, 1973. Scale: 1=250. No index. 3. Aerial photographs - West Mountain by Ron Warner, February and April, 1973. Scale 1=500. No Index.*

2.5.2.6.5 LIBO

McEnaney, Marla, NPS-MWR (2001). A Noble Avenue: Lincoln Boyhood National Memorial Cultural Landscape Report. February 2001. *A report detailing the history of the park property from the 1800's to the present. The report also describes alternatives for preserving the cultural landscape including both designed and natural features.*

2.5.2.6.6 OZAR

Pugh, Aaron L. Jacobson, Robert B. (1992). Effects of Land Use and Climate Shifts on Channel Instability, Ozark Plateaus, Missouri, U.S.A. (ID # 37904). *Historical accounts and stratigraphic information for Ozark Plateaus streams document aggradation of stream channels with as much as 4 meters of coarse gravel beginning after or slightly before European settlement of the region in the mid 1800's. Aggradation was accompanied by increased channel instability, shallowing, and widening. Previous studies have identified logging, grazing, and burning of uplands as the causes of gravel aggradation, presumably through increases in runoff and sediment supply. At least two prehistoric episodes of channel instability during the last 4,000 years indicate that channel instability can occur in the Ozarks without human cause. In the absence of climatic trends, human disturbance, or tectonism during this time period, prehistoric instability can be attributed to episodic climatic shifts. Historical precipitation and discharge records indicate clustering of multiple-year periods of dry and wet weather, and a dendrochronological records indicate clustering of multiple-year variability presumable arises from episodic shifts in upper atmosphere circulation patterns. Historical records of streambed elevation and channel morphology indicate trends that span several decades. These trends are interpreted as a wave of land-use-derived sediment in transit through the drainage basins. Perturbations of the wave are associated with multiple-year intervals characterized by large floods and intervening periods of low discharge, although the magnitudes of the perturbations are not systematically related to either drainage area or the magnitudes of floods. Lack of systematic relations indicates complex responses from interactions of the wave of land-use-derived sediment with episodic floods, and the effects of the sequence and*

Smart, Miles M. (1980). Stream-Watershed Relationships in the Missouri Ozark Plateau Province (ID # 119593). *Land use was the most influential watershed characteristic determining stream chemical concentrations of 23 streams that drained watersheds with different land uses, geologic bedrock, and soil associations in the Missouri Ozark Plateau Province. Streams were investigated from June 1979 through September 1980 and compared to determine relationships among watersheds, stream water chemistry, and algal biomass. Three streams were monitored for each of the following single land use, non-point watersheds--urban, pasture, and forest, the dominant land uses in the Ozarks, to determine how land use affects stream chemical concentrations. Stream draining non-point source, multiple land use watersheds were compared to determine how several land use practices on specific watersheds influence the chemical and algal composition of streams. The influence from non-point sources on watersheds to stream water chemistry and algal biomass can be reduced in complexity and the effects quantified. Predictions of stream chemical concentrations and algal biomass from watershed land use can be used to assess changes in streams that may occur as the result of watershed alterations.*

Jacobson, Robert B. (2000). Downstream Effects of Timber Harvest in the Ozarks of Missouri. Toward Substainability for Missouri Forests, US Forest Service, NC Research Station General Technical Report (in press). US Forest Service; 27 p.

Jacobson, Robert B. and Primm, Alexander T. (1994). Historical Land-Use Changes and Potential Effects on Stream Disturbance in the Ozark Plateaus, Missouri. Rolla, Missouri: United States Geological Survey; 1994; Open-file Report 94-333; Water-Supply Paper 2484. 95 p.

Panfil, Maria S. and Jacobson, Robert B. (No Date). Relations Among Geology, Physiography, Land Use, and Stream Habitat Conditions in the Buffalo and Current River Systems, Missouri & Arkansas. US Geological Survey.

2.5.2.6.7 PERI

Author unknown? (no author included in original record) (1994). Project Statement Sheet: Management of Deer Herd (ID # 98586). *Description of proposed aerial infrared population survey to locate and count deer within the park in order to yield base data on population and habitat.*

Author unknown? (no author included in original record) (1994). Project Statement Sheet: Re-Establish Wild Turkey (ID # 98587). *Description of proposed aerial infrared population survey to locate and count wild turkeys within the park.*

Pea Ridge National Military Park (1992). Statement for Management (ID # 117685). *'The major purpose of this Statement For Management is to identify and communicate management concerns and issues at Pea Ridge National Military Park.' Includes section on natural resources, as well as small sections on land and water use.*

Author unknown? (no author included in original record) (1991). Summaries - 1991 Prairie Restoration Plot (ID # 121199). *Lists of grasses planted during 1991.* Smith, Thomas C. Dale, Edward E.= Jr. (1986). Ninth North American Grasslands Proceedings (ID # 37566). *Three different seeding densities were studied to determine percent cover on prairie plots. It was found that higher seeding densities 'result in more rapid establishment and fewer weed problems during the first 3 years.'*

Pea Ridge National Military Park (1982). Development Concept Plan and Environmental Assessment [REVIEW DRAFT] (ID # 31765). *Information on soils, land use, vegetation, precipitation.*

Dale, Edward E.= Jr. (1981). Reestablishment of Prairie at Pea Ridge National Military Park, Benton County, Arkansas [Final Report] (ID # 102731). *A continuation of the prairie reestablishment project. Describes relative successes of plants species (including 'weeds') and the relative impacts of fire, mowing and weather. For 1982, it was recommended that all plots should be mowed at least every three years; woody species should be removed by hand rather than burned; the prairie should be examined at least once a year by a grassland ecologist; mowing or burning should be reconsidered in 1984 or 1985; more seeds or prairie forbs should be introduced; and weed control and replanting of prairie grasses should be continued as necessary.*

Dale, Edward E.= Jr. (1980). Reestablishment of Prairie at Pea Ridge National Military Park, Benton County, Arkansas [Final Report for 1979] (ID # 102733). *Describes Trends in changes of vegetation cover, effects of mowing and burning, effects of different seeding rates, comparison of species present during give first years of establishment, establishment of forbs, presence of prairie forbs, mowing experiment. Recommendations for the 1980 growing season included reseeding eroded, bare, or weedy areas; establishing more prairie forbs; mowing or burning native prairies periodically; and continuing a vegetation census in all plots in the restoration area.*

3 Conceptual Models and Understanding of Park Ecosystems

3.1 Understanding of Park Ecosystems

3.1.1 Literature review of Parks' Forest Ecosystems

A full literature review of forest ecosystems in the Heartland Network will be available October 15, 2002. Dr. David Weinstein, who also provided the Heartland Network with the conceptual model in Section 3.2, is writing the review.

An overview of disturbance-types that potentially occur within the Heartland Network parks' forest ecosystems and a rating of the importance of each disturbance type to specific parks are included in Table 3.1. Allelopathic effects involve plants that produce by-produces that affect other plants, e.g., inhibit regeneration. Elemental stresses in the Heartland Network include inputs of atmospheric deposition, nutrient loading (especially nitrogen from chemical and animal fertilizers), acidifying substances (e.g., sulfur), chemical compounds (e.g., pesticides), heavy metals (e.g., lead), and other pollutants (e.g. sewage effluent). Fire disturbances include suppression activities and prescribed burning, as well as wildfires. Grazing or hibivory by livestock (especially cattle) and wildlife (especially deer) occurs in some parks. Timber harvesting includes in park activities, especially stand thinning to attain a desired forest composition and structure, and outside of park activities, including clear-cutting and selective cutting, in areas adjacent or near park boundaries. Several types of insects and diseases affect the forest vegetation, including native species to which the ecosystem is relatively adapted and exotic species that have varying effects on the forest vegetation. Extractions from the forest ecosystem include biotic (e.g. ginseng) and mineral or gravel. Soil compaction and erosion occur due to, for example, timber harvesting, grazing, and recreation. Solar radiation can have both beneficial effects (e.g., for regeneration) and adverse effects (e.g., ultraviolet radiation). Other disturbances the parks in the Heartland Network are subject to include wind (e.g., tornados), precipitation (too much or too little), and global climate change.

Table 3.1 Forest ecosystems: Heartland Network parks' ratings for various plant community disturbance mechanisms that affect changes in vegetation structure, composition, and/or function

	Parks with a high forest monitoring priority					*Parks with low or unestablished monitoring priority*				
Disturbance mechanism:	*#1 issue* LIBO (oak-hickory)	*#2 issue* HOCU (mixed mesophytic)	*#3 issue* ARPO (oak-hickory)	*#3 issue* GWCA (elm, ash, etc)	*#3 issue* PERI (oak, sycamore)	BUFF (oak-hickory)	CUVA (mixed mesophytic)	EFMO (mixed mesophytic)	OZAR (oak-hickory)	PIPE (oak savanna)
Allelopathic effects	High	Medium				Low	Unsure	Low	Low	Medium
Elemental stress, inputs of										
atmospheric deposition	Medium	Medium					Unsure	Low	Low	Low
Nutrients	NA	High					Medium	Medium	Medium	Medium
acidifying substances	Medium	High					Unsure	Low	Low	Low
chemical compounds	Low	High					Medium	Medium	Low	Low
Metals	Medium	Medium					Low	Low	Low	Medium
other pollutants	Low	Medium					Low	Medium	Low	Medium
Fire										
suppression	Medium	Medium			High		Low	High	High	Low
prescribed burning	High	High					Low	High	High	High
Grazing/hibivory										
Livestock	Low	Low					NA	NA	Low	NA
Wildlife	Low	Low					High	Low	Medium	Low
Harvesting										
clear-cutting	NA	Low					NA	Low	Medium	NA
shelterwood, selective, or single tree	NA	Low					NA	High	Low	NA
thinning from above (a) or below (b)	NA	Low					NA	High (b)	Medium	Low
Exotic insect species	Low	High				High	Medium	Medium	Medium	Medium
Native insect outbreaks	Low	Medium			Medium		NA	Low	Medium	Low
Invasive exotic plants	Medium	High			High	Medium	High	High	Medium	High
Opportunistic native plants	High	High			High			Medium	Medium	High
Other disturbances/impacts										
human extraction of plant materials	Low	Medium					NA	Low	Medium	Low
mineral extraction							Low			NA
Soil compaction/erosion due to										
Harvesting	NA	High					NA	Medium	Medium	NA
Grazing	NA	High					Medium	High	Low	Low
human impacts	NA	High					Low	Medium	Medium	NA
Solar radiation	Medium	Medium				High	Medium	High	Low	Medium
Weather						Medium				
Wind	Low	Low					NA	Low	Low	Medium
Precipitation	Low	Low					NA	Medium	Medium	Medium
global climate change	Low	Low			Low		Unsure	Medium	Medium	Medium

3.1.2 Literature Review of Ozark Plateau River Ecosystems

A full literature review of Ozark Plateau rivers in the Heartland Network will be available October 15, 2002. Dr. Charlie Rabini, who also provided the Heartland Network with the conceptual model in Section 3.2, is writing the review.

3.1.3 Literature Review of Wetland Ecosystems

A full literature review of wetland ecosystems in the Heartland Network is in progress. In the same format as discussed in Section 3.1.1 for forest ecosystems, an overview of disturbance-types that potentially occur within the Heartland Network parks' riparian-forest ecosystems and a rating of the importance of each disturbance type to specific parks are included in Table 3.2. Allelopathic effects involve plants that produce by-produces that affect other plants, e.g., inhibit regeneration. Elemental stresses in the Heartland Network include inputs of atmospheric deposition, nutrient loading (especially nitrogen from chemical and animal fertilizers), acidifying substances (e.g., sulfur), chemical compounds (e.g., pesticides), heavy metals (e.g., lead), and other pollutants (e.g. sewage effluent). Fire disturbances include suppression activities and prescribed burning, as well as wildfires. Flooding in riparian areas varies in frequency and duration. Grazing or hibivory by livestock (especially cattle) and wildlife (especially deer) occurs in some parks. Timber harvesting includes in park activities, especially stand thinning to attain a desired forest composition and structure, and outside of park activities, including clear-cutting and selective cutting, in areas adjacent or near park boundaries. Several types of insects and diseases affect the forest vegetation, including native species to which the ecosystem is relatively adapted and exotic species that have varying effects on the forest vegetation. Extractions from the forest ecosystem include biotic (e.g. ginseng) and mineral or gravel. Soil compaction and erosion occur due to, for example, timber harvesting, grazing, and recreation. Solar radiation can have both beneficial effects (e.g., for regeneration) and adverse effects (e.g., ultraviolet radiation). Other disturbances the parks in the Heartland Network are subject to include wind (e.g., tornados), precipitation (too much or too little), and global climate change.

Table 3.2 Riparian/lowland forest ecosystems: Heartland Network parks' ratings for various plant community disturbance mechanisms that affect changes in vegetation structure, composition, and/or function

	Parks with a high forest monitoring priority			*Parks with low or unestablished monitoring priority*			
Disturbance mechanism:	*#2 issue* HOCU (mixed mesophytic)	*#3 issue* ARPO (sycamore, cypress)	*#3 issue* GWCA (elm, ash, etc.)	BUFF ?	CUVA (mixed mesophytic)	OZAR ?	Other Parks??
Allelopathic effects	Low			Low	Unsure	Low	
Elemental stress, inputs of:							
atmospheric deposition	Low				Low	Low	
nutrients	High				Low	High	
acidifying substances	High				Unsure	Low	
chemical compounds	High				Medium	Medium	
Metals	Low				Low	Medium	
other pollutants	Low				Low	Low	
Fire							
suppression	Medium				NA	Medium	
prescribed burning	Medium				NA	Medium	
Flooding							
Grazing/hibivory				Low			
Livestock	Low				NA	Low	
Wildlife	Low				High	Low	
Harvesting				NA			
clear-cutting	Low				NA	High	
shelterwood, selective, or single tree	Low				NA	Low	
thinning from above or below	Low				NA	High	
Insects				Low			
exotic species (i.e. gypsy moth)	Medium				Medium	Medium	
native insect outbreaks	Medium					Low	
Invasive exotic plants	High			Medium	High	High	
Opportunistic native plants	High			Medium	High	High	
native species	High					Medium	
Other disturbances				High			
extraction of plant materials	Medium				NA	Medium	
bank erosion					High		
Soil compaction/erosion due to				Medium	NA		
Harvesting	High				NA	Low	
Grazing	High				NA	Low	
other human impacts	High				Low	Medium	
Solar radiation	Low			Low	Medium	Medium	
Weather/Climate				Medium			
Wind	Low				NA	Low	
Precipitation	Low		High		NA	High	
global climate change	Low				Unsure	Medium	

Conceptual Models
3.2.1 Introduction

Developing conceptual models of the ecosystems within the parks is a critical component in the planning process for developing long-term monitoring. Conceptual models summarize the current understanding of linkages within ecosystems. By illustrating ecological linkages, conceptual models are a very important tool towards identifying long-term monitoring indicators.

Previously in Section 2.4 the Heartland Network parks articulated their natural resources at risk, their environmental concerns (effects), and the drivers at work in their ecosystems. The following section provides stress-based, ecosystem level conceptual models of the dominant ecosystems within the Heartland Network: forests, rivers, wetlands, and prairies. Research scientists from various institutions, including the NPS, developed these conceptual models. The models describe links between drivers (natural and human precipitated over-riding forces of change), stressors (impacts as a result of the force), ecological effects (consequences of the impacts from the forces), attributes/monitoring indicators (physical, chemical, and biological indicators that will measure effects), and measurements (data collected for each indicator). The following conceptual model narratives and schematic descriptions will be used by the Heartland Network to delineate the ecological linkages between stresses, attributes/indicators and appropriate measures for each of the attributes.

3.2.2 Format of the conceptual models:

The forest, river, and wetland conceptual models contain a narrative description and schematic design. The overall information includes:

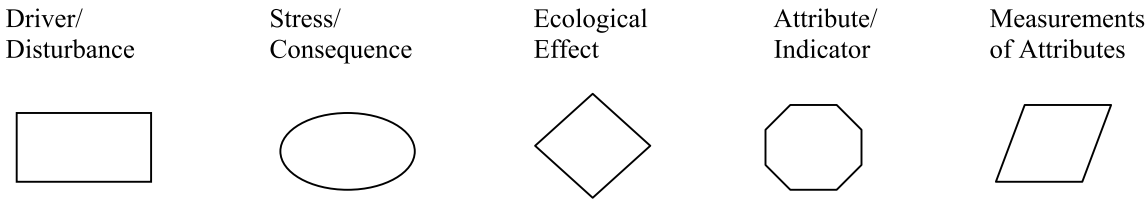
- An introduction and overview that characterizes the ecosystem
- Descriptions of major ecological drivers/disturbances and stresses
- Ecological effects, including major/critical ecological linkages affected by the stress
- Descriptions of potential monitoring indicators and related parameters to measure
- Schematic diagram
- Literature cited

The prairie conceptual model includes:

- An introduction and overview that characterizes the ecosystem
- Description of the primary natural drivers
- Table summarizing primary natural drivers and their effects on terrestrial prairie ecosystems
- Description of the current anthropogenic stressors
- Tables summarizing current anthropogenic stressors, affects, and potential monitoring indicators

3.2.2.1 Schematic diagram

The diagrams follow a top-to-bottom hierarchy of information, which identifies the drivers or disturbances (forces), stresses or consequences (changes due to the forces), ecological effects (system responses to the forces), monitoring indicators (system attributes), and parameters (measures) for each indicator.



