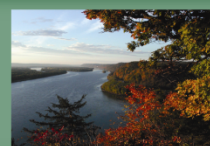




History and Development of the Heartland Inventory and Monitoring Network

Natural Resource Report NPS/HTLN/NRR—2016/1179



protecting the habitat of our heritage



**Heartland
Network**

Natural Resource Monitoring

ON THE COVER

Herbert Hoover birthplace cottage at Herbert Hoover NHS, prescribed fire at Tallgrass Prairie NP, aquatic invertebrate monitoring at George Washington Carver NM, the Mississippi River at Effigy Mounds NM.

History and Development of the Heartland Inventory and Monitoring Network

Natural Resource Report NPS/HTLN/NRR—2016/1179

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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1 National Level

Chapter 1

“The National Park Service has a fundamental responsibility for preserving and interpreting many of the Nation’s most valued cultural and natural resources. Yet it also has a responsibility to preserve and analyze its own history. . . By learning more about problems their predecessors faced, managers at all levels can be better informed about contemporary issues and bring greater awareness to their policy and program decisions.

“Administrative histories are the most effective way to convey this knowledge.”

—Janet A. McDonnell, Bureau Historian, National Park Service, March 2004

The National Park Service (NPS) has an obligation to maintain a thorough, accurate record of its policies, decisions, and activities. We cannot formulate current policies properly without reference to the past. The goal of an administrative history is to document the origin and evolution of an NPS unit. To date, administrative histories applied to parks and not to program units. The NPS Inventory and Monitoring (I&M) Program has functional units, called networks. Each network oversees inventory and monitoring for the I&M Program at one or more parks.

Although documentation from the three-phase system for developing a network and establishing monitoring protocol provides a good history of the progression, it lacks an emphasis on problems and issues that accompanied the process. The Heartland Inventory and Monitoring Network (HTLN) tackled the need for a comprehensive recounting of the decision-making in the birth and development of a network through this document, tailored on the traditional park administrative history format. In it, we will attempt to

- Place the HTLN story in the context of national political and economic trends and events.
- Include the history of various activities leading to the HTLN, occurring during planning phases, and arising during implementation of inventory and monitoring; we will address past controversies and seek to explain why and how certain practices evolved.
- Focus on the things managers need to know as they assume their duties in order to create continuity in management over time.

The institutional history begins with a chronological approach to the process and touches on issues associated with the growing pains of a new program. This history documents the specific issues that the HTLN incurred, including equilibrating and fine-tuning monitoring implementation to best meet the needs of its parks and fit the realities of fiscal

limitations. Additionally, the HTLN has led the way within the I&M Program, integrating fire-effects monitoring, entering into land-management partnerships, instituting an exotic-plant management team as a division within the HTLN, and incorporating science communication and education into its functions. We will discuss the development of those program areas.

This first chapter will cover the National Park System's relationship to natural resource management. It begins with the inception in 1916, recounts the increased awareness of a need for biological inventory, passes through the loss of biologists to the National Biological Survey (HR1845), and resolves with the resurgence of science in the parks as a basis for management decisions.

Appendix 1 provides a glossary of terms used throughout this report.

1.1 Natural Resource Surveys

The National Park Service Organic Act of 1916 (Organic Act) established the goal of the NPS to "conserve" resources in an "unimpaired state" for future generations¹. The duality of this role soon became apparent as preservation and tourism, often conflicting in their goals, created a conflict-ridden management style. George Melendez Wright initiated a wildlife survey program for the NPS in 1929. By 1930, he became the first chief of the wildlife division of the NPS, leading the way in park surveys and assessments of wildlife population status in the parks. With Wright's death in 1936, a long history of controversial interplay between competing forces within the NPS ensued. Recognition that science must undergird resource management resulted in increases in staffing of experts from various scientific disciplines, but then staffing dropped during lean budget years. Finally in the post-World War II era, public interest and concern for the parks, now fully accessible by automobile, expanded, leading to resurgence in conservation in the late 1940s into the 1950s.

Alongside the Organic Act, the U.S. Department of Agriculture (USDA) had developed

¹ "to conserve the scenery and the natural and historic objects and wildlife 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." from the Organic Act.

the first Division of Biological Survey. This division was transferred to the Department of the Interior (Interior) in 1939 and made part of the U.S. Fish and Wildlife Service (USFWS). The survey, or inventory, component declined and the USFWS focused attention on understanding wildlife and fish interactions, instead of inventory on federal lands. The NPS once again tried to meet the demands for scientific information on biotic resources within parks. Large, prominent parks, such as Yellowstone National Park and Yosemite National Park, addressed issues relative to elk, pronghorn, bison, and bighorn sheep, but less notable wildlife issues languished. Often, responses to wildlife problems resulted in remedial action without long-term planning, based on solid understanding of population dynamics or environmental processes.

A controversial culling of elk in Yellowstone National Park led to a major outcry from the public and a subsequent inquiry into management practices. The NPS decided to restructure natural resource management along ecological lines following the Leopold Report (Leopold, et al. 1963). Although the report focused on maintaining wildlife populations below carrying capacity, restoring natural balance, and preventing habitat degradation, the report also mentioned the restoration of wildlands to primitive conditions.

“As a primary goal, we would recommend that the biotic associations within each park be maintained, or where necessary recreated, as nearly as possible in the condition that prevailed when the area was first visited by the white man, ... A national park should represent a vignette of primitive America.” – Leopold Report, 1963.

The report tried to unify the management of park visitors with the management of biotic resources. Then Secretary of Interior, Stewart Udall, charged the NPS to move forward with recommendations of the Leopold Report. A nearly concurrent report, the Rob-

bins Report (Robbins, et al. 1963), came to similar conclusions as the Leopold Report, and criticized the lack of scientific process that had gone into decision-making in the past. The Robbins Report proposed that the NPS should inventory and map the natural history resources of each park. It also recommended that the NPS establish a permanent, independent, and identifiable research unit to conduct and supervise research in natural history and act as consultant on natural history problems. In 1964, the Natural Sciences Advisory Board to the NPS and the Division of Natural Science Studies emerged as the scientific wing of the NPS. Still, management had not made the hoped for advancements expressed in the Leopold Report or Robbins Report by 1972 (Penfold, et al. 1972).

The citizenry became aware of environmental issues in the 1960s and 1970s and expected the NPS to demonstrate the hallmark of conservation (Dilsaver 1994). This environmental concern became evident in the many legislative acts that affected changes to agency ways of doing business. The National Environmental Policy Act of 1969 required an understanding of resource conditions to direct and evaluate effects of management actions. Several other legislative and executive mandates further required a substantial knowledge and understanding of both physical and biotic resources.

- Forest and Rangeland Renewable Resources Planning Acts of 1974 and 1976.
- Endangered Species Act of 1973.
- Fish and Wildlife Coordination Acts of 1980.
- Migratory Bird Treaty Act of 1974.
- Clean Water Act (Federal Water Pollution Control Act of 1972).
- Executive Order 11900 (Protection of Wetlands).
- Clean Air Act of 1970.

The NPS recognized its legal mandate to direct management to perpetuate resource integrity based on knowledge of resources and their conditions. In the 1980s, scientists began to consider ecosystem management the key to resource stewardship. Interior adopted a holistic approach to land man-

agement, but competition for funds and lack of information slowed progress within bureaus. Additionally, an increasing number of lawsuits contended that the federal government did not implement its own regulations, and courts, instead of land managers, determined the actions needed for resource protection.

In May 1987, a group led by Boyd Evison completed A Natural Resources Inventory and Monitoring Initiative Report (Hester 1987). The report addressed the policy, definitions, and rationale of gathering, analyzing, and managing baseline inventory data and long-term monitoring of natural resources. The NPS moved toward drafting Service-wide standards and guidelines for inventory and monitoring during a meeting at Sequoia-Kings Canyon National Park with the intention of drafting a document by December 1987. By 1988, NPS policy stated that natural and social science research should enter into planning and management decision-making. In 1989 Eugene Hester, the Associate Director for Natural Resources appointed a Servicewide task force to implement I&M on a programmatic basis throughout the NPS (Thomas, written communication December 2014). The NPS published a Servicewide guideline for designing and implementing I&M programs in park units during 1992 that the bureau called NPS-75 (Willson 1994).

In the midst of this program development, actions within Interior complicated NPS efforts, while attempting to ensure indisputable objectivity in research, inventory, and monitoring of public trust resources. In the interests of basing land management decisions on science instead of jurisprudence, Secretary Bruce Babbitt raised the importance of science-based resource management to an agency level by creating a National Biological Survey (NBS) within the Interior. The Secretary intended the new NBS to be independent from other Interior bureaus, and like the U.S. Geological Survey (USGS), it would collect, analyze, and disseminate scientific data with objectivity. Not waiting for Congressional action, Secretary Babbitt created the bureau by secretarial order. The new agency drew from existing

personnel in the USFWS, the NPS, and five other Interior bureaus. The 1994 Interior Appropriations Act allocated \$163 million to NBS operations, most of which was transferred from the budgets of the research divisions of the other Interior agencies. Within a year, over 1,800 scientists and staff moved from the research divisions of Interior bureaus into the NBS. This essentially removed all inventory, monitoring, and science activities from the NPS.

Although Secretary Babbitt intended the NBS to serve the needs of the land management agencies, declining budgets obstructed this vision. The politically unpopular bureau had its budget slashed in 1996. Opponents called for the termination of the NBS. After three years of independence, the NBS merged with the USGS. The Department of Interior tasked the new Biological Resources Division (USGS-BRD) of the USGS with providing research relevant to resource management needs (Krahe 2012).

Years of instability within the research program for the NPS left parks to monitor resources or conditions that they deemed important to the overall welfare of their park. In most cases, the surveys and studies that came from this period had a localized intent and did not follow any Servicewide standards. Generally, large parks with diverse staffs were capable of monitoring, but small parks or cultural parks with significant natural resources lacked staff expertise in multiple areas of scientific research and could not undertake extensive inventory or monitoring projects. In addition to funding and staffing difficulties, monitoring project reviews pointed to a number of deficiencies, including inadequate conceptual design and ecosystem model development, wide variation in the quality and currency of written protocols, and insufficient reporting.

1.1.1 Overview of the Long-term Ecological Monitoring Program

Recommendations from the Vail Agenda (NPS 1992), and the National Science Council Report Science and the National Parks (1992) supported the need to reevaluate and retool science and technology in the NPS. This coincided with a significant Service-

wide effort to bring cohesion and direction to monitoring activities under a long-term monitoring program.

The NPS initiated a series of Long-term Ecological Monitoring (LTEM) prototypes to gain experience with natural resource monitoring. The first four monitoring prototypes funded in 1992 were park-based (Channel Islands National Park, Denali National Park and Preserve, Great Smokey Mountains National Park, and Shenandoah National Park). Major areas of concern at this stage included air and water quality, vegetation, rare plant, wildlife (particularly breeding birds), and fisheries and aquatic invertebrate monitoring. The I&M Program adopted the title, Long-term Ecological Monitoring, to reflect not only the intent for the program to endure, but to indicate that it looked at the environment holistically. The practice implemented in 1992 for prototype parks added funding permanently to the respective park base accounts, once they had completed the prototype research and effort of design and protocol development.

In 1993, the Washington office issued a Call for Proposals from which it selected seven additional prototypes. Experience gained from the pilot projects led to selection of second round prototypes, implemented in fiscal year (FY) 1994, representing major biogeographic regions and a range of park sizes. The Great Plains Prairie Cluster of five parks became a second round prototype, the first prototype forming a group of small parks into a bioregional cluster. The NPS tasked the prototypes with leading the development of scientifically credible and cost-effective monitoring projects. The prototypes served as testing ground for long-term monitoring, emphasizing the development of sound monitoring protocols, attention to data and data quality issues, and regular reporting of results to park managers.

One of the difficulties stemming from the NBS depleting the research divisions of Interior bureaus became how to implement the prototype monitoring without scientists to do the planning and work. Prototypes

remained in early stages of planning, where much of the work included ensuring wise indicator selection and protocol efficiency and effectiveness. The directorate argued that these actions constituted research and should accompany the newly created NBS. In contrast, once the design became an operational project, the NPS would administer the routine monitoring as part of resource-management operations.

The duality of the program necessitated clear definition of responsibilities for the NPS and the NBS (NPS Memorandum, August 26, 1993). Congress allotted the NBS funding to support research and development efforts within prototypes. Typically, prototypes could expect to receive NBS financial support for about four or five years. The NPS took over administration and funding once prototypes completed designs and gained operational status. That required the NPS to request new operational funds as prototypes entered their operational phase. Operational prototypes left the NBS's responsibility, and the NBS used their funds for monitoring designs for new prototypes.

The Washington Office requested that those monitoring prototypes aligned with what was the NBS, now administered by the USGS-BRD, develop transition plans for moving financial and staff support, referred to as Full Time Equivalents (FTE), to the NPS (NPS Memorandum, February 20, 1998.). The permanent transfer of funding to park base accounts began in accordance with those transfer plans, and the prototypes became fully functioning units of the NPS. Operational status for the LTEM Program made apparent how the loss of expertise within ranks of the NPS impaired implementation of scientific protocol. Replacing the loss of expertise with new staff threatened to be too costly for the bureau to undertake.

1.1.2 The Natural Resource Challenge²

Dick Sellars published his seminal book, Preserving Nature in the National Parks, in 1997. Sellars, a well-respected NPS historian, wrote the book in response to Alston Chase's Playing God in Yellowstone, which criticized

² Information from this section came primarily from written communication with Robert Krumenacker, March 20, 2014.

NPS natural resource management. Sellars was also critical of the NPS, but as a trusted NPS insider, his arguments had greater credibility than did Chase's findings. The NPS director, Robert Stanton, read Sellars book and declared that the bureau needed to "rejuvenate" natural resource programs in the NPS. Stanton assigned the NPS associate director for Natural Resource Stewardship & Science (NRSS), Mike Soukup, to convene a task group from the regions to identify what the NPS should do to "rejuvenate" natural resource programs. Soukup established a workgroup of varying backgrounds to address the situation. This group wrestled with the current issues of research and resource management that derived from the removal of the research scientists from the NPS, but did not create the Natural Resource Initiative (NRI).

In an after-hours, informal meeting, John Cook³, Deny Galvin⁴, and Bruce Sheaffer⁵ distilled the first NRI draft report down into 12 programs that would serve as a foundation for a NRI. Abigail Miller⁶ and Robert Krumenacker⁷, currently on loan to Washington Office (WASO), formed 12 task groups to flesh-out the 12 points. These task groups, co-chaired by a superintendent and a natural resource expert, became critical to the success of designing the NRI. For the first time, a critical revamping of an NPS division came from both the top-down and the bottom-up. The grassroots approach allowed buy-in on every level of the organization. The NRI developed in complete transparency.

Miller and Krumenacker developed a five-year funding proposal for what had become the Natural Resource Challenge (Challenge). The proposal went to the NPS associate director, NPS deputy director, NPS comptroller, and a carefully selected steering committee for review. A key strategic move to build support for the Challenge was the informal designation of two park superintendents with strong credibility in resource manage-

ment to be the liaisons with Congress. The NPS director also insisted that his entire national leadership team, including all the regional directors, demonstrate their support for the Challenge.

The resulting 1998 Omnibus Act enhanced management and protection of resources through establishing clear authority and directive to conduct scientific study used in management decision-making. It tasked the Secretary of Interior to undertake a program of inventory and monitoring of NPS resources to document resource conditions. The act also stipulated that techniques be developed and employed that protect the inherent qualities of natural systems and restore those systems that had been degraded. It encouraged others (partners, universities) to use parks as study sites that would benefit park management and have broad scientific value. Additionally, the act encouraged publication and dissemination of information from these studies.

The 1998 Omnibus Act required costly changes within the NPS, but it also resulted in increased funding to the bureau to fulfill its much-welcomed mandates. The NPS directorate implemented the act through the Natural Resource Challenge Program of 1999, which encouraged resource management based on scientific knowledge. Director Stanton announced the Challenge publicly at the 100th anniversary celebration for Mt. Rainier National Park on August 12, 1999. The Challenge demonstrated the commitment by NPS leadership and every level of the organization to strengthen natural resource preservation and restoration through strong, science-based programs. It included natural resource funding, starting in FY 2000, and continuing for seven years. The NPS would use funding to increasing professional expertise, expanding research, increasing restoration efforts, enriching education, and improving cooperative programs with partners.

3 Southwest Region director

4 NPS deputy director of NRSS

5 NPS comptroller

6 NPS associate director of NRSS

7 Northeast Region, chief of Natural Resources

1.1.3 Challenge priorities

An important priority addressed providing expertise and support within an organization that had lost many of its scientists. The NPS would accomplish this in two ways, creation of geographically based Research Learning Centers (RLCs) to serve multiple parks and creation of the Cooperative Ecosystem Studies Unit (CESU) national network.

The NPS RLCs encourage the collaboration of science researchers and educators at all levels to preserve and protect nationally significant, public-trust resources. The NPS established RLCs as physically locations with laboratory, workspace, and housing facilities or as virtual centers with web portals to research databases, educational materials, and other services. The RLCs help researchers to work within parks, and RLCs integrate research and findings into visitor experiences and resource management.

Mike Soukup, NPS chief scientist, and Gary Machlis, University of Idaho, formulated a plan for the CESU national network. This new organization formed a consortium between academic institutions, agencies, tribes, and other governmental and nongovernmental organizations, to fill the knowledge gap within Interior's land-management bureaus (Soukup 2007). It also addressed the inherent problems of understaffing, high turnover, and poor institutional memory that occurred in some parks. Partnerships with local colleges, universities, and other agencies through the CESUs bridged these gaps, and maintained continuity and quality control.

One of the highest priorities to implement the 12 points of the challenge expanded the national I&M Program beyond the prototypes. By this time, the LTEM Program had expanded to include the Prairie Cluster. The directorate recognized that the prototype single-park model would not work to encompass all parks with significant natural resources within the I&M Program. Hence, the Prairie Cluster served as a compelling model for an I&M network that served multiple parks.

To this point, the LTEM Program had faced inadequacies caused by low funding and decentralized organization (Fancy and Ben-

nets 2012). Additionally, it did not represent the diversity of ecological systems within the NPS. The goal of the Challenge was to understand, measure, and improve the health of all park ecosystems across the National Park System. The additional funding through the Challenge allowed the development of the Core Park Vital Sign Program and Natural Resource Preservation Program. Both of these programs played an integral role in development of what has become the I&M Program.

The seven LTEM prototypes served as examples of design and implementation of long-term monitoring for the developing networks. The prototypes assisted the networks by (1) serving as training and mentoring sites, (2) providing specialized expertise regarding data management and analysis, and (3) producing exportable monitoring protocols, including ecoregion-specific methodologies and technical guidance, e.g. sampling design, power analysis (Thomas, et al. 2001).

1.1.4 Institutionalizing Long-term Monitoring

Historically, monitoring programs in the NPS have resulted from political pressure or short-term funding, and have not had the longevity to provide needed information on priority management issues. Many threats to resources result in slow changes over time, requiring a long-term monitoring program to detect status and determine trends in resource conditions in order to conserve park resources, unimpaired, for future generations (Fancy, et al. 2009).

The Congressional mandate in 1998 that resulted in the Challenge and funding of the I&M Program enhanced the stature of the NPS as an international leader in natural resources management and stewardship (NPS-75). The Core Park Vital Sign Monitoring Program organized parks into 32 geographically based networks to serve all parks with significant natural resources. These networks, established to maximize monitoring efficiencies, comprised geographical areas with similarities in bioregionalism. The FY 2001 represented the first in a 4-year strategy to implement monitoring in 270 parks (NPS

Memorandum, December 21, 2000) through the I&M Program.

The NPS instituted the LTEM Program and Vital Sign Monitoring Program, along with other legislative and regulatory measures, in the 2001 NPS Management Policies. These policies stated that the NPS would endeavor to understand natural systems on its holdings and to develop management actions when appropriate. In 2006, the goals of the extant I&M Program, a consolidated program drawn from the LTEM Program and Vital Sign Monitoring, were reiterated in the NPS Management Policies 2006, page 40, such that the NPS would:

- Obtain information to help park managers reach park management objectives.
- Develop baseline inventory data on resources in NPS stewardship, and identify processes that influence those resources.
- Use qualitative and quantitative techniques to monitor key resources and processes at regular intervals.
- Analyze the results of monitoring to detect or predict changes in resources that may require management intervention, and to provide reference points for ascertaining the degree and extent of change.
- Use the findings to maintain or restore the integrity of natural systems.

The NPS would document and carry out all research and collection in accordance with all laws, regulations, policies, and professional standards. The NPS would make findings available to the public by professional publication and/or interpretive presentations.

The networks and prototypes followed different strategies for integrating or coexisting. The ideal transition from prototype to network probably should have expanded the existing prototypes to incorporate additional parks with a commensurate increase in funding and staff. Instead, the I&M Program established a rigid, and sometimes changing, process by which networks would develop alongside the existing prototypes.

1.2 Monitoring by Networks

Parks knew from practical experience that they did not have the staff or expertise to measure every important bit of information on every resource important to a park. Instead, focal resources, those resources needing special protection because of their public appeal, mandates, or other management significance, received the direct or indirect monitoring consideration (Fancy and Bennetts 2012). Funding could not support a comprehensive monitoring program, even on focal resources, but it permitted monitoring of core parameters, those indicators most important to understanding resources (Thomas, et al. 2001). The nature of the Core Park Vital Sign Monitoring Program changed over time, becoming the Vital Sign Monitoring Program.

Physicians use vital signs (pulse rate, blood pressure, and other measures) to indicate the condition of a human body. This applies to ecosystems as well, where directly measuring an ecosystem's condition would be prohibitive, but parameters associated with vital signs could indicate ecosystem health. Vital signs in an ecosystem are a subset of physical, chemical, and biological elements and processes that represent the overall health of ecosystems or the condition of resources and human values (focal resources). For example, aquatic invertebrate and fish community composition might indicate the health of a stream. Vital signs help to determine whether conditions are within natural levels of variability, or if they might be the result of adverse human influences. Scientists must select vital signs for ecosystems carefully to reflect the most feasible and reliable measures that represent ecosystem health and resource condition.

The quantitative measurement of Vital Signs, as coined by the I&M Program, satisfied the mandate by Congress to monitor park resources and processes, efficiently and effectively. Monitoring Vital Signs provided scientifically sound information, used by park managers, planners, interpreters, and partners to support management decision-making, park planning, research, education, and public understanding of park resources (Fancy, et al. 2009).

Therefore, the I&M Program established the Vital Sign Monitoring with the goals to

- Determine status and trends of condition for park ecosystems through selected indicators, allowing managers to make informed decisions and to work effectively with others.
- Provide early warning of abnormal conditions for selected resources, resulting in effective mitigation measures and reduced costs of management.
- Provide data to understand the dynamic nature and condition of park ecosystems, and 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.

(Fancy, et al. 2009)

1.2.1 Servicewide Program

Initially, designers of the I&M Program considered establishing a core set of Vital Signs that every park would measure in a similar way. These Core Vital Signs could provide a standardized set of measurements and protocols that would apply to all parks, and determine ecosystem and resource condition (Davis, et al. 1988). Designers rejected this notion once they examined the diversity of ecological systems and important parameters relevant to each system. Very few relevant parameters were common among parks, making a 'one size fits all' approach inadequate to attaining the program goals. Core Vital Signs would not account for variability among parks in ecological context, park sizes, and management capabilities, nor accommodate individual parks with different resource issues, information needs, and partnership opportunities (Fancy and Bennetts 2012).

The LTEM prototypes provided models for developing a long-term monitoring program. Six of the seven original LTEM prototypes consisted of a single park. The seventh,

developed in the second round of funding, consisted of six, small historical parks within the Great Plains. The Prairie Cluster, as this LTEM prototype was called, provided advantages of standardizing a set of indicators and protocols applied to several units with similar ecological systems, park size, park purpose, and management issues, and thereby providing context within and contrast across similar sites. The Prairie Cluster also facilitated sharing a professional staff and funding (Fancy, et al. 2009). It seemed the ideal compromise between using core Vital Signs Servicewide and accommodating park uniqueness.

Therefore, with the Prairie Cluster as a model, the I&M Program organized parks with significant natural resources into networks, generally based on ecoregional similarities and geographic location. The I&M Program assigned more than 270 parks to 32 networks. Each network worked with partners and subject-matter experts to prioritize and select park-specific or network-wide indicators based on their most critical information needs and local partnership opportunities. The network-based program would share funding and work cooperatively to undertake monitoring projects. A board of directors for each network, consisting of superintendents of that network's parks, provided oversight of the network. Each network would develop a network charter, which outlined the procedures used to establish priorities, allocate resources, and create useful products. The key to success lay in effectively collaborating within and among networks.

Lessons learned during the LTEM development were applied to Vital Sign Monitoring within the I&M Program. Basic steps for developing long-term monitoring were similar for all ecosystems within all networks and thus became a Servicewide standard. They included

1. Clearly defining goals and objectives.
2. Compiling and summarizing existing information.
3. Developing conceptual models.
4. Prioritizing and selecting indicators.

5. Developing an overall sampling design
6. Developing monitoring protocols.
7. Establishing data management, analysis, and reporting procedures

(Fancy, et al. 2009).

The plan was to phase in networks over three years with each network accomplishing the seven basic steps in three phases to become fully functional. In the first year, five networks, representing 55 parks, received funding for operational monitoring while trying to start planning. This divided the network attention between developing a monitoring plan, beginning inventories, and properly spending operational budgets before the networks had operations in place. Partners and CESUs stepped in to assist with some of the field operations. Seven networks received start-up funding to hire a coordinator and begin operational monitoring in FY 2002. Later, new networks received startup funds with incremental increases over the three years before becoming operational. They then received full funding once monitoring operations began. This incrementally increased funding prevented the urge to begin field operations before completing planning.

1.2.2 Baseline Natural Resource Inventories

Inventories are extensive, point-in-time surveys to determine the location and condition of park resources. They provide a snapshot assessment of the status of biological resources, such as plants and animals, and information on abiotic resources, such as air, water, soils, landforms, and climate. Inventories allow comparison of existing conditions to the natural or desired state of parks, and establish a solid baseline for long-term monitoring.

Unlike Vital Sign selection, I&M Program established 12 basic or core inventories common to all parks Servicewide (NPS-75). The inventories included

- Base Cartography Data – provides geographic information systems data.
- Air Quality Data – focuses on pollutants regulated under the Clean Air Act of

1970.

- Air Quality Related Values – provides park-specific information on location, distribution, and relative sensitivity of resources sensitive to air quality.
- Climate Inventory –compiles data from climate observation stations relevant to parks and from historical climate data for each network area.
- Geologic Resources Inventory – summarizes processes that act upon the Earth and its biota, and the features formed because of these processes in parks.
- Soil Resources Inventory – details soil processes that support plant growth.
- Water Body Location and Classification – provides the locations of hydrographic features in digital form.
- Baseline Water Quality Data – characterizes baseline conditions for key park water bodies' through physical, chemical, and biological parameters.
- Vegetation Inventory – produces high quality, standardized maps, and associated data sets for land cover within parks.
- Natural Resource Bibliography – maintains citations of documents related to natural resources within each park.
- Species Lists – documents basic information on the status of species in parks.
- Species Occurrence and Distribution – documents occurrence and distribution of at least 90 percent of vascular plants and vertebrate species expected in a park.

The network involvement was prominent in the species occurrence and distribution. The networks have also had a hand in coordinating vegetation inventories, called Vegetation Inventory Mapping, particularly reviewing the vegetation classifications for accuracy. They have also led in ensuring completeness of the natural resource bibliographic collection.

1.2.3 Data and Information Management

The central mission of the I&M Program, as administered Servicewide, is to acquire,

manage, analyze, and distribute scientific information on the status and trends of specific park natural resources (Omnibus Act 1998). The I&M Program needed state-of-the-art standards and practices in a comprehensive data management system that protected and enhanced the long-term value of monitoring data. The program made a substantial investment in database design, data archiving, and reporting to ensure data quality, security, longevity, and accessibility. In addition to meeting Federal Geographic Data Committee standards, data needed accompanying context about how and why they were collected if they were to maintain their long-term value (NPS 2008).