- ✓ Driver/Disturbance: The over-riding driving forces that have a large-scale influence on the system
- ✓ Stress/Consequence: Changes that occur as a consequence of natural and anthropogenic activities (disturbances)
- ✓ Ecological effect: Physical, chemical, and biological responses to stress
- ✓ Monitoring indicators: Physical, chemical, or biological attributes of the system selected to represent the known or hypothesized effects of a particular stress
- ✓ Measurements: Specific measures, related to each indictor, to be recorded. Analysis of this information will assess how well the indicator is responding to the ecological effect

3.1.4 A CONCEPTUAL MODEL FOR FOREST MANAGEMENT AND MONITORING FOR THE HEARTLAND NETWORK

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3.1.4.1 Introduction

This report describes a conceptual model created for the deciduous forests in the Heartland Network of National Parks, Monuments, and Memorials. This conceptual model was developed to aide in the design of a regional, performance-based ecological monitoring program. Further, it can aide in the creation of a consensus regarding a set of causal hypotheses, which explain the affects that the major anthropogenic stressors have on the forested ecosystems.

This model schematically indicates the relationships between potential problems that could occur in these parks and monitoring measurements that could warn against these problems commencing. The problems range from shifts in forest community composition and structure away from their historical patterns, such as is occurring in George Washington Carver National Monument, to invasive plant species (Hopewell Culture National Historical Park), to deer overpopulation (Pea Ridge National Military Park), to potential fire problems (Arkansas Post National Memorial), and others. Although different parks differ in the problem of greatest concern, the similarities in forests among these parks suggests that a single conceptual model containing all of these issues and their potential monitoring indicators would be a valuable asset to all of the parks. This model addresses all of these issues in a comprehensive framework.

This model is simple and non-quantitative, but describes our current understanding of these natural forest ecosystems and identifies the attributes in the ecosystems that are the best indicators of the changes that might occur as a result of stressors. As such, it can be used as an aide in the delineation of the most appropriate measures for identifying each of the attributes.

Five of the 15 parks in the Heartland Network identified forest issues as being high priority for management concerns (Table 3.3).

Table 3.3 Location, landscape-type, forest-type, and forest monitoring concerns of selected Heartland Network parks[1]

Park Name	Park Code	Park Location	Landscape-type	Forest-types	Individual Park's Forest Monitoring Concerns
Arkansas Post National Memorial	ARPO	Eastern Arkansas	Lowlands near riverine environs	Lowland and Upland hardwoods, Cyprus, Sycamore	1. Pesticides 2. Erosion 3. Fire
George Washington Carver National Monument	GWCA	Southwest Missouri		Oak-Hickory	1. Change in forest structure
Hopewell Culture National Historical Park	HOCU	South-central Ohio	Stream valleys, bottoms of glacial outwash plains	Mature 2nd growth hardwoods	1. Invasive exotic species, including gypsy moth 2. Change in forest structure 3. Pesticide pollutants 4. Maintenance of floral and faunal diversity as stress indicators
Lincoln Boyhood National Memorial	LIBO	South-west Indiana		Success-ional Oak-Hickory	1. Invasive exotic species 2. Changes in forest caused by fire suppression 3. Air quality from local industrial growth 4. Maintenance of floral and faunal diversity
Pea Ridge National Military Park	PERI	North- west Arkansas	Upland hills	Oak-Hickory (Post oak, Blackjack oak)	1. Changes in forest caused by fire suppression. 2. Reduced seedling regeneration 3. Excessive deer browse 4. Loss of amphibians 5. Invasive cedar.

1 Plant community monitoring was one of the top four monitoring priorities for these parks

These parks include George Washington Carver National Monument (GWCA), Lincoln Boyhood National Memorial (LIBO), Hopewell Culture National Historical Park (HOCU), Pea Ridge National Military Park (PERI), and Arkansas Post National Memorial (ARPO). Consequently, this analysis and conceptual model is geared toward the issues and forest types found in those particular parks. However, the same forest properties and issues would be expected throughout forested areas of the Midwest, so these concepts are expected to be broadly application throughout the Heartland region.

3.1.4.2 Description of Forests in the Heartland Network

Most of the parks of this network lie in the central hardwood forest (Hicks, 1998), encompassing an area of about 150 million acres in the Eastern Broadleaf Continental Forest ecoregion province (Bailey 1994, 1996). The oak-hickory forests generally occur in hilly or flat upland terrain south of glaciated regions and west of the piedmont on soils that are generally podzolic in origin and deep with clay deposition in the subsoil (Hicks, 1998). The climate of the region is humid (40 to 50 inches per year) and temperate, with precipitation that is evenly distributed throughout the year and a frost-free season of from 180 to 200 days. Oaks are the most abundant trees, with minor amounts of hickories and maples, in these largely deciduous forests, although there are localized concentrations of white pine, shortleaf pine, and eastern red cedar. This forest is the largest and most extensive area of deciduous hardwoods in the world (Buckner, 1989).

Within the northern portion of this region, on sites with greater moister, maple dominated forests are found (Hicks 1998, Fralish and Franklin). These stands tend to be restricted to north facing slopes or ravine bottoms in the more heavily dissected portions of the western Allegheny plateau. It is more characteristic of the areas to the north of the central hardwood forest, where it becomes quite extensive.

Because of fire suppression, maple has become established in the understory of many oak stands over the past 50 years. If the canopies of these stands become open through gypsy moth infestation, oak wilt, or selective logging, these maples can quickly become dominant in the canopy, particularly because oak regeneration has been suppressed by excessive deer browse and the low light levels under the denser than normal forest canopies (see below). The interaction of these factors caused maple stands to begin to develop out of stands that normally would have remained oak dominated. However, because adult maples are not as well suited to the soil and climate conditions of these stands, their future is unknown.

The third general category of forest of concern in the Heartland Network is the lowland forests of the ARPO, characteristic of the Lower Mississippi Riverine Forest ecoregion province (Bailey 1994, 1996). This area receives 45 to 60 inches of precipitation per year, although the vegetation is relatively unaffected by droughts or impermeable soils characteristic of the region because of lateral subsurface water flows (Walker 1999). These forests occupy a collection of former river terraces that have different soil textures and, as a result, support slightly different assemblages of species. Consequently, the riverine forest complex taken as a whole supports a rich diversity of canopy species. These forests can be significantly impacted by floods that erode the physical soil matrix, and by fire and wildlife browsing, which remove the advanced regeneration.

For at least the last 1000 years, and possibly as long as 14,000 years, human habitation has interacted with natural factors to maintain high fire frequencies throughout the region, leading to a younger and more open forest that the one we tend to see on the landscape today. It is likely that there were many more opportunities for early and mid successional species to become established and maintain themselves in the forest, resulting in a more diverse mixture of canopy species than we see today. The forest of 200 years ago was probably much more similar to the typical forest existing for thousands of years than to the forest of today. However, the decline of Native American populations and the rise of European settlement were beginning to cause a decline in the fire frequency and its effect on the forest. As settlement reduced the forest coverage to 50% of the region, lower fire frequencies may have caused the size structure of the forest to peak during the period of 1750 to 1900, before timber use of the forest became sizeable. It is reasonable to suspect that the same species dominated the forest 200 years ago as we find today (Hicks 1998).

With the decrease in acres in agriculture in the area, and with policies of fire suppression in place, the forest has been growing in stature and abundance regionally. It is largely a second growth forest, smaller in size and stature, generally approaching 100 years in age, but with the same complement of species as the original forest. The forest is in the third phase, the transition phase, of a four-stage process of forest succession rebounding from the logging/ clearcutting disturbance. In this stage the early successional species, such as sassafras and aspen have been replaced by intermediates such as scarlet oak, hickories, and cherries. These are rapidly disappearing from the forest, being slowly replaced by the longest-lived species, which in this section of the region are mostly red and white oaks.

The major compositional changes that have been occurring over the past 50 to 75 years have been a shift toward dominance by late successional species, modified by the reduction of abundance of a few species because of introduced pests, including dogwood anthracnose, Dutch elm disease, oak wilt, beech bark disease, and most importantly, chestnut blight. This last disease (*Cryphonectria parasitica*) effectively eliminated the chestnut as a viable species in this forest. It had previously been one of the most abundant species in the forests of the western Appalachian plateau foothills.

Using the remnant old-growth stands scattered around the region as an indicator of what forests may have been like before European settlement, the forests probably had more oak trees (of various species, but mostly white and post oak) dominating the overstory. In many of the current stands the understory is composed largely of maples. In the original stands these maples would have been eliminated and replaced by advanced regeneration of oaks through the frequent ground fires sweeping the forest. The ability of the oaks to regenerate in these original forests was further enhanced by the much lower densities of deer and their browsing pressure and by the absence of defoliation episodes caused by gypsy moths, introduced into the region only in the last 30 years.

3.1.4.3 Methods

The principal concerns throughout these parks were compiled into Table 3.3. Lists of the stressors, ecological effects, and attributes (indicators) associated with these concerns were constructed. The physical and biological components and linkages in each landscape which best characterized these ecological effects were compiled.

Using these lists, a schematic diagram and a narrative description for the conceptual model was prepared, employing the following strategy:

The diagrams follow a top-to-bottom hierarchy of information, which identifies the societal drivers (external sources), the specific stressors on the natural systems, the ecological effects resulting from the stressors, and the recommended ecological attributes (indicators) and measures for each attribute.
The symbols used in the models to indicate each of these model components are as follows. The major components of the models are defined as follows.

Drivers/ Sources: The major external driving forces that have large-scale influences on natural systems. Drivers can be natural forces or anthropogenic.
Stressors: The physical or chemical changes that occur within natural systems that are brought about by the drivers, and which cause significant changes in the biological components, patterns and relationships in natural systems.
Ecological effects: The biological responses caused by the stressors.
Attributes: A set of indicators or endpoints of biological elements that are representative of the overall ecological conditions of the system. Attributes typically are populations, species, guilds, communities or processes. Attributes are selected to represent the known or hypothesized effects of the stressors and the elements of the system that have important human values (e.g., endangered species).
Measures: The specific features of each attribute to be monitored to determine how well that attribute is responding to projects designed to correct the adverse effects of the stressors (i.e., to determine the success of the project).

Each stressor is linked to one or more attributes. Measures of responses by the stressors and attribute in the model have been incorporated as the minimal set of components for the purpose of determining the success of the restoration programs.

3.1.4.4 Conceptual Model

The forests of the Heartland network are experiencing a range of external forces that are driving changes. Figure 3.1 depicts the drivers and stressors in a schematic diagram.

3.1.4.4.1 External Drivers and Stressors

Deer Overpopulation

Deer overpopulation has been the result of a major decrease in hunting activity combined with a forested landscape that provides much more food than was historically available. This later phenomena has resulted from the dissection of the region into smaller and smaller units with residential development, in a landscape filled with successional vegetation, containing abundant amounts of seedlings and saplings, recovering from the abandonment of farms over the past 50 to 75 years. Because of the large numbers of deer in this region, deer browsing has become a stressor to the natural development of the forest.

Fire Suppression

As the region became populated with European settlers during the 1800s, a growing concern became the control of ground wildfires that historically had frequently burned through the litter layers of fields and forests during the relatively hot and dry summers and autumns. Consequently, programs to suppress these fires have been followed for most of the past century. This fire suppression has effectively changed the frequency of fires in the region from common to rare.

Fire suppression has had the additional effect of creating a buildup of fuel on the ground of regional forests. This forest fuel load is a stressor to the system because it threatens to lead to large-scale intense fires that could destroy canopies and reset natural succession back to an early regeneration phase. Needless to say, the elimination of the forest canopy in such a fire would profoundly alter the visual qualities of the forest. Even though fires were frequent in most of these forests during the 1700s and 1800s (Hicks 1998), these were ground fires that tended not to damage canopy trees because of their relatively low temperatures. The fires of today, with their great fuel loads on the forest floor, would burn hot enough to destroy bark and kill canopy trees.

Regional Residential Development

Early regional development contributed to the necessity to curtail fires across the landscape. The recent intensification of this process has created extensive residential developments throughout the region. The activities of high densities of people seem to inevitably lead to an increase in the introduction of non-native insects and pathogens into the forest. In some cases these have been inadvertent introductions, such as in the case of chestnut blight, which was brought into the U.S. as a "hitchhiker" on a tree specimen. In other cases, such as with gypsy moth, the introduction was intentional (silk worm cross-breeding) and occurred because there was too little appreciation for the potential ecological problems it could cause. In either event, these species have become major stressors of the regional forests and act in concert with fire reduction and deer browse to further divert the forest development from the path of its previous structure and composition.

Regional development also has led to large-scale introduction of non-native plant species. As more and more people visit the forests, they unknowingly act as transportation vectors for the seeds of these species. Many of these species are extremely aggressive growers that thrive in ecosystem border areas and disturbed ground and find an abundance of opportunities to become established in the forest and forest margin interface. Because of their high growth rates, they endanger the species diversity of the forest by out competing large numbers of native species for available resources.

Regional Industrial Development

Regional industrial development has also been increasing rapidly in many of the areas surrounding the parks, monuments, and memorials of the Heartland Network. This development, along with the electrical power production that the industry and its workers demand, and the exhaust from the automobiles of those workers, has led to rapid increases in the ozone air pollution being deposited in these forests. While the more widespread toll of this air pollution, lower forest productivity, may not be of great concern to the managers of these natural areas, the potential for loss of sensitive species and subsequent decrease in species diversity is of interest.

Flooding in the Lowland Regions Bordering the Riverine Areas

Human modification of the water levels in river terrace areas has led to erosion of historical habitats. The shifts in water levels have led to adaptive rooting by trees and tunneling by animals. Subsequently, these changes have accelerated erosion, and with the erosion, a loss of these special habitats.

Toxicants Entering from Nearby Spraying Operations in Areas with Large Farming Operations.

The mixed-use nature of these landscapes has led to configurations with agricultural fields adjacent to forests and parklands. The type of agriculture use in the fields surrounding the parks often involves the heavy use of pesticide and herbicide materials. Frequently, these are applied with airplanes. Because of the aerosol application, these toxicants can drift on to the adjacent parkland. Herbicides could burn vegetation adjacent to the farm fields. Once deposited in the forest, pesticides could move into soil and through the food chain, potentially injuring vulnerable groups of species, such as amphibians.

3.1.4.4.2 Ecological Effects and Associated Attributes/Indicators

Natural Successional Shifts in Forest Composition and Structure from Historical Patterns

Historically, these forests would have been expected to have a closed canopy with broad spacing between trees with a range of different diameters and ages. The forests would have a diversity of trees of different ages. The understory would be populated with individuals from the same species as those in the canopy. This understory would be of intermediate density. The lowland forest would have a large diversity of species in both the understory and the overstory.

In the natural pattern of compositional development in the oak-hickory forests, periodic ground fires would greatly reduce the numbers of those species that were not fire tolerant. As a consequence, the understory would be composed of oaks that slowly became established, with some hickories where larger openings in the canopy had developed and light was more available. Over time, through the natural process of canopy tree death, these understory trees would get sufficient light to accelerate their growth and move into the canopy. Maples would undergo a similar process in the maple forests, with beech and basswood joining the hickories in the role of understory opportunists. In the lowland forest a similar process would occur, but the species dominating the canopy and the success of understory species would vary much more across the landscape and be determined more by differences in soil properties than by light availability.

Deer browsing has considerably altered these patterns and processes, leading to the development of a forest that differs considerably in appearance, composition, and the relative sizes of the trees from those present during historic times. Deer browse the young oak seedlings and saplings intensively, leaving the forests without a cohort for regeneration of the canopy when openings occur. Under previous conditions the saplings of many of these oak species resided in the understory for many years waiting for a gap in the canopy and a dramatic increase in light availability. The intense deer browsing has removed these saplings, opening opportunities for saplings from other species less desirable as a food source to the deer. This effect has begun to change the relative abundance of key tree species. Many of these forests today have a dense understory of advanced regeneration of maples and other species, making them far different from what would have been observed in a forest of one or two hundred years ago. This change may be occurring in the understory at present, but will inevitably proceed to affect the attributes of the canopy over the next century.

The absence of a natural frequency of fire disturbance has compounded the effect of deer browsing, although through a somewhat different process. Natural ground fires would have burned hot enough to kill seedlings and saplings of vulnerable species, such as maples. It is the absence of these fires that has allowed the dense understory of such species to become established. The saplings of the canopy tree species, largely oaks, are less affected by ground fires because they have thicker bark and because they have the ability to sprout from their root systems if the fire is hot enough to burn through the bark of the aboveground stem.

Invasive insects, such as gypsy moth, also play a role in causing the forest to deviate from its historic pattern of development. As stated above, the natural pattern of mortality in these forests was gradual, with few canopy trees dying in any given year. Because of the episodic and intense nature of gypsy moth outbreaks, they have the potential to kill large numbers of canopy trees over a short period of time, particularly if there are multiple defoliation periods in a given year or the insect populations remain high for three or four years. These defoliations can open the canopy and send much greater quantities of light into the understory. Rapidly growing species in the understory can take advantage of this unusual abundance in light to gain a competitive edge over slower growing ones. Even if the light levels return to their previous moderate condition, species that would not have normally become established in their understory, such as rapidly growing non-native invasive species, may have gained a foothold with which they can out-compete native plants.

Further, the death of large numbers of canopy trees would alter the gradual pattern of tree replacement by an episodic one in which a cohort of similarly-aged trees become canopy dominants together. Since trees of similar ages have a tendency to have similar susceptibilities to environmental stress, canopy turnover and replacement by understory trees will become more episodic and will leave the forest with an age structure that contains only a few cohorts instead of a wide variety of ages. This phenomenon may in turn limit the number of niches capable of supporting different kinds of native plants and animals, causing a reduction in the overall diversity of the forest.

Fire

Years of fire suppression have led to the buildup of fire fuels. As a consequence, an uncontrolled fire is likely to be hotter than those that historically burned. Trees that evolved an adaptation to survive ground fires would be likely to be killed by these intense burns. It is not even certain that root sprouting species would survive with their root crowns sufficiently unscorched to support re-sprouting.

As a consequence, uncontrolled fire today would be likely to kill the canopy trees and destroy much of what we think of as the attributes of the forest. The forest would eventually return, but it would not approach the current forest in appearance for at least a hundred year. Succession would be reset to its earliest stage, in which fast growing shrubs and trees would dominate the landscape. Because of the current prevalence of non-native invasive species with their aggressive growth habit, it is highly likely that these species would become well established in this regrowing forest and would limit the return of the natural diversity of native species.

Species Diversity

The introduction of invasive plant species into the forest has tended to lead to a reduction of species diversity. The invasive species most often thrive on disturbed habitats or forest edge environments. However, it does not take an enormous change in the availability of resources, such as light, to give them an opportunity to become established. Once they have a foothold they are capable of out competing slow-growing native plants because of their aggressive growth habit. The result is a loss of native plant populations and a potential decrease in the populations of animals that are evolutionarily adapted to the environments created by these native plants. An overall loss of species diversity in the forest is the inevitable result.

Air Pollution, Particularly Ozone

The increasing density of human residential and industrial development, along with its accompanying growth in the production of energy and the use of motor vehicles, is leading to an exposure of these forests to high levels of air pollutants, particularly ozone (Wolf et al 2001). These exposures occur in early to mid-summer, when plant growth is at it's highest and the vegetation is most vulnerable.

Plants differ considerably in their susceptibility to pollutant damage (US EPA 1996). As a rule of thumb faster growing species have greater sensitivity than slow growers, and a greater number of herbaceous species are vulnerable to acute damage than canopy trees (Reich and Admunson 1986, Chappelka and Samuelson 1998). The damage caused by ozone is often the result of season-long accumulations ozone-induced injury, which at the levels most commonly seen in these regions may cause an overall reduction in vigor among many species. However, episodes of high ozone levels can be sufficiently severe to cause visible burning of vegetation and death of particularly sensitive species.

Although the damage to sensitive species is most often observed on leaf tissue, prolonged exposure causes plants to reduce their root systems in order to have sufficient internal resources to repair leaf damage. This process makes the plants increasingly vulnerable to mid and late season drought, which frequently occurs in this region. Species adapted to survive a typical drought can show symptoms of drought damage because of exposure to ozone even if no ozone-induced visible leaf damage was ever detected.

Because of the variability in sensitivity among plants, a selection of the most sensitive species can be observed as indicators of the overall level of stress being experienced by the entire plant community. However, the more subtle effects on loss of vigor and increased sensitivity to drought may eventually take a large toll on non-indicator species even if the indicators have shown no visible damage. Damage is more likely in moister environments because of the higher growth rates under these conditions. However, oaks, particularly red oaks, are more sensitive than maples.

Erosion

In the lowland riverine terrace forests, periodic shifts in water levels have caused erosion of particular habitats. Because of the nature of this forest and the dependence of some species on the availability of these habitats, this loss can lead to a decrease in the diversity of trees and/or herbaceous plants. Even less is known about the dependence of animal communities, including amphibians and invertebrates, on these habitats. Burrowing animals make thorough use of these environments. In fact, their burrowing activity appears to accelerate the erosion process by providing channels for water to penetrate the soil in areas where the soil matrix is not held together by roots. Because many of the archeological features of the historical park may be found among these habitats, their erosion is particularly of concern.

The presence of intact vegetation is a deterrent to the loss of this soil because it provides a root mat to bind the soil matrix together. However, some of these soils contain so much clay that root development is discouraged. Further, the burrowing of animals must in itself be considered to be a natural part of the system even if they are disturbing intact vegetation. The shift in water levels may to some degree be controllable by anthropogenic intervention, but fluctuation in water levels as watercourses change and as weather patterns fluctuate from year to year are also natural components of this system.

Injury to Toxicant-Sensitive Species

The spraying of nearby fields with pesticide and herbicide aerosols could lead to drift and deposition of these materials into adjacent parks. Most of the damage from herbicide application is likely to be observed on plants bordering the agricultural fields. However, pesticides might penetrate the food chains of the forest. Groups that are particularly susceptible to pesticide injury are insects and amphibians, the later because they reside in the portion of the system where pesticides often collect, such as small water bodies. It is also possible that pesticides can accumulate to levels that are toxic to small mammals and fish through bioaccumulation, the process where by toxic chemicals are sequestered in the fatty tissue of an animal and therefore consumed in higher concentrations by predators using that animal as a food source. If there are many trophic levels in the food chain, this process of concentration can continue.

Disruption to the insect or amphibian populations are therefore of concern as they might serve as early warning indicators of pesticides moving through the food chain that have not yet reached concentrations dangerous to organisms on higher trophic levels. However, damage to particular populations of insects or amphibians may in its own right be of concern. These groups of organisms are often part of a tightly interwoven and complex network of species, all depending on one another so that the entire group can utilize the available food and habitat resources. It is nearly impossible to monitor this entire set of populations and their interactions, but monitoring the population dynamics of a few key species can serve as either a direct or indirect indicator of potential pesticide damage.

3.1.4.4.3 Ecological Measures and Their Linkages to Attributes

Change in Abundance of Key Tree Species

Key tree species are those that dominate the canopy of the forest and whose seedlings and saplings would be expected to become established in the understory at a rate sufficient to maintain the species' presence in the canopy. In addition, a species whose recent success in establishment in the understory indicates a high likelihood that the composition will gradually deviate from the historic pattern is also a key species. For example, in the oak-hickory forest type key species would include several species of oaks and maples and could be extended to include species of hickory.

An understanding of the future direction of change of the forest composition begins with the establishment of permanent plots in which the current diameter distribution and tree species composition for all mature trees, saplings, and seedlings is measured. If possible, historical records of the trends in growth and species presence/absence should be compiled. However, monitoring forest change can commence with measurement of the seedling survival and sapling growth rates of key species. These rates, in concert with rates of mortality of canopy dominants, will reveal the future changes destined to occur in the forest.

However, these changes are dictated by long-term phenomena only. A few years of high rates of establishment of maple seedlings can be wiped out by several years of drought that allow oaks to regain their competitive advantage and position in the understory. Since forests take 75 to 100 years in this region to reach maturity, processes must be persist over periods of 10 to 20 years in order to exert much of an effect on the overall trends in forest dynamics. Deer browse has become such an important factor, for example, because seedlings are being removed every year, year after year. If deer populations went through wild fluctuations, a window of consecutive years of low levels of deer browse might open sufficiently wide to allow saplings to grow above the height from which deer can effectively strip leaves.

Change in Structure of the Forest

Stressors such as gypsy moths or pathogens directly causing canopy tree death can lead to an increase in light in the understory. By the same token intense deer browse can increase light to the herbaceous layer. A forest that develops an age structure that has cohorts of similarly aged groups of trees instead of a mixture of ages and sizes will have a different light regime from the historical one under which most of the native species of the forest evolved. Since light availability is the most important limiting resource in these forests, most species will be adapted to be a superior competitor under one type of light regime only. (Periodic droughts also make water an important resource, but patterns of water availability are less likely to change over time as long as a closed canopy is maintained). Consequently, monitoring the light environment of the forest can provide important understanding about changes in the opportunity for species to continue to exist in that forest.

Years of fire suppression have probably caused less light to be available in the understory than would have been available 100 to 200 years ago. Consequently, a return to the forest dynamics and compositions of that period will be possible only when the forest changes its structure so that it can begin to recreate those light environments. Estimates of the rates of canopy tree mortality are essential. Measurements of the amount of defoliation by invasive insects and its effects on this light environment are therefore also critically important. Documentation of the structure of the forest and monitoring the changes in this structure will give information that can be used to predict the likely changes in the light environment.

Change in Key Animal Populations

The populations of animals that are capable of maintaining themselves in these forests are directly determined by the structure and, to a lesser extent, the composition of the forest because these determine the food resources available. Consequently, an understanding of the changes occurring in the forest structure should lead to predictions about what animals can be supported. The reverse is therefore also true; animal populations can be monitored to measure the long-term viability of each population and to measure whether changes are occurring in forest structure that are affecting these populations. It is important to monitor the size of these populations, but it is also necessary to monitor the age structure to understand the long-term dynamics of the population.

Since only a subset of all animal populations can be monitored, some guidelines will have to be established to determine which species are most critical. Obviously, deer must be inventoried to estimate the degree of browsing. Invasive insect populations, such as gypsy moth, must be closely monitored for the same reason. For these populations, it is particularly important to try to estimate when population outbreaks might occur. Amphibians seem to be particularly sensitive to changes in forest conditions that lessen the ability of the forest to support a diverse flora and fauna. Other animals to monitor may include those that depend heavily on tree fruits and nuts.

Fire Pattern

The enormous importance of the fire regime of the forest has been outlined above. Historical vegetation composition and structure are difficult to reconstruct or maintain without a return to the historical fire frequency and intensity. Therefore, detailed knowledge of the history of fire frequency and intensity must be constructed. Further, since the fire pattern was likely to vary significantly in spot to spot over the landscape, it is important to estimate this variability.

Fire suppression has led to enormous fuel loads in the forest floor. These loads will have to be reduced before a normal fire frequency can be reinitiated. The rate of accumulation of loads and the rate of reduction of woody debris through decomposition will have to be monitored.

Native Plant Populations and Plant Diversity

Many of the processes discussed in this plan affect plant diversity. Diversity itself is an important endpoint, since it is now understood that an ecosystem is likely to have healthy dynamics and a wide assortment of resources and habitats if it supports a rich species diversity. Therefore, the plant diversity can be monitored directly to give an indication of overall system health. It is also desirable to have these systems maintain as many different species as possible because a rich genetic pool is critical to maintain natural systems that can adapt to change.

A subset of these populations that contribute to the number of species in the diversity index are known to be threatened or endangered. Documentation of the local status of these populations, and particularly those of forest herbs, should be constructed. The populations known to be locally rare should be monitored closely, since small changes in habitat or stress could easily start them on the road toward elimination. This monitoring should be linked to a potential rescue plan.

Since invasive plant populations can so strongly affect native plants, monitoring the distribution and growth of these populations is essential.

Loss of Ozone-Sensitive Species

Air pollutants will damage particularly sensitive populations at current levels. If rural ambient air monitoring information is not available nearby, an air monitoring station can be established. Alternatively, it is possible to establish a garden of sensitive plants that could provide an early warning indicator of toxic levels of ozone. Periodic assessments of the amount of leaf injury detected should be made, especially during and immediately after periods when regional measurements indicate high ozone levels and a high probability of damage. Sensitive populations should be mapped and monitored to see if continued ozone exposure is leading to declines in their population.

Lost Habitat

In areas where changes in water levels or new patterns of water flow are causing loss of soil and its associated habitats, monitoring should be initiated to identify the distribution of problem areas and the rates of loss. In lowland habitats, burrowing activity is associated with accelerated erosion, so the amount of this activity should be quantified and followed.

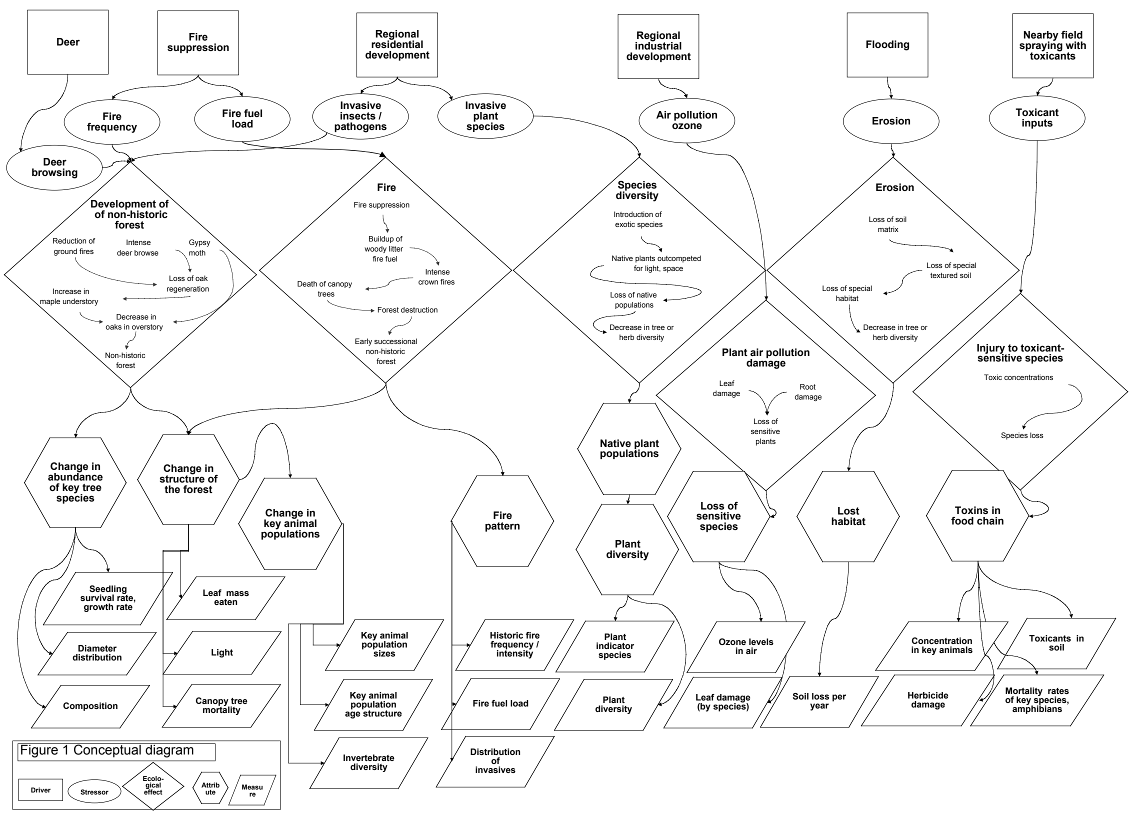
Toxins in Food Chains

Herbicide damage caused by aerosol drift should be monitored, particularly in vegetation that borders the farm fields. Particular attention should be given to an evaluation of whether locally rare populations, which may gravitate to these farm-forest edges, have significant damage. It is important to know whether there is enough of this type of damage to rare populations to warrant protection.

Pesticides may be accumulating in soil material and in food chains. Some selective monitoring of representatives of each trophic levels of a suspected food chain should be initiated. Checks for internal concentrations of toxics, while expensive, are likely to give a clearer idea of the extent of the problem than observations of population fluctuations. By the time these fluctuations become apparent it is likely to be too late to remove the toxic material from the food chain.

Pesticides entering the soil system are likely to affect mortality and deformity rates of sensitive organisms. Amphibians are once again candidates for careful observation, although an effort should be made to identify other key soil-dwelling populations likely to be affected.

Figure 3.1 Heartland Network forest ecosystem conceptual model (draft 10/1/2002)



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3.1.5 OZARK PLATEAU RIVER CONCEPTUAL MODEL

Model Leads
K. E. Doisy, C. Rabeni, V. Grant

Parts of this narrative were extracted from the *Ozark Riparian and Aquatic Systems: a literature review and information synthesis* (Doisy and Rabeni 2002). Full citations for the literature cited in this conceptual model may be found in that document.

3.1.5.1 Introduction

This report describes a conceptual model created for the Ozark Plateau rivers in the Heartland Network.

3.1.5.2 Description of Ozark Plateau Rivers

The major regions within the Ozark Highlands of interest to this conceptual model include the Ouachita Mountains and the Ozark Plateau that may be subdivided into the Boston Mountains, the Springfield and Salem plateaus. The Ouachita Mountains consist of a series of strongly folded and faulted formations composed predominantly of sedimentary rock such as sandstone and shale, with some igneous formations scattered between Hot Springs and Little Rock (Thornberry 1965). The Ouachita Mountains reach altitudes of about 2,600 feet. With respect to groundwater, aquifers in the Ouachita Mountains are generally very discontinuous because of these faults and the complex underlying geologic structure. This intense fracturing facilitates the flow of groundwater but causes aquifers to be diverse and, therefore, somewhat unpredictable with regard to their distribution and yields (USFS 1999). Hot Springs National Park is found within the Ouachita Mountains.

The Boston Mountains are composed predominantly of sandstone and shale with elevations of more than 2,000 feet; the Springfield Plateau that is composed predominantly of cherty limestone with elevations from 1,000 to 1,500 feet; and the Salem Plateau composed predominantly of dolomite, limestone, and sandstone with elevations below 800 feet (Smith 1989). Secondary mineralization has occurred in many of the rock units, and uplifting has resulted in fracturing and faulting of the rock units.

The presence of sedimentary, calcareous rocks that are rich in carbonates within the Ozark Highlands area result in well-buffered, hard-water streams with high pH, usually in the 7.5–8.5 range (Allan 1995). The geology of this area is dominated by mineral dissolution, ion exchange, and oxidation-reduction reactions (Adamski et al. 1995, Adamski 2000). The Ozark Plateau is characterized by limestone and dolomitic rock with “karst” topography, meaning that the surface and groundwater are integrally connected. Karst features such a springs, sinkholes, and caves are common in the Springfield Plateau and abundant in the Salem Plateau. Unlike groundwater that is filtered through dense soil layers, groundwater in karst systems often moves rapidly through underground channels that fail to provide the effective natural filtration and absorption that characterizes other systems. As a result, these waters often 2 contain contaminants and pollutants not found in groundwater from other types of systems.

3.1.5.3 Methods

The following narrative and schematic diagram (Figure 3.2) present information that identifies the following elements of the model:

- Drivers/ Sources: (Rectangles) The major external driving forces that have large influences on natural systems. 17
- Stressors/Consequences: (Ovals) The changes occurring within natural systems brought about by the drivers, causing significant changes to the natural system.
- Ecological effects: (Diamonds) Ecological response to the stressors.
- Attributes/Monitoring indicators: (Hexagons) Indicators known to respond to stressors.
- Measurements: (Trapezoids) Easily identifiable and measurable element of the indicator.