Prototypes, such as the Prairie Cluster LTEM, created the first data management plans. Data management sections within the prototypes would maintain an accurate and complete record of thousands of observations in perpetuity. Specific data management objectives related to three themes, (1) data management infrastructure, (2) data integration and exploration, and (3) long-term data integrity and security. The I&M Program invested considerable resources in developing tools to archive and disseminate data (e.g. NPSpecies, Dataset Catalog, NRBib). The Dataset Catalog recorded data sets generated by the prototypes. The NPSpecies database records species observations and tracks source reports and voucher information. Finally, NRBib contained citations of all reports and publications relevant to I&M Program parks. General guidance regarding data management procedures for handling and validating data were contained in a Draft Data Management Protocol (Tessler and Gregson 1997). One of the first data management protocols produced was for Shenandoah National Park, but the Channel Islands National Park Data Management Protocol completed in 1998 added an Access® relational database to the protocol. These protocols, combined with certain modifications that incorporated new Servicewide data standards, served as a guide to subsequent data management protocols and their core elements became part of the Natural Resource Database Template adopted by the WASO.

The relational database system used by prototypes accommodated a diversity of data, eliminated redundancy, and maintained integrity among data tables using software tools. Quality assurance and quality control (QA/QC) became integral to data management plans. Additionally, planning addressed data archive and storage, data maintenance, and version control (allowing tracking of changes to data over time). Prototypes made provisions for data security and for dissemination of information through data summary, analysis, and reporting.

Just as the I&M Program and each network worked through a rigorous process for planning, the data management portion of I&M Program began creating a comprehensive Servicewide plan that would maintain existing reports, data, and documentation, while expanding to meet the needs of the I&M Program. The I&M Program network data management plans, which accompany network monitoring plans, provided specific guidance on how data resulting from inventory and monitoring efforts would be acquired, processed, checked, analyzed, distributed, and archived. These plans, although developed by the individual networks, resulted from ongoing collaboration among data managers in all networks.

Finding a database-template design that worked across all networks and Vital Sign databases proved to be one of the biggest obstacles to implementation of the networks. It took three years to determine a functional database template that would work Servicewide. The data managers leading the effort decided to relate data entries and associated tables by data collection events, defined by the location and time of data collection. The result, the Natural Resource Database Template, developed as a set of Access® relational database tables that parks and networks could use for capturing natural resource inventory and monitoring data. The Natural Resource Database Template is a core-database structure that managers can modify and build upon, depending on the components of their inventory and monitoring program. The critical feature for any database was a user interface that worked across programs and projects.

The NPS continued to transform the way they managed natural resource information and delivered it to parks, partners, and the public. It based these transformations on lessons learned during prototype and network implementation, and on the need to organize and make available unprecedented quantities of digital data, information, and reports. The Natural Resource Program Center (NRPC), Office of Inventory, Monitoring, and Evaluation established and maintained three national databases for the networks' use.

- **NPS Data Store** – Servicewide repository for documents, publications, and data sets that are related to NPS natural and cultural resources.
- **NPSpecies** – Species lists documenting occurrence and status of species in park.
- **NatureBib** – Centralized catalog of natural resource information about parks, previously called NRBib.

Over a multi-year effort, about one third of the I&M Program data managers, those managers from fully implemented networks, worked on a final, Servicewide structure of the databases and a data management plan. A draft plan took shape with small groups designing and documenting different parts of the plan over time. The data managers combined the parts into a draft that the I&M Program leader reviewed. In 2008, after the implementation of most of the networks, the WASO drafted a national-level data management plan. This document provides overarching objectives, guidance, and recommendations, applicable to all networks. This plan also sets standards that network plans incorporated.

During the process of developing a Servicewide data management plan, managers chose to make ArcGIS® the standard for spatial databases (geodatabases). Monitoring data would include a spatial aspect, making the use of geodatabases necessary. Because of software costs and the specialized skills associated with ArcGIS® usage, specialist in large parks or regional centers managed these data. The Alaska Regional Office of the NPS developed a set of software tools, such as Theme Manager, compatible with ESRI® products, which presented data in an orga-

nized manner usable by managers with little ArcGIS® facility. As I&M Program networks increased their monitoring efforts, they recognized a need to decentralize geodatabase manipulation and began to expand their own ArcGIS® capabilities. Data still resided in national databases (Clearinghouse, a part of NPS DataStore), but networks also used databases extensively at the network level.

Each databases had developed independently with the promise of, but not the implementation of, cross walking between databases. Often, managers had to enter a datum into more than one database in more than one format, increasing the burden of data entry. This resulted in a confusing system of databases, each emphasizing a different focus. Additionally, users worked on the databases offline in an Access® platform and then uploaded the resulting database to an Oracle® based client-server. As Internet connectivity improved, data managers recognized the need to have web-based, online capabilities and a seamless approach to data access. The I&M Program envisioned and began developing a portal through which all database applications could be accessed. The Natural Resource Information Portal (NRInfo) initially focused on natural resources, but the system broadened its scope to encompass all types of park resource data by 2011. For this reason, the name IRMA (Integrated Resource Management Applications) replaced NRInfo to represent the inclusivity of the data portal.

The IRMA project has guided the transformation to a service oriented architecture that provides access to web-based applications through a portal. The IRMA portal is a “one-stop” for data and information on park-related resources. The user can search for, view, and download and print documents, reports, publications, data sets, park species lists, and links to additional data sources from multiple sources and systems, all from a consistent user interface. Most of the systems used by I&M Program can be queried, accept data entry, and create reports through the IRMA interface. An exception to this user interface is the NPStore database for water quality, which retains its offline access, and links to the Environmental Protection

Agency's STORET (STOrage and RETrieval) data warehouse. The IRMA portal has become the access point for many other NPS repositories of information, tools for planning and processes, and links to some external references. No logins or passwords are required for the intranet user to enter the various systems within IRMA. The IRMA portal is replacing and integrating some of the older, stand-alone information "silos" that were often difficult to find or use, and that duplicated effort and data. From NPS Data Store to Monitoring Protocols, Park Visitor Use Statistics, Planning, Environment & Public Comment (PEPC), and many other applications, IRMA has become a one-stop that goes far beyond the traditional needs of

the I&M Program.

After several years of implementation of the data management system, the I&M Program created an evaluation survey to identify the strengths and weaknesses of the data management program, particularly focusing on service to the user. The I&M Program data managers sent the evaluation to all the networks. The data managers then asked non-data management staff and project leaders to complete the survey, receiving a 50% response rate. Some of the questions addressed the key benchmarks for data management standards addressed in the national plan.

2 From Prototype to Network

“A park administrative history explains how the [unit] was conceived and established and how it has been administered up to the present. It focuses on the history of the [unit] as a [unit], to include the history of various [unit] programs and activities”

—National Park Service Administrative History: A Guide, NPS 2004.

2.1 The Prairie Cluster LTEM

Consistent attention and funding for ecological monitoring began in the early 1990s with the LTEM Program. The original proposal and plan, Long-term Ecological Monitoring Plan: Great Plains Prairie Cluster, submitted in August of 1994 (NPS/NBS 1994), was a joint effort of the NPS and the NBS. It was one of the second phase LTEM proposals, submitted after the formation of the initial four, park-based LTEMs, making the Great Plains Prairie Cluster Long-term Ecological Monitoring (Prairie Cluster) one of 11 LTEM prototypes.

The LTEM Program intended the Prairie Cluster to focus on issues identified in a comprehensive survey of natural resources within 32 parks in the Great Plains. Climate, soils, and topography varied among parks, creating great diversity in the plant-community potential and in existing community structure. The five Midwestern park administrative units (six actual parks with two parks under one administration) selected for the Prairie Cluster represented much of the biotic diversity of the Great Plains, and the monitoring issues selected for consideration reflected concerns commonly faced by small parks and cultural parks with significant natural resources.

The selection of this cluster of small, cultural parks tested the range of NPS units in which a network design would work. The parks within the Prairie Cluster were

- Agate Fossil Beds National Monument (AGFO) and Scotts Bluff National Monument (SCBL), under one administrative unit.
- Effigy Mounds National Monument (EFMO).
- Homestead National Monument of America (HOME).
- Pipestone National Monument (PIPE).
- Wilson's Creek National Battlefield (WICR).

Generally, the parks treated their native prairie and savanna vegetation as a backdrop for interpreting each park's cultural

significance. The managers restored prairie and savanna communities mainly to recreate historical landscapes. As the impacts of the loss of prairie and savanna throughout the Great Plains became apparent to ecologists and park managers, the NPS recognized the contribution of these remnant systems to regional biodiversity (NPS/NBS 1994).

The ecological communities ranged from high quality to degraded prairie and savanna sites. Management strategies varied greatly from park-to-park. Although selected for their diversity, all of the parks had completed inventories for significant natural resource, and had developed a number of monitoring protocols. Most of the parks had developed restoration action plans (WICR, HOME, PIPE, SCBL, and EFMO), but needed assistance with monitoring in the project areas, and with evaluating project success and subsequent maintenance actions. The LTEM Program eased the inherent problems of understaffing, high turnover, and poor institutional memory within small parks. The Prairie Cluster did not intend to replace existing monitoring, but rather, to enhance existing park-based monitoring (NPS/NBS 1994).

Appendix 2 provides a timeline of significant events.

2.1.1 Organizing the Prairie Cluster

In 1995, the acting Midwest Region (MWR) director announced the funding of the Prairie Cluster and the hiring of the coordinator⁸ for the prototype unit. The Prairie Cluster coordinator directed the developmental phase of the prototype and the first years of monitoring implementation.

Early emphasis for monitoring focused on major ecological or management questions (NPS/NBS 1994):

- To what extent are small remnants and restored prairie ecosystems sustainable?
- What are the land-use and watershed impacts to small prairie preserves?
- What are the impacts of landscape and habitat fragmentation on park resources?

These were associated with three areas of

8 Lisa Thomas, first Great Plains Prairie Cluster LTEM coordinator (November 1994 – January 2003).

concern: ecosystem restoration and management, external threats, and biological diversity.

The original proposal (NPS/NBS 1994) and basis for organization and design relied on an ad hoc committee of contributors⁹, familiar with the parks within the Prairie Cluster, and on input from park resource managers and superintendents. This ad hoc committee established an initial goal to develop and implement monitoring protocols for resources requiring active management. The program design did not go through a formalized planning process, nor did a large panel of specialists guide the development of a monitoring plan. Instead, the three architects¹⁰ of the Prairie Cluster worked cooperatively to design the components of the program with review and input from the other contributors.

The superintendents of the Prairie Cluster parks served to guide and, to some extent, to authorize implementation of the prototype under the proposed design within their parks. The Prairie Cluster contributors met with the superintendents, often, and they met with regional representation, annually, to discuss prototype administration, outcomes of monitoring, and issues that arose.

2.1.2 Administration

In 1995, WICR became the home location for the Prairie Cluster in accordance with the initial proposal for the prototype to serve prairie parks. The park provided supervisory direction and support. Associated funding included one PFT employee and a small premium for administrative support from the park. Some concerns arose regarding the assignment of the Prairie Cluster and its coordinator to WICR, but the MWR chief scientist remained directly involved in technical guidance and performance evaluation to maintain a core focus on science relating to the entire Prairie Cluster. Bound by the terms of the Memorandum of Understanding between the NBS and the NPS, the coordinator position was one of liaison, while the

NBS administered the Prairie Cluster, during the developmental phase. The announcement of a coordinator selected for the Prairie Cluster clearly stated that the coordinator would focus on the Prairie Cluster, and would not serve as *de facto* park staff. The selected individual, Lisa Thomas, had been engaged in restoration projects for prairies and savannas within the MWR. Because the coordinator had worked with the host park on restoration, she retained oversight for existing park projects at WICR as a minor part of her duties. Monitoring of restorations and other projects associated with WICR and individual parks, such as Missouri bladderpod (*Lesquerella filiformis*) monitoring and a multipark macroinvertebrate monitoring project, eventually transitioned to the Prairie Cluster. The Prairie Cluster coordinator, the MWR chief scientist, and the superintendent of WICR established work plans, to ensure equitable distribution of the coordinator's time within the Prairie Cluster.

The field director of the Midwest Field Area corrected any misgivings about the arrangements through a memorandum and subsequent actions in January of 1996. The alignment of the Prairie Cluster administration with WICR had proved advantageous to the prototype. The field director proposed that the alignment continue through the developmental phase, which the NBS conducted. Funding would transfer later to the park account and the FTE remained "on loan" to the park and not officially transferred. The Servicewide director of NRSS requested the budget office transfer FTEs allocated to the I&M Program to the Operation of the National Park Service (ONPS) budgets for host parks and regional offices (NPS Memorandum, September 19 2000).

The superintendent of WICR found administrative concerns with the arrangement to host the Prairie Cluster. The WASO did not transfer promised funds to the ONPS nor did it allocate the FTE to cover the Prairie Cluster coordinator position. Other administrative problems included travel authoriza-

9 Gary Willson (USGS-BRD) and Lisa Thomas (NPS) as primary authors; Terrence Boyle (Aquatic Ecologist, USGS-BRD), Victoria Grant (NPS), and John Harrington (Restoration Ecologist, University of Wisconsin/Madison) as contributors; Ron Hiebert, NPS MWR Chief Scientist, and Steve Cinnamon, MWR Natural Resource Specialist, provided advice.

10 Ron Heibert (NPS), Gary Willson (USGS-BRD), and Lisa Thomas (NPS).

tion, procurement, and day-to-day budget tracking and reconciliation. The difficulty arose from too many cooks: several offices took a role in administrative activities on behalf of the coordinator and prototype. This led to fragmentation of responsibilities that disrupted tracking of those actions.

As the program progressed, funding and FTEs also increased (Figure 1). The added workload from additional administrative duties necessitated the hire of an administrative assistant with the authority to prepare travel documents, procure most equipment needs, and track prototype funds, reducing some of the fragmentation. By 2001, WICR hosted six team members of biologists, botanists, and ecologists and an administrative assistant. The prototype remained field based with the hope that WICR would provide permanent facilities to house the Prairie Cluster staff, as it increased staff size without consequent increase in office space within the temporary, modular units.

The memorandum stipulating WICR as the host park for the operational Prairie Cluster gave WICR supervisory authority over a prototype that served several parks. This action was unprecedented, placing the supervision of the cluster into one park's domain with input from other Prairie Cluster park superintendents.

The park continued oversight for the coordinator's travel and for large purchases. The MWR offered to provide personnel support for classifying, advertising, and filling staff

positions. The Midwest Region I&M Program coordinator provided technical input to the Prairie Cluster and the I&M Program networks in the region after 2002.

2.1.3 Monitoring Objectives

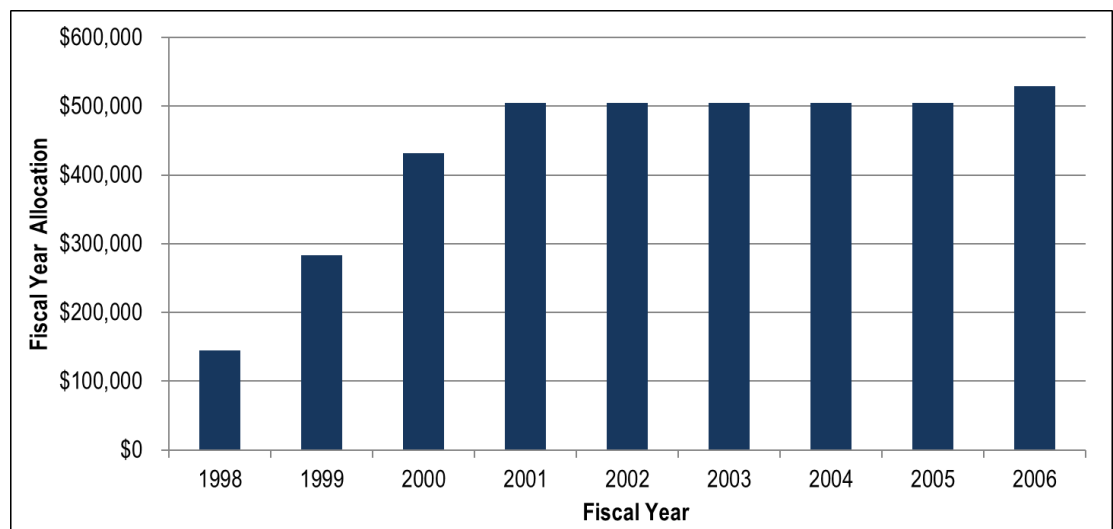
The selected monitoring themes revolved around the major ecological questions, central to management decisions and relevant to restoration ecology and conservation biology. The planners intended that monitoring results be accessible and fully integrated into park decision-making. Monitoring objectives needed to articulate support of management needs and of the long-term monitoring program. Thus, the successful monitoring program would help to evaluate the effectiveness of management practices and to develop a predictive understanding of environmental changes. The contributors to the 1994 proposal for the Prairie Cluster (NPS/NBS 1994) identified a measureable goal for monitoring that satisfied the parks' needs:

“The overall goal for this prairie cluster I&M proposal is to develop and/or implement monitoring protocols for resources likely to be enhanced or alternately suppressed by active management and/or external park threats.

Program objectives to reach this goal include:

1. *Complete high priority inventories.*

Figure 1. Funding allocations for the Prairie Cluster



2. *Test existing protocols for cluster-wide applicability.*
3. *Develop and test additional protocols for high-priority resource issues.*
4. *Design mechanisms to integrate monitoring results into park decision-making.*
5. *Achieve program accountability through periodic evaluation.”*

The purpose of long-term monitoring was to provide managers with timely and relevant information on which to base management decisions. In addition, the LTEM produced information that park interpreters could use in promoting an understanding of natural resources, elements affecting those resources, and NPS efforts in protection of park resources. Analysis could also extend to data collected prior to the Prairie Cluster, placing it in context of the current program (NPS/NBS 1994; NPS Meeting Notes).

2.1.4 Selecting Targets and Indicators

In order to sustain a long-term monitoring program, monitoring was limited in extent, precise in focus, and targeted toward the most significant issues and resources. Monitoring of resources that management actions or external threats would likely affect became an important theme. The monitoring complemented existing park monitoring and restoration projects funded by Natural Resource Preservation Program. The Prairie Cluster coordinator detailed prototype strategy in a design document (Thomas, et al. 2001).

The Prairie Cluster selected monitoring components based on:

- Park resource management plans.
- Recent natural resource inventories.
- Legal mandates, park managers' priorities.
- Existing park monitoring protocols.
- Applicability to other grassland parks.

Contributors to the monitoring strategy se-

lected key indicators that assessed the parks' the most significant of the managed natural resources, and the processes maintaining those resources. The indicators would capture changes that resulted from known or expected threats, as well as response to current management actions. Indicators represented two ecological levels: (1) population level applied to rare species, and (2) community level applied to the integrity of a system. Community structure within prairie vegetation can inform managers whether prairie remnants support diverse faunal assemblages. Within streams, community structure indicates general stream health. Therefore, information on status and trends of indicators would provide information on ecosystem integrity. Changes in indicator conditions within restored and managed areas would indicate the effectiveness of specific management strategies and tactics.

The small size of the parks made them susceptible to threats outside the realm of their management influence. Managers recognized that water pollution and exotic-plant impacts on park plant communities originated outside of the park borders, but affected both natural, and in some cases, cultural resources. These parks also had unique habitats that harbored rare species, species protected by the Endangered Species Act of 1973, or species protected by state legislation and regulation. The proposed protocols addressed three high priority issues: (1) external threats to important park resources, (2) ecosystem restoration and management effectiveness, and (3) maintenance of biological diversity. The initial plan recognized altered water quality as the most immediate external threat facing the Prairie Cluster parks, and urban encroachment with associated habitat fragmentation as another key issue.

Heeding the recommendations of the early pilot prototype parks, the Prairie Cluster opted to focus on monitoring few indicators (Table 1) well, and devoted staff time to data management, analysis, and interpretation. This permitted the staff to assess data, and develop results and discussion that they could disseminate to the parks.

Table 1. Selected monitoring components (Thomas, et al. 2001)

Ecosystem	Monitoring Components	
Terrestrial and Aquatic	Landscape Monitoring	Adjacent land use
Terrestrial Ecosystem	Community Monitoring (direct and indirect)	Grassland plant communities Grassland birds and grassland butterflies ¹¹ as indicators
	Population Monitoring (direct monitoring of rare species)	State-listed T&E plants Missouri bladderpod (<i>Lesquerella filiformis</i>) ¹² Western prairie fringed orchid (<i>Platanthera praeclara</i>) ¹³ Black-tailed prairie dog (<i>Cynomys ludovicianus</i>) ¹⁴
	Environmental Monitoring	Local weather (related to Missouri bladderpod and western prairie fringed orchid dynamics) ¹⁵
Aquatic	Community Monitoring (indirect)	Aquatic invertebrates as indicators
	Population Monitoring (direct monitoring of rare species)	Topeka shiner (<i>Notropis topeka</i>) ¹⁶

Protocol development began in 1994 with protocols for principle indicators completed by 2001. The prototype program did not require a phased in structure with extensive protocol development, review, and ground testing. The Prairie Cluster did not have the current NPS publication series in which to publish protocols, but all protocols passed through peer review. The NBS/USGS-BRD scientists had conducted much of the protocol development work (Williams 2002), but for the Prairie Cluster, much of the protocol development, testing, writing, and reviewing, as well as database development, fell to the Prairie Cluster staff. The design phase included input from a Science Advisory Panel, including five regional ecologists, invited reviewers for USGS-BRD protocols, Threatened and Endangered Species Recovery Teams, and state agencies (Adams 2001a). Data collection during protocol development allowed trials of techniques, verifying feasibility of execution.

During protocol development, the Prairie Cluster completed inventories of vertebrates

(particularly birds), insects, and lichens. Supplemental money from outside of I&M Program funded grassland-bird and lichen inventories. The Prairie Cluster collected inventory data using a best-practices approach as the basis for their protocols.

2.1.5 Vision for the Future and Concept Design¹⁷

The Prairie Cluster sought to review the original design of the prototype within an ecological context (Thomas, et al. 2001). The internal review had two purposes. First, the Prairie Cluster wanted to ensure that monitoring addressed components that detect change in the ecological integrity of the system. Second, it wished to ensure understanding of defining characteristics in functioning prairie ecosystems so that investigators could differentiate between normal ecosystem variability and trends in resource condition that resulted from external stresses. Models also contribute to identifying limiting factors that investigators could monitor in conjunction with biotic components of the system and with the expected consequences of human

11 Phase 2 (moderate priority) in original proposal (NPS/NBS 1994).

12 Federally listed threatened species, but listed as endangered species until 2003.

13 Federally listed threatened species.

14 US Fish and Wildlife Service removed the black-tailed prairie dog from the Endangered Species Act Candidate Species List in August 2004.

15 Not included in original proposal.

16 Federally listed endangered species. No park occurrence recorded at time of original proposal.

17 This section is taken from Thomas, et al. 2001.

induced (anthropogenic), environmental change.

The Prairie Cluster adopted a process developed by Noon, et al. (1999) to guide the monitoring program within an ecological context. It emphasized the following steps:

- Clearly state monitoring goals and objectives.
- Identify stressors and develop conceptual ecosystem models.
- Select indicators and establish a sampling design.
- Define response criteria.

The design of the program intended to link data interpretation, explaining system changes caused by natural and anthropogenic influences and consequences of those changes, to decision-making and management goals.

A review of the successes and failures of previous long-term monitoring efforts led the Prairie Cluster to describe five key characteristics of an effective monitoring program:

- Be relevant to current management issues and resource threats.
- Anticipate future issues and threats to park ecosystems.
- Be scientifically credible.
- Generate accessible, high-quality data.
- Provide feedback into decision-making with timely, relevant data.

Although all of the developing prototypes used their own design to create a program that met their parks needs and inherent

limitations, the Prairie Cluster provided a basis for multi-park prototype and network design, and acted as a Servicewide model.

Objectives

New objectives, created after prototype review, looked at what had been successful in other LTEM prototypes, NPS directives guiding the LTEM, and what parks said they needed. The LTEM once again emphasized the importance of *long-term* monitoring over short-term findings in their stated objectives:

- Determine status and trends of the health of park ecosystems.
- Establish normal limits of variation in key park resources.
- Provide early warning of resource decline.
- Evaluate the effectiveness of resource management practices.
- Develop a predictive understanding of environmental change.

Stressors and Conceptual Ecosystem Models

Conditions within the environment can act as ecosystem drivers that mold the system into its current shape. Scientists must identify natural drivers to understand natural variability in a system (Table 2). Human actions became the anthropogenic stressors in the ecosystem models. The Prairie Cluster identified stressors from scientific literature, review of documents from prior studies in the parks, and park input (Table 3). Each stressor had expected impacts on resources, and potential indicators could identify type and extent of impacts associated with the stressor.

Table 2. Natural drivers associated with the primary ecosystems.

Ecosystem	Natural driver	Effect
Terrestrial Prairie	Climate	Drought mortality on plant communities
	Fire	Regulation of plant communities, changes to soil and hydrology, foraging patterns
	Grazers	Composition of plant communities, soil constituents
	Prairie grasses and soil biota	Positive feedback of a prairie system
Aquatic / Riparian	Climate	Hydrologic regimes affecting extremes of in-stream conditions
	Prairie vegetation	Evapotranspiration, light availability and nutrient cycling
	Soils	Surficial ground water storage affecting hydrology
	Riparian vegetation	Allochthonous energy input

Table 3. Anthropogenic stressors associated with the primary ecosystems.

Resource	Stressor	
Plant communities	Isolated native plant populations Fire suppression Prescribed fire ¹ Reduced wildlife habitat Exotic species invasion Invasive species control Elevated CO ₂ levels Trail development / use Cattle fencing & watering; overgrazing	Community monitoring Landscape Monitoring (sustainability)
Grassland-bird communities	Reduced wildlife habitat Over-grazing Prescribed fire	Community monitoring
Rare-species populations and habitat Unique habitats	Isolated rare populations Quarrying pipestone Exotic species invasion Invasive species control	Population monitoring Environmental monitoring
Landscapes Historic landscapes	Prescribed fire Prairie / savanna restoration	Community monitoring
Streams Ground water and springs	Water pollution Cattle fencing & watering Water diversion, ground water pumping Loss of riparian corridor vegetation	Community monitoring Landscape Monitoring (sustainability)
Aquatic faunal communities Rare-fish populations Amphibians	Water pollution Diversion dams, ponds, dewatered reaches Stocking ponds for fishing, introduction of exotic bait fish	Community monitoring Population monitoring

¹ **Bold green font** represents management actions intended to result in a desired condition, based on park planning or based on evaluation of ecosystem processes and resource conditions.

As is apparent in the list of important resources and stressors, the Prairie Cluster selected some monitoring to meet park priorities. For instance, historical landscapes do not enhance ecosystem health, but play a significant role in cultural resource preservation or define a historically occurring ecosystem as a restoration model. Additionally, some of the stressors specifically resulted from management actions (e.g., the stocking of ponds for fishing that otherwise functioned as amphibian habitat), and may not relate to ecological health of the system. Some stressors may include management actions intended to reestablish conditions (e.g., a suite of restoration actions) or natural processes (e.g., prescribed fire) that will help to restore or maintain a system.

2.1.6 Partnerships

The purposes of the I&M Program included

developing partnerships, working collaboratively within and outside of the NPS to leverage the I&M funding to attain shared organizational goals. Therefore, partnerships became key to the success of the program.

Fire Management Program

The Prairie Cluster began designing plant-community monitoring in 1996. Staff completed protocol development, including two years of baseline data collection, by 1999. The protocols called for plant-community monitoring within representative areas of each of six parks, at regular (2-3 year) intervals. This would allow detection of long-term changes in prairie communities related to management actions, particularly use of prescribed fire.

In 1997, the Midwest Fire Management Program¹⁸ (MWR Fire Program) initiated plans to establish fire-effects monitoring to

¹⁸ The NPS refers to the Servicewide fire program operation as the Fire Management Program. It refers to the funding portion as FIREPRO.

complement the prescribed fire operations in MWR parks. Fire-effects monitoring would assess whether the prescribed fire program met objectives in the field. Parks used prescribed fire to accomplish both community-based objectives (e.g. maintain prairie communities, restore historical disturbance regimes) and to manage particular species or species assemblages (e.g. reduce certain invasive species, improve rare species habitat), as well as to treat hazard fuels. The MWR Fire Program initiated some monitoring programs in 1997, and intended to hire technicians to establish more monitoring projects. This resulted in several permanent, subject-to-furlough personnel at Wind Cave National Park, Indiana Dunes National Lakeshore, and Ozark National Scenic Riverways.