3.1.5.4 Conceptual Model

3.1.5.4.1 External Drivers and Ecological Stressors

The two overriding External Drivers are climate and geology. Five principal drivers that are influenced by humans and amenable to management activities are identified as agriculture, mining, urbanization, timber management, and recreation.

Agriculture

Agriculture in the form of row crops and range land in the northwest part of the Ozark Plateau, and expanding animal production in the southwest part, have caused elevated levels of pesticides, nitrate, ammonia, and bacteria in surface and groundwaters of this area (Ziegler et al. 1994, Adamski et al. 1995, Adamski 1996, Adamski and Pugh 1996). Pesticide data collected in 1993-94 indicated that pesticides were found more often in the aquifer supplying the Springfield Plateau rather than the Salem Plateau. This is believed to be the result of land use, because the Springfield Plateau is primarily agricultural land (58%) and the Salem Plateau is dominated by second-growth forest (71%). Pesticides and nutrients were also more common in springs than in wells, and studies indicated that water in springs was more susceptible to surface contamination than water in wells (Adamski 1997, Adamski 2000). Concentrations of dissolved nitrite plus nitrate, total phosphorus, fecal coliform bacteria, and dissolved organic carbon were also usually larger at sample sites associated with agriculture rather than forests (Davis and Bell 1998).

For several rivers within the Ozark Plateau (Buffalo, Current, Eleven Point, Jacks Fork, Little Black, and Warm Fork of the Spring), agricultural development and associated land clearing has been reported as the largest, long-term threat increasing both point and non-point source pollution (Duchrow 1977, Mott 1991b, Mott 1997, Scott and Udouj 1999). Tributaries contributing to the lower one-third of the Buffalo have shown increasing nitrate concentrations in recent years and this increase in now being reflected in the main river. Also of concern is Gilbert spring, which over a recent 10-year period had the highest average fecal coliform counts and nitrate-N concentrations, and showed increasing fecal coliform concentrations. The suspected source of contamination is septic leachate from the town of Gilbert migrating into the spring's recharge area, and from cattle and dairy operations in the Dry Creek drainage (Mott 1997, ADEQ 2000). Although fecal coliform counts remain low through most of the Buffalo, elevated levels have been reported from the Ponca site due to cattle operations (Mott 1997). Increased cattle production throughout the north central portion of Arkansas has been reported as a threat to some of the most environmentally sensitive drainages in this area (Wall 1996). The Arkansas Department of Environmental Quality (ADEQ 2000) reported high quality water throughout the Boston Mountains, but noted that periodic, elevated levels of turbidity occasionally 3 occurred in some waters of this region due to land clearing and associated road construction. They also expressed concern about potential water quality degradation due to expansion of confined animal operations and localized natural gas production.

Mining

Lead and zinc mining along the northeastern part and in the tri-state region have adversely affected aquatic systems within the Highlands. Effects of mining-related extraction activities have primarily come from two sources: increased sediment discharges into streams from present-day operations (Duchrow et al. 1980, Duchrow 1982a, Duchrow 1983b) and runoff waters leaching metals and chemicals into streams from abandoned mines and ore tailings left by historical operations (USFS 1999). Mining, and the wastes associated with extraction, were reported in the 1996 Arkansas Water Quality Inventory Report (ADPCE 1996) as a "major effects contributor" to segments of four streams totaling 116 miles in length (Hurricane Creek, Lost Creek, Crooked Creek, and Kings River), and as a "minor effects contributor" for another 83.9 miles of stream segments in three streams (James Fork, Illinois River, and War Eagle Creek). On the Buffalo River, leachate of heavy metals from mine tailings and other sources have caused EPA freshwater criteria for copper, cadmium, lead, and zinc to be exceeded several times (NPS 1997a).

In the Missouri Highlands, more than 160 miles of streams have been listed by the Missouri Department of Natural Resources (MDNR) as Category 1 303(d) waters based on extraction pollutants such as pH, lead, zinc, sulfate, and sediment (MDNR 1998). Additional problems in the form of increased sediment have resulted in both states due to gravel mining or dredging. More than 50 miles of northwestern Arkansas streams (Crooked Creek, Illinois, and War Eagle) are reported to be affected by this activity (USFS 1999), while only a few small sites on the Osage, Meramec, and Black rivers in Missouri have been listed.

Urbanization

Within the Ozark Highlands, population densities around Springfield, Missouri, have increased 175% since 1974, and have almost tripled during that time in the counties containing Branson. In Washington County, Arkansas (the location of Fayetteville), the population has doubled since 1974 (anonymous 1979, U.S. Census Bureau 2000). This sort of dynamic growth puts huge demands on existing water treatment facilities, and consequently may compromise the health of receiving waters within these areas. Missouri currently lists 156 miles of streams within the Highlands as Category 1 303(d) due to increases of at least one of the following parameters: nitrogen, ammonia, phosphorus, non-filterable residue, chlorine, chlorides, or biochemical oxygen demand (MDNR 1998). Portions of the Jacks Fork River were sampled in 1998 for fecal coliforms and nutrients (total phosphorus and nitrite+nitrate). Crawford (1998) showed that, while overall quality in the Jacks Fork is excellent, there were occasional problems associated with the Eminence WTTP.

In Arkansas, the Department of Environmental Quality (ADEQ 2000) has designated the waters within the Ouachita Mountains as "suitable for the propagation of fish/wildlife; primary and secondary contact recreation; and public, industrial, and agricultural water supplies. Approximately 36 percent of the waters within this segment were designated as "extraordinary resource waters." Water quality in this area was generally good and major rivers, such as the Caddo, South Fork of the Caddo, and the Ouachita above the lake, were all improving or holding steady. However, Prairie Creek, a tributary of the Ouachita River, occasionally had elevated nutrients and high turbidity values below the City of Mena sewage treatment plant. As mentioned above, Gilbert Spring on the Buffalo River has been reported to have elevated nitrate concentrations which may originate from the water treatment plant for the town of Gilbert.

Timber Management

At the time of European settlement, shortleaf pine was the dominant tree species within the Ozark Highlands. However, by the 1880s, sawmills could be found throughout the region, particularly in the Current, Black, and Piney River drainages. The result was conversion of these vast Ozark pine forests to either pastures or reforestation by sunlight-tolerant hardwood species. Currently, oak-hickory forests cover more than a one-third of the Ozark Highlands (Stambaugh and Muzika 2001).

There is general agreement that the majority of Ozark streams currently support a larger bed load of chert gravel than before European settlement. The disagreement is how it came to be there. One theory is that this gravel is a result of massive hill slope erosion due to extensive timber harvests in the late 19th and early 20th century, and the subsequent introduction of open-range grazing (Saucier 1983, Jacobson and Primm 1997). Recent work has argued that the apparent aggradation of these streams is due to channel instability and redistribution of gravel from upstream and flood-plain sources because of land use within the riparian corridors (Jacobson in press). The geomorphic response to this increased gravel load has been "disturbed" river sections with rapid bar growth, sharp channel bends, repetitive chute cutoffs within discrete sedimentation zones, and a shallow, shifting channel (Saucier 1983, Jacobson and Primm 1997). These shifting waves of gravel are an unnatural process that may adversely affect the biota of these streams. Studies of streambed elevations in the area (Jacobson 1995, Jacobson and Gran 1999) have shown that many gravel waves are currently located in the upper and middle sections of Ozark streams. They suggest that the upper stream sections may be recovering from historical land-use disturbance, but lower sections may not yet have encountered the gravel wave.

Changes in watershed land-use patterns throughout the Ozarks continue to affect the flow regime and channel form of the streams. Although mainstem portions of the Current and Buffalo rivers are somewhat protected by the National Park Service (NPS), removal of watershed vegetation and soil compaction as a result of forestry practices, agriculture, and urbanization in tributary watersheds are probably the primary threat. These types of land-use changes in upland areas of a watershed usually have two effects: an increase in runoff and an increase in sediment yield. Clearing and compaction of riparian areas in direct proximity to a stream include increased sediment yields, decreased flow resistance, and erosional resistance of the streambed and banks (Jacobson et al. 2001). Another more localized threat to some streams within the Ozarks is dredging and instream aggregate mining. Effects from these activities include sediment yield decreases, and increases in channel slope and cross-sectional area (Jacobson *et al.* 2001).

Timber harvest and related road development may alter a stream's hydrology, sediment budget, nutrient cycles, and morphology (Bilby *et al.* 1989, Jones and Grant 1996, Christie and Fletcher 1999, Jacobson 1999, Beschta et al. 2000, Bowling et al. 2000, Swank *et al.* 2001). Dissmeyer (1980) used modeling to predict the effects of different harvesting techniques, and found noticeable differences in annual erosion rates in areas including the Ouachita Mountains in Arkansas. He compared site preparation techniques including logging, chopping, sheering, disking, dozing, and grazing. Predicted recovery periods varied from two to four years, with soil losses increasing in ascending order for chopping, grazing, dozing, logging, shearing, and disking. Beasley and Granillo (1985) reported significant increases in sediment loss in Arkansas, by following clearcutting with mechanical, versus chemical treatments. Recognizing the variable effects of timber management practices on different soil types, the Missouri Department of Conservation reported that various forms of cutting in Madison County, Missouri, resulted in different amounts of exposed soil. Three clearcuts, two pulpwood cuts and one conventional sawlog harvest were estimated to have produced 33%, 22% and 12% exposed soil, respectively (Barnickol *et al.* 2001). Studies performed in the Ouachita Mountains looking at the effects of road building found that the amount of erosion was related to the amount of soil disturbance, the size of the area draining onto the roads, the soil erosiveness, the slope and slope length, and the amount of rainfall shortly after harvest (Scoles *et al.* 1994). Other studies from western, mountainous regions have indicated that the associated road building is more damaging than the actual cutting (Brown and Krygier 1971, Megahan and Kidd 1972, Schnackenberg and MacDonald 1998, Christie and Fletcher 1999). Sediment has been found to erode from the road surface, road fills, and slope failures associated with road building (Megahan 1978, Reid and Dunne 1984, Duncan *et al.* 1987, Megahan and Bohn 1989, Wemple et al. 1996, Jones et al. 2000, Wemple *et al.* 2001). Road construction and use also increase the amount of chemicals introduced into an area. Oil products, lead, and salt may accumulate on road surfaces, associated soils, and vegetation, gradually moving into waterways through runoff (Motto *et al.* 1970, Hofstra and Smith 1984, Reid 1993).

The watersheds of the BUFF and the OZAR systems are predominantly forested, with less than 35% of these areas cleared for timber or agricultural use. 6 Because the NPS is the main landholder along the corridors of the mainstems of these two rivers, adequate buffer strips exist along these areas. However, land clearing, for either timber or agricultural use in privately held areas along the tributaries, has been reported as a long-term threat to the rivers within the Ozark Highlands (Scott and Udouj 1999, ADEQ 2000). The potential for problems may be greater in the BUFF system because a larger proportion of the cleared land occurs on steep slopes (Panfil and Jacobson 2001). Chip mills are located in Morrillton and Menefee, Arkansas, and the predominant land use throughout the Ouachita Mountains is silviculture, both in private timber companies and National Forest holdings (USFS 1999). In southern Missouri, two chip mills have been using wood from the state since the 1960s, and presently three chip mills are located in the state. Surveys conducted by MDC indicated that most private forest owners do not consult a professional forester, and they reported it is unlikely that BMPs are being employed on the majority of private forest lands. They recommended that efforts to ensure the use of BMPs on all timber sales within the state should be a top priority (Barnickol *et al.* 2001).

Recreational Activities

The effect of recreational users has been a long-time concern of the NPS. A preliminary study in 1980 of fecal coliform data within waters of the area indicated a positive relationship between levels of canoe use and fecal coliform densities. Further studies performed in the mid-1980s looked at the effects of canoe and inner tube use, back country and gravel bar campers, horseback riders, and precipitation. For these data, no significant relationships were found between canoe use or campers and fecal coliform densities. There were relationships between precipitation and fecal coliform levels, but the source of the fecal contamination was not determined. The highest levels were found in portions of the Jacks Fork below the Eminence Trail Rides, livestock areas, and the Eminence sewage lagoon (Emrie 1986). A follow-up study by Wernick and Chilman (1995) looking at elevated fecal coliform counts and the number of canoeists and day users on the Upper Jacks Fork, also did not support any relationships. Again, it was suggested that increased bacterial levels following holiday weekends might be a result of the flushing effect of rainstorms. Although these periods of high fecal contamination appear to be temporal phenomena, it should be noted that studies of whitewater canoeists have shown a significant relation between water quality and disease attack rates after recreational activities in freshwater (Fewtrell et al. 1992).

3.1.5.4.2 Stressors and Consequences

Flow Regime and Sediment Movement

Femmer (1997) reported that of these three major physiographic regions, basins within the Boston Mountains had the steepest gradients and greatest stream depths, streams within the Springfield Plateau had the greatest channel sinuosity and mean current velocities, while stream channels within the Salem Plateau were the widest. The Buffalo National River runs through the Boston Mountains and Springfield Plateau, the George Washington Carver National Monument and the Pea Ridge National Military Park occur in the Springfield Plateau, and the Ozark National Scenic Riverway runs through the Salem Plateau.

The form of an Ozark stream channel is determined and maintained by interactions between its bedload, vegetation, and valley walls, with discharges that fill but do not exceed the bank, termed "bankfull" (Wolman and Miller 1960, McKenney 1984). In many Ozark rivers and streams this discharge is reached about every 1.5 years on average. These frequent bankfull flows maintain the existing channel form while transporting the most sediment through the system (Wolman and Miller 1960). In contrast, low frequency flows that exceed the banks, cause channel changes that may be irreversible or require decades to recover (Wolman and Gerson 1978). Natural streams of the Ozarks tend to be low-gradient, alluvial streams with a rectangular cross section that skews on bends. They also tend to have alternating deep (pool) and shallow (riffle) areas. These pool-riffle sequences are the result of particle sorting and require a range of sediment sizes to develop. In most streams riffles tend to be spaced at more or less regular distances of 5 to 7 bankfull stream-widths apart, and are formed by the deposition of gravel bars in a characteristic alternation from one side of the channel to the other (Allan 1995). In the Ozarks, riffles tend to be spaced closer together than normal, which may be an indication of disturbance. However, McKenney (1997) hypothesizes that this is more likely a naturally occurring response to interactions between alluvial streams and bedrock walls.

Effects of Flow Alteration

An increase in runoff may result in increases in channel cross-sectional area, flood disturbances, and large woody debris (LWD) recruitment, while causing decreases in drought disturbance, embeddedness, cover, and LWD retention. Sediment yield from upland areas usually experiences a period of storage and lagged remobilization. However, once it starts moving, it acts like sediment released from the riparian areas, resulting in decreases in the channel cross-sectional area, and increased sediment disturbance, embeddedness, and LWD retention. Clearing of riparian areas along a stream that lead to decreased flow resistance and erosion resistance may be signaled by increases in the channel cross-sectional area, width-to-depth ratio, and general disturbances such as a decreased available cover. Increases in channel slope and cross-sectional area as a result of dredging or instream mining, may manifest themselves through decreases in embeddedness, cover, and LWD retention (Jacobson *et al.* 2001).

Physical Habitat Quality

A pervasive idea in stream ecology is the linkage between organisms and physical habitat: that elements of depth, velocity, and substrate characteristics define the presence and abundance of individual species and the composition of 8 the biological community. Recent research on the Jacks Fork River on fishes (Peterson and Rabeni 2001a, b), and invertebrates (Rabeni *et al.* 2002) confirmed these relations in an Ozark stream situation. Instream physical habitat quality is closely linked to flow regime and channel morphology, and is usually defined with a variety of structural characteristics of streams including: stream size and gradient, water depth and current velocity, substrate type, embeddedness, and cover.

A combination of valley physiography, fluvial mechanics, and geomorphic history has been reported as the primary determinant of the type and sequence of physical habitats within Ozark streams (Rabeni and Jacobson 1993b). Recent studies of channel and habitat change processes and the rates of these processes have been used to determine the spatial and temporal controls on this habitat formation and distribution (Rabeni and Jacobson 1993a, Rabeni and Jacobson 1993b, McKenney 1997, Jacobson *et al.* 2001). In these studies stream habitats in the Ozarks were defined as specific combinations of depth, velocity, and bed material within a stream reach (McKenney 1997). The following general low-flow parameters have been provided for the indicated habitats: slow waters including scour pools and glides that had gradients of 0- 0.075%, depths of 40–500 cm, velocities of 5–75 cm/s-1, and substrates ranging from sand-gravel to cobble-boulders; slack waters including forewaters, edgewaters, and backwaters that had gradients of 0-0.075%, depths of 0-40 cm, velocities of 0–20 cm/s-1, and substrates ranging from clay-gravel to sand-gravel; and fast waters including races and riffles that had gradients of 0.075-4.0%, depths of 5–100 cm, velocities of 30–250 cm/s-1, and substrates ranging from gravel, gravel-cobble, to cobble-boulders. As mentioned in the discussion on flow regime, Ozark streams suffer from an unnatural amount of gravel aggradation. In addition to this increase in gravel, there is a corresponding decrease in the deposition of fine overbank sediments (Jacobson and Pugh 1992). This decrease is believed to be a result of open-range grazing that substantially reduced the amount of riparian vegetation available to act as a soil stabilizing influence along stream corridors (Jacobson and Primm 1997).