By 1999, the Prairie Cluster recognized potential for overlap between the long-term plant-community monitoring of the LTEM Program and that required by the National Fire Management Program (Thomas 1999). The overlap suggested a potential for collaboration, but the two organizations had differing mandates setting their timeline. The LTEM Program emphasized scientific design with attention to data management and QA/QC. The MWR Fire Program staff had stressed the mandate to conduct fire-effects monitoring, using approved protocol. Still, there was keen interest in avoiding unnecessary duplication of effort between the two monitoring programs.

One obstacle to combining or collaborating on the monitoring appeared to be a rigid fire-effects protocol that did not allow for alternative methods. This National Fire Management Program protocol attempted to be broad enough to satisfy all needs in all parks. The Servicewide uniformity resulted in data uniformity. The single protocol also saved money by eliminating further protocol development, and it would allow technicians instead of a fire ecologist to implement the protocol. However, as with the 'Core Vital Signs' concept, the standardized protocol could not achieve the goals of fire-effects monitoring in all cases. The jack-of-all-trades masters none, such that the compromises necessary to create a Servicewide protocol

would result in a protocol that did not satisfy each park's situation. Thomas (1999), in support of collaboration between the Prairie Cluster and Fire Management Program, made several observations relative to her perception of the weaknesses in relying on the Fire Management Program monitoring alone:

- It was unlikely that monitoring could be implemented and repeated with enough regularity (and sampling intensity) to detect fire effects in most vegetation associations currently managed with prescribed fire. Much of the Fire Management Program monitoring relied on short-term monitoring, which would be inadequate for ecological goals.
- Collaboration among monitoring efforts within the NPS builds an integrated picture of resource status and trends. A broad approach to ecological health would distinguish the effects of fire from those of other system drivers.
- If the Fire Management Program could accept alternative protocols, the NPS Natural Resources Initiative with its strong monitoring component could result in intensified monitoring, which could strengthen the fire-effects monitoring program.
- Observers may perceive two expensive monitoring programs, proceeding along parallel but separate paths, as a duplication of effort. It would result in a loss of support for both programs.

During the same period, a newly hired fire ecologist, James DeCoster, joined the MWR staff, administering the Midwest Fire Ecology Program. The fire ecologist recognized the benefits of an integrated program. He considered the two largest obstacles to be (1) the location of the monitoring plots and (2) the timing of plot sampling. An example of the plot location problem was with PIPE, where the Prairie Cluster plots were only located in a small area of Sioux quartzite prairie at that time. These plots did not represent fire effects across all the prairie types within the park. The problem of timing of sampling resulted from the different objectives of the

two programs. The Prairie Cluster sampled on a set schedule, regardless of prescribed fire scheduling, while the National Fire Management Program had interest in pre- and post-fire data to determine efficacy of prescribed fire, relative to the objectives.

A vision emerged in which the fire funding would augment the Prairie Cluster monitoring. An expanded crew would allow for establishment of plots in areas that the MWR Fire Program considered priorities. Establishing this project required that a fire ecologist and several seasonal crewmembers become part of the Prairie Cluster staff.

The consensus on the various issues underscored the shared common goals and objectives between the Prairie Cluster and Midwest Fire Management Program (DeCoster 2002). Thomas's efforts in creating a collaborative approach to plant-community and fire-effects monitoring led the Prairie Cluster to initiate discussion of fire-effects monitoring for EFMO. The meeting of September 17, 2002 addressed the park's draft Fire Management Plan that outlined fire-effects monitoring, and developed priorities and objectives for monitoring landscape-level fires. The MWR fire ecologist and Prairie Cluster vegetation staff focused attention on EFMO in an effort to collaborate on the monitoring for both plant communities and fire effects. The MWR fire ecologist worked with Prairie Cluster vegetation staff in the field to determine how vegetation monitoring might integrate fire-effects monitoring. The Prairie Cluster developed a site selection plan for monitoring within various community types and a schedule that ensured frequent enough sampling to satisfy fire-effects monitoring. The fire ecologist found the methodology well suited to fire-effects monitoring, particularly with the inclusion of Brown's Lines¹⁹ for measuring fuel reduction.

The USGS initiated vegetation mapping during this planning at EFMO, providing the level of detail invaluable to fire management planning and fire-effects monitoring. The monitoring collaboration also followed several Wildland/Urban Interface (WUI)

projects to remove hazard fuels manually. The park implemented these WUI projects in a manner that supported their desired vegetation conditions within the park, as well as ensuring the removal of hazard fuels. This required monitoring to evaluate achievement of WUI goals.

In June 2002, the MWR fire ecologist sent a proposal to the national office asking for funding of a fire ecologist, stationed with the Prairie Cluster. Although this proposal was not funded, the MWR fire ecologist began funding GS-5 seasonal positions for the Prairie Cluster, since seasonal positions did not require national office approval. This funding allowed for establishment of forest study plots at EFMO, and for intensive sampling at Tallgrass Prairie National Preserve (TAPR) in 2003. It also contributed to the establishment of a Fire Ecology Program Area for the HTLN.

Konza Prairie Long-term Ecological Research

An informal partnership developed between the Prairie Cluster and the Konza Prairie Long-term Ecological Research program (Konza LTER), Kansas State University. The Konza LTER engages and promotes research and education on the tallgrass prairie, primarily centered at the Konza Prairie Biological Station. The National Science Foundation funded the Konza LTER in 1980 to support long-term research. The Konza LTER had developed and implemented a number of protocols for long-term monitoring of terrestrial and aquatic resources. The issues that they investigated included many, relevant to the Prairie Cluster. Therefore, the Prairie Cluster used some protocols established by the Konza LTER and adapted them to use in cluster parks. The Prairie Cluster also relied on expert guidance from the Konza LTER staff.

2.1.7 Addressing Issues

As with any new program, issues arise during the development that no one had foreseen. Some issues resulted from changes and redefinition from the WASO,

¹⁹ Brown's Lines are transects assessed to determine fuel loading and are a part of NPS monitoring protocol and taken from Brown 1971.

while others arose from local problems or misunderstandings.

The NBS/USGS-BRD Affected Prairie Cluster Development

Three NPS employees had become the early architects of the LTEM through their extensive work with the Prairie Cluster. Lisa Thomas, Prairie Cluster coordinator, Ron Heibert, MWR chief scientist, and Gary Willson, MWR ecologist, had designed the Prairie Cluster with assistance of several other NPS and academic associates. While in the midst of finalizing design and protocols, the research division of the NBS became an independent bureau, which the USGS absorbed two years later. This transition of personnel out of the NPS, including one of the three principal architects of the LTEM Program, hampered operation of the Prairie Cluster.

Willson remained with the NBS/USGS-BRD and continued to remain involved in the design of the Prairie Cluster through the USGS. Although involved, Willson's range of responsibilities extended beyond the I&M Program, restricting the degree of involvement he could maintain. Thomas remained as the Prairie Cluster coordinator, and became the sole institutional memory of day-to-day workings of the prototype. Thomas began to ramp up the prototype by hiring necessary staff to fine-tune and develop additional protocols and implement monitoring, thereby sharing the burden of project development. After the departure of Heibert, the MWR chief of natural resources also assisted with prototype administration.

Not only did the migration of scientists from the NPS to the USGS-BRD offer additional challenges to the LTEM prototypes, but also necessitated planning to transfer USGS-BRD responsibilities back to NPS staff, once a prototype completed design and implemented monitoring. Three operational LTEM prototypes, including the Prairie Cluster, developed transition plans that specified how program management and funding transfer would occur between the USGS-BRD and the NPS. The transition plans identified needs for research, analysis, and synthesis by the USGS-BRD in support of the LTEM

prototypes. Additionally, the transition plans articulated the USGS-BRD protocol development and pilot-testing responsibilities, needing completion by USGS staff.

The Prairie Cluster submitted its transition plan on June 24, 1997. The plan proposed hiring NPS staff over a three-year period, while continuing USGS-BRD involvement in protocol design through FY 2000. The Prairie Cluster staff formed a necessary bridge between the scientists in the USGS-BRD and park management, ensuring relevance of monitoring data to park issues. Prairie Cluster staff continued to test monitoring protocols, confirming that they could execute the methods under expected funding levels and within logistical constraints of the program, identify natural variability in the data, and develop data management and reporting processes. An increase in staff would also allow representation of the Prairie Cluster at professional meetings and conference, and facilitate dissemination of monitoring results to parks and within other forums, generating further support of the LTEM Program.

The transition of the program to the NPS also necessitated examination of grade-levels for professional positions. The plan reflected increased salary costs, commensurate with increased complexity of Prairie Cluster duties that would ensue with full-operational status in 2001. The proposed increases remained consistent with the original proposal, but circumstance delayed full operational status by one year. Between FY 1998 and FY 2001, staff salaries went from \$104,800 to \$404,800 within the budget, and total overhead costs nearly doubled.

Protocol Examination

Having recently abandoned the initial concept of using Core Vital Signs, the same Vital Signs across all parks Servicewide, the NPS emphasized developing standard sampling protocols, Servicewide (Fancy and Bennetts 2012). The NPS eventually recognized that one-size-fits-all protocols would not serve the needs of any park fully. The emphasis on standard protocols relaxed at the national level, but still lingered within the regions. Concern arose over the need to make protocols compatible, at least with regional pro-

grams, to put data into regional context. Although the LTEM had abandoned this idea, some regions wanted to maintain continuity across parks. For example, data are more powerful if 50 locations find a decline in a particular bird species within a region. The thinking was that trends in resource conditions would only be comparable if derived from the same protocol. In time, authorities realized that direction of trends on a regional basis were adequate to alerting managers to a concern, while the degree of change must be characterized in the most appropriate manner for each park and resource being monitored. Authorities took a new approach very early in planning that recognized LTEM prototypes as individual experiments to develop local, long-term monitoring. Vital Sign selection and protocol development became a process that used 'bottom-up' planning that addressed park issues.

The acceptance of individuality in protocol development resulted in a relatively difficult experience for the NPS after the removal of the agency's research division. This meant that each prototype required separate protocols, but the NPS had few scientists available to write them. The USGS-BRD attempted to provide the prototypes with protocols that remained simple, but generally satisfied the intent of monitoring. The Prairie Cluster remained involved in all aspects of protocol development, keeping sampling methods consistent, while adapting to differences in park circumstances.

The Prairie Cluster used a Weight of Evidence approach for critically examining, prioritizing, and integrating results to identify the general changes in status and trends of resources. The Prairie Cluster determined the level at which changes in indicator values must be detected (threshold) to inform the managers of significant changes in resource condition. Finally, the Prairie Cluster determined the best way to detect that threshold and revised protocols to reflect that method of detection. Community and population level monitoring among plants, fish, and aquatic invertebrates, land-use change, grassland birds, and rare plants appeared the best topics for monitoring. Some indicators, for example butterflies, were highly variable

and would have little value in establishing detectable trends and thresholds.

Long-term Versus Short-term Monitoring

The objectives of long-term monitoring may differ from the immediate, or short-term, needs of parks. The parks saw a need for guidance management activities and feedback regarding adaptive management. The long-term monitoring sought to help establish management strategy, as opposed to short-term tactics. Therefore, the Prairie Cluster needed to revisit the identified objectives of long-term monitoring and prioritize them to eliminate conflicting objectives.

Park needs and the I&M Program mandate for long-term monitoring placed a burden on the Prairie Cluster, which tried to meet all requests for assistance. Unfortunately, the Prairie Cluster worked on limited funding that forced prioritizations in light of operational funding. The Prairie Cluster recognized the need to relinquish monitoring topics to address adequately the most important topics and to give suitable effort to field collection and data management.

Therefore, the Prairie Cluster narrowly defined target populations and shifted *sample size* (traditionally the *n* value in computations) from the number of samples within the sampling period to the number of years sampled. This paradigm shift retained power in analysis, allowing extrapolation of resource condition trends to the park level. This ensured that the monitoring reflected a long-term program and did not seek short-term results. The parks needed to maintain their own monitoring projects, including monitoring the effects of management actions, outside of the Prairie Cluster monitoring.

Communicating Results of a Centralized Program

The one very different aspect of this centralized program from the park-based monitoring that preceded it was its need for a comprehensive, decision-support framework that integrated results from Prairie Cluster monitoring into each park's resource management decision-making. In 2001, the Prairie Cluster was still in a research and

developmental phase for the clustered prototype concept. The Prairie Cluster had not established a standardized reporting system for monitoring results. Status and trends in resource conditions did not become clear for several years. Never the less, the Prairie Cluster had an objective of disseminating an increased understanding of natural resource management to a wide range of audiences, including all 32 of the prairie parks in the Great Plains, in the hope that the information would become part of management decisions within those parks as well. After further consideration, the application of results to all prairie parks came into question. Although the Prairie Cluster could provide a model of how to develop a centralized program, they could not apply the scientific results across all parks.

The Prairie Cluster parks expressed the need for an interpretive component to the program. They emphasized the importance of building internal support and public understanding for long-term monitoring. Although the Prairie Cluster anticipated obtaining some assistance from existing park interpretive staff, the small, primarily cultural parks of the Prairie Cluster did not devote large amounts of interpretive effort to natural resource issues. For this reason, parks and superintendents suggested that the Prairie Cluster include an interpreter position to make monitoring results more readily available for interpretive and educational purposes. Unfortunately, the demands of the scientific aspects of the prototype did not permit dedicating a position to interpretation.

Tallgrass Prairie National Preserve

On November 12, 1996, Congress passed legislation creating TAPR in the Flint Hills region of Kansas. The preserve protects a nationally significant example of the once vast tallgrass ecosystem. The National Park Trust originally purchased the 10,894 acres for the preserve in 1994. On September 20, 2002, the trust donated approximately 32 acres to the NPS. The Nature Conservancy purchased the remaining acreage from the National Park Trust in 2005.

The enabling legislation for TAPR calls for the NPS and the private landowner to man-

age the entire acreage cooperatively, blending the management of cattle grazing, bison restoration, and prairie management. This created a need to include the park in a monitoring program, so that information on status of resources and trends in conditions could affect active management of the constituencies within the preserve.

Recognizing that TAPR fit well into the Prairie Cluster, the Prairie Cluster coordinator recommended TAPR's inclusion with the prairie parks. Reassignment of TAPR to the Prairie Cluster would result in a transfer of funds to the Prairie Cluster to support monitoring at TAPR. The two coordinators could not agree to the amount of funds to transfer, and given TAPR's relative youth, there was little hard data to inform the decision. The coordinators tabled the proposal to include TAPR in the Prairie Cluster. The network and prototype came to a compromise, and using temporary funds from the WASO and the Heartland Network, the Prairie Cluster began monitoring at TAPR in 2000.

New questions arose with TAPR that had not been included in the original protocol design for the other Prairie Cluster parks. For example, TAPR had cattle grazing as an important part of their management strategy. This was in part because of the nature of the preserve with a private owner and administering TAPR jointly with the NPS, and because the enabling legislation revolved around the historical inter-relationship between cattle and the prairie. Ecologists and managers understand the importance of wildland fire and grazing by native species as stressors that shaped prairies, but they do not understand the impacts of grazing by domestic species. The premise under which the original Prairie Cluster parks operated was that domestic cattle grazing had a negative impact on park resources. The Prairie Cluster needed to re-evaluate the importance of grazing by native and domestic species as a natural process within grassland ecosystems.

Despite the additional questions posed by the situation at TAPR, the preserve only received monitoring commensurate with the funding that the Heartland Network transferred to the Prairie Cluster for that pur-

pose. This meant that TAPR had monitoring underway before other Heartland Network parks, but monitoring remained at a lower intensity than that of the other Prairie Cluster parks.

Invasive Plants

The parks within the Prairie Cluster had large boundary-to-area ratios because they were all relatively small parks. This made them extremely vulnerable to exotic species infestations from surrounding lands. Plant-community, long-term monitoring did not capture fast moving invasions early enough to be useful. The Prairie Cluster originally requested development of an exotic-plant protocol, but the USGS-BRD did not have enough time to complete this protocol before the Prairie Cluster became operational and funding shifted to the NPS. The Prairie Cluster could not effectively monitor exotic plants without a specific protocol.

The Prairie Cluster recognized that exotic-plant invasion required a very different approach than that of long-term monitoring, because they could not use one, 'typical' exotic plant on which to model monitoring. Different species required different monitoring strategies and different sampling frames for use across the parks. In contrast, plant-community monitoring did not infer conditions within the entire park, but took samples that exposed change at a location over time. The high quality unique habitats and active management areas received the most attention. Exotic species monitoring needed to focus on corridors for invasion, areas of disturbance, and a broader coverage than plant-community monitoring surveyed. Therefore, prairie plant-community monitoring did not satisfy exotic and invasive-plant monitoring.

2.1.8 2001 Review Recommendations for the Prairie Cluster

During November 14-16, 2001, an interagency panel of scientists convened to review the Prairie Cluster prototype, which was then one of 11 monitoring prototypes in the NPS. The Prairie Cluster had completed its monitoring strategies and protocols and the panel would determine whether the parks in the Prairie Cluster received scientifically

credible, relevant data on high priority needs that helped park managers properly address resource issues. The review intended to offer recommendations to improve the prototype, where needed.

An NPS memorandum dated January 3, 2002, from the I&M Program director reported on the panel's findings. The panel had a favorable impression on the overall design and operation of the Prairie Cluster. The prototype was of high technical quality and provided needed information to parks. The staff demonstrated professionalism and dedication. The panel recognized that the Prairie Cluster's data management, analysis, and reporting provided a model for the Servicewide program. It also acknowledged that much of the Prairie Cluster could attribute success in part to the partnerships developed within the NPS and with the USGS-BRD, academic institutions, other government bureaus, and private conservation groups during the formative years.

The HTLN, the merged product of the Prairie Cluster and the Heartland Network, implemented several recommendations from the panel. The panel recommended that the Northern Great Plains Network (NGPN) administer the long-term monitoring at SCBL and AGFO, using the same sampling protocols, and monitoring intensity developed by the Prairie Cluster. The panel recommended that the Prairie Cluster include TAPR be included in the Prairie Cluster and eventually in the HTLN. The panel also considered the addition of George Washington Carver National Memorial and Herbert Hoover National Historic Site in the Prairie Cluster at this time.

The panel saw a need to state explicitly the specific objectives for each park in terms of measureable outcomes. This would permit the Prairie Cluster to tailor sampling frame and frequency that satisfied long-term needs. The Prairie Cluster needed to develop a formal process for developing new protocols and modifying old protocols. This process included cross walking data between protocols, relating data to the protocol used for collection. The panel made specific recommendations about protocols and their

execution.

The panel also addressed staffing issues. They saw the centralized Prairie Cluster critical to success. The panel recommended adding an aquatic professional to staff and using technicians for appropriate tasks. The need for connecting monitoring products to interpretive presentations and products arose during this review.

Overall, the panel regarded the Prairie Cluster as a model for future network development. The Prairie Cluster produced credible science that met the needs for long-term monitoring within the parks, providing a service to those parks, and met the mandates of the I&M Program.

2.2 The Heartland Network

The acting NPS associate director, Abigail Miller, for NRSS sent a memorandum (NPS Memorandum, December 21, 2000) to the regional directors officially announcing the funding of several networks for Vital Sign Monitoring in 2001. The funding was a component of the Natural Resources Challenge, and FY 2001 represented the first in a 4-year strategy to implement Vital Sign Monitoring in all 270 parks with natural resources. The I&M Program allocated funding for a program that would not replace the prototypes, but would enter the remaining parks with significant natural resources into an inventory and monitoring program. In the Heartland Network, the parks spread across eight states, included approximately 245,000 acres, and spanned roughly 2,700 feet of vertical relief.

Guidance for designing an integrated monitoring network had become available in 1999 and continued to evolve until all 32 networks reached full operation in 2012. The NRSS funded the Heartland Network as part of the first round of network development. The I&M Program and other national resource programs, such as NPS Water Resources Division (WRD), annually transferred funding for core network staff and for monitoring. The NPS budget office assigned an organization code for each network to facilitate funding transfers and to allow transfer of annual pay adjustment increases to the networks.

The WASO also assigned FTEs, equipment, and other resources to the networks.

2.2.1 *The Birth of the Heartland Network*

The Heartland Network involved all 15 of the eventual network parks. It did not include AGFO or SCBL, which eventually would leave the Prairie Cluster and join the NGPN. Until that time, the two monuments were included in Prairie Cluster activities, but excluded from Heartland Network planning. The Heartland Network also included Prairie Cluster parks that would benefit from some projects administered only through the networks, while still receiving monitoring services from the Prairie Cluster. The parks of the Heartland Network were:

- 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)
- Wilson's Creek National Battlefield (WICR)

The same group that had contributed to the early planning in the inventory of park resources had begun planning for network monitoring. The Prairie Cluster with its

experience in blending a multi-park cluster into an effective prototype program had contributed much to the planning for the Heartland Network. Additionally, planning also drew upon other NPS employees with specific expertise.

The Prairie Cluster served as a testing ground for long-term monitoring, emphasizing the development of sound monitoring protocols, attention to data management and data quality, and regular reporting of results to park management. The Prairie Cluster had years of on the ground experience in monitoring select resource conditions at four of the Heartland Network parks. Therefore, the Prairie Cluster staff devoted a great deal of time to laying the foundation for the Heartland Network and poised itself to assist in stepping through the rigorous procedure of designing a successful monitoring program. The Prairie Cluster staff arranged and facilitated the earliest organizational meetings, which included subject matter experts and technical representatives from the parks, for several purposes:

- To introduce the LTEM concept to parks not included in the prototype program.
- To identify the major issues and management questions to address within each park.
- To identify the principal resources to monitor within each park.
- To establish the boundaries of LTEM Program and park monitoring.

A workgroup of park resource managers²⁰, Prairie Cluster LTEM staff²¹, and MWR staff²² began meeting in October of 1999 to plan inventory and monitoring activities for the Heartland Network. The Prairie Cluster invited a natural resource representative from each park within the Heartland Network to participate. The workgroup outlined a series of steps and a timeline for developing a full monitoring proposal for the Heartland Network.

The Prairie Cluster took the lead in organizing the methodology outlined in the WASO guidance by facilitating two workshops in February and March of 2000. Participants devoted one day of each workshop to inventory planning, and one day to the developing monitoring priorities. The first workshop involved brainstorming significant resources, current and future stressors, and potential indicators of park resource condition with 19 invited taxa experts. The summary document became one of the supplemental documents in the monitoring plan (DeBacker, et al. 2005).

At the second workshop, the Prairie Cluster had used a matrix approach for parks to score the need for monitoring various resources. This early process emphasized resources more than it did processes and values. A list of potential Vital Signs entered into the Vital Sign prioritization database. For each potential Vital Sign, the database included a justification statement about why the Vital Sign needed monitoring, an initial set of monitoring questions and objectives, and a list of parks to which each Vital Sign applied.

The Prairie Cluster had coordinated the early development of the Heartland Network, until the Heartland Network hired its own coordinator, Janet Eckhoff. The newly hired Heartland Network coordinator discarded the ranking done to this point, when she took over the process, nearly restarting the prioritization process. The I&M Program had not defined the relationship between prototype coordinator, Lisa Thomas, and Heartland Network coordinator, creating uncertainty as to where one authority ended and another began. Although the I&M Program intended prototypes to function as the research and development wing of the networks, the degree of autonomy in the two, co-located programs resulted in confusion and contention. The Prairie Cluster offered to continue assisting the Heartland Network in development, but the Heartland Network

20 Regularly including Victoria Grant, Kristen Legg, Gary Sullivan, George Oviatt, Stephen Rudd, and Gia Wagner; advisory assistance from Johnny Neal

21 Lisa Thomas and Michael DeBacker

22 June McMillen and Steve Cinnamon

did not always accept assistance. The development of the Heartland Network and its interaction with the Prairie Cluster became similar to the relationship between parent and child, and it included the growing pains and strife commensurate with adolescence.

2.2.2 Following WASO Guidelines

In 2000, the Heartland Network began to follow recommendations from WASO guidelines on network development. These guidelines continued to change over the next 13 years, as networks learned the best way of doing business. Being one of the first networks, the Heartland Network sometimes chased a moving target to follow guidelines. The successes and failures of the Heartland Network also influenced the evolution of the guidelines. The NPS published the final guidelines (NPS 2012) after all 32 networks became operational.

The guidance prescribed a seemingly simple, seven-stage course of action for developing a monitoring program:

- Form a network Board of Directors and a Science Advisory Committee.
- Summarize existing data and understanding.
- Prepare for and hold a scoping workshop.
- Write a report on the workshop and have it widely reviewed.
- Hold meetings to decide on priorities and approaches.
- Draft the monitoring strategy.
- Have the monitoring strategy reviewed and approved.

Whereas the Prairie Cluster had developed the methodology to achieve an intended outcome through collaboration and consensus, the Heartland Network had to follow a defined recipe that changed, as the WASO learned what worked and what failed in the design approach. Although the WASO recognized that the one-size-fits-all monitoring design was not effective for the NPS, they established a one-size-fits-all approach to creating monitoring designs. This led to a top-down hierarchy, determining the best

practices in building a network. The Midwest Region's approach to the Heartland Network development reflected this nationwide, top-down control. The MWR staff took a hands-on approach to network development, including selection of the Heartland Network coordinator. Sometimes, this had a positive effect in bringing the process back on track, but sometimes it caused conflict with the Technical Committee, which preferred a grassroots approach to Heartland Network's development.

At the same time, funding and park needs caused pressure for the Heartland Network to enter the field stage of the program. Without the rigid design process, the planning phase could have fallen victim to temptations to rush into the field. Moving into the field too quickly could have resulted in instituting the wrong monitoring and the wrong protocols. Instead, the seven-step, three-phase planning process ensured that the Technical Committee and Heartland Network considered each question addressed, priority set, park resource considered, indicator selected, and protocol developed to meet goals of a long-term program, and serve the parks.

Monitoring occurred on three levels, national (e.g., climate change), network (e.g., plant communities), and park (i.e., continuation of established monitoring for park specific resources). The Heartland Network monitoring plan attempted to integrate network monitoring with the other two levels of monitoring.

2.2.3 Elements of the Heartland Network Charter

While the park superintendents directed the Prairie Cluster, the Heartland Network developed a network charter that described governance of the network under the authority of a Board of Directors (Board). The first Heartland Network Charter, approved in 2001, was a variation on the boilerplate example from the WASO. The Heartland Network rewrote the charter as it evolved to operational status. Revisions occurred in 2004 and 2007.

The Heartland Network Charter describes the process used to plan, manage, and evalu-

ate the inventory and monitoring program within the Heartland Network. It first guided the Heartland Network (prior to integration with the Prairie Cluster) and then guided the HTLN (Heartland Network and Prairie Cluster). It addressed the responsibilities of the Board, comprised of five park superintendents, each with a two-year term. The Board provided guidance and review for the program, helped 'leverage' funds and personnel, and approved plans, budgets, and personnel selection. The Board would meet annually for a formal meeting with a set agenda. Telephone conferences and electronic mail kept members informed of issues between annual meetings.

The charter also described the science advisory committee, called the Technical Committee, comprised of one natural resource representative from each park, the MWR and Heartland Network coordinators, and a member from the Prairie Cluster staff. It met at least annually during the planning phases, 2001 through 2005. The Technical Committee not only provided technical assistance to the Heartland Network, but also served as principal liaison between Heartland Network and parks, providing information about park resources to network staff. It could also address areas of need that arose within the Heartland Network, such as education and interpretation, or particular specialists for projects. The Technical Committee oversaw much of the Heartland Network design relative to the strategic plan. It also contributed to technical review of annual work plans, annual reports, and data reports. The Heartland Network coordinator chaired the Technical Committee meetings and could bring recommendations to the Board for approval. The coordinator consulted with the Technical Committee and obtained the concurrence of the Board, when establishing and recruiting staff positions.

Additionally, the first Heartland Network Charter described the relationship between the Prairie Cluster and Heartland Network, as well as establishing governance, responsi-

bilities of coordinators, procedures, coordination, partnerships, and reporting. At this time, the Prairie Cluster remained independent of the Heartland Network. The superintendents of the network parks signed the Heartland Network Charter as a document binding those parks and I&M Program to mutual responsibilities and commitments.

2.2.4 *Inventory in the Midst of Planning*²³

Initially, the I&M Program identified 12 inventories for network parks:

- Base Cartography Data
- Air Quality Data
- Air Quality Related Values
- Climate Inventory
- Geologic Resources Inventory
- Soils Resources Inventory
- Water Body Location and Classification
- Baseline Water Quality Data
- Natural Resource Bibliography
- Vegetation Inventory
- Species Lists
- Species Occurrence and Distribution

A meeting on December 7, 1999 included ten people from six parks, the region, and the Prairie Cluster,²⁴ who met to finalize a pre-proposal for biological inventories. The group wished to move forward and begin herpetological inventories in FY 2000. The WASO stated that funding would not be available for field projects until FY 2001. Thus, the efforts had to slow to remain in line with progress at the WASO and ensure proper planning.

The I&M Program set three goals for the biological inventories:

1. Establish a baseline inventory by documenting the occurrence of at least 90% of the expected vertebrate and vascular plant species.

23 This section taken from Williams (2004).

24 Michael DeBacker – Prairie Cluster, Victoria Grant – OZAR, Zach Holden – PERI, Kristin Legg – PIPE, Dena Matteson – GWCA, June Mcmillen – MWR, George Oviatt – OZAR, Gary Sullivan – WICR, Stephen Rudd – HOSP, and Lisa Thomas – Prairie Cluster

2. Describe the distribution and relative abundance of species of special concern, such as threatened and endangered species, exotic species, and other species of special management interest.
3. Provide the baseline information needed to develop a general monitoring strategy and design for implementation by parks.

The Heartland Network created an Inventory Strategy in 2000 (Boetsch, et al. 2000) that added three components to a successful inventory scheme:

1. Develop final reports for each project and an annual inventory report.
2. Develop inventory databases/geodatabases to allow effective data storage/archival and interaction within a Geographical Information System (GIS) environment.
3. Develop and initiate a plan to curate voucher specimens and photos, collected as part of the vertebrate and vascular plant inventories.

This strategy laid out actions and the justifications for completing inventories of vascular plants and vertebrate animals. The Heartland Network initiated a species certification process to determine taxa expected within the park that required inventory. This information identified key park inventory needs, objectives, costs, and timelines.

The Heartland Network administered 41 inventory projects, comprising 59 individual taxa inventories. The Heartland Network cooperated closely with several principal investigators both within and outside the NPS to complete the inventory component of the program. The Heartland Network assisted external investigators with understanding the inventories required, providing information about the parks' resources, and resolving technical difficulties. Appendix 3 lists the cooperators and contractors. Contractors completed half of the inventories, CESUs completed nine, Interagency Agreements

resulted in completion of seven inventories, and Cooperative Agreements resulted in two completed inventories. Park staff completed 15 inventories.

Inventory projects consisted of several tasks. Projects began with a scope of work written and reviewed by the MWR, the Heartland Network, the Prairie Cluster, the park resources managers, and sometimes by outside topic specialists. A scope of work included problem statements and justifications, objectives, methods, obligations/requirements, deliverables, timelines, budget and payment, and a detailed map of the park and data collection points. An inventory specialist²⁵ kept the projects organized and proceeding towards culmination. Inventories created a significant workload and required strategic timing to maximize collaboration as well as spread the workload over time (Table 4). Summary reports generated by the inventory specialist consolidated findings from vascular flora and vertebrate fauna into one report for each park.²⁶

Administration of the contracts and Cooperative Agreements required that Heartland Network staff receive training and certification as technical representatives for the contracting officer. Furthermore, the inventory specialist assisted with technical issues relating to Global Positioning Systems (GPS) and GIS, database design, metadata entry, and other specifics related to the NPS way of doing business. Subsequent to an inventory, the inventory specialist oversaw NPSpecies certification to ensure correct listing of expected species. This was paramount to confirming that investigators documented the occurrence of 90% of the 'reasonably' expected species. The certification process included several preliminary steps such as compiling organism lists via data mining (initiated by the Prairie Cluster prior to Heartland Network), processing lists to an Access® database, and verifying and updating lists. Subject matter experts compared expected-species lists to inventory lists to determine completeness of taxa documenta-

25 Phillip Hughes was the first inventory specialist, followed by Michael H. Williams.

26 Michael H. Williams summarized inventories and oversaw final reports. Reports may be found in the Natural Resource Technical Report series, NPS/HTLN/NRTR 2009, report numbers 230, 233, 246, 248, 249, 254-262.

Table 4. The fiscal year for inventory completion at each park.

Park	Bats	Birds	Deer	Exotic Plants	Fish	Herpetofauna	Mammals	Vascular Plants
ARPO	2003	2002				2001		
BUFF	2002	2002			2002	2002		2001
CUVA	2002			2001/02		2003		
EFMO		2002						2003
GWCA				2001	2002	2001	2004	2002
HEHO	2003	2002		2003		2002	2004	
HOCU	2003	2003			2003	2002	2003	
HOME	2003		2003	2003		2002	2004	2002
HOSP				2002	2002	2001		2001
LIBO				2003				2001
OZAR		2002/03				2001		
PERI	2002			2001	2002			2001
PIPE					2002	2002		
TAPR	2003		2002		2002	2002	2004	
WICR	2002				2002	2001	2004	

tion. The inventory specialist published final reports of inventories for each park in the Natural Resource Technical Reports (NRTR) report series.

CESUs and Inventories

The CESU network was one of the simplest ways for the NPS to engage the work of experts to complete needed work in parks. The CESU network provided an interdisciplinary structure capable of addressing needs for knowledge on which to base management decisions. Partner universities hosted the units through a Memorandum of Understanding that defines the roles of the host, agencies, and partners. Two CESUs, Great Rivers CESU and Great Plains CESU, became important to the Heartland Network. Both CESUs included university partners that overlapped with the Prairie Cluster and Heartland Network parks.

The CESUs contributed greatly to inventories for the Heartland Network. Cooperative Agreements expedited the process of engaging investigators in partnerships focused on various tasks. Partners from CESUs completed many of the aquatic inventories for the Heartland Network. The CESU partners completed inventories for aquatic inver-

tebrates, fish, invasive plants, birds, small mammals, and other taxa (Appendix 3).

Products of Inventories

The I&M Program made information available for management, research, education, and integration into park operations a priority. Results of the inventory projects include several reports, databases, and voucher data. The investigators finalized their portion of the inventories with a report and database. The inventory specialist, Michael H. Williams, commenced the review of deliverables. The review ensured that the final report met the objectives and followed protocols. The inventory specialist also performed QA/QC on the data to determine correctness of results, reliability and usability of the database, and compliance of GPS/GIS data to Federal Geographical Data Committee standards. As the inventory specialist finalized reports and data, he posted them to NPS online databases, including reports in NatureBib, species data in NPSpecies, and datasets in Dataset Catalog. The Heartland Network Intranet site and the I&M Program Applications and Databases site house sensitive items for NPS use only. The inventory specialist used databases and associated metadata to develop a geodatabase (a

relational database management system used in conjunction with GIS) which consisted of both spatial and non-spatial data relevant to the inventories. The inventory specialist then posted the final report and geodatabase to the Biodiversity Data Store.

The inventory specialist consolidated inventory information into one summary report for each park. Reports may be found in the Natural Resource Technical Report series, NPS/HTLN/NRTR 2009, report numbers 230, 233, 246, 248, 249, 254-262.

2.2.5 Phases in Monitoring Development

The NPS intended for monitoring to provide the cornerstone of the NPS Natural Resource Challenge, revitalizing and expanding the natural resource program. This would improve park management through greater reliance on scientific knowledge. As such, the NPS established a rigorous procedure for designing and implementing the monitoring networks. The rigidity of the top-down hierarchy that established the standards of design and implementation ensured a well-structured, effective, and credible program.

The networks each underwent a three-year, three-phase planning period. The guidance established for designing a monitoring network included two Phases prior to being field ready:

- Phase 1: Planning
 - Define natural resources, issues, and management objectives.
 - Complete data mining.
 - Define monitoring themes.
 - Develop conceptual models.
- Phase 2: Design
 - Prioritize and select Vital Signs.
 - Design the monitoring program, including protocol development.
- Phase 3: Implementation

The mission of the Vital Sign Monitoring was narrow in scope, emphasizing the few Vital Signs that best indicate resource conditions over the long-term.

Phase 1 -- Planning

Having established a Heartland Network Charter and a Board of Directors, the Heartland Network used Phase 1 of planning to establish program tenets and objectives, based on the nationwide program goals and the needs of the parks and network. The tenets (Eckhoff, et al. 2002) effectively addressed the prioritization process:

- The Heartland Network will achieve efficiency in implementing monitoring by sharing resources. The network will derive common monitoring themes from the top park priorities, where possible, to achieve economies of scale.
- Every park in the Heartland Network will have their highest priority monitoring need addressed. Priorities will be commensurate with the complexity of park issues and significance of their resources as determined by enabling legislation, strategic planning objectives, and regional and national conservation significance. The Heartland Network will address park-specific priorities not covered by a common theme. The Heartland Network will maintain flexibility to respond to episodic or catastrophic events. Monitoring will address, where possible, issues of public concern.
- Sound scientific principles will guide all aspects of the Heartland Network monitoring program for timely use in management decisions.
- The Heartland Network will build a foundation to institutionalize long-term monitoring within parks. The Heartland Network will share information about the program, generated from monitoring activities, with the greater public through avenues such as web pages, meetings, presentations, and posters in the parks.

The Heartland Network documented these tasks in a Phase 1 report, which received peer review and approval at the regional level before it proceeded to the next phase. The Phase 1 report turned into a first draft of the Introduction/Background and Conceptual Models chapters of the final monitoring plan (DeBacker, et al. 2005).

Step One: Define Resources, Issues, and Management Objectives

This step identified each park’s natural resources, natural resource concerns, and management objectives. Park managers identified the key management issues, current or potential threats to those resources and processes, legal mandates, and Government Performance and Results Act of 1993 (GPRA) goals. The Heartland Network, under the guidance of the Prairie Cluster, began formulating monitoring issues and objectives during two scoping workshops with park managers during meetings in February and March 2000 (Eckhoff, et al. 2002), prior to establishing a network charter. The workshops allowed the parks to prioritize the types of monitoring required and prioritize potential monitoring projects.

The Prairie Cluster and invited contributors, as organizers of the early planning, developed an ecological overview that attempted to tie certain regions of the extensive and varied network into similar, functional groups. The Prairie Cluster used Fenneman physiography, Kuchler Potential Natural Vegetation Type, and Bailey Ecoregions in dividing parks into their respective ecological groups (Table 5) that characterized climates, landforms, geology, hydrology, aquatic resources, vegetation, fauna, and natural disturbance regimes (Eckhoff, et al. 2002). The

organizers thought that clustering parks by similarities facilitated identifying conceptual models and potential stressors.

The entire scoping process involved a series of literature reviews, questionnaires, and workshops to identify monitoring questions and data needs. A report documented each workshop (except the terrestrial workshop at CUVA). Both the parks and the MWR reviewed the reports.

Each park entered Phase 1 with its own prioritized list of monitoring needs. Often, these lists represented long-standing park management concerns or specifically identified resource issues from GPRA goals. The list of resources and processes in contention for priority consideration varied as greatly as the parks presenting them. The parks adamantly fought for inclusion of their individual priorities in the list. The Heartland Network tenet stating that the network would address each park’s needs exacerbated the problem of narrowing the range of potential Vital Signs. In order for the Heartland Network to develop a feasible list of resource priorities, it had to combine the rankings from each park with the number of parks sharing those resources as high priorities for monitoring. The prioritized lists in combination with other criteria, such as efficient use of personnel, logistical feasibility, partnership opportunities, etc., guided the selection of resources and indicators to consider. The scoping resulted in focal resources receiving more emphasis than physical dynamics as potential Vital Signs.

When the scoping process changed from Prairie Cluster driven to Heartland Network driven, the process nearly started over from the beginning. Having not been involved in the early scoping efforts by the Prairie Cluster, the new Heartland Network staff had to go through the process themselves to climb the learning curve and meet the Technical Committee and parks level of process accomplishment. In February 2002, the Heartland Network led park managers to reassess and reprioritize monitoring issues identified in 2000 and 2001. Park managers provided documentation for the top three park priority issues. This activity became

Table 5. Ecological grouping of Prairie Cluster and Heartland Network parks

Park Ecological Group	Park Units
Eastern Deciduous Forest Parks	Cuyahoga Valley National Park
	Effigy Mounds National Monument
	Hopewell Culture National Historic Park
	Lincoln Boyhood National Memorial
Mississippi Embayment Parks	Arkansas Post National Memorial
Highland Parks Ouachita subgroup	Hot Springs National Park
	Buffalo National Scenic River
Highland Parks Ozark subgroup	George Washington Carver National Monument
	Pea Ridge National Military Park
	Wilson’s Creek National Battlefield
	Ozark National Scenic Riverways
Tallgrass Prairie Parks	Homestead National Monument of America
	Herbert Hoover National Historic Site
	Pipestone National Monument
	Tallgrass Prairie National Preserve

a sweeping reordering of priorities, rather than a reexamination of priorities set to this point. The process caused considerable confusion among parks and staff, seemingly setting back the process, once again, to the beginning.

The setback led to a meeting of Heartland Network staff with the MWR I&M Program coordinator, Prairie Cluster coordinator, and four park representatives, including one superintendent from the Board in March of 2002. The meeting established a “Roadmap” to achieving Phase 1. The Roadmap document (Eckhoff, et al. 2002, Supplemental Document 7) was to establish a network-wide consensus view of the following:

- Heartland Network specific tenets and goals.
- Appropriate roles and functions within the network.
- Outline, timeline, and description of information needed to complete Phase 1.

Within this context, the Heartland Network tenet concerning the resource priorities was simplified to state, “Every park in the Heartland Network will have their highest priority monitoring need addressed in the process of developing the monitoring plan.” Heartland Network goals in the Roadmap still alluded to creating a broad, encompassing program that solved a myriad of park monitoring concerns. The Roadmap reiterated and further defined roles and functions of the coordinator and the Board, and the relationship between the Prairie Cluster and the Heartland Network. The workgroup agreed upon tasks, due dates, and responsible personnel for each task. The workgroup submitted decision points of this meeting to the Technical Committee and Board for consideration.

Step Two: Data Mining and Design

Phase 1 of the I&M Program monitoring plan required networks to summarize previous and ongoing monitoring within and around the parks. This information served as background for developing a scientifically sound monitoring program that built off previous monitoring efforts. Most parks had some documentation of past and present

monitoring. In the spring of 2002, the Heartland Network data manager, Brent Frakes, developed a series of steps and guidelines to facilitate data mining at the parks and to produce complete documentation of previous studies. Data mining included:

- Inventory resources within NPS information databases and determine completeness.
- Develop data mining guidelines.
- Train park staff to update records.
- Collect natural resource materials.
- Organize materials within parks.
- Update records in NPS databases.
- Analyze and evaluate materials (this activity is part of Phase 2).

The Heartland Network determined that an organized data mining effort would synthesize previous and present monitoring efforts. The Heartland Network requested that one representative from each park complete the data mining for that park with its financial assistance. All but two of the parks provided a staff member for this purpose. The Heartland Network completed initial data mining in the summer and fall of 2002.

The Heartland Network data manager with input from other networks and prototypes established a standardized approach to data mining. The data mining materials added to the NPS databases were included in the Phase 1 draft document. The Heartland Network resumed data mining with a focus on teasing-out the most important monitoring information in 2003 with results documented in May 2003 (DeBacker, et al 2005).

Step Three: Define Monitoring Themes

After the parks identified and prioritized their respective natural resource monitoring issues within the Phase 1 process, the results indicated that several parks had relatively similar issues that allowed grouping under network level ‘monitoring themes’. Themes included plant communities, exotic plants, aquatic resources, land-use changes, and wildlife.

Five ‘workgroups’ were subsequently orga-

nized to further develop the monitoring program for each theme. Park staff, regional and network I&M Program coordinators, and NPS and non-NPS subject area experts comprised the theme workgroups. The Aquatic Workgroup also collaborated with the WRD, a supplemental source of aquatic monitoring funds. The Plant Community Workgroup collaborated with the NPS Fire-Monitoring Program, which conducted fire-related monitoring in several of the parks. Likewise, the Exotic Plant Monitoring Workgroup coordinated program development with input from the WASO Exotic Plant Management Team. Workgroups discussed and refined the parks' monitoring questions in subsequent meetings, incorporating conceptual models and external expertise (Table 6).

Aquatic Theme

In response to early efforts to organize inventory and monitoring within a highly diverse group of parks, one of the organizers (George Oviatt) tasked the hydrologist at BUFF to write a plan for the Ozark Highland parks. This plan (Mott 2000), presented at a meeting in June 2000, outlined the basic goals for Vital Sign monitoring with an aquatic resource framework for six parks (BUFF, OZAR, PERI, HOSP, ARPO, and GWCA) and it recommended the development of a monitoring program designed

to assess river integrity within these parks. This document suggested the use of USGS National Ambient Water Quality Assessment Program (NAWQA) aquatic monitoring protocols. Mott recommended modifications to the NAWQA protocols, based on Mathis (2000), to accommodate special park needs and to employ superior monitoring tools or approaches. Unfortunately, although the Mott Plan (2000) satisfied the task as initiated, it did not fit the context of the evolving I&M Program. The plan required the bulk of network funds to support a largely aquatic program in six parks, and it did not comply with the developing set of guidelines coming from the WASO. The significant effort placed on this early planning had been premature and fell outside of the context of a 15-park-network monitoring plan. Therefore, the plan never came to fruition, disappointing BUFF and the other five parks that would have benefitted from the extensive monitoring in the Ozark Highland parks.

The Heartland Network established the Aquatic Workgroup to develop the Aquatic Theme portion of the monitoring plan. The Aquatic Workgroup, consisting of managers from parks with significant aquatic resources, Heartland Network staff, and NPS aquatic experts convened several meetings between 2001 and 2003. Conference calls

Table 6. Workshop objectives and timing.

Theme	Workshop dates	Key points
Landscape Theme	December 8, 2001	Spatial and temporal aspects Detail of imagery Level of classification Contracting or in-house logistics
Aquatic Theme	April 24-26, 2001	Draft aquatic monitoring objectives and questions Identify a list of candidate indicators
	October 30-31, 2001	Add to and better define long list of indicators Consider indicator value and feasibility Compare list with current ongoing studies Connect monitoring in regional context Link monitoring questions to conceptual models
	October 15-17, 2002	Further refine objectives and validate Review criteria for Indicator Ranking and Selection Select Vital Signs Outline a sampling Design Determine the protocols needed
	February 11-12, 2003	Phase 2 completion
Terrestrial Themes: Plant Communities Exotic Plants Wildlife	November 2001	Select terrestrial resources to monitor Identify a list of candidate indicators

and workshops facilitated the continued planning and design of aquatic long-term monitoring.

In April 2001, the workgroup met at Hot Springs, Arkansas, for the first attempt to move the Aquatic Theme towards Phase 1 objectives. Participants intended to draft a list of measurable objectives and identify a long list of indicators for further consideration. The workgroup recognized the need for conceptual models that considered resources and their stressors, but participants also wished to separate monitoring for stressor effects from monitoring of general ecological conditions. An internal report documents this workshop (Adams 2001a).

The Ozark Highland Rivers dominated much of the early development of the Aquatic Program Area because of their status as outstanding or significant water resources. Workgroup members attributed some of this emphasis on these stream systems to the significance of the water resources, but they also attributed much of the emphasis to the strong influence of parks with national status and the original Mott (2000) plan. Both BUFF and OZAR comprise pristine river systems, but do not contain much of the land associated with the rivers' watersheds. They are essentially river-based parks with most of their focus on river issues. Therefore, they had a great stake in the Aquatic Theme and had the greatest interest in ensuring the ecological integrity of the rivers, which constituted the basis for their parks.

Aquatic monitoring differed somewhat from the other themes in that Heartland Network received \$82,000 from WRD annually for planning and implementing water quality monitoring. The WRD proposed that the Heartland Network identify, design, and implement long-term monitoring in coordination with Vital Sign monitoring, but also required measurement of a core set of parameters along with the Vital Signs. The Aquatic Workgroup addressed impaired streams (Clean Water Act, 303d, impaired waters designation), largely focusing on the Yellow River at EFMO (EFMO 2004), Jack's Fork at OZAR, Pipestone Creek at PIPE, and Wilson Creek at WICR in addition to

the pristine waters of BUFF and OZAR. The workgroup labored under the idea that WRD had earmarked supplemental funding for monitoring of impaired and pristine waters only. In fact, the WRD supplemental funding had no mandates, other than to maintain the scientific rigor of monitoring within network waters. The WRD had become involved in protocol planning and seemed to promote this idea of preferentially funding certain classes of water, but then relinquished planning to networks and withdrew influence in use of funds.

Due to the variety of state aquatic standards and biological assessment methodologies, the Heartland Network established a Cooperative Agreement with Donald Higgins of the Central Plains Center, University of Kansas, to summarize state and national aquatic biological assessment methods, physical habitat assessment methods, and biological criteria. This information played a role in parameter selection and prioritization in those parks assured of aquatic monitoring.

Terrestrial Theme

Vegetation predominated in the early development of the Terrestrial Theme. The Heartland Network plant-community monitoring evolved, primarily, from the existing Prairie Cluster monitoring design. Additionally, the Prairie Cluster had rare plant species protocols for both Missouri bladderwort and western prairie fringed orchid. An additional area of vegetation monitoring arose when 12 of the 15 parks identified invasive-plant monitoring as a high priority (Table 7).

In November 2001, a workshop at CUVA, including park, Heartland Network, and MWR staff, and several subject-matter experts, focused on ways to measure or assess overall community health in dominant plant communities. They selected overall community health as the starting point, because it presented the big picture (landscape level) conditions. Subsequently, the group focused on threatened and endangered species, and on invasive flora and fauna on the population level. Participants placed habitat issues into the context of plant-community conditions. Cuyahoga National Park identified wetland monitoring as a critical need. An early study

Table 7. Extent and priority of park's vegetation-community Vital Signs.

Park	Vegetation Monitoring Extent (2004)	Invasive Plants Identified as High Priority (2000)	Revisit Schedule (adopted in 2008)
ARPO	Parkwide	Priority #4	2017
BUFF	-	-	-
CUVA	-	Priority #1	-
EFMO	Grasslands & woodlands	Priority #2	2014 (woodlands); 2017 (all)
GWCA	Parkwide	Priority #3	2016
HEHO	Parkwide	Priority #2	2017
HOCU	Parkwide	Priority #1	-
HOME	Parkwide	-	2017
HOSP	Parkwide	Priority #4	2016
LIBO	Parkwide	Priority #2	TBD
OZAR	-	-	-
PERI	Parkwide	Priority	2016
PIPE	Parkwide	Priority	2017
TAPR	Parkwide	Priority #2	annually
WICR	Parkwide	Priority #2	2016

(Davey Resource Group 2001) identified 1200 wetlands within the park. The facilitator emphasized the deciduous forests and wetlands, but excluded prairies, because the Prairie Cluster had adequately addressed them, having developed key indicators and protocols.

Grassland birds had suffered declines in the years preceding the establishment of the I&M Program, and so the Prairie Cluster had initiated grassland-bird surveys for two prototype parks. Several parks identified breeding-bird indices as a Vital Sign. Thus, the Heartland Network added breeding birds to the Terrestrial Theme. Three parks identified whitetail deer as a stressor on terrestrial systems. Therefore, deer monitoring could serve as an indicator of community conditions in those parks.

Step Four: Developing Conceptual Models

A conceptual model is a visual or narrative summary that describes the important components of the ecosystem and the interactions among those components. The conceptual model provides a basis for selecting the best indicators of ecosystem change by clarifying linkages between the indicator and the ecological function or resource.

Subject matter experts prepared conceptual models to summarize stressors, drivers, and cause-effect relationships within important

portions of park ecosystems or landscapes (monitoring themes). Both NPS staff and partners prepared the conceptual, ecosystem models for specific systems (Table 8). They were developed for dominant ecosystems found in the Heartland Network: forests, prairies, rivers (subdivided by type), and wetlands (riparian ecosystems, freshwater marshes, and swamps). In addition to the ecosystem models, the Heartland Network developed a conceptual model for land-use changes. The conceptual models largely took the form of box-and-arrow diagrams with accompanying narrative. Conceptual models helped to organize and to communicate the information compiled during scoping, and to identify cause-effect relationships between some stressors and response variables.

Although characterization of big rivers, such as those defining BUFF and OZAR, received considerable attention from early in the process, small streams, particularly those in small parks, received little attention until late in the planning process. Parks with small streams continued to stress the need to consider stream dynamics and water quality in small streams. Therefore, the Heartland Network added a small stream conceptual model late in the project. The Prairie Cluster prairie stream model also joined the recently developed conceptual models.

Table 8. Models included in the Phase 1 report.

Model	Model Leads
Forest Management	D.A. Weinstein, Boyce Thompson Institute, Cornell University, Ithaca, NY 14850, Supplemental Document 20
Ozark Highland Rivers	K.E. Doisy, Charles Rabeni, Victoria Grant (Doisy and Rabeni 2002), DeBacker, et al. 2005, Supplemental Document 16
Midwestern Wetlands	Daren Carlisle, NPS, Midwest Regional Office, DeBacker, et al. 2005, Supplemental Document 22
Terrestrial Prairie Ecosystem	L.P. Thomas, et al 2001, and DeBacker, et al. 2005, Supplemental Document 21
Landscape analysis	Andrew Hansen, Montana State University, DeBacker, et al. 2005, Supplemental Document 23
Small Midwestern Streams	Sherry Middlemis-Brown, NPS, DeBacker, et al. 2005, Supplemental Document 18
Prairie Streams	L.P. Thomas, et al. 2001 and included as DeBacker, et al. 2005, Supplemental Document 19.

The scoping of priority resources and conceptual models resulted in a prioritized list of potential Vital Signs, using criteria agreed upon by the parks. Vital Sign selection continued into Phase 2.

Phase 2 -- Design

Phase 2 involved final prioritizing and selection of Vital Signs for inclusion in the monitoring program. This phase also outlined the scientific platform and statistical rigor within the monitoring plan. This design phase affected scientific credibility of the network program.

Prioritization and Selection of Vital Signs

The Technical Committee and Heartland Network staff found it easy to generate a list of potential monitoring projects or indicators to address critical data needs, but the process of paring the list down to a few Vital Signs that best represented the composition, structure, and function of the larger ecosystem proved challenging. The amount of funding available for Vital Sign Monitoring allowed most parks to monitor only a few indicators. The NPS allowed each network to determine what they monitored, based on their most critical data needs and local partnership opportunities. The I&M Program encouraged networks to use or modify standard protocols, and to collaborate with existing programs to allow comparability and synthesis of data.

The Heartland Network database manager, Brent Frakes, established the early databases using a manual that he developed from I&M Program guidance. The database, developed in Access®, applied to Vital Sign selection during Phases 1 and 2. It organized the list of all Vital Signs and provided a means for addressing park resources and questions,

much as the matrices that the Prairie Cluster had developed to prioritize resources requiring monitoring. Parks used a set of forms to score potential vital signs that went into the database. This assisted the Terrestrial Theme workgroups in finalizing Vital Sign selection, but the Aquatic Workgroup required additional discussion.

Aquatic Theme Prioritization

The Aquatic Theme covered a broad assortment of resources and situations that the Prairie Cluster had not addressed. Whereas the Terrestrial Theme had attained prioritization largely during Phase 1, the Aquatic Theme required additional work in establishing Vital Signs for navigable water, small streams, karst springs, impaired waters, and waters with outstanding resources. Several workshops led to the eventual selection of Vital Signs and identification of needed protocols.

An Aquatic Theme workshop, October 30-31, 2001, linked monitoring questions to the conceptual models drafted for Ozark Highland Rivers and for wetlands. Participants brainstormed indicators that fit the monitoring objectives, based on identified stressors, human activities, and ecological responses. Indicators matched the general indicators suggested by a workshop held in April 2001 (Adams 2001a), but participants further refined the list by only including measurable parameters. Participants considered indicator value and sampling feasibility in each park. They also compared the list with current, on-going studies in the parks or near parks, placing monitoring in a regional context.

The Aquatic Theme portion of the plan had fallen behind the timeline for Phase 1 and

Phase 2 development. Assistance came from the MWR aquatic ecologist, Daren Carlisle, to bring the process back on track (Roadmap: Eckhoff, et al. 2002, Supplemental Document 7). The October 2002 workshop drafted a framework for aquatic monitoring in six parks with impaired water and for outstanding or significant water resources in two parks (Carlisle 2002), completing tasks for Phase 1 and Phase 2. Parks with minor aquatic resources, low priority for aquatic resource monitoring, or aquatic resources associated with consumption, instead of natural systems, received little consideration during these talks. The focus moved from physical aspects of streams (geomorphology) to water quality issues during this meeting. Two parks with impaired waters (CUVA and HOCU) withdrew from consideration for monitoring, because impairment in their rivers resulted from actions over which the parks had no control. The state of Ohio continued to address the impairment within these parks.