An extensive study of the hydraulic parameters, substrate, and invertebrate communities within the Jacks Fork River reported that current velocity appeared to be the dominant influence (Doisy and Rabeni 2001), with substrate a secondary influence. Studies of various macroinvertebrate and fish species in Ozark streams have shown definite preferences for particular substrates. Young-of-the-year *Orconectes neglectus* (crayfish) were found primarily in cobbled, high velocity areas, while adults were found in low velocity, macrophyte beds (Gore and Bryant 1990). Three other species of sympatric *Orconectes luteus, O. punctimanus*, and *O. ozarkae*, were found to have definite species and life stage preferences for habitat elements that effectively partitioned available resources (Muck 1996). Various species and life stages of black fly larvae and elmid beetles in two Ozark streams were shown to prefer cobble or woody debris (Doisy 1984, Doisy et al. 1986, Lloyd 1996, Lloyd and Sites 2000). Studies of variability in the density and biomass of smallmouth bass and rock bass found that for both species these characteristics were most strongly associated with amounts of large substrate (boulders and cobble), undercut banks, and aquatic vegetation (McClendon and Rabeni 1987), while the rocky shiner was found to prefer gravel and rubble substrates (Humphries and Cashner 1994). Visual estimates of embeddedness within several Ozark headwater streams found embeddedness levels of much less than one-third (K.E. Doisy, personal communication). Research on the effects of siltation on invertebrates and fishes within the Ozark Highlands found that siltation did not have an effect on invertebrate community structure, but did affect taxa richness and density (Zweig and Rabeni 2001), while fish guilds composed of herbivores, benthic insectivores, and simple lithophilous spawners were found to be most sensitive to siltation (Rabeni and Smale 1995).

Energy Sources and Relations

Studies of benthic community metabolism measured in three habitats (riffles, runs, and pools) in the Jacks Fork River, using an *in situ* chamber technique showed that net community productivity and gross community productivity were highest in riffles, lowest in pools, and intermediate in runs (Whitledge and Rabeni 2000). Other studies of periphyton done in Ozark streams found that at least in these streams, nitrogen appeared to limit periphyton production (Lohman et al. 1991), and also that the longer the length of the flood-free period the greater the maximum standing crops of periphyton (Lohman et al. 1992).

In studies of nutrients and suspended algal chlorophyll in Ozark streams, both variables were found to be more strongly related to land-use practices within a watershed, than bedrock geology or soil association. In general, concentrations of nutrients and chlorophyll a were lowest in streams draining forests, intermediate in streams draining pastures, and highest in streams draining urban areas. In streams draining forest and pasture areas, there was an exponential increase in the concentration of total P, total N, NO3--N, and suspended chlorophyll a with increases in percent pasture area within the watershed (Smart 1980, Smart et al. 1985). Another study investigated relationships between suspended chlorophyll, total phosphorus, and total nitrogen at 23 sites in 13 streams in the Missouri Ozarks. Results showed a strong curvilinear relationship between mean suspended chlorophyll and both mean total P and mean total N. Both models were improved when watershed area was included with either nutrient. Land use (percent row crop or percent forest), together with watershed size, was shown to be a good predictor of suspended chlorophyll in Ozark streams (Lohman *et al.* 1999).

A study of leafpack processing in three Ozark streams found increasing exposures were required to break down materials upstream, from 5th to 3rd and finally 1st order streams (Horton and Brown 1991). Studies on the dynamics of POM in Ozark streams include effects of gravel mining on FPOM (there was a decrease in its transport from riffles to pools; Brown et al. 1998), and its longitudinal distribution (CPOM was not found in higher quantities in headwater streams as predicted by the RCC; Brussock and Brown 1991). Relative percentages of organic matter in various stream habitats of the Jacks Fork have been reported (Doisy 1997). A more detailed analysis of chlorophyll a and BPOM in the Jacks Fork is underway (K.E. Doisy, personal communication). Some work has been done on the relations of stonefly distribution and production to available organic matter in Ozark streams (Ernst and Stewart 1986, Jop and Stewart 1987).

Water Quality

Within the Ozark Plateau the main factors affecting water quality include geology, land use, and factors related to population density. The geology of this area is dominated by mineral dissolution, ion exchange, and oxidation-reduction reactions (Adamski 1995, Adamski 2000). The presence of sedimentary, calcareous rocks that are rich in carbonates within the Ozark Highlands area, result in well-buffered, hard-water streams with high pH, usually in the 7.5–8.5 range (Allan 1995). The Ozark Plateaus are characterized by limestone and dolomitic rock with a “karst” topography, meaning that the surface and groundwater are integrally connected. Karst features such a springs, sinkholes, and caves are common in the Springfield Plateau and abundant in the Salem Plateau. Unlike groundwater that is filtered through dense soil layers, groundwater in karst systems often moves rapidly through underground channels that fail to provide the effective natural filtration and absorption that characterize other systems. As a result, these waters often contain contaminants and pollutants not found in groundwater from other types of systems. Another difference in the groundwater from karst systems is that it may be oxygenated due to contact with air spaces within channels and caves. Aley and others have provided an extensive series of reports delineating the groundwater recharge areas and the resultant potential problems for the OZAR and BUFF (Aley 1973, Aley 1984, Vineyard 1974, Aley 1975, Aley 1976, Aley 1976, Aley 1979, Aley 1982, Gardner 1983). This information must be considered in all efforts to determine the source of non-point source pollutants of surface waters within these riverways.

Specific parameters that have been monitored in the Ozarks include dissolved oxygen and nutrients (especially nitrogen and phosphorus; Smart 1980, Smart 1981, Smart 1985, Emrie 1986, Knowlton 1989, Davis 1995, Wernick 1995, Davis 1998, Crawford 1998), temperature (Bowie 1971), turbidity and light (Duchrow 1980, Duchrow 1982, Duchrow 1983), organic and inorganic chemicals (Adamski 1996, Bell 1996, Bell 1997), heavy metals and toxic substances (Proctor 1974, Duchrow 1983, Duchrow 1983, Smith 1988, Survey 1995, Pulley 1998), and pH (Duchrow 1983). Unfortunately, methods of collecting these data have not been consistent (Adamski 1997).

Historical data for OZAR was reviewed by the NPS (Service 1995) in 1995 from EPA national databases. These reviews found more than seven water quality parameters that exceeded screening criteria at least once from 1973 to 1995. These included cadmium, copper, lead, silver, and zinc, and total coliform, and fecal coliform. Generally, the highest levels of the inorganic compounds were found in the 1970s, while coliform levels continued to increase into the 1990s. During the spring and fall of 1998, the Missouri Department of Natural Resources (MDNR) checked coliform and nutrient levels within the Jacks Fork River (Crawford 1998). Results of these studies found no noticeably higher levels of phosphorus or nitrite and nitrate within the Jacks Fork. However, fecal coliform counts below the Eminence WTTP exceeded the daily maximum limit three times, usually in association with large rainfall events. Exceptionally high counts were also found in two tributaries of the Jacks Fork. Livestock access and inadequate sewage systems of residents along the creeks were listed as possible causes. Work on the Buffalo National River (Mott 1991) has indicated similar problems with agricultural areas along this river containing higher nutrients, bacteria, and turbidity than sites on less affected sections.

Within the Ozark region, several studies have been done on relations between water quality and the extent of human activities within these catchments. Summarizing these studies, the major water quality problems in the rivers of the Ozark Highland region appear to be a result of agriculture, mining, urbanization, logging, or recreational use. Nutrient data from 395 ground-water samples in the Ozark Plateau showed that nutrient concentrations, in particular nitrite plus nitrate concentrations were related to hydrogeology and land use. Approximately 4% of these samples had nitrite plus nitrate concentrations that exceeded the maximum concentration level allowed in drinking water by the EPA (Davis 1995). Additional studies of this problem reported that nitrite plus nitrate was the nutrient most often found, and indicated a relation between the nutrients in groundwater and the land use in the area (Adamski 1997). In the Boston and Ouachita Mountains, the Arkansas Department of

Environmental Quality (ADEQ; Quality 2000) has not found any noticeable trends in the nutrient concentrations of the groundwater of these areas.

Research by the U.S. Geological Survey on the surface water quality of rivers within the Ozark Plateau (Davis 1998) showed statistically significant differences that were attributed to land use, physiography, and drainage basin size. Most recently, Panfil and Jacobson (2001) and Panfil (2001) analyzed drainage basin variables in the Current and Buffalo Rivers in an effort to evaluate links between land use and stream habitat quality. They found that physiography and catchment size were the dominant drainage basin controls on the habitat of these streams, and to a lesser extent, land use. However, they concluded that correlations between land-use patterns, geology, and physiography made it difficult to separate anthropogenic from natural impacts on these rivers. In Arkansas, research by the ADEQ found that surface waters in the Boston and Ouachita Mountains are most threatened by silviculture practices such as land clearing (Quality 2000).

Biotic Interactions

A long-standing debate in ecology is whether communities consist of a network of tightly interacting species that act to maintain that community at or near equilibrium, or merely loose assemblages of individual species controlled by abiotic forces that persist in an area merely because they're adapted to those particular conditions.

Several studies have looked at the effects of competition between indigenous fish species of Ozark Highland streams (Covington 1983, McNeely 1987, Matthews 1998, Peterson 2001, Wildhaber 2000). One study looking at the effects of introduced rainbow trout in an Ozark stream reported that the annual introduction of rainbow trout might increase feeding competition and disrupt spawning by native fish species in their natural habitat (Metcalf 1997).

The effects of predation in streams are variable. In some instances strong biological associations occur, resulting in a cascading effect throughout the food web. In other instances the effects of predation are limited (Allan 1995). Studies looking at the effects of predation in Ozark streams included invertebrate grazing (Power 1988) and crayfish predation by centrarchids (Rabeni 1992).

3.1.5.4.3 Environmental/Monitoring Indicators (Performance Measures)

Indicators of Agricultural Practices

Effects of agricultural practices on the stream channel can include increases in runoff and sediment yield, or decreases in flow resistance and erosion resistance (Jacobson *et al.* 2001). Cattle grazing increases the stream sediment load through erosion of streambanks (Quinn *et al.* 1992b, Trimble 1994, Kondolf 1994b, Sheffield *et al.* 1996, Myers and Swanson 1996, Belsky *et al.* 1999, Lyons *et al.* 2000b). An increase in sediment load from grazing or row crops may result in physical changes in the channel structure or biological changes within invertebrate and fish communities (Quinn *et al.* 1992b, Magilligan and McDowell 1997, Quinn *et al.* 1997b).

Changes in the aquatic biota have also been associated with the removal of riparian vegetation both within the immediate buffer area (Newbold *et al.* 1980, Murphy et al. 1986, Davies and Nelson 1994, Whiles *et al.* 2000) and within the watershed as a whole (Griffith and Perry 1991, Rutherford *et al.* 1992, Stone and Wallace 1998, Trayler and Davis 1998, Kedzierski and Smock 2001).

Animal production such as poultry and swine facilities, and cattle grazing adds nutrients and bacteria to streams (Sheffield et al. 1996, Mallin *et al.* 1997, Wernick *et al.* 1998, Fisher et al. 2000), while row-crop production adds nutrients and pesticides (Cuffney et al. 2000). It is a long-held belief that nutrients and pesticides have detrimental effects on aquatic biota (Hilsenhoff 1977). Recent studies have substantiated clear connections between increased nutrients and pesticides with changes in biological measures of algae, invertebrates, and fish (Lenat and Crawford 1994a, Rabeni et al. 1997, Pan et al. 1999, Shieh et al. 1999, Cuffney et al. 2000). In a study of fish community samples collected at 22 stream reaches within the Ozark Plateau (Petersen 1998), differences in the fish communities were attributed to differences in land use and related water quality and habitat characteristics. Communities from agricultural reaches tended to have more species, increased relative abundance of stonerollers and members of the sucker family, and decreased relative abundance of members of the sunfish and darter families.

Indicators of Mining Activity

In addition to increased sediment loads, gravel mining significantly altered the geomorphology in three Ozark streams (Brown et al. 1998). Affected reaches had increased bank-full widths, lengthened pools, and decreased riffles. Research done in California found that gravel mining not only changed local channel morphology by means of bed and bank erosion, channel incision, and coarsening of bed material, it also accelerated distant beach erosion through reduced sediment delivery (Kondolf 1994a, Kondolf 1997). Other changes in channel morphology may include increases in slope and cross-sectional area of affected streams due to direct excavation (Jacobson et al. 2001). Recommended physical monitoring includes a combination of bed particle size and an aggradation indicator such as pool depth, channel cross sections, or longitudinal profile (MacDonald et al. 1991).

Because of the difficulty in continuous monitoring of water chemistry parameters, it is essential to regularly sample stream biota to detect sudden, toxic releases that may be missed with chemical measures. Assessing the effects of mining on biological communities may be complicated by increases in sedimentation and acidification, along with heavy metals accumulation (Ward 1984, Hoiland and Rabe 1992). Brown et al. (1998) reported that transport of FPOM from riffles to pools decreased, and densities of invertebrates and fish decreased in Ozark streams due just to gravel mining. Mining induced sedimentation has been reported to reduce both biomass and nutritional value of stream periphyton (Van Nieuwenhuyse and LaPerriere 1986). Others have reported that large influxes of dissolved metals resulted in decreased chlorophyll a content of periphyton (Hill et al. 2000b), and decreased invertebrate community diversity, richness, and density (Winner et al. 1980, Quinn et al. 1992a, Richardson and Kiffney 2000). Total invertebrate generic richness, genetic diversity, mayfly density and richness, collector-gatherer richness, and scraper density and richness were positively correlated to stream pH in studies of streams in eastern states (Smith et al. 1990, Rosemond et al. 1992). Constant acid mine drainage was found to eliminate the mayfly and stonefly fauna in western Pennsylvania streams (Roback and Richardson 1969). Studies in acid streams of Ontario (pH 4.3–4.5) (Mackay and Kersey 1985) showed that communities were greatly simplified with reductions in mayfly and stonefly richness. In addition, recovery of the invertebrate community to acidity may be slow. Chadwick et al. (1986) found that macroinvertebrate communities were still in the recovery process more than five years after major improvements to the wastewater treatment at a mining facility on Silver Bow Creek, Montana. Laboratory studies of the effects of acidic water on young-of-the-year smallmouth bass suggested that environmental acidity was sufficient to cause losses in this species, even in the absence of synergists such as heavy metals (Hill et al. 1988). However, other studies of the effects of acidification on adult stream fish in New York found that the total biomass of fish communities was not seriously affected at moderately to strongly acidified sites, while species richness and total density of fish were adversely affected at strongly to severely acidified sites (Baldigo and Lawrence 2000). Although streams in the Ozark Highlands are well-buffered and alkaline relative to those in the northeast, Matthews noted that he typically found greater densities of fish in the more alkaline Ozark mountain streams (usually 8.3 - 8.5), than in their less alkaline Ouachita counterparts (Matthews 1998).

Indicators of Urbanization

Urbanization can affect flow regimes and channel morphology through increased runoff and sediment yields, or decreased erosion resistance. Instances where urban streams are channelized for containment purposes may result in increased channel slopes and cross-sectional areas, or decreased flow resistance (Jacobson et al. 2001).

Chloride can be used as a biological indicator of human waste within water samples (Herlihy et al. 1998), but is not of particular concern to freshwater quality except at very high levels. However, elevated levels of fecal coliform may be an indicator of potentially serious public health problems. An analysis of demographic and land-use factors done on rivers within coastal estuaries demonstrated that fecal coliform abundance was significantly correlated with watershed population, and even more strongly correlated with the percentage of developed land within the watershed. However, the strongest correlation was between fecal coliform abundance and percentage of watershed with impervious surface coverage, such as roofs, roads, driveways, sidewalks, and parking lots (Mallin et al. 2000). Determining the source of these bacteria can be complicated by mixed uses of a watershed, such as animal production, population centers, and recreational use. Recently, methods of identifying host sources of fecal coliform in water have been developed to assist in the formulation of pollution reduction plans (Carson et al. 2001, Murray et al. 2001).

Invertebrate communities have been used for several decades to monitor nutrient effects. Recently, invertebrate and fish communities have also been used successfully to monitor physical effects of urbanization (Klein 1979, Garie and McIntosh 1986, Jones and Clark 1987, Lenat and Crawford 1994a, Masterson and Bannerman 1994, Baker and Sharp 1998).