An Aquatic Theme workshop in February 2003 (Middlemis-Brown 2003b) attempted to resolve deficiencies and changes in the aquatic portions of Phase 2 and Phase 3. Although the October 2002 workshop (Carlisle 2002) identified and selected indicators, the MWR staff had concerns that the I&M Program process had been annotated. This meeting analyzed the scientific rigor of the process used. It also ensured that investigators met deadlines for protocols that met the rigors of peer review. In June 2003, the leadership of the Heartland Network changed. The MWR I&M Program coordinator, Phyllis Adams, became interim Heartland Network coordinator until the MWR assigned an acting coordinator. The finalization of Vital Sign selection and monitoring design followed this change in leadership. An update of progress (Middlemis-Brown 2004) showed Phase 2 had advanced to completion.

Issues Outside of Long-term Monitoring
Hot Springs National Park had identified water quality, as it related to hot springs as a top priority. The park mission is to pro-

vide naturally occurring, geothermal spring water to the public in perpetuity. This water must remain uncontaminated for human consumption and bathing. The predominant component of flow from the springs is thermal water. Temperature and hydrograph data indicated that a small, cold-water component of flow affected some thermal springs within a few hours or days after a storm event. Contaminants related to land use might enter into the thermal springs through the cold-water component of flow, presenting a problem of immediate concern for public health and safety. The Heartland Network assisted the park with two studies to determine potential contaminant and temperature issues of concern. These studies, conducted through an Interagency Agreement with the USGS, constituted an inventory-type study. Because of the nature of the concern, providing uncontaminated water for human consumption, long-term monitoring of thermal waters seemed to fall outside of the mission of the I&M Program. The concern would receive attention, as part of the land-use and land-cover monitoring that would identify changes in the watershed that could affect water quality of cold-water input into thermal springs.

Herbert Hoover National Historic Site had listed aquatic issues as a top priority. This concern revolved around the hydrology, water quality resulting from high water events, and high water impacts to the geomorphology. Shortly after this prioritization, the park learned that the state of Iowa intended to list the stream as impaired (Clean Water Act, 303d designation). Therefore, the Heartland Network worked in cooperation with HEHO, the Iowa Department of Natural Resources, and the USGS, Iowa District, to complete a series of studies characterizing the hydrology of the stream, identifying inundation areas, and locating sources of coliform contamination. This work continued into 2007, but did not become a long-term monitoring focus.

*Vital Sign Workshop, July 2003*²⁷

The process of prioritization had begun in March 2000. The Heartland Network held

27 Information in this section came from personal communication with Meg Plona, CUVA, NPS, conversations and emails in August 2013.

one final prioritization workshop in July 2003. Subject-matter experts, park managers and others divided into workgroups and reviewed, revised, and improved the information entered into the Vital Sign selection database (e.g., justification, monitoring questions and objectives). The data manager generated prioritized Vital Sign lists for each park and one list for the Heartland Network overall. Each workgroup used the highest-ranking Vital Signs to develop a set of specific measurable objectives for each Vital Sign. Two parks, OZAR and BUFF, ranked their Vital Signs separately of the other parks, because of their strong emphasis on aquatic resources. The Technical Committee used the results of the workshop to guide the selection of the Vital Signs.

Participants in this workshop reiterated the importance of developing partnerships, including identifying the stakeholders, finding ongoing and prospective partners, and laying out strategies for further developing productive partnerships for mutual benefit in the monitoring arena. This effort at both the park and network levels could result in increasing the amount of Vital Sign monitoring accomplished within parks.

The interim Heartland Network coordinator, Phyllis Adams, submitted the ranking

of resources to be monitored and potential indicators to the Technical Committee and Board in August 2003. Table 9 and Table 10 represent the scoring and ranking.

The Heartland Network dropped some Vital Signs, because (1) other agencies had capacity to monitor them, (2) it did not have capability to provide the intensity of sampling required, or (3) other information came to light that lessened the priority of that Vital Sign. The final Vital Signs that became part of the monitoring plan (DeBacker, et al. 2005) appear in Table 11.

Sampling Design

Sampling design required taking the selected Vital Signs and determining the methodology necessary to ensure that data represented the target population, such that scientists and managers could make conclusions relevant to resource issues. The sampling design played an important part in the full sampling protocols developed for each monitoring project. The original design appears in DeBacker, et al. (2005). Terrestrial designs were adapted largely from Prairie Cluster designs. Aquatic design required additional work. The Aquatic Program Area portion of this document discusses this process.

Table 9. Top 15 monitoring indicators for BUFF and OZAR.

Category	Indicator	Average score on a 5 point scale
Rivers/Streams ¹	Physical-Stream Discharge	4.7
Springs ¹	Physical-Spring Discharge	4.6
Terrestrial ²	Flora-Exotic Forest Species	4.6
Rivers/Streams ¹	Biotic-Pathogens	4.5
Terrestrial ²	Fauna-Gray Bat	4.5
Terrestrial ²	Fauna-Indiana Bat	4.5
Rivers/Streams ¹	Chemical-Water Clarity	4.5
Unbounded	Land Use/Land cover	4.5
Rivers/Streams ¹	Biotic-Stream Invertebrates	4.4
Rivers/Streams ¹	Chemical-Nutrient Loading	4.4
Terrestrial ²	Special Terrestrial Habitats	4.2
Rivers/Streams ¹	Chemical-Stream Core elements	4.2
Rivers/Streams ¹	Biotic-Fish Community	4.1
Rivers/Streams ¹	Physical - Habitat quality	4.0
Rivers/Streams ¹	Chemical-Metal Contaminants	3.9

¹ Aquatic

² Terrestrial

Table 10. Top 15 monitoring indicators for all other parks. Excludes BUFF, OZAR, and LTEM.

Category	Indicator	Mean	Count
Terrestrial ¹	Flora-Exotic Forest Species	3.5	8
Unbounded	Land Use/Land cover	3.2	9
Terrestrial ¹	Fauna-Breeding-bird communities	3.0	9
Terrestrial ¹	Forest community structure, composition, & diversity	3.0	8
Unbounded	Climate-Weather Patterns	2.3	9
Wetlands ¹	Biotic-Wetland Amphibians	2.3	7
Terrestrial ¹	Fauna-Deer	2.2	7
Rivers/Streams ²	Chemical-Stream Core elements	2.2	6
Unbounded	Air Quality-Chemical & Physical	2.2	9
Terrestrial ¹	Gypsy moths	1.9	5
Rivers/Streams ²	Chemical-Nutrient Loading	1.9	6
Rivers/Streams ²	Physical-Stream Discharge	1.9	6
Terrestrial ¹	Flora-Exotic Grassland Species	1.9	4
Terrestrial ¹	Fauna-Terrestrial Amphibians	1.7	7
Rivers/Streams ²	Biotic-Stream Invertebrates	1.6	5

¹ Terrestrial² Aquatic**Table 11.** Final list of Vital Signs that became part of the monitoring plan.

Category	Vital Sign	Monitoring Conducted	Frequency, implementation year
Air and Climate	Ozone	Air quality monitoring in the HTLN would be limited to collecting and summarizing data from air quality monitoring stations near parks.	Continuous; Air Resource Division does the groundwork with no Heartland Network funds.
	Wet and dry deposition		
	Visibility and particulate matter		
	Air contaminants		
Geology and Soils, also relative to water quality	Fluvial geomorphology	Dropped as a unique protocol in 2006	Portions added into aquatic habitat analysis or after significant events
	Stream discharge	As part of the Aquatic Program Area	Continuous (where available)
	Stream habitat / riparian assessment		Every 3 years, starting year 2
	Core water quality parameters		Variable
	Aquatic invertebrates – rivers		Every 5 years, starting year 1
	Aquatic invertebrates – prairie streams		Annual (originally Prairie Cluster)
	Pollutant metals	Undertaken with partner agency	Every 10 years, starting year 1
Biological integrity	Exotic forest plants	Invasive-plant Project and Exotic Plant Management Team after 2010	Every 4 years, starting year 1
	Exotic grassland plants		
	Wetland plant communities	Wetland Monitoring Project, CUVA	Annual
	Prairie community	Plant-community Monitoring Project	Sampled 2 consecutive years in 5; changed to 1 year in 4 years
	Forest community		
	Fish community – prairie streams	Aquatic Program Area	Every 5 years, starting year 1
	Fish community – Ozark rivers		
	Land birds	Breeding-birds Monitoring Project	Annual (originally Prairie Cluster)
	Deer	Deer Monitoring Project	Annual
	Missouri bladderpod	Rare-plant Monitoring Project	Annual (originally Prairie Cluster)
	Ozark hellbender	Potentially undertaken by partner agency	
	Topeka shiner	Aquatic Program Area	Annual (originally Prairie Cluster)
	Western prairie fringed orchid	Rare-plant Monitoring Project	Annual (originally Prairie Cluster)
Ecosystem patterns and processes	Land cover and use	Landscape Program Area	Return once every 10 years

Phase 3 -- Implementation

Phase 3 entailed the detailed design work needed to implement monitoring, such as specific monitoring objectives for each Vital Sign, sampling protocols, statistical sampling designs, data management and analysis, and description of products of the monitoring effort, such as reports and websites. Because of the number of Vital Signs selected, implementation occurred over several years, providing the basis for the rotational schedule for data collection in the field (Table 11).

The Heartland Network monitoring program would deliver current, consistent, and credible information on the condition of key natural resources within participating parks. It established several objectives within the monitoring plan:

- Collect, analyze, summarize, and report status and trends for each park.
- Use applicable technologies to acquire data by fieldwork and remote sensing.
- Place information into regional context via collaboration with outside partners.
- Involve outside experts to augment research, analysis, and monitoring techniques.
- Use rigorous quality assurance procedures to verify accuracy and validate results.

The monitoring plan in development during this phase was unique to the Heartland Network. The Prairie Cluster was responsible for the activities related to the four prototype parks and TAPR. The Heartland Network was responsible for overseeing non-prototype parks, except TAPR, and activities in prototype parks that were not part of the LTEM Program. Hence, the monitoring plan included descriptions of all 15 Heartland Network parks, full monitoring project information for the non-prototype monitoring, and aquatic monitoring program information that included prototype parks. The last several sections establish a 'work plan,' outlining monitoring implementation and reporting mechanisms.

2.3 Program Area and Protocol Development

Program areas formed from the monitoring design originating with the Prairie Cluster and from the monitoring themes identified by the Heartland Network. The program areas may have several Vital Signs associated with them, such that the Terrestrial Theme contains the Vegetation Program Area and Wildlife Program Area; the Vegetation Program Area has plant communities, rare-plant species, invasive-plant species, and wetlands.

Protocol development began with the Prairie Cluster in 1994 and continued through the planning and implementation of the Heartland Network, and into the merging of the two programs into the HTLN. Many of the early protocols developed for the Heartland Network were merely extensions of protocols used by the Prairie Cluster. The I&M Program required networks to produce peer-reviewed protocols for each Vital Sign before implementation of monitoring. The quality of the protocols used by the Prairie Cluster gave the Heartland Network a solid footing for protocol development. The Prairie Cluster had fine-tuned what worked in the field and had several years of data to verify the data management methods. The HTLN adopted these protocols with only minor changes and included them in the Monitoring Plan for Phase 3 (DeBacker, et al. 2005).

Each program area and protocol has its own history that included conceptualization, field trial, peer review, implementation, and further alteration to address changing issues or expansion to other parks. This section will address protocols within each program area from inception, often within the Prairie Cluster, to final, full deployment or discontinuation within the HTLN. The process exemplifies evolution within an environment of changing program-based stressors, consisting of improved understanding of the parks' needs, inclusion of new parks into the system, and reconciliation of desired monitoring with what was feasible under the prevailing conditions and operational limitations.

2.3.1 Vegetation Program Area

In May 1996, the Northern Prairie Research Center, the NBS, hired a temporary botanist, Michael DeBacker, to assist with initial vegetation sampling for the Prairie Cluster. At about the same time, the NBS liaison, Gary Willson, to the Prairie Cluster hired a post-doctoral professional (Sean Jenkins) and a technician (Keith Grabner) through the University of Missouri, Columbia, as temporary employees to begin testing field protocols for vegetation monitoring. Those three positions and the Prairie Cluster coordinator led early protocol development. During the subsequent two years, staff compared sampling methods *in situ*, collected and analyzed pilot data, and determined the appropriate sample stratification to accomplish long-term monitoring. The Northern Prairie Research Center created a permanent botanist position²⁸ dedicated to the Prairie Cluster to assist with this process. The USGS-BRD transferred the permanent botanist to the NPS in 1998. The cooperative efforts of the USGS-BRD and the NPS resulted in a protocol for the six parks of the Prairie Cluster, published several years after implementation (Willson, et al. 2001).

Plant Communities

The Prairie Cluster plant-community monitoring protocol was not a comprehensive monitoring project, but rather addressed changes in high quality, remnant prairie communities, and sites undergoing transition between community types (Adams 2001b). It accomplished this by capturing changes in species composition, structure, and diversity in a manner that separated natural variability from human-induced stressors, including management actions. Development of the project continued amidst changes in personnel with the original post-doctoral staff leaving the project. A University of Missouri staff employee joined the project, Cindy Buck, but left the project in 2001 before finalizing the protocol. The permanent botanist, Michael DeBacker, remained with the project and a new USGS-BRD liaison, William Rizzo, joined the project, assisting with

writing. In conjunction with this, the Prairie Cluster hired a botanist, Karola Mlekush, in 1999 to establish a working herbarium for the six parks.

The protocol development team completed a second draft of the vegetation monitoring protocol by August 2000 (Buck, et al. 2000), submitted as a USGS report for peer review. The Northern Prairie Wildlife Research Center, USGS, published the final protocol, having received review and ground testing, in 2001 (Willson, et al. 2001). This protocol required further expansion to include TAPR. Tom Eddy of Emporia State University had used the Prairie Cluster protocol in the collection of baseline data for TAPR. These data and Eddy's work contributed to the inclusion of TAPR in Prairie Cluster sampling.

The Heartland Network adapted and revised the plant-community protocol in 2004 (DeBacker, et al. 2004). The revision expanded the scope to serve all Heartland Network and Prairie Cluster parks with plant-community structure identified as a high priority Vital Sign. It also made the protocol consistent with the guidance issued from the WASO NRSS as delineated in Oakley, et al. (2003). The plant-community protocol extended to 12 Heartland Network parks, having identified plant-community structure as a high priority.

Expansion of the vegetation monitoring occurred over a four-year period, starting in 2004, and helped to integrate the Prairie Cluster and the Heartland Network. Besides the general expansion to include the parks, some changes applied to specific parks that broadened the scope of network assistance. The vegetation staff established seven new monitoring sites in the restored prairie at GWCA in 2004. They selected four new monitoring sites at HEHO and established three sites previously installed by Paul Christensen²⁹ for inclusion in monitoring. At TAPR, the new HTLN plant ecologist, Kevin James, installed and sampled additional monitoring sites in the West Branch portion of Big Pasture during 2006. He also

28 Filled by Michael DeBacker in February 1998.

29 Paul Christiansen, formally of Cornell College, Mt. Vernon, IA (deceased) completed 23 years of monitoring in the HEHO reconstructed prairie.

established an additional seven monitoring sites in the woodlands at HOSP and PERI in 2007. Staff added archival digital photos as a way to record overall conditions within the plant communities. The photography project began in 2008, and should conclude by 2015, creating a baseline of digital images associated with monitoring sites and events.

In anticipation of the transfer of AGFO and SCBL to the NGPN, scheduled for 2010, staff began to examine streamlining the current vegetation monitoring, while providing the best possible products to parks, and increasing service to several parks. Staff proposed significantly altering the revisit schedule from the original protocol. The changes to the revisit schedule aligned all vegetation sampling at a park within the same year. Staff would conduct plant-community sampling, invasive-plant surveys, and breeding-bird surveys with the habitat component in the same year on a four-year rotation through the parks. The Board recommended enactment of this proposal at the Board of Directors meeting August 21, 2008. The vegetation staff revised the protocol to accommodate this change in 2008 (James, et al. 2009).

This change in scheduling opened the door to expanding spatial coverage of plant communities within Prairie Cluster parks. The Prairie Cluster protocol initially focused on particular communities (e.g. high quality, restored, protected species habitat). Prototype parks requested information that comprehensively covered plant communities, reflecting the overall plant-community health. Staff established four new monitoring sites in the restored prairie management units at WICR in 2008. They added two monitoring sites at HOME and three at PIPE in the following year. By 2011, the need to expand plant-community monitoring in LIBO woodlands became apparent. The staff added four new monitoring sites there.

Rare Plant Species

The Prairie Cluster identified approximately 40 species of rare plants as occurring or probably occurring within the parks. Intrinsic value of these species, their value as indicators of unique habitats, and their potential as edge-of-range species formed the

basis for interest in monitoring rare species. Experts predicted that the parks shared the effects of human caused fragmentation and isolation of small populations, which affects the equilibrium between extirpation and recolonization. The Prairie Cluster produced a monitoring guide for rare plants in 2001 (De-Backer, et al. 2001), but the Prairie Cluster never implemented it.

The Prairie Cluster had identified two federally listed (Endangered Species Act of 1972) plant species within two parks that it served: the threatened western prairie fringed orchid (*Platanthera praeclara*) and the endangered Missouri bladderpod (*Lesquerella filiformis*). Each federally listed species required its own protocol.

Western Prairie Fringed Orchid

Loss of prairie reduced habitat available to this orchid regionally. Fragmentation of habitat may have affected the local availability of the orchid's pollinator, a hawk moth (primarily *Sphinx drupiferarum*), also. Fertile capsules produce thousands of microscopic, wind-dispersed seeds, and seed germination requires inoculation by a particular mycorrhizal fungus. This makes localized prairie conditions critical to species persistence. The western prairie fringed orchid protocol used abundance of reproductive individuals as an indication of species status at PIPE. Changes in abundance and distribution of flowering individuals in the context of changes to habitat provide population trend information. Experts agreed that distribution of non-flowering and flowering plants would best indicate overall species conditions, but several studies completed early in the Prairie Cluster monitoring (John Boetsch, unpublished) found that discovering non-flowering plants resulted in trampling damage to the plants.

Park and MWR personnel initially completed surveys in the short seasonal window, while orchids bloomed each year. From 1993 to 1995, the monitors used a hand compass and a meter tape to document locations of flowers. In 1996, the Prairie Cluster and the USGS-BRD took over monitoring and used a Total Station®, electronic transit with electronic distance meter, to determine

plant locations. The USGS-BRD published the first protocol in 2000 (Willson 2000), and the Prairie Cluster used it until 2006. By 2001, the Prairie Cluster had started collecting locations with GPS units, but the GPS units varied in their levels of accuracy. The variable accuracy from prior methods and divergence from early methodology did not reduce the effectiveness in achieving the principal objective, to track population distribution over time.

In 2002, the Prairie Cluster established a spatial search area and created an Access[®] database to store western prairie fringed orchid records. In 2005, staff initiated seed capsule monitoring and added height to inflorescence to the protocol. The GIS specialist, Jennifer Haack-Gaynor, designed a geodatabase in 2006 to house all the spatial records for the orchid project. The HTLN added vegetation profile and continuous soil moisture sampling to the protocol in 2007. These several changes in procedures and new WASO guidelines resulted in the release of a slightly updated protocol revision to the Willson (2000) version (Young, et al. 2007a).

In the same year, staff at PIPE found a single orchid in a non-monitored area, where a biologist had reported an orchid sighting in 1984. After monitors observed a record number of orchids in 2011, HTLN staff enlarged the main search area, and included the area where orchids occurred in 2006. In 2012, the new search area became part of the monitoring methodology. The GIS specialist developed much of the new database to store all data, including the new measures associated with the project (population size, capsule condition, vegetation profile, and soil moisture), and ancillary environmental data acquired from other sources (air temperature, precipitation, and fire data).

Missouri Bladderpod

The NPS conducted a comprehensive study, consisting of several small studies, of Missouri bladderpod at WICR from 1987-1990 (Thomas and Jackson 1990). From 1988-1997, monitoring of Missouri bladderpod occurred at Bloody Hill Glade using a stratified random design. In addition, a study addressed concerns of impact from the surveys

on the plants (Thomas and Willson 1992).

The Northern Prairie Science Center, USGS, entered into a Cooperative Agreement with the NPS in 1995 to develop a Missouri bladderpod monitoring protocol (Kelrick 2001). This protocol examined annual changes in abundance of plants within the context of habitat and environmental factors to determine long-term trends in abundance and population persistence. The protocol actually consisted of two protocols: a grid-based population census protocol (referred to as a GIS survey) and a demographic monitoring protocol. Kelrick implemented the GIS survey in 1997 and 1998 under the Cooperative Agreement for the protocol. Since that time, HTLN staff has improved upon sampling methodology over time to achieve the best design that indicates population trends, while remaining within the constraints of the project. Staff implemented adaptive sampling as a possible alternative to the GIS survey from 1999-2005.

A demographic study conducted from 1991 through 1992 at Bloody Hill Glade (Thomas 1996) became the basis of subsequent demographic monitoring. Kelrick also had conducted demographic monitoring in 1996/1997 and 1997/1998. These data are not in a database, and discerning the data on data sheets is now difficult. Staff attempted to implement demographic monitoring again in 2000. They never wrote a permanent report on the demographic work and discontinued the demographic measurements because of concerns about impacts from sampling on individual plants and the time-intensive nature of the measurements. These demographic data remain linked to their methodology for analysis and interpretation purposes, but they do not reside in a long-term storage format.

The HTLN began implementing the GIS-based survey for Missouri bladderpod as the program standard in 2005. The HTLN botanist, Craig Young, expanded this grid-based approach to other glades in the park using virtual grids consisting of 15-meter-by-15-meter cells and stratified random cells. These other sampling sites included Manley Woods, Walnut, North Bloody Hill, North-

west Bloody Hill, Terrell Creek, and Wire Road glades. The HTLN published a revised protocol in 2008 (Young, et al. 2008). The habitat-data collection has changed significantly over the history of Missouri bladderpod monitoring, becoming less and less subjective over the years. Missouri bladderpod monitoring has led to three published papers: (1) a comparison of various sampling designs using simulation (Morrison, et al. 2008), (2) an overview of the grid-based sampling method (Young, et al. 2008b), and (3) a habitat analysis (Young, et al. 2009). Assessments of population size and habitat for the Bloody Hill Glade resulted in two technical reports (Cribbs, et al. 2007; Young, et al. 2006).

Weather Conditions

A protocol related weather and local climate conditions to population dynamics of western prairie fringed orchid at PIPE and Missouri bladderpod at WICR (Akyuz and Guinan 2000). Investigators believed that climate and physical site conditions affected plant survival and fecundity. Therefore, continuous weather monitoring could be a key to factoring out natural variables from the effects of management on rare grassland species. Akyuz and Guinan ran models examining the impacts of environmental factors on species abundance for each species. They intended to provide a protocol and data to predict the population dynamics of the two species and account for annual variation in plant-community composition, based on yearly climate fluctuations, but the models did not show any significant relationships.

Willson et al. (2006) attempted to determine how precipitation during various phenological stages affected numbers of flowering western prairie fringed orchid at PIPE. They also made management recommendations for prescribed fires based on the results. The HTLN quantitative ecologist and rare-plant staff reevaluated the dataset on 20 years of data, using an information theoretic, multi-model inference approach (Morrison, et al. 2014). This dataset and technique revealed

different results than those obtained by Willson et al. (2006), and different inferences as to the optimal time for prescribed fire.

Invasive Plant Species

The Heartland Network completed an inventory of plants within natural areas of the 12 parks.³⁰ Network staff began preliminary work on an invasive-plant monitoring protocol by 2002. The Heartland Network began pilot sampling at PERI and CUVA in 2004/2005. They tested methods including random sampling, stratified random sampling with stratification based on distance from roads, and basic mapping methods. Additionally, the Heartland Network created and maintains a watch list of those species known to exist in the region or to have a potential to become problematic.

Early in 2007, the USGS-NPS published a draft of the HTLN protocol (Young and Shrader) in a compendium entitled Early Detection of Invasive Plants: A Handbook. The Heartland Network designed this protocol to maximize detection of invasive plants, while still obtaining reasonable estimates of abundance. Staff used two methods, (1) recording invasive-plant species and cover within belt transects through delineated search units, or (2) recording invasive-plant species and cover along contiguous 200-meter or 400-meter belt transects. Staff mapped reference frames for each park using GIS.

A summary of multiple invasive-plant lists provided the basis for a list of plants targeted for management action. The HTLN used contractors extensively to expedite the first round of monitoring (see Appendix 3). The HTLN let the first contract to implement the draft protocol in 2006 for work at ARPO, GWCA, HOME, LIBO, TAPR, and WICR. Network staff used data for “small parks” (<300 acres) collected in 2006 for a Park Science publication in autumn 2007. The protocol required the survey of each of 12 parks every five years. In subsequent years, staff reduced this return interval to four years to match the return intervals for other vegeta-

³⁰ Invasive plant inventories were completed by Michael H. Williams and others. Williams consolidated invasive species findings with other inventory information into one summary report for each park. Reports may be found in the Natural Resource Technical Report series, NPS/HTLN/NRTR 2009, report numbers 230, 233, 246, 248, 249, 254-262.

tion and wildlife habitat monitoring.

The original protocol did not include BUFF, HOSP, and OZAR. The invasive-plant project staff created a separate monitoring approach along roads for HOSP, because of the park's rugged topography. They also conducted two off-protocol monitoring projects at Big Springs in 2009 and Powder Mill Natural Area in 2011 in OZAR.

Wetland Monitoring

An early study (Davey Resource Group 2001) identified 1200 wetlands at CUVA. This inventory included establishing a geo-database with locations of each wetland.

Cuyahoga Valley National Park funded University of Akron to identify indicators of wetland ecosystem health (Fraser 2004). The project set a goal to define ecological properties for the evaluation, management, and restoration of inland freshwater wetlands in CUVA. Monitoring questions revolved around indicators of wetland integrity and threats to wetlands. The Vital Sign selection process established wetland plant communities as a priority, but also acknowledged the significance of physical aspects of wetlands (nutrients, water chemistry, and hydrological fluctuations) that affected wetland plant communities. Wetland Vital Signs moved from the Aquatic Theme to the Vegetation Program Area during Phase 3 of network planning.

The draft wetland monitoring protocol (Fraser 2004) received peer-review comments from CUVA and HTLN staff in 2007. A student in the Student Career Experience Program, Sonia Bingham, began revising the protocol, basing it on the Ohio Environmental Protection Agency's Vegetation Index of Biotic Integrity in 2007. The HTLN staff began preparations for research and fieldwork in 2008, and began developing Standard Operating Procedures in 2009. The HTLN hired Bingham to implement the draft protocol in selected wetlands as a pilot-test of these methods in 2011. Bingham engaged NPS volunteers from the CUVA citizen scientist program to make water-depth measurements at several sites. Databases are currently under development.

2.3.2 Wildlife Program Area

The Prairie Cluster emphasized prairie related wildlife issues. The HTLN contains several additional habitat types and wildlife issues, beyond those within prairies. Breeding birds remained an important Vital Sign carried from the Prairie Cluster and maintained to the present. During this period, the same wildlife biologist, David Peitz, has overseen the bird and mammal projects.

Rare Species

The Prairie Cluster and the USGS-BRD monitored black-tailed prairie dogs (*Cynomys ludovicianus*) jointly in one colony at SCBL, called Main Colony, between 1995 and 1999, using a protocol eventually published in 2001 (Plumb, et al.). This protocol looked at changes in abundance and colony size over time. It used not only counts of animals, but also observations of grazing areas and active burrows, contributing to an assessment of habitat. In 2000, the Prairie Cluster took over exclusive monitoring of Main Colony. The Prairie Cluster used the methodologies developed by the USGS-BRD throughout all monitoring. In 2002, a colony (North Colony) developed across the canal road from Main Colony, and a third colony (Saddle Rock Colony) developed on the east side of the monument. During a review of the monitoring, questions arose considering the efficacy of monitoring only one colony, when colonies show strong connectivity. Therefore, the Prairie Cluster started monitoring both of the new colonies in 2003. Sometime between 2007 and 2008, Saddle Rock Colony went extinct leaving North and Main Colonies for monitoring. The quantitative ecologist, Lloyd Morrison, reviewed the monitoring protocol to determine if population estimates could improve in precision. He determined that given the variability in published studies, investigators could not increase precision of estimates without increasing intensity of fieldwork (Morrison 2004).