Indicators of Timber management

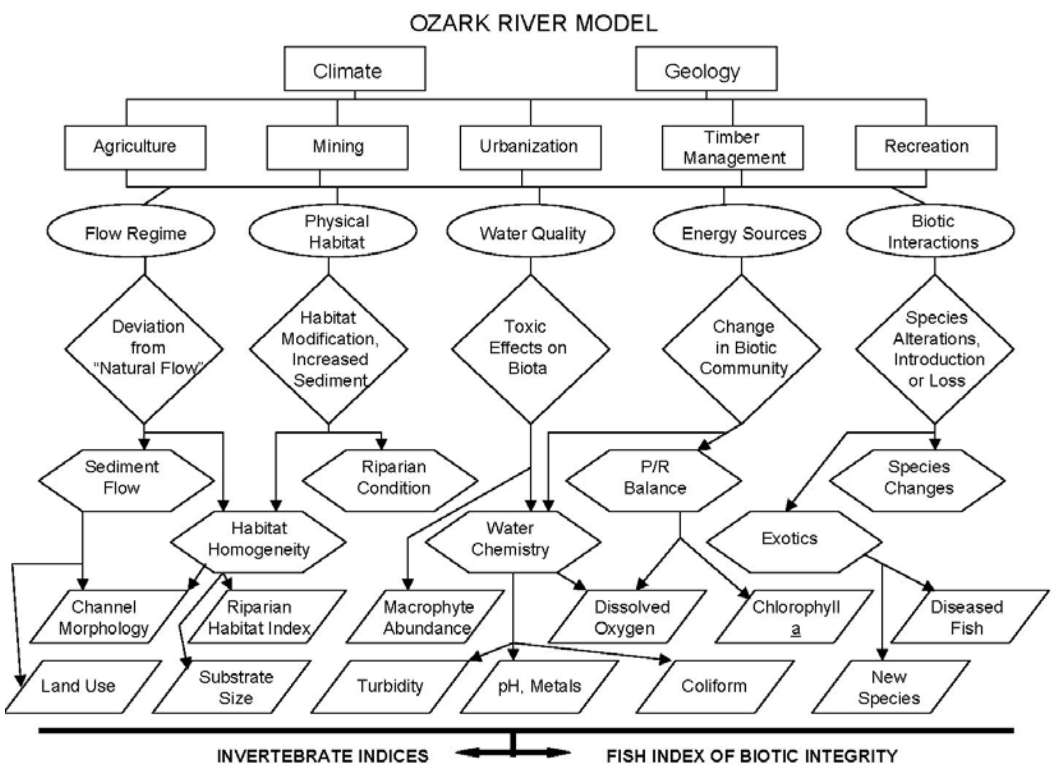
Timber harvesting both within the uplands and along the riparian corridors of streams may result in changes in the water yield, peak flows, water quality, and sediment yield, as a result of increased amounts of surface water flowing into a stream due to reduced evapotranspiration and increased runoff (MacDonald et al. 1991, Jacobson 1999, Jacobson et al. 2001, Swank et al. 2001). Changes can occur in the nutrient cycle due to increased water temperatures, increased primary production, and the long-term loss of leaf litter and woody debris, which promotes BPOM retention (Bilby 1981, Webster and Waide 1982, Lynch et al. 1985, Webster and Benfield 1986, Silsbee and Larson 1983, Golladay et al. 1987, Webster et al. 1990, Wallace et al. 1993, Davies and Nelson 1994, Webster et al. 1994, Webster and Meyer 1997, Bunn et al. 1999, Mitchell 1999, Steel et al. 2000, Kedzierski and Smock 2001). Finally, changes occur in the channel morphology due to the flashy nature of the hydrograph, increased erosion and deposition, and the loss of the stabilizing effect of vegetation (Smith et al. 1993, Ralph et al. 1994, Fetherston et al. 1995, McKenney et al. 1995, Birkeland 1996, Simon et al. 1999, Jacobson et al. 2001).

An increased sediment load is often the most damaging effect of forest management activities (MacDonald et al. 1991). Large increases in sediment entering the stream channel can result in the loss of animal habitat by increasing riffle area while reducing pool area (Ralph et al. 1994, Waters 1995). Sediment increases can also have an effect on channel shape, sinuosity, and bed material size (Roberts 1987, MacDonald et al. 1991). Biological indicators have included the use of invertebrate communities (Noel et al. 1986, Duncan et al. 1989, Tierney et al. 1998) and fish (Hlass et al. 1998).

Indicators of Recreational Activities

A study done in Oregon on multiple in-stream recreational activities found that stream sites exposed to intense recreational use had no effect on chlorophyll a biomass, but resulted in significantly lower densities of an abundant herbivorous caddisfly larva (Wright and Li 1998). In Ontario streams, nutrient additions, from either pipeline leakage or recreational activities have been shown to change the invertebrate community (Corkum 1996).

Figure 3.2. Heartland Network Ozark Plateau river conceptual model (draft October 1, 2002)



3.1.5.5 Bibliography

Full citations for the literature cited in this conceptual model may be found in *Ozark Riparian and Aquatic Systems: a literature review and information synthesis* (Doisy and Rabeni 2002).

3.1.6 MIDWESTERN WETLANDS CONCEPTUAL MODEL

Model Lead
Daren Carlisle, National Park Service, Midwest Regional Office

3.1.6.1 Introduction

The term "wetland" is a generic descriptor of a wide variety of places, including saltwater marsh, freshwater marsh, tidal marsh, wet meadow, wood swamp, bog, muskeg, mire, pothole, vernal pool, river bottom, mangrove forest, and floodplain swamp. The commonality among these environments is the presence of water sufficient to inundate the ground. A broad reference definition of wetlands is as follows:

> *A wetland is an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features reflective of recurrent, sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physicochemical, biotic, or anthropogenic factors have removed them or prevented their development (NRC 1995).*

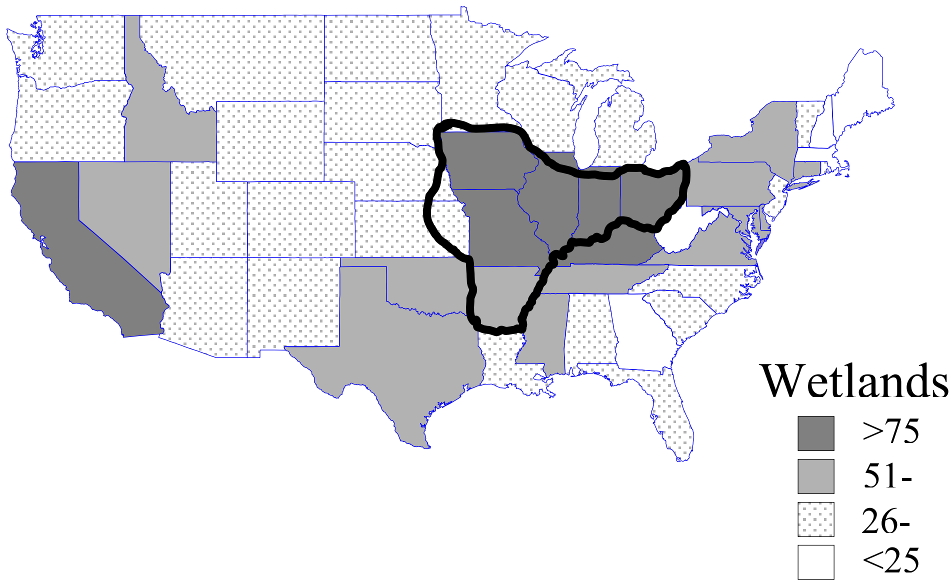
Wetlands naturally form in places where surface water periodically collects for some time or where groundwater discharge is sufficient to saturate soils. Such places include depressions surrounded by upland and with or without a drainage system; relatively flat, low-lying areas along major water bodies; shallow portions of large water bodies; sloped areas below sites of groundwater discharge; arctic and subarctic lowlands; and slopes below melting snow banks and glaciers.

Although wetlands often comprise a small portion of the landscape, they contribute greatly to local and regional biological diversity (NRC 1995). On a global scale, wetlands cover <1% of the earth's surface but support more than 40% of the world's species (ramsar). Wetland-dependent shellfish, fish, waterfowl, furbearers, and timber provide important and valuable harvests and recreational opportunities. Wetland ecosystems moderate floods, improve water quality, and have heritage and aesthetic values that are difficult to quantify. On a global scale, wetlands contribute to stable levels of available nitrogen, atmospheric sulfur, carbon dioxide, and methane. Wetland habitats are required for the survival of a disproportionately high percentage of threatened and endangered species. Despite comprising <10% of the landscape in North America (on an areal basis), wetlands are important habitat for 68% of birds, 66% of mussels, and 75% of amphibians on the U.S. list of threatened and endangered species (Mitsch and Gosselink 2000).

Despite the obvious benefits of wetland environments, they have been extensively modified or destroyed by human expansion. About 30% of the world's existing wetlands occur in the

United States, where about 53% of all wetlands have been lost in the last century (NRC 1995, M&G). The main reason for this widespread destruction of wetlands is that it was encouraged by U.S. government policies until the 1970s (NRC 1995). Currently, wetlands are the only ecosystem type that is comprehensively regulated across all public and private lands within the United States (NRC 1995). Nevertheless, wetland losses have continued over the past two decades (Dahl 2000). Urban development, rural development, and agriculture accounted for 30, 21, and 23%, respectively, of these losses (Dahl 2000). State-specific estimates of wetlands lost since European settlement are shown in Figure 3.3. The Heartland Network contains five of the seven states with the most dramatic wetland losses. Clear priority should be given to monitoring restored and remnant wetlands within this network.

Figure 3.3. Wetlands loss in contiguous 48 states of the United States, through the 1990's.



3.1.6.2 Descriptions of Wetlands in the Heartland Network

Numerous definitions and classifications have been developed for wetlands, but the system adopted by the U.S. Fish and Wildlife Service (Cowardin et al. 1979) is the one most commonly used by scientists worldwide (Mitsch and Gosselink 2000). This classification system is hierarchical and all-encompassing, but too complex to serve as a framework for this wetland ecosystem model. Nevertheless, because this classification system is widely accepted in the academic and regulatory arenas, the Heartland Network will adopt it as well. There are at least three general types of wetlands within the Heartland Network. These correspond to very broad groupings in the Cowardin et al. (1979) system, but are nevertheless useful for descriptive purposes. Each is briefly described below.

3.1.6.2.1 Freshwater Marshes

This category includes a very diverse group of wetlands that are characterized by: 1) emergent, soft-stemmed aquatic plants such as cattails, arrowheads, reeds, and other species of grasses and sedges; 2) a shallow water regime; and 3) generally shallow deposits of peat. This wetland type is the most ubiquitous in North America and includes places like the prairie potholes and Florida Everglades. Over 1,000 individual wetlands of this type have been identified at CUVA (Davey 2000), and are probably very common in other Network Parks.

3.1.6.2.2 Riparian Ecosystems

Riparian systems, by definition, are adjacent to rivers, lakes, and other water bodies. These systems are occasionally flooded but are otherwise dry for varying portions of the year. In the southeastern U.S., riparian ecosystems are often referred to as bottomland hardwood forests, and contain a diverse floral assemblage adapted to various degrees of flooding. Riparian ecosystems are likely the dominant wetland form at BUFF and OZAR, but are also common in other Network parks with small streams and permanent waterbodies.

3.1.6.2.3 Freshwater Swamps

This category is comprised of freshwater wetlands in the southeastern United States that have standing water for most, if not all, of the growing season. Although a variety of hydrologic and nutrient conditions exist in these places, they are normally dominated by species of *Taxodium* (cypress) and *Nyssa* (gum/tupelo). At least one park in the Network (ARPO) contains wetlands of this type.

3.1.6.3 Methods

Lists of the stressors, ecological effects, and attributes (indicators) associated with concerns were constructed. The physical and biological components and linkages in each landscape that best characterized these ecological effects were then compiled. Using these lists, a schematic diagram and a narrative description for the conceptual model was prepared, employing the following strategy:

The diagrams follow a top-to-bottom hierarchy of information, which identifies the societal drivers (external sources), the specific stressors on the natural systems, the ecological effects resulting from the stressors, and the recommended ecological attributes (indicators) and measures for each attribute.
The symbols used in the models to indicate each of these model components are as follows. The major components of the models are defined as follows.

Drivers/ Sources: The major external driving forces that have large-scale influences on natural systems. Drivers can be natural forces or anthropogenic.
Stressors: The physical or chemical changes that occur within natural systems that are brought about by the drivers, and which cause significant changes in the biological components, patterns and relationships in natural systems.
Ecological effects: The biological responses caused by the stressors.
Attributes: A set of indicators or endpoints of biological elements that are representative of the overall ecological conditions of the system. Attributes typically are populations, species, guilds, communities or processes. Attributes are selected to represent the known or hypothesized effects of the stressors and the elements of the system that have important human values (e.g., endangered species).
Measures: The specific features of each attribute to be monitored to determine how well that attribute is responding to projects designed to correct the adverse effects of the stressors (i.e., to determine the success of the project).

Each stressor is linked to one or more attributes. Measures of responses by the stressors and attribute in the model have been incorporated as the minimal set of components for the purpose of determining the success of the restoration programs.

3.1.6.4 Conceptual Model

The following narrative and schematic diagram (Figure 3.4) present information that identifies the following elements of the model:

3.1.6.4.1 External drivers and stressors

Ecosystem Drivers

All ecosystems are influenced by natural and anthropogenic forces. Variation in climate and consequent hydrology, succession, herbivory, and fire are important natural processes controlling all wetlands. With the discovery of atmospheric contaminant deposition and global climate change, it appears likely that every ecosystem in the biosphere is or will be influenced by humans as well (Vitousek et al. 1997).

For the purposes of this model, "Ecosystem Drivers" refers to the major natural and anthropogenic forces that influence wetland ecosystems. Agriculture and urbanization are the dominant human influences on Midwestern wetlands. These anthropogenic influences occur within the context of several natural processes that also control wetland ecosystems.

Each Ecosystem Driver exerts "Stressors" on the ecosystem. The definition of stress offered by Barrett et al. (1976) is used in this model. Specifically, " Stress is defined here as a perturbation (stressor) applied to a system (a) which is foreign to that system or (b) which is natural to that system but applied at an excessive [or deficient] level." (Barrett et al. 1976, p.192). Hence, agricultural pesticides are a stressor foreign to wetlands. Similarly, nutrients and fire suppression are stressors applied at unnaturally high and low levels respectively. Each Ecosystem Driver of Midwestern wetlands and its associated stressors is discussed below.

Natural Processes

Hydrology is probably the most important factor in wetland ecosystem maintenance and processes. The hydrologic regime is defined as the magnitude, frequency, duration, timing, and rate of change of water level fluctuation (Poff et al. 1997). The hydrologic regime affects soil bio-geochemical processes, nutrient cycling, and nutrient availability. These processes, in turn, influence the biological communities that can be supported in a wetland. Wetland biological communities exert strong influences on the hydrologic regime. For example, accumulation of senesced plants can hinder water circulation. Similarly, *Castor canadensis* (beaver) are considered "ecosystem engineers"because they directly alter water levels and circulation. Duration, frequency, and timing of water level fluctuations are the primary determinants of hydroperiod, which is characteristic of different wetland types. Climatic variation can cause large seasonal and annual fluctuations of the hydroperiod, leading to profound changes in wetland ecosystem structure and function.

The dynamics of succession, or ecosystem development, have been documented in a variety of wetlands. Although alternative theories of succession exist, the collective evidence suggests that wetland biological communities undergo natural changes due to external influences on the hydrologic regime (e.g., climate change) and internal processes that alter environmental conditions (e.g., accumulation of organic matter) (Mitsch and Gosselink 2000).

Natural disturbances associated with fire and herbivory are important to some wetland ecosystems. The regular occurrence of fire and inundation maintain native plant communities in Florida freshwater swamps by preventing invasions of fire-sensitive, woody species (NRC). *Ondotra zibethicus (*Muskrats) and geese can remove substantial amounts of plant biomass from wetlands, which alters plant community and hydrological processes (M&G, NRC).

Anthropogenic Influences

Human activities that are most influential on Midwestern wetlands are agriculture and urbanization. Conversion to agricultural land is the major cause of wetland loss worldwide (Mitsch and Gosselink 2000). In fact, some of the world's most fertile soils were once wetlands in the present states of Iowa, Illinois, and southern Minnesota. Although most land conversion occurred prior to the 1970s, current losses can be attributed to farm programs and economic conditions.

Park Service agricultural activities threaten wetlands within CUVA. A recent Cultural Resources initiative from CUVA management proposes to restore active farmsteads on lands that are currently in various stages of secondary succession. Because many proposed agricultural fields are proximal to wetlands, Park Resources Management is designing a wetland mitigation and monitoring plan.

Agricultural activities outside park boundaries pose threats to wetlands within Midwestern parks. Runoff contaminated with sediment, nutrients, and pesticides reach park wetlands through waterways and drainages that have inadequate buffer zones. Aerial deposition of pesticides and nutrients has been documented in wetlands downwind of agricultural areas. Wetland destruction and fragmentation on adjacent lands threatens wetland species dependent on migration or dispersal corridors. The primary stressors associated with agricultural activity are drainage, sediments, nutrients, and toxicants.

Urbanization is the leading cause of wetland loss in the United States (Dahl 2000), and directly or indirectly threatens many wetlands within Midwestern Parks. Compared to land converted to agriculture, wetland losses to urban and suburban development are small. Nevertheless, wetlands not directly affected (e.g., removed or altered) by development are subject to a variety of indirect influences. Drainage and physical disturbance are stressors directly to wetlands if development occurs on the wetland itself. Adjacent development and navigation corridors may alter wetland hydrology, usually by means of hydrologic stabilization. Polluted runoff from urban areas contains

Toxicants, nutrients, and sediments that potentially enter nearby wetlands. Water diversion, flood control, and reservoir projects often associated with local human population growth, cause permanent flooding in wetlands. Finally, fire suppression generally accompanies urban development due to fears of property loss.

Stressors and their Hypothesized Ecological Effects

Toxicants

"Toxicants" in this model refers to any anthropogenic chemical that reaches wetlands and potentially elicits toxic effects on organisms, communities, or the ecosystem (Rand et al. 1995). Wetlands receive toxicant inputs from upstream water sources, direct releases, and aerial deposition. Polluted streams, runoff, and groundwater transport toxicants from adjacent or distant sources. Natural or artificial wetlands are often used specifically for filtering contaminants that are released directly into the system. Finally, wetlands receive toxicant inputs from aerial deposition, which has become recognized by widespread Hg contamination of water bodies (Wiener et al. 2002).

The well-known ability of wetlands to assimilate contaminants and "purify" water (Mitsch and Gosselink 2000) is largely due to the perception that contaminants entering wetlands are eventually "locked-up" in sediments, and therefore benign to organisms. However, there is mounting evidence that contaminants buried in wetland soils and sediments are still available to biota and therefore threaten aquatic and terrestrial ecosystems (Landrum and Robbins 1990, McIntosh 1991). For example, up to 2% of the total amount of organochlorines present in a lake's sediments were removed from the lake as sediment-dwelling insects emerged into the terrestrial environment. The contaminated insects in turn became a source of contamination to a aquatic and terrestrial food webs (Fairchild et al. 1992).

Toxicants influence biota at varying levels of ecological organization. Typically, toxicant exposure is first manifested by the presence of detoxifying enzymes or toxicant metabolites in organism tissues. These so-called "bio-markers" are an active area of research and have the potential to signal early warnings of toxicant exposure. As toxicant exposure time or levels increase, organisms suffer malformations, tumors, stunted growth, lost reproduction, and eventually death. Populations are therefore affected when sufficient individuals suffer toxic effects and alter population abundance, biomass, and productivity. Disproportionate losses of populations lead to changes in community composition and, conceivably, alterations in ecological processes.

Nutrients

The most common reason for impairment of U.S. surface waters is eutrophication caused by excessive inputs of Nitrogen (N) and Phosphorus (P) from non-point sources. More than half of the rivers and lakes that currently fail to meet water quality standards are impaired by nutrients (USEPA 1998). The dominant source of nutrients in U.S. surface waters is non-point runoff from agricultural and urban areas (Carpenter et al. 1998). Excessive N and P can cause drastic changes in plant communities. The most prominent effect of nutrient enrichment is a proliferation of algae, which can lead to a wide array of additional problems. Algal blooms can cause fish kills as decomposition and respiration consume large amounts of oxygen. High algal biomass reduces water transparency, which hinders growth of submergant plants. Aesthetic, recreational and drinking water values are also reduced by eutrophication.

Sediment

Sediment considered in this model is comprised of mostly inorganic particles < 2mm in diameter, thus encompassing sand, silt, and clays (Wood and Armitage 1997). Although sediments are a natural park of most aquatic ecosystems, human activities have dramatically increased sediment inputs to lakes, streams and wetlands. Most sediment enters wetlands through urban and agricultural runoff. Wetland sedimentation is a common result of highway construction (Mitsch and Gosselink 2000). When suspended in water, fine sediments increase turbidity, decrease light penetration, and alter primary productivity. Sediment particles < 63 micrometers (µm) in size are frequently adsorbed to by a variety of contaminants, especially nutrients and heavy metals (Wood and Armitage 1997). Consequently, sediments are an integral part of nutrient- and toxicant-related effects in wetlands. In some cases excessive sediment accumulation can alter the hydrologic regime.

Drainage

Draining, dredging, filling, and ditching are human modifications specifically designed to dry out wetlands. By removing the source of water influx, wetlands are desiccated and the land used for urban development, highway construction, or agriculture. Levees are often constructed with the primary goal of preventing water from entering the former wetland area. This practice has led to farming and development in the floodplains of many rivers, which has also caused widespread property damage and loss of life when rivers flood. Wetland removal and subsequent fragmentation of remaining habitats is associated with declines in the diversity of wetland organisms (Lehtinen et. al. 1999).

Flooding

Wetlands are flooded as part of water development and management programs. The most common scenario is the loss of riparian wetlands by reservoir construction. A related human impact is the stabilization of wetland hydrology, typically a result of dams designed to reduce flooding. Because the hydrologic regime is unquestionably the most important controller of wetland ecosystems, human alterations of water flow have damaged wetlands on a grand scale. The effects of drainage, flooding, or any other hydrologic alteration are variable. On one extreme wetlands are drained and entirely obliterated. On the other hand, many wetlands are cut off from their water source by roads or levees but remain physically in tact. The loss or alteration of water influx reduces inputs of sediments, nutrients, and propagules. Consequently, long-term changes in plant and animal community composition are the most common effects of hydrologic alteration.

Fire Suppression

Fire is necessary for the maintenance of many types of wetlands (review by Kirby et al. 1988). Although humans suppressed fires through most of the 20th century, we now recognize its importance in nutrient cycling and plant community dynamics. Unfortunately, fire is still suppressed in wetlands near urban and many agricultural areas. As a consequence, many wetlands have become dominated by woody (often exotic) vegetation.

Invasive Exotic Species

The invasion of non-indigenous species seriously threatens wetland ecosystems nationwide (U.S Congress 1993). Most invasive species in wetlands have escaped landscaping cultivation or were intentionally planted to stabilize sites already disturbed by human activities. Lacking natural enemies, many exotic species rapidly infest wetlands and displace native flora and fauna. *Lythrum salicaria L.* (Purple loosestrife) is currently the most well-known and widespread invasive that is degrading U.S. wetlands. As with other invasive exotics, purple loosestrife alters biogeochemical cycling and hydrologic regimes in wetlands in addition to directly out-competing native plants.

Ecosystem Attributes

A parsimonious set of ecosystem attributes is needed for designing a long-term monitoring program. The eleven attributes selected for Midwestern wetlands include characteristics of the physical (e.g., hydrologic regime) and chemical (e.g., water chemistry) environment. In addition, numerous levels of biological organization are represented, including tissues, organisms, populations, communities, and ecosystem processes. Each attribute is identified and its selection justified in this section.

Physiology and Organism Health

Some attributes of physiological processes and organism health are indicative of stress on ecosystems and therefore useful in long-term monitoring. Contaminant-induced biochemical processes provide evidence that organisms are being exposed to contaminants in their environment. For example, exposure to heavy metals stimulates cellular production of metallothionein, a protein used to regulate essential metals in most organisms. Cellular damage is minimized because the toxic metal is sequestered by metallothionein and effectively removed from circulation (Klaverkamp et al. 1991). Similarly, analyses for contaminants that accumulate in the tissues of organisms provide important information about exposure. Finally, growth and reproduction, which are essential for all organisms, are often indicative of anthropogenic stress (e.g., Beyers et al. 1999).

Sediment Quality and Chemistry

Sediment is defined here as the organic and inorganic soils and substrates of wetlands. Sediments are a major part of biogeochemical cycling in wetland ecosystems (Mitsch and Gosselink 2000) and provide habitat for many organisms. Most anthropogenic chemicals eventually accumulate in sediments due to a variety of hydrological and chemical processes (Ingersoll 1995). Sediment contamination is a widespread problem in aquatic ecosystems of the U.S. and poses significant threats to ecological and human health (NRC 1989). Contaminated sediments may be directly toxic to organisms or can be a source of contamination in the food chain. The most common contaminants found in sediments are heavy metals, pesticides, persistent organic chemicals, and hydrocarbons.

Primary Production and Decomposition

Ecosystem processes, and the biogeochemical cycles they control, are fundamental attributes of all ecosystems. Primary production, which is the rate of plant biomass accumulation, is sensitive to anthropogenic alteration of the nutrient budget, hydrologic regime, and natural disturbance processes. Primary production in freshwater marshes often equals or exceeds cultivated crops (Mitsch and Gosselink 2000). Riparian ecosystems are generally much more productive that adjacent uplands because of their unique hydrologic conditions. Primary production in riparian ecosystems and freshwater swamps is highly influenced by the duration and timing of flooding, and therefore sensitive to anthropogenic alterations of wetland hydrology.

Decomposition, which is the rate at which carbon from organic matter is metabolized and released as carbon dioxide, is a significant part of wetland ecosystems. Decomposition is slow in anaerobic or permanently wetted environments (Mitsch and Gosselink 2000). Wetlands are therefore a major carbon sink in the biosphere because they tend to accumulate dead organic matter (Mitsch and Gosselink 2000). Hence, much of the food webs supported in these ecosystems are ultimately dependent on detritus and microbes.

Submergent Plant Populations

Submergent plants have their photosynthetic tissues completely submerged, but flowering structures often extend above the water surface (Richardson and Vimazal 2001). Submerged plant communities are important habitat for numerous wetland animals. For example, many fish species rely on submergent beds for spawning and larval development (Tiner 1999). The productivity and distribution of submergents is strongly influenced by light penetration to the benthic environment. Consequently, anthropogenic increases in suspended inorganic particles or phytoplankton biomass are detrimental to submergent plant populations.

Water Quality and Chemistry

Water quality is fundamental to the functioning of all aquatic and semi-aquatic ecosystems. Although water quality standards for lakes and streams are well-established, chemical and biological criteria for wetlands are still under development. The U.S. Environmental Protection Agency mandated that states would have water quality standards for wetlands by 1993 (USEPA 1990). However, most states are still developing standards and criteria (e.g., Apfelbeck 2001). Within the Heartland Network, the state of Ohio is probably the most advanced in efforts to create wetland water quality standards (OhioEPA 2000).

Macroinvertebrate Community

Insects, crustaceans, and other invertebrates are highly diverse and abundant, and play central roles in aquatic food webs. Within most taxonomic groups there are typically many species with a variety of environmental requirements and sensitivity to stressors. As a result, macroinvertebrate communities have been used for over three decades in ecological evaluations of aquatic systems (Rosenberg and Resh 1993).

Algal Community

Algae occur in most wetlands that contain standing water for even short periods. Algae are important sources of wetland primary production, transform and retain nutrients, stabilize substrates, provide habitat for other taxa, and are an important food source for many animals

(Stevenson 2001). Algae are useful for wetland biological assessments because they are diverse, abundant, and have a wide range of known tolerance to environmental (e.g., water quality) factors (Mayer and Galatowitsch 1999). Taxonomy is sufficiently developed to ensure consistency and relative ease in identifying most common algal genera.

Emergent Plant Populations

Emergent macrophytes are the dominant form of plant life in most wetlands (Richardson and Vymazal 2001). In general, they produce aerial stems and leaves and an extensive root system. These plants are morphologically and physiologically adapted to growing in waterlogged environments, and are therefore used to delineate wetlands (NRC). Emergent macrophytes are a major component in wetland food webs and nutrient cycles. Because many emergent plants have narrow tolerances of hydrological conditions, salinity, water chemistry, and nutrient levels, population and community-level monitoring can be used to detect changes in environmental conditions (Tiner 1999).

Hydrologic Regime

As discussed above, the hydrologic regime is the dominant environmental control of wetland ecosystems. Consequently, the hydrologic regime itself is an important ecosystem component and requires monitoring in addition to other physical, chemical, and biological attributes. This model adopts the definition of hydrologic regime given by Poff *et al.* (1997), which includes magnitude, frequency, duration, timing, and rate of change of flows in river systems. Each of these attributes of river hydrology apply to wetland ecosystems as well, and are briefly described below.

The magnitude refers to the amount of water that inundates a wetland, and can be measured by water depth or volume. The frequency refers to how often a wetland is inundated. Seasonal inundation is most common, but annual time scales are relevant for many wetlands. The duration is the period of time associated with a specific inundation level, and may be weeks or years depending on the type of wetland and climate. The timing refers to the regularity with which inundation occurs. For example, although many wetlands are predictably inundated during specific seasons, others may be inundated intermittently and unpredictably based on weather conditions. The rate of change refers to how quickly water levels change, and strongly influences the water residence time in wetlands. This, in turn, has important implications for numerous ecological processes. Lent *et al.* (1997) developed indicators for monitoring wetland hydrologic regimes.

Fish & Amphibian Populations

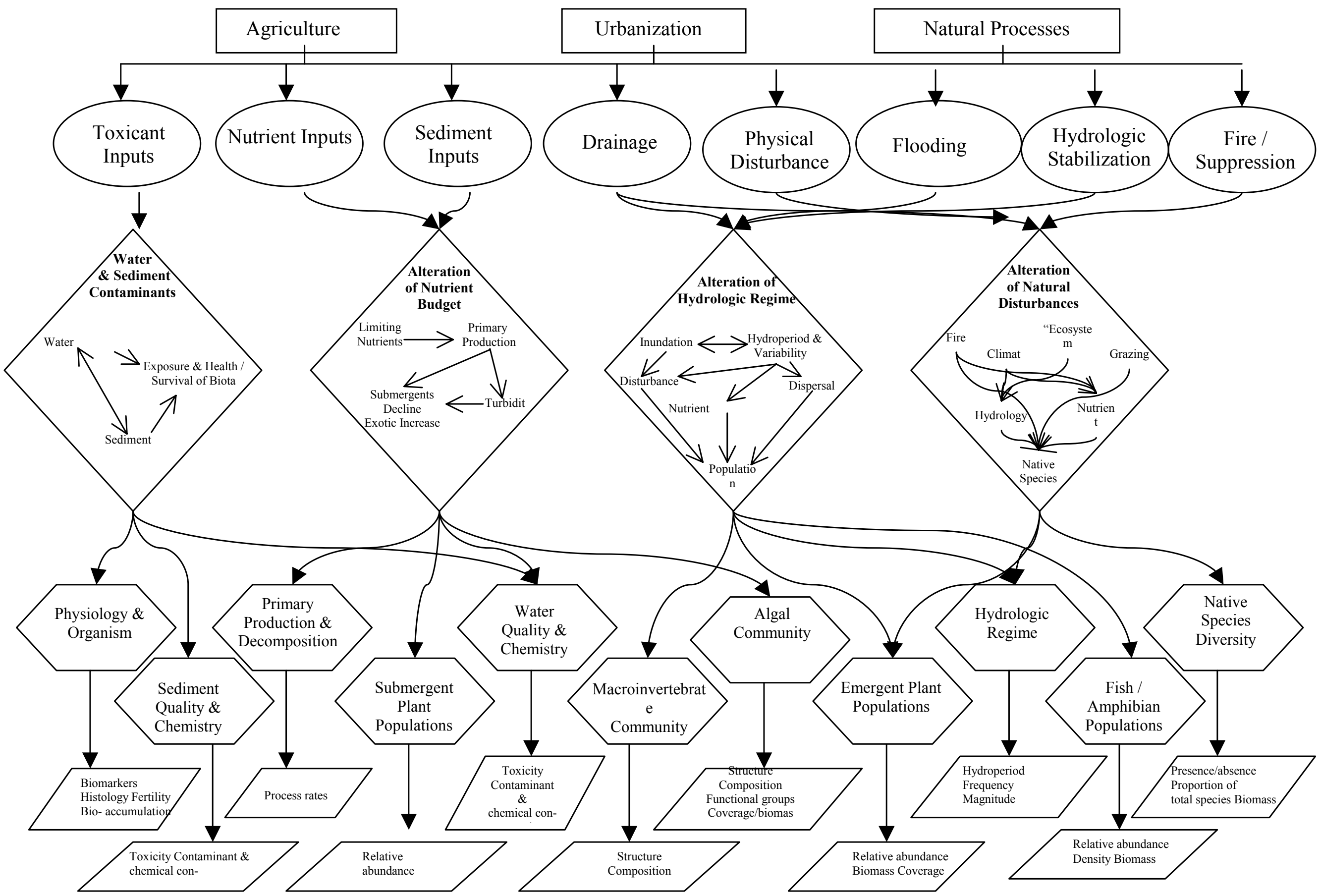
Although small, ephemeral wetlands rarely support fish, deeper wetlands that are hydrologically connected to larger water bodies may support great varieties and abundance of fish species. The relatively warm, productive habitat with abundant plants provides ideal nursery habitat for many fish species. Population monitoring of such fish species would provide an important linkage between vegetation communities and vertebrate populations (Mitsch and Gosselink 2000).

Amphibians are an important taxonomic group in freshwater wetlands. Populations of many amphibian species are currently in a global decline (Blaustein and Wake 1990), and have therefore received much attention in scientific and public dialogue. Because their life cycle integrates aquatic and terrestrial systems amphibians are excellent indicators of overall watershed condition. Amphibians are also an important trophic link between aquatic invertebrates and birds, reptiles, and mammals. Amphibian monitoring should clearly be a priority for any wetland monitoring program.

Native Species Diversity

The Endangered Species Act is a legislative affirmation that the preservation of native species is a long-standing priority in the United States. The National Research Council (2000) also identified native species diversity as an important indicator of all ecosystems. In general, native species diversity is negatively associated with the degree of human disturbance in ecosystems, and therefore represents a useful indicator of the human imprint on the land (NRC 2000). This indicator would undoubtedly be useful in wetland ecosystem monitoring.

Figure 3.4 Heartland Network wetland ecosystem conceptual model (draft 10/1/2002)



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3.1.7 TERRESTRIAL PRAIRIE ECOSYSTEM CONCEPUTAL MODEL

Information from *Conceptual framework, monitoring components and implementation of a NPS Long-Term Ecological Monitoring Program: Prairie Cluster Prototype Program Status Report (Thomas et. al 2001).*

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3.1.7.1 Introduction

Our understanding of prairie ecology has been advanced by several significant research syntheses -- Weaver's classic description of decades of research concerning the response of prairie species and communities to cattle grazing and drought during the 1930's and 1950's (Weaver 1954; 1968); Risser's summation of the International Biological Program studies at the Osage site in northeastern Oklahoma (1981); and the synthesis of twenty years of research from the Konza Prairie Long-Term Ecological Research Program (Knapp et al. 1998). Other recent volumes devoted to prairie ecology include discussion of the role of fire in tallgrass prairie (Collins and Wallace 1990), conservation and management of prairie ecosystems (Joern and Keeler 1995), and the ecology and conservation of Great Plains vertebrates (Knopf and Samson 1996). Various authors have reviewed the literature, summarizing the key roles of climate, fire and grazing in prairie ecosystems (Risser 1981; Anderson 1982; Singh et al. 1983; Axelrod 1985). The following descriptions are derived from several recent overviews of terrestrial (Anderson 1990; Risser 1990; Bragg 1995; Knopf and Samson 1996; Knapp and Seasteadt 1998) and aquatic (Gray and Dodd 1998; Gray et al. 1998; Fausch and Bestgen 1996) prairie ecosystems.

3.1.7.2 Descriptions of Prairies in the Heartland Network

Fragmentation and isolation, fire suppression, loss of ungulate grazers, alteration of stream hydrology, and introduction of exotic species all act as stressors on prairie ecosystems today. Several Prairie Cluster parks are also facing growing developmental pressures on their boundaries. Cultural use, including trail-related impacts in sensitive areas and protected usage by Native American groups, may also be affecting park resources.