Monitoring continued until the project transferred to the NGPN in 2010. Several reports (annual reports 1999 through 2005; Hummel, et al. 2006; Peitz and Cribbs 2007 and 2008, and Morrison, et al. 2010), a conference proceeding (Peitz and Cribbs 2006),

and a peer-reviewed publication (Morrison and Peitz 2011) resulted from over a decade of monitoring.

Bird Protocol

Grassland birds could indicate prairie condition and ecological status under some conditions (Thomas, et al. 2001). Long-term monitoring eventually would indicate trends in conditions within the prairies, assuming that the prairies provided adequate habitat to support populations of grassland-obligate birds. A USGS bird survey of several Mid-western parks in 1998 and 1999 determined that TAPR and AGFO were of sufficient size to support breeding birds, where the other Prairie Cluster parks were too small to support grassland-obligate bird breeding. Within these parks, vegetative structure, composition, and fragmentation affected the grassland-obligate community. The effects of fire suppression and adjacent pesticide use could also affect grassland birds. The Prairie Cluster began developing a protocol in 2000 and began breeding-bird surveys at TAPR and AGFO in 2001. The Prairie Cluster wildlife biologist used preliminary data and early literature research to draft a breeding-bird monitoring protocol for these parks (Peitz, et al. 2004). This protocol became the standard for future monitoring protocols in the I&M Program. The Wildlife Society Bulletin published a paper (Oakley, et al. 2003), providing guidelines for monitoring protocols, referenced Peitz's work as a good model for a protocol that included all key elements.

Several Heartland Network grassland parks wished to monitor birds as well. The wildlife biologist added three parks of the Heartland Network (HEHO, HOCU, and TAPR) to breeding-bird monitoring in 2005 (De-Backer, et al. 2005). Unfortunately, several parks had to place breeding-bird monitoring at a lower priority than other resource issues during the Vital Sign selection process, but they still had a concern for bird populations within their parks. This led the wildlife biologist to develop a plan to add parks, including prototype parks, to the project, and maintain a schedule for long-term monitoring by the HTLN staff at those parks. Adding parks to the breeding-bird sampling covered the needs of more parks, while decreasing

the sampling intensity at each park. The Board considered the pros and cons of the change, including the potential for missing rare birds with the reduced survey intensity. Parks offered the possibility that volunteers might report bird observations in the interim years. The Board encouraged the HTLN and parks to locate experienced bird watchers to contribute to the project as volunteers.

In 2007, the Board approved that HTLN staff could start monitoring birds on a schedule of once every four years. The wildlife biologist developed a field-methods guide and a bird-identification guide for park volunteers. The HTLN includes the volunteers' data in the database. Consistent, dependable, and knowledgeable volunteers proved to be available at most parks. Every fourth year, sampling by professional staff would test QA/QC of the volunteers' field techniques. The wildlife biologist found the volunteers' data to be consistent with survey data collected by the professional staff. The wildlife biologist completed a new protocol reflecting the addition of parks to the surveys (Peitz, et al. 2008). Additionally, a change to the habitat sampling improved the quality of the data and allowed an increase the number of sample sites.

The local birding community became critical to the surveys in interim years, stepping up to supplement the HTLN surveys. Volunteers sampled birds at HEHO, HOCU, and TAPR in 2008 signaling the start of the volunteer monitoring program. In 2013, volunteers and/or HTLN staff monitored breeding birds at all 11 parks for the first time. Prior to this, volunteers or park staff had completed annual surveys only on about 80% of the parks.

Whitetail Deer

Four parks (ARPO, LIBO, PERI, and WICR) identified whitetail deer as a problem within their boundaries. High deer populations contribute to over-browsing of vegetation, resulting in adverse impacts to plant communities. The Heartland Network developed a protocol to determine status and trends in white-tailed deer populations within ARPO, PERI, and WICR, and initiated sampling in winter of 2005. The protocol did not cover

LIBO, principally because the park's small size meant that it could not contain its own population of deer, but rather shared deer populations with surrounding landscape. Later that year, hemorrhagic disease significantly reduced deer abundance at both PERI and WICR, and possibly affected deer abundance at ARPO. This change in deer numbers proved a good test of protocol efficacy. Using preliminary data and literature search, Heartland Network developed a final protocol in 2007 (Peitz, et al. 2007). The protocol produces an index of deer density from spot-light surveys conducted from park roads to ensure safety. The non-random route, however, limits the statistical inference of the data.

The wildlife biologist initially reported data in NRTR report series. By 2009, the Heartland Network determined this vehicle of reporting to be less effective than reporting through imagery. The wildlife biologist and data managers devised a platform for reporting data using interactive PDF (Portable Document Format), providing a spatial report of where deer occurred and in what numbers. In 2011, in an effort to explore the relationship between the index of deer density and true deer density, a graduate student working with the National Capital Region I&M Program analyzed the HTLN data and determined that habitat near each survey route was similar to the habitat throughout the parks. In winter of 2012-2013, the HTLN launched an infrared-triggered camera study in conjunction with the spotlight surveys conducted at WICR. This project, assisted by students from the College of the Ozarks, estimated deer density from randomly distributed cameras. This allowed the wildlife biologist to compare the spotlight survey results to the randomly located camera survey results. The study continued into the 2013-2014 sampling year.

2.3.3 Aquatic Program Area

The Aquatic Program Area includes integrated monitoring of aquatic communities in the context of habitat conditions. Aquatic-community composition serves as a long-term indicator of biological integrity of a stream. Where instantaneous water quality tests provide a snapshot of habitat conditions,

biological composition shows how those conditions support the communities within the water. This program area has grown since its inception as a project to monitor Topeka shiners and aquatic invertebrate communities in a few small prairie streams. It has become a set of monitoring projects uniquely tailored to fit the needs of the parks with springs, small streams, pristine rivers, and impaired water bodies.

Before the beginning of the Prairie Cluster, the WRD arranged aquatic invertebrate sampling in 1988 under a Cooperative Agreement between the NPS and Boris Kondratieff of Colorado State University (CSU). An unpublished manual (Boyle, et al. 1990) became the initial strategy for sampling streams in prairie parks. Harris, et al. (1991) compiled a report that summarized the first two years of inventory data, collected using the Boyle, et al. (1990) guidance, from six parks (WICR, PIPE, AGFO, HOME, HEHO, and GWCA). James T. Peterson, USGS, published a protocol (Peterson 1996), using data dating back to 1988. Peterson collected stream invertebrates at GWCA, using methods similar to those described in the Peterson (1996) guidance, but GWCA had no further monitoring after that study.

In 1999, Peterson completed the official "macroinvertebrate biomonitoring protocol," drawing heavily on his 1996 results (Peterson, et al. 1999). Although sampling using this protocol first occurred in 1988, Peterson (1996) considered 1989 as the "baseline" year, because it was the first year with "reasonably thorough sampling" (Peterson, et al. 1999, p. 2). The protocol analyzed aquatic invertebrate community composition as an indicator of change in water quality that affected aquatic habitat. This indirect assessment compared the numbers of species intolerant of disturbance versus those tolerant of disturbance within the watershed.

Small Stream Communities

The Prairie Cluster wildlife biologist, David Peitz, used the Peterson protocol (Peterson, et al. 1999) to implement monitoring for aquatic invertebrates, and relied on park staff and volunteers for fieldwork and sample collection in four prairie parks (WICR, PIPE,

AGFO, and HOME). Charles Rabeni's lab at the University of Missouri-Columbia processed and identified benthic samples for the Prairie Cluster until 2005. Aquatic invertebrate monitoring required several protocols to address differing aquatic conditions for biomonitoring at the respective parks. The Prairie Cluster developed a draft stream habitat and riparian assessment protocol for prairie streams, but they did not publish this protocol. Habitat and riparian conditions to be measured included water depth, current velocity, point discharge, substrate size, woody debris, canopy coverage, bank vegetation cover, presence of grazing damage, bank height and slope, water clarity and chemistry, and cross-section and channel profiles. The data manager, Gareth Rowell, and wildlife biologist developed a database for this protocol, completed in March 2003. Larissa Bailey of the Patuxent Wildlife Research Center, USGS, provided short-term statistical analysis and advice aimed at refining the prairie, aquatic invertebrate protocol (Peterson, et al. 1999) for use by the Prairie Cluster and Heartland Network (unpublished report and e-mail communications).

The Prairie Cluster wildlife biologist also initiated annual fish monitoring at PIPE and TAPR in 2001. Although focused on Topeka shiner populations, the protocol required sampling the entire fish community to assess Topeka shiner occurrence and distribution. The Prairie Cluster reviewed the methodology and recommended expanding the protocol to address general fish-community structure in prairie streams.

With the hiring of the Aquatic Program Area leader (David Bowles) in late 2004, the Prairie Cluster aquatic monitoring and Heartland Network aquatic monitoring unified as one program area. By June of 2005, supervision of invertebrate monitoring in Prairie Cluster parks transferred to the Aquatic Program Area leader. The Prairie Cluster wildlife biologist and Aquatic Program Area leader conducted a site visit to GWCA and determined conditions warranted resuming aquatic monitoring at that park. Monitoring resumed in June 2005 at GWCA following the Peterson, et al. (1999) protocol. The hiring of a fisheries biologist, Hope Dodd,

within the Aquatic Program Area furthered the new organization and unification of Prairie Cluster aquatic projects with HTLN activities.

The parks outside of the Ozark Highland Rivers and Prairie Cluster aquatic monitoring (EFMO, HEHO, HOSP, and PERI) had no long-term monitoring planned at this time. In 2006, the Aquatic Program Area leader and the quantitative ecologist proposed (Bowles and Morrison 2006) reducing invertebrate sampling within prairie stream parks (HOME, PIPE, and TAPR) to a single, annual event and modifying site selection, sample number, and spacing at AGFO, HOME, PIPE, and WICR. The proposal also added GWCA to the parks sampled. The HTLN staff implemented these changes after approval, during the 2006 field season.

The next modification derived from a proposal (Bowles, et al. 2007) to increase monitoring capabilities for aquatic resources at other parks. The Aquatic Program leader, fisheries biologist, and HTLN coordinator proposed to modify the Vital Sign aquatic protocols to allow monitoring of aquatic communities (invertebrates and fish) and their habitats in nine parks with small streams (EFMO, GWCA, HEHO, HOME, HOSP, PERI, PIPE, TAPR, WICR), while reducing fish sampling at PIPE, TAPR, and HOME (AGFO transferred to NGPN in 2009). This proposal suggested modest modifications to methodology as well. This proposal improved quality of effort for collections at parks with monitoring, added invertebrate monitoring to TAPR, and added invertebrate and fish monitoring to parks with small streams. The Prairie Cluster parks agreed to the recommended reduction in sampling at their parks. The Board approved these changes and modifications, and the HTLN staff implemented the changes in 2007. The HTLN could still perform trend analysis for parks, where protocol changes occurred, with the data collected under previous protocol versions.

Based on these approved proposals, the Aquatic Program Area staff developed in-house protocols for aquatic invertebrate monitoring (Bowles, et al. 2008a) and fish

community monitoring (Dodd, et al. 2008) in small streams. The fish protocol incorporated a modified version of the prairie stream protocol developed by Peitz and Rowell (2004) for sampling HOME, PIPE, and TAPR and added NAWQA protocols for sampling other small stream parks.

Completion of the small streams protocols in 2008 marked the point at which all of the Aquatic Program Area's protocols were written or revised (Bowles, et al. 2008a, Bowles, et al. 2008b, Bowles, et al. 2008c, Dodd, et al. 2008, Peterson, et al. 2008, Schmitt, et al. 2008). The Board acknowledged the demands placed upon the aquatic staff in their 2008 Annual Meeting. The protocol preparation, the number of projects and coordination with cooperators and contractors, the backlog in sample processing, and the pilot sampling at BUFF and OZAR contributed to a strain on the staff as they continued regular fieldwork. Accordingly, the HTLN hired Student Conservation Association (SCA) interns and seasonal employees to assist staff. The Aquatic Program Area also took other measures within BUFF and OZAR monitoring projects to make those projects sustainable. In addition, the fisheries biologist proposed modifications to the revisit design for TAPR and PIPE (Dodd 2010), changing these parks from an annual revisit schedule to a three-year rotation in 2010. The TAPR and PIPE resource staff agreed to the change.

Ozark Highland Rivers Biological Integrity

Early work of the Aquatic Workgroup focused on the Ozark Highland Rivers (Mott 2000). Both NPS and external researchers have conducted many studies over the years at BUFF and OZAR. Mathis (2000) proposed a bioassessment methodology, using stream invertebrates, designed specifically for the Buffalo River. The USGS had engaged in early fish inventory work at Ozark Highland parks from 2001 through 2003 (Justus and Petersen 2005a, Justus and Petersen 2005b, Petersen and Justus 2005a, Petersen and Justus 2005b, Petersen and Justus 2005c), which helped develop a baseline for fish community studies. Additionally, both BUFF and OZAR had concerns for rare species, such as native mussels and Ozark

hellbenders. After consideration, stream integrity assessment seemed to be the most effective way to address the many concerns associated with these two river systems and their outstanding aquatic resources. Therefore, the development of protocols for river monitoring at BUFF and OZAR developed apart from the small stream and spring protocols. Focusing on ecological integrity in protocol development would facilitate long-term monitoring of the river systems.

In May of 2004, an Interagency Agreement with James C. Petersen of the USGS began the development of a fish monitoring protocol for BUFF and OZAR, based on the NAWQA protocol. The Heartland Network convened a workshop of biologists, statisticians, and administrators to discuss sample design for ecological monitoring of the Buffalo River (at BUFF) and Current and Jack's Fork rivers (at OZAR), July 13-14, 2004. The workshop participants identified specific elements of a spatial and temporal survey design for river ecosystems that unified ongoing monitoring protocol development efforts and future data collection. The overall survey design would promote efficiency in implementation while accommodating the unique biological, logistical, and statistical sampling considerations of each monitoring project. The workshop participants identified elements of a spatial and temporal survey design targeting multiple ecological resources within the river ecosystems.

Based on the workshop, Trent McDonald of West, Inc. proposed sampling and site selection guidance in a document, titled *Ecological Survey Recommendations for the Buffalo National River and Ozark National Scenic Riverways Parks* in October of the same year. McDonald suggested using Generalized Random Tessellation Stratified sampling (GRTS), a process that supports selection of random but spatially balanced sampling sites within a study area. This would allow the parks to make inferences to the entire park based on sample data.

Discussions continued in November 2004 with a meeting held at WICR about aquatic invertebrate protocol development and monitoring at BUFF and OZAR. The HTLN

coordinator (Michael DeBacker), newly hired Aquatic Program Area leader, BUFF hydrologic technician (Faron Usrey³), and HTLN aquatic ecologist (Jessica Luraas) determined that McDonald's recommendations would result in a protocol that answered the principal monitoring questions. The workgroup submitted a proposal, suggesting that the HTLN aquatic ecologist and BUFF hydrologic technician develop an aquatic invertebrate protocol, based on McDonald's recommendations (Luraas and Ursey 2004). During the winter of 2004-2005, the Aquatic program Leader observed BUFF staff conducting a water quality study of the Buffalo River in order to fine-tune protocol recommendations. The HTLN fisheries biologist joined the effort in 2005, and helped to direct the fish community protocol towards addressing ecological integrity in pristine waters with high fish diversity.

The HTLN employed a GRTS computer program to establish sampling sites for aquatic monitoring projects at BUFF and OZAR in summer of 2005. Pilot monitoring on main-stem, river sites began in October 2005, but a drought in the Buffalo River watershed necessitated postponing BUFF fish sampling until May of 2006. Fish sampling occurred at OZAR in October and November of 2005 and invertebrate sampling occurred in January 2006. Successes on the main stem of each river permitted establishment of GRTS sites on tributaries for BUFF and OZAR.

The Aquatic Program Area staff developed the final aquatic invertebrate protocol (Bowles, et al. 2008), based on the preliminary work from Luraas and Usrey (2004) and GRTS site selection with the assistance of several other staff members. Coinciding with finalizing the aquatic invertebrate protocol, James C. Petersen of the USGS worked with the HTLN fisheries biologist and database managers, Rowell and Williams, to finalize a protocol from the USGS open file report originally submitted in 2006, resulting in the final fish-community monitoring protocol (Petersen, et al. 2008).

In a memo to superintendents for OZAR (Reid Detring³) and BUFF (Kevin Cheri)

dated May 10, 2010, the HTLN coordinator called for the establishment of an ad-hoc committee of park natural resource managers and HTLN staff to deliberate the merits of various approaches to scaling back the monitoring at Ozark river parks to a sustainable level. The ad hoc committee held the first of several meetings at WICR on February 17, 2011. Staff halted invertebrate and fish fieldwork at BUFF and OZAR for one year to allow the committee time to make recommendations for sampling and protocol revisions, and to allow the Aquatic Program Area to catch up on sample processing, analyses, and reporting. The ad hoc committee made its recommendations, and BUFF and OZAR staff reviewed its report and sampling revisions (DeBacker, et al. 2012). The HTLN staff implemented these revisions during the Fall/Winter 2012 field season.

Rare Species

The Prairie Cluster implemented its first fish sampling at PIPE and TAPR by 2001 with a final protocol published in 2004 (Peitz and Rowell 2004). This monitoring focused on assessing the annual status and long-term trends of Topeka shiner populations in headwater streams, where biologists expected them to occur. It also determined long-term trends in Topeka shiner populations and examined the condition of habitat. The wildlife biologist felt that habitat, analyzed in conjunction with management actions, might explain how those actions affect the Topeka shiner or their habitat. The Prairie Cluster then expanded fish monitoring to HOME using Peitz and Rowell (2004) to determine if Topeka shiners were present in that park. Rare species analysis became a portion of the full fish community protocol in 2008 (Dodd, et al. 2008) and the Peitz and Rowell (2004) no longer served as a stand-alone protocol.

Ozark National Scenic Riverways had collaborated with experts on Ozark hellbender (*Cryptobranchus alleganiensis bishopi*) to develop a monitoring program within the park. Park managers required population information to understand trends in abundance and distribution of Ozark hellbender within waters managed by the park. In 2004, Chris Phillips, Illinois Natural History Survey, entered into a Cooperative Agreement with

the HTLN to develop a protocol for Ozark hellbender at OZAR. Phillips and HTLN staff completed a draft protocol for formal peer review by December 2006. The Technical Committee reported to the Board that the scope of the protocol lay beyond the HTLN capabilities to implement. The review panel at the August 2008 Annual Meeting concurred, and the protocol was not published or implemented. The HTLN sent the draft protocol and peer reviews to Jeff Briggler, Missouri Department of Conservation, for his consideration and further action.

Spring Communities

The HTLN hoped to modify the Cooperative Agreement with Kansas University so that the Central Plains Center for Bioassessment would lead an effort to develop invertebrate protocol for Ozark springs. This modification did not occur. The workgroup subsequently chose Charles Rabeni, University of Missouri, an expert on Ozark stream and spring ecology, to develop the protocol. Charles Rabeni developed a unique protocol for examining aquatic invertebrate communities within large springs at OZAR. The Aquatic Program Area staff revised and rewrote the protocol to add monitoring of fish, aquatic vegetation, habitat (in stream and riparian), and water quality. The revision also ensured that efforts fit capabilities of the HTLN and that the results retained statistical power (Bowles, et al. 2008). Annual monitoring of vegetation, invertebrates, fish, and habitat at six OZAR springs began in July 2007. In 2011, the HTLN added Phillips Spring to the OZAR spring-monitoring project (as requested by OZAR) and reduced overall aquatic invertebrate sampling (DeBacker et al. 2012), based on recommendations of an ad-hoc committee of BUFF, OZAR, and HTLN staff. Staff sampled Phillips Spring for the first time in July 2011 and implemented revisions to aquatic invertebrate sampling in July 2012.

Elemental Contaminants

The Ozark Highland of Missouri supports the largest lead-zinc mining district in the world. Mines and potentially exploitable deposits are located near OZAR and BUFF, including within the groundwater recharge

area of Big Spring. Big Spring is an important feature within OZAR that contributes substantially to flows in the Current River. Experts have linked mining to lead levels higher than ambient amounts in the environment.

The HTLN went to the USGS for a protocol to assess environmental lead levels in the streams of OZAR. A two year, Interagency Agreement with Chris Schmitt, Columbia Environmental Research Center, USGS, to draft, test, and provide final monitoring protocol for metals in aquatic invertebrates at OZAR resulted. The protocol consisted of measuring the concentrations of cadmium, cobalt, lead, nickel, and zinc in composite samples of crayfish (*Orconectes luteus* or alternate species) and Asian clam (*Corbicula fluminea*). The USGS completed the final protocol in 2008 (Schmitt, et al. 2008). In the summer of 2010, HTLN aquatic staff implemented the contaminants protocol at BUFF mainstem GRTS sites and Rush Creek using Asian clam and crayfish (*Orconectes neglectus* and *Orconectes longidigitus*). The HTLN intended to sample contaminant metals at OZAR every five years, but canceled the 2013 sampling due to funding issues. Future sampling is still likely.

Fluvial Geomorphology

Several parks named fluvial geomorphology as a resource issue. Fluvial processes affected focal resource conditions, particularly conditions for rare Unioid mussels and the Ozark hellbender. In September 2003, Robert Pavlowski, Missouri State University (MSU), entered into a Cooperative Agreement with the HTLN to develop a geomorphology protocol for OZAR and BUFF, due November 2004. Pavlowski submitted a protocol in July 2007, but the Technical Committee reported to the Board that the protocol was beyond the capabilities of HTLN staff to implement. Further work on the protocol discontinued.

Although several parks had great concerns about geomorphology and flow regimes in small streams, the Aquatic Workgroup neglected selecting indicators of those characteristics. This may have been because of the I&M Program emphasis on biological aspects of aquatic systems and the need to pare-down indicators for Vital Signs. After

the Aquatic Program Area became operational, the Technical Committee with the Board's approval suggested incorporating simple measures of parameters associated with geomorphology into aquatic habitat monitoring for all parks with aquatic resource monitoring.

2.3.4 Landscape Program Area

The lack of baseline GIS imagery, as the Prairie Cluster began considering ecological stressors, made looking at the broad-scope influences on park resources difficult. Therefore, efforts to fill these gaps began. The data manager, Brian Witcher, designed a land-use monitoring project for three of the six Prairie Cluster parks (EFMO, PIPE, and WICR)³¹. The Prairie Cluster acquired aerial photography (Digital Orthophoto Quarter Quadrangles [DOQQ]) for these parks from the 1940s, 1960s, and 1990s. Between 2001 and 2004, a contractor classified vegetation, based on the National Vegetation Classification Standard (NVCS). They used a post-classification, change-detection algorithm to analyze changes among DOQQs from the three historical periods (Narumalani, et al. 2004). This project assessed loss of natural vegetation, and it described human population pressures on park ecosystems. Specifically, the project identified invasive exotic species colonization sources, wildlife corridors, pressures from human development, and visual intrusions. It also considered habitat fragmentation effects on grassland birds and landscape effects on plant communities. The study also identified upstream pollution that could affect Topeka shiners and invertebrate communities.

Interest in external pressures on park resources continued beyond the three parks. Encroaching agricultural and urban development threatened many parks, particularly small parks in the Heartland Network. Parks wished to know the long-term trends in land-use change, the rate of change, and the potential impacts on park resources. The Land Use and Land Change Workshop of December 18, 2001 addressed landscape change analysis. Subject matter experts

provided background on land-cover change, forest stand dynamics, biological diversity, spatial analysis of change, and remote sensing. This helped to define what the Landscape Program Area used for the baseline analysis.

In 2002, the Heartland Network contracted for land-cover analysis in PERI, HEHO, LIBO, and HOSP, based on USGS National Land Cover Database and NVCS classifications. Instead of using DOQQs, the contractor used Landsat-5 imagery, dating from the mid-1980s. This technique proved to have too low resolution to be helpful, and it did not include a standard accuracy assessment. Additionally, Landsat-5 images were not recent enough to assess status, and the classification system did not accommodate the urbanized areas around parks.

The Heartland Network intended to develop a land-use and land-cover protocol for use at BUFF, EFMO, HOSP, LIBO, OZAR, PERI, PIPE, and WICR (DeBacker, et al. 2005, Supplemental Document 51). A Cooperative Agreement with Montana State University, a CESU member, resulted in an unpublished report in 2003 (Hansen and Gryskiewicz 2003). This document addressed land cover at BUFF, CUVA, HEHO, HOSP, LIBO, OZAR, and PERI, but did not address EFMO, PIPE, and WICR.

In 2004, Robert Weih (University of Arkansas, Monticello) began image classification, using SPOT-5 imagery to determine historical changes in land-use patterns at Hot Springs, Arkansas. Weih researched new methodologies and compared the differences between unsupervised, supervised, and object-based classifications based on different types of imagery. The best classification (object-based) produced had 82% accuracy. The project on image classification incurred problems with imagery capture and consistent availability of graduate students to do the work. Additionally, Weih became ill, requiring a reduction in the scale of the project.³² Weih's work supplied a few Standard Operating Procedures in 2009 that applied to

31 Written comments in meeting notes, Adams (2001a)

32 Robert Weih passed away during the course of the study.

protocol development.

A Servicewide effort to nationalize the land-use and land-cover methodologies interrupted the direction of landscape classification work, as well. The Servicewide effort originally suggested that networks would receive a standard protocol and operating procedures. The efforts never fully realized this goal, but instead resulted in NPScape database.

Network staff led by Jennifer Haack-Gaynor renewed efforts to develop the program area. They reviewed the use of USGS National Land Cover Database data for the parks and concluded that spatial resolution was insufficient for land cover classifications on the typically small (<10,000 acre) parks. The HTLN staff began conducting land cover work in-house, starting with HOCU and using some of the methodologies produced by Weih. Due to scale and cost, the NPS deemed some of Weih's methods impractical. In the end, the HTLN produced an 88% accurate, supervised classification for HOCU.

In 2010, the HTLN staff wrote a draft protocol, which applied to all its parks, based on past successes. The draft protocol went through peer review in 2012, and recommendations from the review led to changes in accuracy methods. The Landscape Program Area implemented the Land Cover Monitoring Protocol (Haack et al. 2014) in 2014.

2.3.5 Data Management Plan

The Prairie Cluster's first data manager, Don Catanzaro, began employment in September 1998 and remained for approximately one year. The data manager primarily focused on developing GIS capability and managing spatial data. By 2000, Prairie Cluster monitoring staff made thousands of observations about plant and animal populations, communities, and their environments annually. The Prairie Cluster botanist (Michael DeBacker) managed data in the interim, after the first data manager left and until a new data manager, Brian Witcher, began employment in April of 2000.

Data management ensures maintenance in

perpetuity of an accurate and complete record of observations. Specific data management objectives related to three themes: data management infrastructure, data integration and exploration, and long-term data integrity and security. The Prairie Cluster botanist and data manager drafted a data management plan to address those themes (DeBacker, et al. 2002). The draft plan defined the data management process, including:

- Entering data into the database system
- Development of incremental files
- Acquisition of external files
- Editing of logs to reconcile with field forms

The data management system included a built in validation process with limitations on values and cross checks of data. They did not develop web access initially. However, future development included data access through the Internet.

As the data management protocol evolved between 2001 and 2003, the Prairie Cluster allocated an estimated 2.45 FTEs of personnel time to data management activities, including data entry. A new data manager, Gareth Rowell, hired in January 2003, facilitated activities, but shared responsibilities for data management with project managers. While the data manager oversaw archiving, dissemination, database development, report automation, and overall QA/QC, the project managers took responsibility for data entry, validation, and verification, and for data summary, analysis, and reporting. Data facilities, located in Prairie Cluster offices at WICR, maintained connection by secured Internet to the MWR offices in Omaha.

The data management plan, implemented by the Prairie Cluster (DeBacker, et al. 2002), became the foundation for the published data management plan for the HTLN (Rowell, et al. 2004). It also set the groundwork for individual data protocols for each project within the network. A data management plan essentially establishes protocols that identify key data resources and processes to manage data, in this case for both inventory and long-term monitoring. Data management

procedures follow five steps: acquisition, verification, validation, analysis, and dissemination. The plan described the standardized file structure on the server, back-up strategies, monitoring databases, and data dissemination strategies.

The data manager worked extensively with WASO staff and data managers in other I&M networks to create standardized database design and the Natural Resource Database Template. The HTLN staff remained on the leading edge of data management within the I&M Program. They had developed databases for several monitoring projects, including the first Federal Geographic Data Committee compliant geospatial metadata for the grassland-bird database. The data management staff led the way in 2003 in integrating Access® databases with ArcGIS®, using location and events tables.