One could argue that ecosystem models are barely relevant to the management of small prairie remnants such as those that occur within Prairie Cluster parks. These modest patches of prairie seem insignificant in comparison to the vast landscape that spanned the Great Plains one hundred years ago. Cut off from the driving forces of fire and grazing that worked at grand scales to maintain them, often isolated from sources of gene flow and recolonization – do remnant prairies still function as ecosystems, or are we merely maintaining prairie gardens? Considering the long generation lengths of many prairie dominants (many exceeding 100 years) and the prevalence of vegetative reproduction, it is clearly too soon to tell.

In the meantime, particularly within the tallgrass prairie region where over 99% of the original habitat has been lost, many prairie associations preserved within NPS units represent some of the best regional examples of unique prairie types. Resource managers have little choice but to actively manage remnant prairies to preserve their ecological integrity and biodiversity. They employ prescribed fire to mimic natural disturbance regimes, attempt to control exotic species invasions, and restore native prairie and savanna vegetation to disturbed sites. These management actions may also be viewed as stressors, undertaken in the hope of mimicking natural processes and effecting positive change to prairie ecosystems. Their ultimate success will be judged on whether remnant and restored prairies can support a diverse array of grassland species, including conservative prairie insects and vertebrates. Table 3.4 outlines some of the key characteristics of prairie ecosystems and briefly discusses implications for monitoring those characteristics.

Table 3.4. Characteristics of prairie ecosystems and implications for monitoring

KEY CHARACTERISTICS OF PRAIRIE ECOSYSTEMS	IMPLICATIONS FOR MONITORING
Interannual variability in ANPP (aboveground net primary production) in tallgrass prairie ecosystems is extreme.	High natural variability in ANPP may make it difficult to detect stressor-driven trends in foliar cover. Plant community monitoring should be accompanied by local climate data.
Prairie vegetation evolved in a nitrogen-limited environment.	Overgrazing of prairie vegetation may result in increased nitrogen availability, thus altering composition and increasing susceptibility to exotic species invasion.
Light to moderate grazing pressure may promote spatial heterogeneity within prairie ecosytems.	Plant community monitoring in grazed prairies should include a measure of beta (among-site) diversity.
Fire regimes that mimic natural fire frequency and seasonality may promote spatial heterogeneity within prairie ecosystems.	Plant community monitoring in prairies undergoing prescribed fire should include a measure of beta (among-site) diversity.
Heavy grazing pressure may result in soil compaction, resulting in reduced soil moisture infiltration.	Plant community monitoring in heavily grazed prairie should include measures of soil compaction/soil porosity.

3.1.7.3 Methods

Monitoring data are intended to detect long-term environmental change, provide insights into the ecological consequences of change and help decision-makers determine if observed change indicates that a correction to management practices is needed (Noon et al. 1999). Detecting meaningful change is complex because natural systems are inherently dynamic and spatially heterogeneous. Changes in time may not be the result of human-induced effects, but rather the result of intrinsic variability of natural systems (e.g., stochastic or cyclic variation and succession). Generally, extrinsic drivers of change arising from human impacts are of greater interest to environmental monitoring programs than intrinsic factors. One goal of a monitoring program is to filter out the effects of expected intrinsic variation from the additive, human-induced patterns of change (Noon et al. 1999).

Aquatic and terrestrial models were developed to describe prairie ecosystems. In the interest of brevity, only the terrestrial model is presented below.

The conceptual model consists of the following:

- Narrative description of the primary natural ecosystem drivers

- Table summarizing primary natural drivers and their effects on terrestrial prairie ecosystems
- Narrative description of the current anthropogenic stressors
- Tables summarizing current anthropogenic stressors and their effects on park resources

3.1.7.4 Conceptual Model

3.1.7.4.1 External natural drivers and anthropogenic stressors

Natural Drivers – Terrestrial Prairie Ecosystem

Climate

Temperate grasslands worldwide are characterized by climates with periodic drought that permit the vegetation to dry, by periodic fires, and by landscapes that are level to gently rolling, which allows fires to spread across extensive areas (Sauer 1950). The central grasslands of North America occupy an area resembling a broad triangle, with its base running along the foothills of the Rocky Mountains, and its apex extending as far east as Indiana, with scattered prairie outliers in Michigan, Kentucky and Ohio (Risser 1981). The eastern sector of this grassland region, the prairie peninsula (Transeau 1935), has historically fluctuated between a climate capable of supporting grassland and one supporting forest. Borchert (1950) summarized the common climatic attributes of North American prairie as 1) low winter snow and rainfall, 2) high probabilities of large rainfall deficits in summer, 3) fewer days of rainfall compared to forested areas to the north, south and east, 4) low summer cloud cover, 5) low summer relative humidity, 6) large positive departures from average temperature, 7) frequent hot, dry winds in summer; and 8) frequent large departures from average climatic conditions. Transeau (1935) emphasized that to understand the distribution of grassland in this region, the extremes of climate must be considered, and not the average.

Fire

Fire occurs in a wide variety of plant communities, but is particularly important in temperate grasslands because without fire, most grasslands would ultimately succeed to forests or shrublands (Sauer 1950). North American prairie fires historically occurred in all months of the year, but fuel conditions and weather patterns lead to peak fire probabilities in July/August and secondarily during late spring (Bragg 1982). American Indians frequently ignited fires to drive or attract game (Pyne 1982; Higgins 1986). In mixed grass prairies, both dormant-season and growing-season burns generally decrease total plant production, while in tallgrass prairie, mid- to late-spring burning generally increases overall productivity (Bragg 1995). The patchy distribution of burned and unburned areas affects grazing patterns, attracting bison and other ungulates to the greater productivity and nutritive quality of forage following fire. The overall effect of grazing would therefore be concentrated in the most recently burned units of the landscape (Risser 1990).

Fire results in substantial losses of nitrogen through volatilization, with perhaps twice as much nitrogen lost in a single fire as enters the system yearly in rainfall or by nitrogen-fixing organisms (Seastedt 1988; Ojima et al. 1990; Hobbs et al. 1991). The removal of vegetation and plant surface litter also results in an exposed, soil surface that is warmer and drier than that of unburned prairie. Losses of nitrogen in a fire, followed by losses of water due to increased surface evaporation result in both of these resources becoming less available. With enhanced plant growth, available nitrogen is locked away in plant tissue, while higher photosynthetic rates place strong demands on soil water. Plants respond to nitrogen and water limitations by allocating more photosynthate to roots. This input of new roots to prairie soil has been critical to the accumulation of soil organic matter and humus (Seastedt 1995).

Grazers

Grasslands generally support large numbers of herbivores (Detling 1988). Worldwide, native large mammalian herbivores and cattle remove, on average, 30 to 40% of the aboveground net primary production (ANPP) in grasslands, while insects remove another 5 to 15%. Belowground invertebrate consumers, primarily nematodes, consume another 6 to 40% of the belowground net primary production. While dominant tallgrass prairie species such as *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem) and *Sorghastrum nutans* (Indian grass) decrease under regimes of prolonged grazing, dominant shortgrass species such as *Bouteloua gracilis* (blue grama), *Bouteloua curtipendula* (side-oats grama) and *Buchloe dactyloides* (buffalograss) increase (Weaver 1954). In the tallgrass prairie, the behavior of grazing animals promotes among-site heterogeneity of vegetation, especially in conjunction with periodic fire (Glenn et al. 1992). In shortgrass prairie, heavy grazing promotes homogeneity of the landscape and light grazing pressure results in enhanced heterogeneity (Larson 1941; Milchunas et al. 1988). Heterogeneity within shortgrass landscapes historically was fostered by the nomadic nature of large herds of bison.

Ungulate grazers increase nitrogen cycling rates in grasslands and are likely to affect export rates as well (Blair et al. 1998). Chronic over-grazing may result in a loss of root mass, as plants respond to herbivory by using root reserves to produce new foliage, rather than sending photosynthate to the root system to find new sources of N and water. The short-term effect of chronic grazing is therefore a more rapid nitrogen cycle, which allows a diminished root mass to provide sufficient nitrogen to maintain foliage production. In the western portions of the prairie, this system may prevail, with the dominant species well adapted to grazing. In the more easterly grasslands, the tendency for the dominant grasses to be outcompeted with nitrogen enrichment suggests that chronic grazing was not the rule (Seastedt 1995). Infrequent grazing may function similarly to infrequent fire, causing a transient pulse of productivity in response to increased availability of nitrogen, water and light.

Table 3.5 summarizes drivers of prairie ecosystems.

Table 3.5 Primary natural drivers and their effects on terrestrial prairie ecosystems

Driver	*Resource*	*Effect*
Climate:		
Periodic drought	Plant communities	Mortality of trees/shrubs; reduced, patchy vegetative cover; reduced seed production; shifts in species composition
Fire	Plant communities	Prevention of woody species establishment; increased productivity and seed production (tallgrass prairie); dominance of C4 grasses (spring fire). Varied seasonality and fire frequency resulted in increased landscape heterogeneity.
	Soils	Loss of nitrogen through volatilization; water loss through surface evaporation; increased root production
	Bison	Foraging patterns follow recently burned areas
Grazers:		
Bison	Plant communities	Reduced C4 grass dominance due to selective grazing; increased heterogeneity & species diversity associated with grazing patches, wallows; moderates fire effects by decreasing C4 grass dominance
	Soils	Consumption of ANPP and redistribution of N in urea and feces moderates fire-regulated N loss through volatilization
Prairie grasses & soil biota	Soils	High organic matter & nutrient retention; high below-ground productivity, low nitrogen availability, high moisture holding capacity

Anthropogenic Stressors

Knopf and Samson's (1996) description of today's prairie landscape provides a short overview of the most significant ecological alterations following European settlement.

The Prairie Landscape in 1996
Condensed from Knopf and Samson (1996)

The arrival of European descendents on the North American grasslands drastically altered the face of the landscape as well as ecological relationships within the biota. The overwhelming influence has been to modulate the inherent range of natural variation in ecological drivers of the prairie. Water management in the shortgrass and mixed-grass regions has locally removed the threat of periodic drought, resulting in increased cultivation and a westward extension of cereal grain agriculture. Fire suppression in the tallgrass and mixed-grass prairie has led to loss of species richness.

Cultivation and residential and industrial development have obliterated potential habitats for many vertebrate species locally. Total losses of native prairie range from 20% of shortgrass prairie in Wyoming to greater than 99% of tallgrass prairie in Illinois and Iowa. Overall, estimates of conversion of native prairie to either cropland or pastureland in the United States range from 29% of shortgrass, 41% of mixed-grass, and more than 99% of tallgrass landscapes (U.S. Dept of Agriculture 1987). Pastureland provides surrogate prairie habitat for some vertebrate species of the eastern Plains (Herkert 1993; 1994).

The loss of native grasslands as potential vertebrate habitats is even more devastating as remnant grasslands become more and more fragmented and isolated. The effects of fragmentation are threefold. First, many species of vertebrates require large, intact parcels of grassland for survival and reproduction (Samson 1980; Herkert 1994). As remnants decrease in size, these area-sensitive species are progressively extirpated locally. Second, as remnants become more isolated, the probability of colonization/recolonization of a patch decreases with distance from another patch (Kaufman and Kaufman 1996). Third, populations in isolated patches suffer from genetic inbreeding and accelerated rates of genetic drift (Benedict et al. 1996).

The estimated tens of millions of bison on the western Plains were replaced by an estimated 45 million cows and an equal number of domestic sheep by 1890 (Fedkiw 1989). Management of cattle with fences has created endless homogeneous landscapes by removing the differential intensities of grazing among sites that historically created the mosaic of habitats necessary to support many species (Knopf 1996)… The uniformity of grazing management on the Great Plains probably has a more negative effect on endemic avian assemblages than the actual presence of livestock or the consequences of grazing (Knopf 1996).

Prairie streams had a strong riffle/pool structure that resembled more a series of seasonally connected small ponds or lakes during periods of low flow (Brown and Matthews 1996). Size of pools increased and length of riffles generally decreased moving down the drainage; all except the Missouri River periodically may have become intermittent in periods of drought. Today, water diversion and ground-water pumping have accentuated the intermittency of these streams on most of the Great Plains.

A less noticeable, but equally pervasive, threat to native fishes has been the rampant accidental and deliberate introduction of alien (North American species native to biogeographic provinces other than the Great Plains) and exotic (species from other continents) fishes into native streams. Ross (1991) reported that more than three of every four introductions of exotic fishes resulted in declines in populations of indigenous species.

Across the northern Great Plains, historic natural wetlands have been destroyed at an alarming rate. Estimates of wetland loss range from 86% in tallgrass prairie states (Illinois and Iowa) to 40% in Montana (Dahl 1990)….Drainage of wetlands and conversion of the landscape to row cropping continues to destroy these major breeding grounds for waterfowl populations (Betheke and Nudds 1995).

Tables 3.6 and 3.7 summarize current and potential anthropogenic stressors to terrestrial prairie ecosystems.

Table 3.6 Anthropogenic stressors of terrestrial prairie ecosystems – development and use impacts

Stressor	*Resource*	*Effect*	*Indicator*
Adjacent Habitat Loss & Fragmentation			Land use change maps
Isolation of native plant populations	Grassland plant communities	Loss of colonization and pollination sources, resulting in reduced abundance or loss of native species	Plant community composition; pollinator abundance
Fire suppression	Grassland plant communities	Woody invasion of prairie; conversion of savanna to woodland	Woody seedling/sapling density
Reduced wildlife habitat	Woodland plant communities	Deer over-abundance resulting in selective browsing pressure, loss of forb species	Plant community composition using exclosures
Reduced wildlife habitat	Grassland birds communities	Increase in edge and ruderal species resulting in displacement of grassland species	Bird community composition, relative abundance
Isolation of rare populations	Rare species populations	Loss of re-colonization sources following local extinction; reduced gene flow between populations	Decreased population persistence; reduced genetic diversity
Exotic Species Invasion	Grassland plant communities	Displacement of native species, alteration in community composition, structure and diversity	Plant community composition; distribution, abundance of exotics
Elevated CO2 levels	Grassland plant communities	Shifts in species' range	Changes in persistence/abundance of edge-of-range populations
Trail Development/Use	Grassland plant communities, unique habitats	Further fragmentation of remnant communities, corridors for exotic invasion, soil compaction	Plant community composition
Fencing for cattle, watering points,		Disrupt spatial distribution of grazing, reducing landscape heterogeneity; high-impact zones adjacent to water, shade	Reduced Beta diversity, compositional changes in high-impact zones
Over-grazing	Grassland plant communities	Increased allocation to foliar production, resulting in reduced root mass; more rapid N-cycling results in increased soil N availability -- reduces dominance of prairie grasses. Reduced root mass & soil compaction reduce soil moisture retention.	Plant community composition, dominance; increased abundance of exotic species; soil nitrogen availability, soil compaction
Over-grazing	Grassland bird communities	Changes in vegetation structure result in poorer habitat quality for grassland birds	Bird community composition, abundance, diversity
Quarrying pipestone	Rare species habitat	Pumping water from quarries may result in altered ground-water hydrology, ultimately affecting mesic prairie and stream habitats of T&E species	Rare species abundance, plant community composition, stream, groundwater hydrology

Table 3.7 Anthropogenic stressors of terrestrial prairie ecosystems – resource management actions

Stressor	*Resource*	*Effect*	*Indicator*
Prescribed Fire	Prairie landscapes	Increased habitat heterogeneity and structural diversity	Distribution of community types; beta diversity; grassland bird diversity and abundance
	Grassland plant communities, unique habitats	Maintain prairie communities; potential for species losses related to fire seasonality and frequency	Community composition, abundance, diversity; guild abundance; butterfly diversity
	Oak savanna plant communities	Conversion of woodland to savanna	Overstory composition, basal area; understory composition
	Grassland bird communities	Changes in vegetation structure, habitat quality; potential for fire-related mortality during breeding season	Community composition, diversity, abundance;
Nesting success	Ground-nesting vertebrates	Fire-related mortality	Community composition, abundance and diversity
	T&E plants	Improve quality of T&E plant habitat; potential for fire-related mortality	T&E species persistance, abundance
Prairie / Savanna Restoration	Historic grassland landscapes	Recreation of historic landscapes	Distribution of community types, Beta diversity
	Grassland plant communities	Increase extent of prairie/savanna areas, buffer remnants from exotic invasion	Community composition, abundance & diversity approaching that of model plant community
	Grassland birds/vertebrates	Increase in habitat size	Community composition, abundance and diversity
Exotic Species Control			Distribution/size of exotic patches; frequency, abundance of invasive exotic species
	Grassland plant communities	Improve native communities	Community composition, abundance & diversity
	T&E species habitat	Improve quality of T&E plant habitat	T&E species persistence, abundance
	Woodland/savanna communities	Reduce abundance of targeted species	Density of woody species
	T&E species	Improve quality of T&E habitat	T&E plant population size

3.1.7.5 Bibliography

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3.1.8 Land Use Change

This conceptual model will be incorporated in Phase II of the monitoring design process.

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13 Appendices

The following appendices each represent independent documents that are refered to in this Monitoring Plan.

Arkansas Post National Memorial
Buffalo National River
Cuyahoga Valley National Park
Effigy Mounds National Monument
George Washington Carver National Monument
Herbert Hoover National Historic Site
Homestead National Monument of America
Hopewell Culture National Historical Park
Hot Springs National Park
Lincoln Boyhood National Memorial
Ozark National Scenic Riverways
Pea Ridge National Military Park
Pipestone National Monument
Tallgrass Prairie National Preserve
Wison's Creek National Battlefield
Data Mining Methods
Workshop Reports - Phase II and III information from here on
Sampling Protocols
Database Design Details
Data Management Plan
Aquatic Monitoring Plan
Safety Plan