As the Heartland Network and Prairie Cluster merged, several actions demanded the data manager's time. The staff needed a new server to house data from both programs. A revised data management plan had to include all network activities, integrating ArcGIS® and Access® databases. Each program area within the HTLN required Standard Operating Procedures for data management and analysis.

While developing the basic structures for handling data, field scientists continued to collect data that required processing and archiving. The Landscape Program Area continued to acquire high-resolution orthophotography for all parks. By 2007, the data managers actively maintained core ArcGIS® and Access® databases for each of 12 program areas and projects. In 2008, more than a half-million data records resided in the monitoring databases and geodatabases maintained on the WICR-site server and the MSU-site server. The number of records increased by about 15%, annually, necessitating purchase of a new server for the WICR office in 2009. The addition of fire ecology to the program areas required development of new geodatabases and Access® databases, and the installation of the FFI Software for the Fire National Database System. By 2011, the number of databases managed had

increased to 20 databases and geodatabases with a record count exceeding 750,000.

Data management constantly evolves as the needs increase and technology improves. The HTLN has remained in the forefront of innovation within I&M Program. The data management section began to explore data visualization techniques that allowed staff to examine large, complex data sets in a schematic or graphical form. Ideally, this would convey information on trends and other analyses clearly and intuitively. They began experimenting with the large, community datasets (invertebrates and breeding birds) to convey species diversity indices. They also explored time series visualization with water-depth data from the wetlands project at CUVA.

The HTLN data management section proposed the use of a new monitoring database design, using a Microsoft SQL Server®, relational database management system. The SQL platform forms the foundation for cloud-based information and allows other software applications to store and retrieve information on a network. It supports data queries and provides an excellent platform for data visualization. The WASO database developers in Fort Collins are reviewing the proposal.

2.3.6 Data Summary and Analysis

Most statistical analysis techniques rely on null hypothesis significance testing, an approach that may work well for controlled laboratory experiments, but is inherently flawed for long-term ecological monitoring. The quantitative ecologist, Lloyd Morrison, explored numerous alternative methods of data analysis, considering methods that provide scientifically rigorous results, yet remain readily interpretable by resource managers, who may not have a background in statistics. This work led to the publication of two peer-reviewed papers (Morrison 2007 2008), which highlighted the advantages of parameter estimation and confidence intervals over significance testing (Morrison 2007), and the use of control charts to alert managers to potential problems with the resources monitored (Morrison 2008).

The HTLN has used ordination analyses, which allow for the two-dimensional visualization of multidimensional relationships of ecological communities, to provide graphical results for managers (e.g., DeBacker et al. 2012, Dodd and Morrison, in preparation). The quantitative ecologist also became involved in evaluating new protocol-specific

methodologies, including the most efficient sampling design for rare plant populations (Morrison et al. 2008), the use of digital photography in plant biomass estimation (Leis and Morrison 2011) and the optimal plot size for vegetation monitoring (DeBacker, et al. 2011).

3 Fine-tuning a Network

“Network staff are involved in numerous activities and functions, such as organizing and cataloging data; performing data analysis, synthesis, and modeling; and providing data and expertise to park planners. Network personnel are also occasionally called upon to provide data and expertise for resource assessments and resource stewardship strategies, and to contribute to performance reporting.”

- from website About the Inventory & Monitoring Program,

<http://science.nature.nps.gov/im/about.cfm> ³³

³³ Accessed January 7, 2014

3.1 Structure of the HTLN

Budgets remained separate for the Prairie Cluster and the Heartland Network for six years (Figure 2). The prototypes conducted a more comprehensive and more intensive level of monitoring than did the I&M Program networks. Prairie Cluster staff and parks retained responsibility for monitoring activities, budgeting, and reporting related to the prototype parks. Heartland Network staff, the Board of Directors, the Technical Committee, and parks oversaw monitoring activities, budgets, and reporting related to non-prototype monitoring. Funding sources dedicated to both prototype and parks (e.g., WRD monitoring funds) afforded the opportunity for all 15 parks to collaborate on those monitoring activities.

The separation of prototype and network created redundancies and inefficiencies. For example, the Heartland Network coordinator tracked her budget in Excel® and worked with the WICR administrative officer to reconcile accounts. The MWR I&M Program coordinator oversaw the Heartland Network coordinator's time and travel, but the WICR superintendent had a role in day-to-day personnel supervision. The Prairie Cluster coordinator and an administrative clerk oversaw program administration for the Prairie Cluster. The WICR administrative officer processed the Prairie Cluster coordinator's time, travel, and purchases. Such seemingly minor distinctions proved to divide the two entities into two unique camps (see Figure 3). Other stresses deepened the divide.

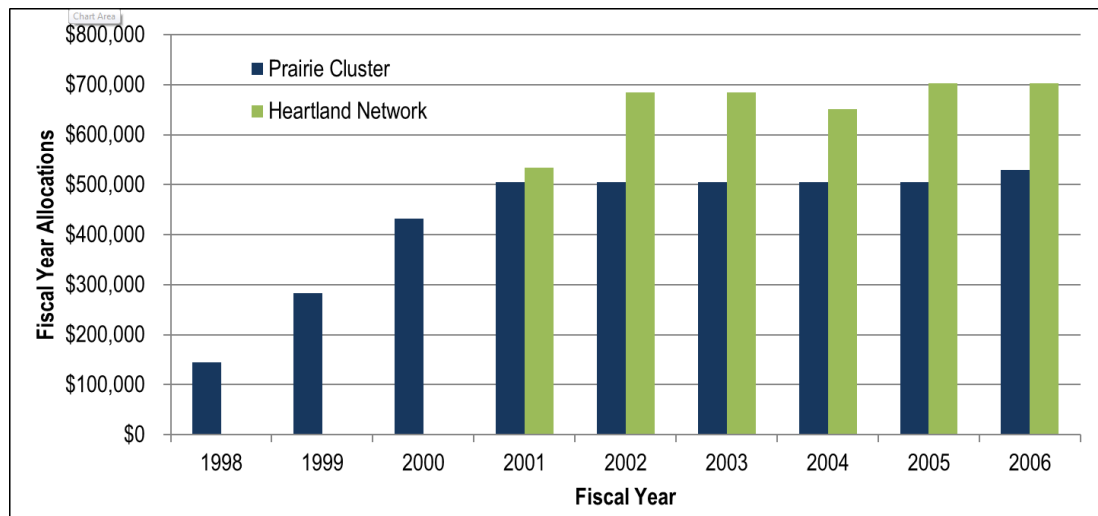
3.1.1 Integration

The long-term view of the prototype program had changed on the national level as the networks developed. Originally, the prototypes developed the protocols needed to give the networks a basis from which to start. They served all networks, Servicewide. Once networks neared operation, the view of the role of the prototypes changed to one of continuing research and development, and to mentoring network staff.

While having separate budgets, work plans, and lines of supervision, professional and collegial cooperation between the Prairie Cluster and the Heartland Network was necessary to ensure provision of services. The Heartland Network coordinator position became vacant in 2003, resulting in the need for oversight of the Heartland Network and provided an opportunity to merge the two programs into one streamlined, robust entity. Immediately prior to the Vital Sign Workshop in July 2003, a discussion with the I&M Program director introduced the subject of integration. A last minute alteration to the workshop agenda accommodated the preliminary discussion of potential integration of the program. The participants recognized the advantages of integration during the Heartland Network planning phase, and supported an organization composed of a single coordinator for the two programs.

In August of 2003, the MWR I&M Program coordinator called a special meeting of prototype park managers and superintendents, plus Heartland Network Board chair,

Figure 2. Comparison of budgets for the Prairie Cluster and the Heartland Network.



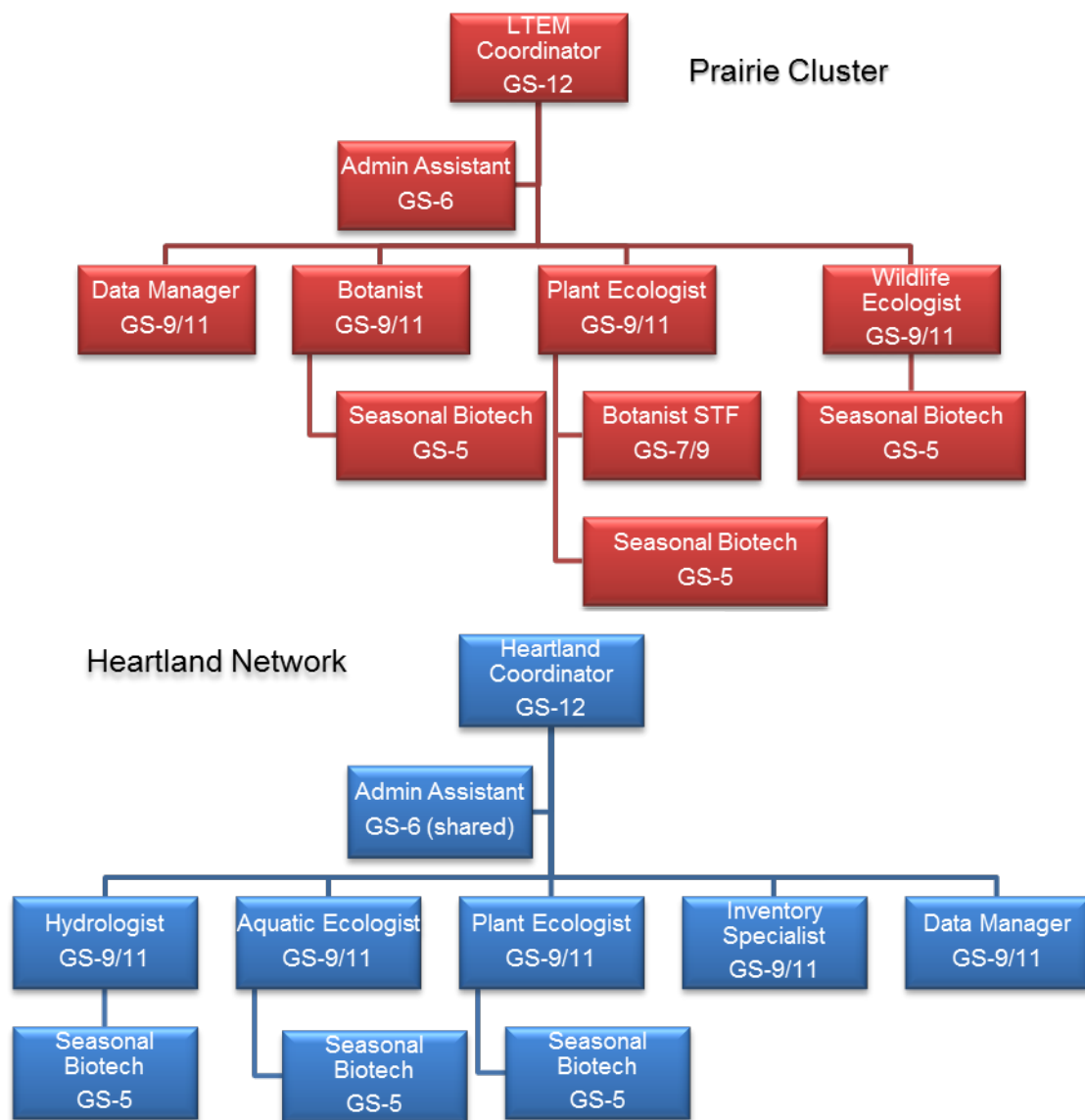


Figure 3. The staff structure for the two entities, the Heartland Network and the Prairie Cluster.

Dean Alexander, in Madison, Wisconsin to discuss the merits of integrating the Prairie Cluster and the Heartland Network. The acting Heartland Network coordinator carried the Technical Committee's preferences for integration to the meeting. At that meeting, the superintendents of Prairie Cluster parks agreed to integrate programs, and proposed a staffing plan. Immediately following the meeting, the Board chair initiated a conference call with the Board and they too voted to approve integration following the proposed staffing plan.

After considerable negotiation and reorganization, the Board approved an integration model (Appendix 4). It required minimizing redundancies, while staffing all program

areas appropriately. The integration led to sharing administration and data management resources. Integration proved advantageous to the Prairie Cluster, since budgets for the prototypes remained flat, while the I&M Program directed new increases toward the networks. The NPS accepted applications for the permanent HTLN coordinator position in 2004, and selected the individual for the position in July of that year. The acting Heartland Network coordinator, Michael DeBacker, became the HTLN coordinator and the integration of the program moved forward. The institutional merger required careful budget integration from several funding sources. Funding came from two principle sources, Vital Sign Monitoring funds

from the Challenge, and Prairie Cluster the LTEM Prototype budget. In addition, WRD contributed funding for water quality monitoring. Furthermore, FIREPRO provided funds for joint fire-effects monitoring in Great Plains parks. All funds came under the management of the HTLN coordinator under the oversight of the Board. The Heartland Network and Prairie Cluster officially integrated their operations in 2004. The HTLN would operate according to rules and procedures outlined in a Heartland Network Charter.

The emotional integration may have taken a little longer than physical integration. Some internal reluctance to integration remained, in part because of the high regard for and status of the Prairie Cluster, which had led the I&M Program in developing a successful program for a cluster of parks. The hesitancy to relinquish its good name became apparent in the naming of the integrated network. First, the unit called itself the *Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program*. Later the name changed to the *Heartland and Prairie Cluster Monitoring Network*. Finally, as the network built its own reputation for excellence, practicality made the unit take the name *Heartland I&M Network* (HTLN).

The new HTLN brought together prairie ecosystems and a host of new ecosystems. It spread across eight states, covering 757 latitudinal miles and 777 longitudinal miles. The HTLN contained not only prairie, but also several different forest types, wetlands, and aquatic systems.

Integration Steps

Revision of the Network Charter

The HTLN revised the Network Charter in 2004 to accommodate the merger of the Heartland Network and the Prairie Cluster. The new charter went beyond integrating the program to address a few other issues, including a staffing plan that had remained in negotiation for over a year. It also established the official abbreviation for the network as HTLN.

The charter explicitly recognized the role of Technical Committee members in reviewing the program every five years. The Technical Committee would continue as the primary source of information to the Board for evaluating the HTLN's effectiveness in meeting the parks' management needs.

Staffing

Early in Vital Sign Monitoring planning, the WASO organizers considered the minimum core staff for each network to include a full-time, permanent network coordinator and a permanent data manager. The Servicewide model established that network coordinators and Boards decided job series, grade, supervision, and duty stations of network personnel, reflecting local network needs and priorities. A monitoring program required professional-level staff to analyze and interpret data, prepare reports, and provide the information in a useable format to park managers, other scientists, and interested parties. The vision behind the Vital Sign Monitoring was to provide each network of parks with consistent annual funding and staff to develop a core, long-term program.

In 2003, the acting Heartland Network coordinator and Board concluded that they needed to hire several new positions. To this point, Heartland Network staff consisted of a coordinator, part time administrative assistant (shared with Prairie Cluster), data manager, term³⁴ inventory specialist (not to exceed four years), and an interim, part time aquatic ecologist (through agreement with HEHO). New positions went primarily to the Heartland Network, because of increases in budgets from the Challenge, but the HTLN also considered the Prairie Cluster personnel needs (Figure 4).

Program integration required shifting responsibilities between staff members. Whereas the Prairie Cluster staff included a few well-rounded biologists and ecologists, comfortable in a range of subjects, the HTLN would eventually have more staff and the capability for specialization. By January 2004, hiring had begun for the following positions:

³⁴ Term employment is temporary, not to exceed a year, but renewable up to three times for a total of four years.

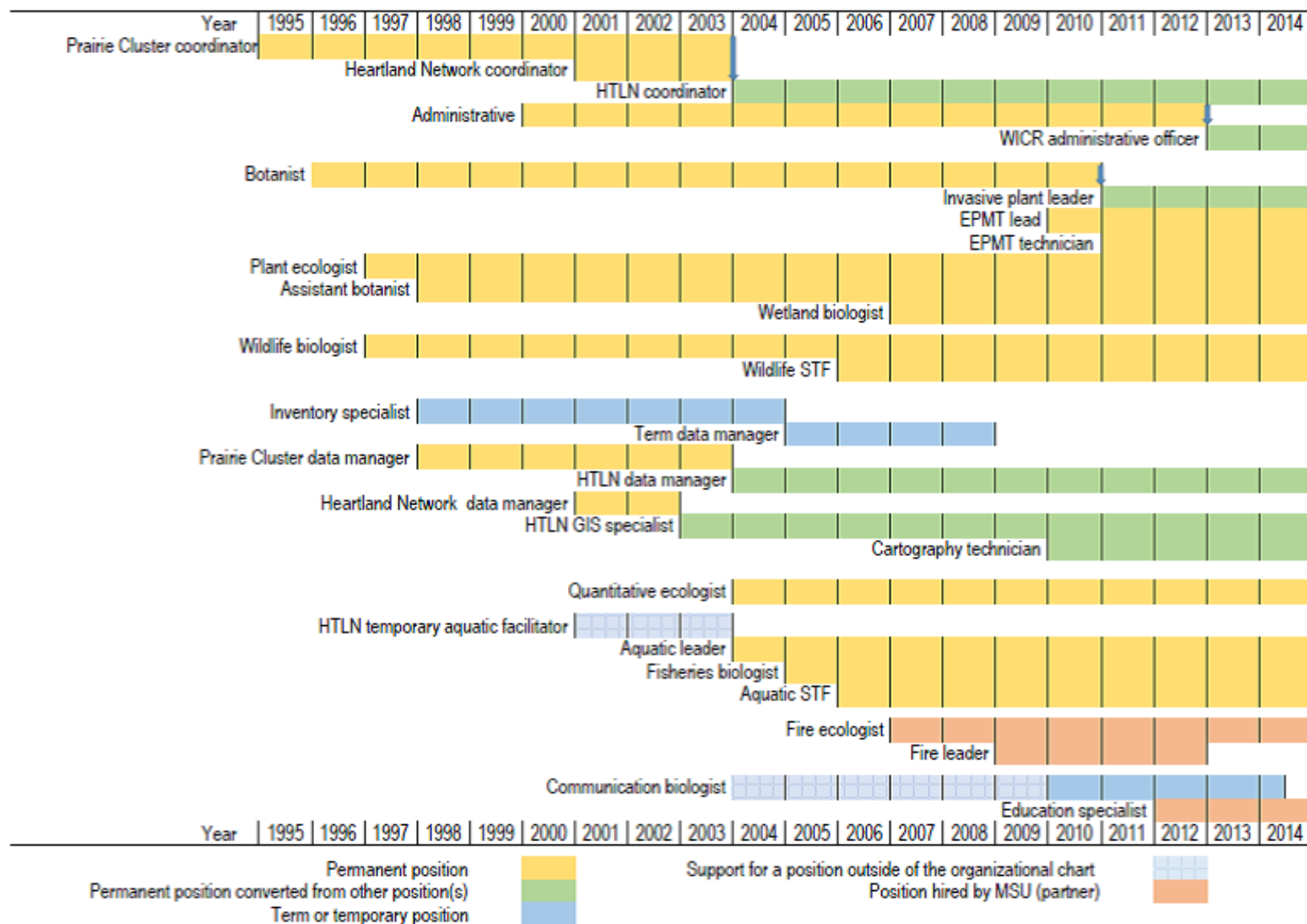


Figure 4. Staffing changes for Prairie Cluster, the Heartland Network, and the HTLN over time.

- Term hydrologic technician, GS-6 at OZAR (Jessica Luraas)
- Prairie Cluster botanist, GS-9/11 (Alicia Sassen)
- Term data manager GS,-9/11 (Michael H. Williams)
- Aquatic Program Area leader, GS-12 (David Bowles)
- Quantitative ecologist, GS-408-11/12 (Lloyd Morrison)
- Integrated program coordinator, GS-12/13 (Michael DeBacker)

During Heartland Network planning in 2003, the Heartland Network identified a clear need to include a quantitative ecologist position within the staff, particularly in the light of the protocol development in Phase 3. The quantitative ecologist needed a strong background in sampling design to develop the spatial and temporal details of protocol execution, to evaluate proposals and products from cooperating scientists, and to incorporate input from outside review. The Prairie Cluster had similar needs. This position was hired and retained after integration. As it has turned out, the quantitative ecologist has become an author on all 12 of the final protocols completed for the HTLN.

The Prairie Cluster wildlife biologist³⁵ relinquished aquatic duties in June 2005 to the HTLN Aquatic Program Area leader. During the transition, the Aquatic Program Area leader worked with the Prairie Cluster wildlife biologist to become familiar with the Prairie Cluster parks and aquatic procedures. The wildlife biologist absorbed the HTLN breeding-bird monitoring and deer monitoring into the Wildlife Program Area. This sort of passing and parsing of duties occurred within all program areas with the biologists demonstrating great flexibility and resilience during the changes.

The quantity and complexity of data acquired by I&M Program projects required a well-planned and consistent approach to database design, development, and management. During the network development

process, both the Prairie Cluster and the Heartland Network had their own data managers³⁶. Additionally, the inventory portion of the Heartland Network had a coordinator with extraordinary data management skills and contributed to data management for the Heartland Network. With the completion of the inventories, the inventory specialist, a term employee, left employment. As the two monitoring programs combined, the original Heartland Network data manager went to the WASO to assist with Servicewide inventory and monitoring efforts. One data manager, Gareth Rowell, remained to cover the ongoing management of inventory and monitoring data for the combined projects.

Appendix 4 shows the changes in staffing and provides position descriptions for the HTLN personnel.

Evolution of the Data Management

Databases are the primary repositories of data from long-term studies that need to be accessible and applicable for decades. The Prairie Cluster and Heartland Network consolidated protocols by program area in order to merge their monitoring efforts. Where possible, the HTLN expanded and adapted the existing Prairie Cluster protocols to meet the needs of the additional parks. New monitoring projects required new protocols. Each protocol contained a section on data management, developed through the combined efforts of the data manager and the project leader.

The data manager found that his role in protocol development was largely one of communication (Gareth Rowell, personal communication, November 21, 2013). He had to work closely with the project leader to determine project needs and how to report information. Often, the project leader developed a data sheet to use in the field from which the data manager could create a framework for the database. The data manager set up data tables that the project managers reviewed. This process would help the project leader to focus on the specific questions that the data would address. Once the project manager agreed to the data

³⁵ David Peitz

³⁶ Brian Witcher and Gareth Rowell (Prairie Cluster), and Brent Frakes (Heartland Network)

tables, the data manager designed the Access[®] data forms to reflect the field data and created the tables. The process was iterative, fix-as-you-go approach to developing the most functional design possible.

Influence that the Prairie Cluster and the HTLN had on the I&M Program and subsequent networks continued. The WASO did not complete a Servicewide data management plan until 2008. By that time, the Prairie Cluster and Heartland Network had combined into the HTLN with a single data manager. That data manager contributed to discussions of data templates and basic structure, along with other data managers from the first group of implemented networks, based on actual data management experiences within the network. The HTLN's long record of accomplishment permitted it to contribute significantly to the final Servicewide data management plan.

Monitoring Plan

Much of the network's Vital Sign Monitoring plan (DeBacker, et al. 2005) had stemmed from the development of the prototype, as the I&M Program leadership had intended. It adapted strategies and protocols currently in use within prototype parks and added to that rich base with new Vital Signs and new protocols. The monitoring plan was unique to the HTLN. The document serves as the monitoring plan for the combined long-term monitoring program under Vital Sign Monitoring. This plan:

- Outlines HTLN monitoring goals and the planning process used to develop the monitoring program.
- Summarizes existing information concerning park natural resources and resource management issues across the network.
- Provides a conceptual model framework for park ecosystems.
- Selects and prioritizes Vital Signs.
- Presents a sampling framework for aquatic and terrestrial ecosystems in parks.
- Summarizes monitoring protocols.

- Describes the network's approach to data management.
- Provides information on program administration, funding, and operations.

The MWR and the WASO approved the final monitoring plan (DeBacker, et al. 2005) by October 2005.

Transfer of AGFO and SCBL

Two parks, AGFO and SCBL, originally were included in the Prairie Cluster to represent parks with short-grass prairie. With establishment of the NGPN, it was determined that these parks better fit the ecological foundation for the NGPN, than the HTLN with its varied ecotypes. The parks, along with their monitoring protocols and data, would move to the NGPN, when that network became operational. The NGPN ran at least three years behind HTLN development. Until that time, the Prairie Cluster continued the monitoring already established at these two parks, using prototype funding.

Heartland staff prioritized several data analysis and reporting efforts to facilitate transfer of monitoring to NGPN. The Prairie Cluster wildlife biologist completed annual reports (1999 – 2005) and summary reports on black-tailed prairie dogs monitored at SCBL for transfer to the NGPN. Staff completed additional reports during NGPN start up and the transition of black-tailed prairie dogs monitoring.

- Hummel, et al. 2006.
- Peitz and Cribbs 2007.
- Peitz and Cribbs 2008.
- Morrison, et al. 2010.

The wildlife biologist also produced breeding-bird reports for AGFO, before transfer to the NGPN:

- 2001 - 2003 Status Report: Grassland-bird monitoring at Agate Fossil Beds National Monument and Tallgrass Prairie National Preserve.
- Peitz 2007.

The HTLN staff completed additional re-

ports from data collected by the Prairie Cluster, including summary reports on vegetation monitoring and aquatic resources.

- 1989-2002 Summary Report: Aquatic invertebrates at Agate Fossil Beds NM.
- Bowles 2010 (no citation). A final but informal summary report on the full invertebrate monitoring dataset.
- James 2010. Vegetation community monitoring at Agate Fossil Beds NM.
- James 2010. Vegetation community monitoring at Scotts Bluff NM.

Monitoring at AGFO and SCBL ended in 2009, and all monitoring responsibilities for AGFO and SCBL shifted to the NGPN. Up until 2009, the HTLN had maintained databases for SCBL and AGFO. These databases went to the NGPN, once that network's data management section was ready to receive them. The transfer of AGFO and SCBL became final August 9, 2010 (NPS Memorandum). The NGPN became the official repository of data for these parks. Documentation provided by the HTLN for the transition included:

- All monitoring reports
- All monitoring protocols
- Scanned copies of all original field data sheets
- Access databases with verified and validated original data
- Geodatabase of prairie-dog spatial data

One of the complications encountered during this transfer involved the financial arrangements for AGFO, SCBL, and TAPR. When TAPR joined the Heartland Network, the Prairie Cluster received temporary monitoring funds to cover an interim arrangement. The arrangement had the Prairie Cluster initiate monitoring at TAPR, while continuing monitoring of AGFO and SCBL. Based on the final arrangement between the HTLN and the NGPN, half of the temporary funding that originally supported monitoring at the three parks (AGFO, SCBL, and TAPR) transferred with AGFO and SCBL, and the WASO supplemented that transfer with additional money going to the NGPN.

The other half of the funding remained in the HTLN budget to cover TAPR monitoring. This resulted in a net loss to the HTLN budget.

Annual Administrative Reporting

As part of the overall managerial and budgeting process, monitoring networks submitted an Annual Administrative Report in early November and a Draft Work Plan in late January to the WASO. The Board and MWR I&M Program coordinator formally reviewed and approved the Heartland Network's submissions. The Prairie Cluster and Heartland Network submitted separate reports and work plans through 2003. Beginning in 2004, they began preparing one integrated report for the WASO annually. Initially, networks proposed, reviewed, and submitted the Annual Administrative Report and the Work Plan as two separate documents, doubling the administrative work for the requirement. In 2005, the Board approved combining the documents into one document, the *Annual Administrative Report and Draft Work Plan* (AARWP). The Annual Administrative Report component of the document provided a summary of monitoring activities and accomplishments achieved during the previous fiscal year, relative to an accounting of network expenditures. The Draft Work Plan component provided a description of anticipated monitoring activities and budgetary allocations for the next fiscal year. The Board approved the Work Plan before staff forwarded it on to the WASO by mid-November.

3.1.2 Working out the Wrinkles

Numerous problems arose during the building of the both the Prairie Cluster and Heartland Network programs, as well as during the merging of the two entities. Some of the problems provide insight as to why leadership made certain administrative decisions.

Office Space for Staff

The Prairie Cluster had purchased two doublewide trailers as modular offices in 1995 and in 2000, respectively. As the Heartland Network ramped up, resources and space within the trailers stretched beyond acceptable limits. The Heartland Network expand-

ed into two offices in the fire cache building in 2001. This building, not designed as office space, lacked plumbing. A retrofit, paid for by the Heartland Network, sectioned off offices, bathrooms, and a common room. As the staff and program grew, a portion of the HTLN staff had dispersed to several parks and MSU.

In 2008, the Board applauded the efforts of WICR and the HTLN to move towards a permanent office space solution. The trailers were aging, and had seen heavy use. The WICR General Management Plan 2003 called for converting the Sweeney Museum building into office space for the HTLN and for the removal of the office trailers. The Board discussed this potential in May of 2011 and agreed to the expenditure of funds to explore this possibility further. By committing to support preliminary activities to rehabilitate the Sweeney Museum building by 2013, the HTLN could possibly occupy the building by 2015. The Board has not committed funds to the Sweeney Museum rehabilitation, but the potential still exists.

Staffing Locations

Locating HTLN staff outside of the confines of WICR seemed an appropriate way to address the extreme distances between parks and the overcrowding in the trailer units at WICR. Several employees over the course of the last eight years have located at CUVA, and served the eastern parks (e.g., CUVA, HOCU, and LIBO) in various capacities. Occasionally, a park and HTLN have shared employees. In some cases, the host park hired the employee and the HTLN paid a portion of the salary and benefits in return for part time work on HTLN projects. In other cases, the HTLN located an employee at the park. Having a HTLN employee located at a park required an Intra-agency Agreement, defining the responsibilities of the host park and the HTLN, often offering in-kind and/or monetary compensation to the host park.

The Mott Plan (Mott 2000) had recommended the location of HTLN staff within OZAR and BUFF. Grant (2000) reiterated a need for a network hydrologist at OZAR to supervise and conduct a water-quality moni-

toring program there. Grant acknowledged that BUFF had a hydrologist to supervise monitoring at that park. Additionally, Mott (2000) suggested two hydrologic technicians, one at OZAR and one at BUFF, could assist with field and laboratory work at each park. A seasonal hydrologic technician at BUFF would also assist with data collection from the other four parks in the Ozark Highlands. These recommendations did not carry, because of the demands on financial resources of the Heartland Network as sole support for those positions. Term technicians, hired by the HTLN, remained stationed at BUFF and OZAR for several years. In both instances, however, the parks chose not to renew the agreements when turnover occurred citing extreme space limitations.

Location of “Aquapod”

The organizational framework for the HTLN identified several aquatic specialist positions that would design and implement aquatic resource monitoring within the HTLN. The HTLN would hire the Aquatic Program Area leader by mid-year 2004. The ultimate composition of the module and exact workload were uncertain at that time. In October 2003, the HTLN requested proposals from member parks and regional CESUs interested in hosting the aquatics module and up to three permanent scientists. Proposals were due by December 10, 2003. The host would share existing aquatic materials and expertise with the HTLN and would receive financial compensation for administrative support.

The HTLN received proposals from OZAR, BUFF, WICR, University of Missouri-Columbia, and MSU. A subset of the Technical Committee served as a review panel, evaluating the proposals to determine which host offered the best administrative and technical support. The review panel forwarded a recommendation to the HTLN coordinator and Board. It found that MSU offered the best location to host the Aquapod, a name coined by staff. The Board approved the review panel’s recommendation during a conference call on January 26, 2004. The Heartland Network revised its charter, so that it reflected the decision. The HTLN and MSU joined in a Cooperative Agreement, placing the Aquapod on the MSU campus.

Support for Campus Operations at MSU

Having relocated the Aquapod, the HTLN saw an opportunity to enhance the partnership with the university further. The HTLN entered into other agreements with MSU, co-locating additional staff with MSU faculty to facilitate professional interaction that would ensure continuing access to expertise. Missouri State University became a core partner in meeting the needs of parks. The HTLN and MSU have worked in partnership for over 10 years towards the development and implementation of ecological monitoring. As of October 2013, the HTLN had agreements in place with MSU covering four areas, Vital Sign Monitoring, fire ecology, Great Plains Fire Science Exchange, and science education.

Missouri State University provides office and lab space for NPS staff in a university campus environment, and provides access to university resources for all HTLN staff. In return, the NPS provides educational and training opportunities to MSU students and faculty through student employment, graduate student stipends, undergraduate internships, research assistantships, guest lectures, graduate committee participation, and informal mentoring. The first agreement began this important relationship in 2004, and the second agreement renewed the relationship non-competitively in 2008. Seven modifications adjusted funding to sustain the partnership over the years. Total NPS expenditures over the period amounted to \$223,307 or about \$22,000 per year.

Through the partnership, HTLN employed 22 student workers to assist with field and laboratory tasks under the direction of NPS scientists: six students completed paid undergraduate internships with course-credit for a special project completed while working with the NPS, and four Master's students have completed their research and theses with support from the NPS. Missouri State University currently employs two part-time research assistants assigned to assist with NPS projects. The arrangement has facilitated the exchange of information and ideas that result in a stronger NPS monitoring program and enhance the educational opportunities for MSU students.

Program Authority

Shortly after the hiring of the of the HTLN coordinator, the MWR reviewed the personnel issues associated with employees having dual supervision, one technical supervisor and one personnel supervisor. Practically speaking, this split hierarchy can lead to two sets of conflicting priorities with the employee caught in the middle. In an effort to prevent this personnel issue within the fledgling network program, the MWR director chose to place all supervision of network coordinators within the authority of the MWR I&M Program coordinator.

Abrupt changes in supervisory responsibility can temporarily destabilize relationships within an organization. Therefore, the Board expressed concern over the process used to change the supervision of the HTLN coordinator. However, the Board supported the MWR director's decision and the new hierarchy resulted. The Board worked to clarify the roles and relationships resulting from the change, and helped to return the HTLN to a stable organization.

Transitioning the Role of Technical Committee

As the HTLN became operational, the role of the Technical Committee changed from leadership and oversight of network development to an uncertain role. During the 2006 Annual Meeting, the Technical Committee discussed the change in their role to that of an advisory group. The implementation of the monitoring plan had removed the principal function of the committee. Several possibilities for the Technical Committee's role included:

- Technical Committee members could bring information generated by the network into the decision-making processes within parks.
- The Technical Committee could serve as mentors to assist new superintendents and resource management staff in becoming familiar with the HTLN.
- The Technical Committee could elect a chairperson to serve as liaison to the Board.
- The network could provide a forum for

the Technical Committee to talk about park issues, and arrive at commonalities.

- The Technical Committee could work collaboratively to find solutions to park problems, emphasizing avenues for Vital Sign information use.

The Board decided that the HTLN coordinator should convene an ad-hoc subcommittee of the Technical Committee to refine the roles and responsibilities of the Technical Committee before the network charter revision of 2007. The ad-hoc committee suggested that the new charter place the Technical Committee into a supporting role, instead of one of oversight for the program because a hierarchy already existed.

The issue of Technical Committee role and responsibilities remained unresolved in 2008. The Board solicited ideas from the HTLN staff and Technical Committee again in February 2009. The Board felt that new opportunities for the Technical Committee to support HTLN activities had emerged. The Technical Committee still envisioned their role as one of support, but it felt distanced from the HTLN activities. Therefore, the data manager assisted the Technical Committee in establishing a SharePoint® site to facilitate the flow of ideas and information. Thus, the Technical Committee could reenergize the synergy that prevailed during the network startup.

A team from the Technical Committee and HTLN staff continued work with the invasive-plant management proposal. The Technical Committee would continue to help with prioritizing projects when funding became available for the Exotic Plant Management Team (EPMT). The breeding-bird project also worked closely with the Technical Committee to initiate monitoring by volunteers. Several deeply invested members of the Technical Committee continued to serve as a critical link between parks and HTLN staff.

3.1.3 Complexity of Funding

The MWR I&M coordinator supervised operations and funding through several revenue streams. Prototype monitoring funds (\$585,493 in FY 2010) and invasive-plant

management funds (\$667,000 in FY 2010) reside in WICR base accounts. The WASO transferred funds for water quality monitoring (\$78,800 in FY 2010) and Vital Sign Monitoring (\$821,300 in FY 2010) to the HTLN annually. The partnership with MSU supports several partners, hired through MSU, but dedicated to HTLN to accomplish specified work. Additional money comes from other divisions of the NPS for activities such as fire-effects monitoring, Condition Assessments, Vegetation Mapping Inventory, and other initiatives. The various sources have certain mandates, thus adding to the complexity of the funding streams and the products from those funding streams. These funding streams change annually as the NPS appropriations and program allocations change. The HTLN also provides an administrative umbrella for partners, such as the Central Great Plains Fire Ecology Program and the Great Plains Fire Science Exchange, with activities closely integrated with HTLN operations. This further complicates annual budgeting for operations.

Reductions in Funding and Travel

Reductions in travel allocations in budgets began in 2004 and continue to the present. The MWR cut the travel allocation for the 2006 Annual Meeting in half. The Board decided to shift to biennial meetings, which aligned with the 50% cut in travel from 2006. The Board encouraged park managers and HTLN staff to interact at George Wright Society conferences, which met in the interim years. The Board sent justifications to MWR for biennial meetings in 2008 and 2010 and the MWR reinstated some travel allowance for those meetings.

Although the HTLN worked around travel restrictions for fieldwork, travel restrictions eventually eliminated the annual meetings of the Board, Technical Committee, and HTLN staff. The Board intended to financially support HTLN and park staff attendance going to George Wright Society conferences. The Board chose to meet by conference calls or at gatherings of superintendents (HTLN 2008) to fulfill the requirements of the Network Charter in years without a biennial meeting. As it turned out, only one HTLN meeting occurred after the decision to shift

to biennial meetings. The HTLN facilitated attendance by a few staff and park personnel at two George Wright Society conferences, 2009 and 2011. Unfortunately, travel budgets have reduced to a level that staff and park personnel rarely attend conferences or meetings of any type. Thus, the travel restrictions hamper publication and presentation by HTLN scientists, reducing their credibility as leaders in resource monitoring. These restrictions also severely diminish the communication and camaraderie that had developed during the development of the network.

Cuts to base funding for the HTLN began in 2004. By 2006, a five-percent funding cut and a hiring freeze affected the program. This was the beginning of significant limitations in operation. Despite this, the HTLN has leveraged funds and used external sources to retain a high-quality monitoring program and to extend into new program areas that address park needs.

Fair Play in Agreements

In the five years following the transition of prototypes from the NBS to the NPS, increases in personnel costs and rising fixed expenditures eroded the Prairie Cluster budget. By 2002, personnel costs had risen to 86% of the Prairie Cluster program's base funding. Annual increases to WICR ONPS base funding to offset Cost-Of-Living-Allowance (COLA) adjustments were insufficient to meet actual increases in costs for existing personnel. The park used COLA increases, designated for Prairie Cluster FTEs, to compensate for increased administrative costs incurred by the park as host for the program. The COLA increases did not actually go to the Prairie Cluster. The cumulative effect of withholding COLA increases resulted in a substantial loss of funds for operations of the I&M Program. The FY 2006 base funding for the Prairie Cluster started at \$519,200. After negotiations, the park agreed to repay the withheld funds. A new Intra-agency Agreement stipulated that WICR would add an additional \$15,700 to the Prairie Cluster budget to make up for the money not transferred to the Prairie Cluster between FY 2003 and FY 2006.

The HTLN located its headquarters at WICR, with staff duty-stationed at MSU, BUFF, OZAR, and CUVA. The host parks provided utilities, maintenance, janitorial, and administrative support. Compensation for these services began to WICR in 1999 through an informal agreement between the LTEM Program and the park. Initially WICR received \$5,000 per year from the Prairie Cluster, but the amount increased to \$10,000 per year in 2001. Through a similar agreement in 2001, the HTLN agreed to compensate WICR \$10,000 per year from Challenge funds for support services for the enlarging Heartland Network staff. This began the use of Intra-agency Agreements between the Board and host parks that specifically stated payment for support services annually.

Several parks collaborated with the early Heartland Network through handshake agreements. Some of these informal agreements paid for park staff to work on HTLN projects. Other agreements involved complex arrangements of support and services. Over time, the HTLN found it necessary to formalize all agreements with well-defined roles and responsibilities for the parties involved. Table 12 summarizes these Intra-agency Agreements. Descriptions of some of these agreements appear in Appendix 3.

Interagency Agreements and CESUs

Many activities fell under agreements that ensured collaboration with the best available expertise and provided the best possible facilities for accomplishing the task. Memorandums of Understanding between federal and state agencies and with CESU universities allowed the HTLN to develop Cooperative and Interagency Agreements. These agreements, although very beneficial, add to the complexity of the HTLN budget process.

Interagency and Cooperative Agreements proved instrumental in providing expertise to a fledgling Heartland Network. As the Heartland Network began planning, it received funding equivalent to an operational network. Agreements with trusted agencies and CESUs provided a safe way to invest single-year money (funds appropriate for use within a single Fiscal Year) with confidence that the products would meet the

Table 12. Partial list of Intra-agency Agreements

Intra-Agency Agreements	Number	Year	Subject
HTLN-BUFF		2006-2009	Aquatic technician duty station at BUFF
HTLN-CUVA		2006	Wetlands biologist duty station at CUVA
	G2106000008	2011	Exotic Plant Management Team
HTLN-EFMO	G2106000005	2010	EPMT location-terminated the next year
	G2016000007	2012	Collaborate on restoration OFS request
HTLN-OZAR		2006-2008	Aquatic technician duty station at OZAR
HTLN-PERI	G2106000006	2010	Exotic Plant Management Team
HTLN-WICR	G2106000001	2005	First hosting of HTLN
	G2106000006B	2011	Revised agreement to include hosting the EPMT
	G2106000006	2014	Revised to reflect integrated administrative division

needs. Table 13 summarizes many of these agreements. Appendix 3 contains details on several agreements.

3.2 Developing Science Communication

The goals of the I&M Program could be achieved only through a systematic and routine process for communicating relevant science that would enter into the resource management decisions.

(Fancy and Bennets 2012)

The HTLN and I&M Program hoped that information gathered through the monitoring program would become an integral part of the planning and operations of parks. Vital Sign Monitoring reports included annual summaries and five-year trends in resource conditions. The HTLN also shares information through Internet websites for public use and through the Intranet for NPS staff. A single data portal, IRMA, makes all HTLN products available to the appropriate constituency through online searches. Although park staff and the public could access information, the HTLN needed to market the value and uses of this information to various constituencies.

At the completion of Phase 3 of planning, the HTLN staff would have less frequent interaction with the Technical Committee, the Board, and the parks. Some communication would occur through conference calls on specific monitoring issues, but a formal

communication project became critical to the cohesiveness of the network. The Board also recognized that public understanding of the value of the I&M Program would help to support its longevity. Therefore, the Board wished to establish a project to facilitate intra-network and public communication.

During the Board meeting, August 18, 2004, after a strong statement supporting the need for a communication project, given during the 2004 Annual Meeting, the Board devoted considerable discussion to the topic of broadly communicating and interpreting findings of the HTLN. In October, the Board considered adding a communication specialist position to the organizational chart, but after further consideration, determined that other positions took priority. As the communication project concept developed, the HTLN coordinator and Board recognized a need to have one person organize these efforts. The HTLN funded a term employee, Sherry Middlemis-Brown, of the MWR Office with experience in education and resource management, as a communication biologist. She spent a day a week overseeing communication and education efforts.

The HTLN needed a strategy for conveying information about the purposes and objectives of the I&M Program, its inventory and monitoring activities, research results and trends, and examples of successes in providing critical information for management decisions. The Board approved funding a CESU partner through a Cooperative Agreement to write a communication plan. The MWR deputy director for NRSS and the

MWR I&M Program coordinator, Carmen Thomson, supported the project. It would be the first such emphasis on communication

within a network, and it proceeded in collaboration with WASO offices of NRSS and the I&M Program.

Table 13. Interagency and CESU Cooperative Agreements. This list is not exhaustive, neglecting a multitude of short-term or small agreements.

Parties in Agreement	Agreement # (if available)	Year	Description
Prairie Cluster - Univ. Missouri / USGS-BRD, (Charles Rabeni)		1999-2005	Prairie Cluster invertebrate identification and enumeration
HTLN-University of Kansas (Don Huggins)		2001	Water quality
HTLN-Univ. Missouri / USGS-BRD, (Charles Rabeni)	IA238099002, TO# 2003-10	2003	Springs monitoring protocol
HTLN-USGS, Water Resource Division AR District (Dave Friewald)		2003	Geothermal springs - spring temperature and precipitation project
HTLN-Missouri State University (Bob Pavlowski)		2003	Fluvial geomorphology protocol
HTLN-University of Wisconsin, MWR GIS, (Pete Budde)		2004	MWR-GIS Support Office for geodatabases and metadata from the inventory data
HTLN-Illinois Natural History Survey (Chris Phillips)		2004	Hellbender monitoring protocol
HTLN-PIPE-Pipestone County		2004	Water sampling analyses to determine TMDLs
HTLN-USGS (Chris Schmidt)		2004	Heavy metals protocol
HTLN-OZAR-USGS, Water Resource Division MO District		2004	Core-5 and indicator bacteria sampling; WRD funded
HTLN-HEHO-USGS, Water Resource Division IA District		2004	Initiate pilot project for an automated, real-time multi-parameter instrument at HEHO
HTLN-USGS (Jim Petersen)		2004	Fish Community protocol
HTLN-University of Missouri (Scott Sowa)	J 2106-04- 0086	2004	Develop "'valley segment" map and sample frame construction
CUVA-University of Akron (Lauchlin Fraser)		2004	Wetlands study; protocol work
HTLN – University of Arkansas, Monticello (Bob Weih)		2004	Land cover protocol
HTLN- MWR Fire-Missouri State University	CAH6000030300 TA# J6064-04-00011	2004-2009	Heartland fire ecology
HTLN-Missouri State University (Steve Jensen)	J 2106-04-0015	2004-2009	Partnership to conduct vital signs monitoring
HTLN-USGS, Rolla (Jerri Davis)		2005	Validate TMDL on impaired reaches of the Jack's Fork - OZAR
HTLN-Colorado State University	J – 2106-05-0086	2005	Communication plan
HTLN-Missouri State University (Wanda Brandon)	J-2106-05-0070	2005	Layout and design of the Vital Sign Monitoring plan
HTLN-EFMO-Iowa Department of Natural Resources			Develop TMDL and install continuous gauging for the Yellow River at EFMO
HTLN-HEHO-Iowa Department of Natural Resources		2005-2006	Water quality, identify source of coliform at HEHO
HTLN-Missouri State University (Alicia Mathis)	J 6370-08-0436	2008-2013	Partnership to conduct vital signs monitoring - renewal
HTLN-University of Kansas (Kelley Kindscher)	CAH6000030300 TA# J 2106-H-0050	2007	Vegetation inventory for TAPR and HOME
HTLN-Missouri Resources Assessment Program (Dave Diamond)	CAH6000030300 TA# J2106 J 0056	2008	Natural resource condition assessment for four parks
HTLN-Missouri Resources Assessment Program (Dave Diamond)	CAH6000030300 TA# J2106 10 0039	2010-2015	Vegetation inventory for 6 parks
HTLN- MWR Fire-Missouri State University	CAH6000030300 TA# J6064-10-0003	2010-2015	Heartland fire ecology - renewal
HTLN- Missouri State University (Janice Greene)	P11AC60519	2011-2016	Science education and outreach
HTLN-Missouri State University (Alicia Mathis)	P14AC00221	2014-2019	Partnership to conduct vital signs monitoring - renewal

3.2.1 Communication Plan

The communication biologist developed a Scope-of-Work (SOW) to advance an interpretation and education strategy. The strategy would not involve producing any specific interpretive material; rather, it would identify an appropriate means for communication and the types of materials needed to support those means. The product from the first phase (i.e., communication plan) would contribute to soliciting additional funds for its implementation and the production of interpretive and educational materials.

A Cooperative Agreement with Colorado State University (CSU) resulted in the development of a communication plan designed to meet the needs of the HTLN and the parks. The CSU cooperators worked with the HTLN to develop a strategy to enhance communication between scientists and resource and interpretation managers at parks. The project addressed how to develop clear and concise messages about the efficacy of the I&M Program and disseminate findings to internal and external audiences.

In January 2005, a conference call of Board and Technical Committee members addressed the communication-planning project. At this time, with the plan well underway, the emphasis turned toward creating products based on inventory results. Products distributed to the public would strengthen the connection between the public and the parks. The CSU cooperators supplied a matrix of interpretive product options (e.g., print publications, electronic media, signage, etc.) with the *Heartland Network Inventory & Monitoring Program Communication Plan* (NPS and Colorado State University 2006). These matrix options served as templates for customized products applied to specific park issues. Products related to the Natural Resource Preservation Program Interpretive Component guidelines.

The communication plan and the association with the CSU cooperators provided opportunities to guide scientists in interpretive techniques that effectively connect the significance of their research to a wide audience (park managers, interpreters, public, etc.). Eppley Institute furthered this through

a training session for resource managers and scientists at the 2006 Annual Meeting at HOCU. The HTLN and CSU cooperators created a solid foundation for science communication in the communication plan and the execution of the science communication workshop.

The partnership with CSU strengthened the HTLN's relationship with the NRPC, Office of Education and Outreach, later referred to as the Natural Resource Stewardship and Science, Office of Education and Outreach (NRSS-OEO). The uniqueness of the HTLN communication project encouraged the office director to provide opportunities to further efforts in internal and external communication. One of the original CSU students continued to work with the HTLN after graduation, when the NRSS-OEO hired Sara Melena after graduation. She assisted in arranging a revised communication plan in 2008. The revision corrected a few errors and updated production costs within the matrix of projects, but did not result in substantial changes to the original document.

3.2.2 Developing Internal Vehicles for Communication

Communication between the HTLN and parks was imperative to a successful monitoring program, which contributed to knowledge and understanding of natural resources and processes within the parks. The HTLN had begun publishing a bi-monthly newsletter, later named *The Weather Vane*, in 2004, even before engaging in developing a communication plan. The *Weather Vane* featured a different project area, recounting a successful use of monitoring data, in each issue. The newsletter also contained an article highlighting how a park or group of parks had used science to complete a project or inform a decision. Each program area and project provided a brief update. The target audience included park staff in all divisions, partners, other networks, and resource management and interpretation staff at the regional and national level.

One of the tasks in communicating science is to transpose the language of science into an understandable message for the non-scientist. Many park staff have limited

science backgrounds, but a need to understand resource issues so that they can make informed management decisions or present accurate interpretive programs. The monitoring reports written by HTLN scientists do not always contain the message that an interpreter or manager may need to derive from the results and discussion. Therefore, the communication biologist took the major highlights from each report and created a Resource Summary. These briefs would convey the importance of the resources and Vital Signs, a simple summary of sampling methodology, results of the monitoring, and the implications for resource conditions.

The HTLN developed an Internet web site with a section devoted to education and outreach, which would attract educators and would provide useful products and information for park interpreters. Interpreters and other park personnel could download brochures, site bulletins, seasonal staff orientation information, and templates for developing park specific products with Vital Sign data. Parks could download audio and visual products of issue-based presentations as well. Past issues of *The Weather Vane* and Resource Summaries also resided on the web site. Many of these products served as training materials for personnel outside of the permanent resource management staff.

3.2.3 Creating Products

The communication plan, written as a strategy, included a number of examples of projects that parks could undertake, outlining project objectives, materials procurement information, and descriptive text. The HTLN commenced developing several projects for parks to distribute to visitors or as displays in visitor centers.

In 2010, the HTLN hired a communication biologist, Sherry Middlemis-Brown, in a part time, term position to continue executing the communication plan. The communication biologist implemented several of the products recommended in the communication plan's matrix to address specific park issues. The communication biologist also continued production of *The Weather Vane* newsletter

and Resource Summaries.

Displays

The development of displays seemed to interest park interpretive staff. Many parks have space for temporary displays within their visitor centers. The HTLN worked with CSU to create the principal static display, Science in the Parks, with two banners exemplifying the role of science in resource management. Although the HTLN logo appeared discreetly in the corner of one banner, the display celebrated the many ways that science becomes part of decision-making in the NPS. The HTLN purchased two sets of the banners. The same collaboration resulted in two additional dual-sided banners, (1) the values of biodiversity on one side and threats from invasive species on the other side, and (2) the benefits of prescribed fire on one side and the inter-relatedness of cultural and natural resources in parks on the other side. The HTLN made these banners available for loan and several parks made use of these banners in the first three years after completion. They fit into large cases for shipping or could accompany staff, traveling by vehicle, to conferences and meetings. A brochure rack accompanied the display and could hold Resource Summaries or site bulletins related to the park in which the display resided. The displays have longevity, using messages that have long-term value within the parks and at conferences. Those using the displays found that they worked well indoors, but that they did not serve well at outdoor events.

The communication biologist, administrative assistant, and education specialist, Theresa Johnson³⁷, have created additional interactive displays, more accommodating of use outdoors. Interactive displays require staffing the activities included in the displays. The costs associated with travel and staffing have precluded participation in many events at parks, particularly those requiring the participant to enter travel status (greater than 50 miles from duty station).

³⁷ This position exists through an agreement with a CESU partner, Missouri State University. Further discussion of this position is forthcoming in the Education Partnership.

Distributed Items

The HTLN arranged for production of several items for distribution to visitors. Items ranged from bookmarks to notecards featuring prairie plants and other paper products. The collaboration with CSU occasioned the production of small quantities of other products from the matrix, but did not encourage the park interpreters to work directly with the HTLN on more than a few projects. In time, the HTLN determined that producing materials for the parks was ineffective. Instead, the HTLN offered incentives for park interpreters to work with the HTLN biologists to produce materials and presentations. Bird checklists became a popular collaboration between the communication biologist and park interpreters. The communication biologist also reviewed materials entirely produced by the collaboration between resource managers and their park interpretive staff.

One of the products prepared for parks to distribute has proved successful. The CSU students had created several artistic renditions of familiar prairie plants. A printer transferred these artistic renderings of prairie plants on one side of cards and printed the natural history information of the species of the opposite side. The card sets fit into small packets that carried a message on prairie values for distribution. The wildflower card packets became very popular, and the HTLN reprinted them in 2013.

Presentations

Early in the communication effort, the CSU cooperators created a DVD about the I&M Program, the HTLN, and the parks. It served as an introduction to inventory and monitoring within the parks. The HTLN coordinator established a complementary program to use at the parks, familiarizing park staff with the work of the I&M Program within their park. Visiting HTLN scientists made presentations to the staff and stakeholders at each park shortly after implementation of monitoring within the park.

Park and HTLN staff have successfully used monitoring results in presentations given within the park, at professional conferences, and to focus groups. These presentations

have also become part of external scoping for park planning.

Citizen Science

Interpreters, resource managers, and the HTLN program-area leaders worked together to develop citizen science that not only served as education/communication tools for the public, but functioned as a method to acquire ancillary monitoring information. The best example of this, the breeding-bird project, allowed expansion of breeding-bird monitoring. The lead interpreter at HEHO received funding through an NPS interpretation grant to support purchase of the equipment needed for volunteers to monitor breeding-birds. The interpreter shared his success in finding external funding with other parks and at the George Wright Society conference in 2009 (DeBacker, et al. 2009).

Several parks used other resource issues as the focus for their citizen science. The resource manager and chief of interpretation at HOME have a long established water quality project with local schools, and HTLN staff has assisted in the program. The wetland monitoring lead at CUVA uses citizen scientists to monitor ground water wells and staff gauges. A BioBlitz at GWCA used HTLN scientists and other experts to record the biotic diversity. These citizen scientists act as ambassadors to interest groups and the public.

Handing Interpretation Back to the Parks

After creating small quantities of materials for distribution and presentations for use by interpreters, the HTLN communication biologist and HTLN coordinator determined that facilitating interpreters' efforts, making them familiar with how they could use HTLN data, provided greater return than creating materials for parks to distribute. Interpreters worked most effectively with materials that they created for themselves. Fostering relationships between HTLN staff, park managers, and park interpreters became a priority for the HTLN. The interpreters are the NPS front line, carrying the message of resource stewardship to the public. This fostered the first efforts to include park interpreters in the annual meetings of the HTLN in hopes of making the interpreters

comfortable with the HTLN staff, familiar with the HTLN program, and creative in their use of HTLN data and findings in collaboration with staff.

3.2.4 HTLN Meeting Interpretive Workshop 2007

Although several parks appreciated the materials provided to them, trying to predict what materials parks would want proved difficult. Therefore, the communication emphasis moved from physically providing materials for distribution to visitors to supporting efforts by the park interpreters to use results of monitoring in creating materials.

The 2007 Annual Meeting of the HTLN reflected a new approach to intra-network communication. For the first time, the HTLN invited park interpreters to participate in the annual meeting. The meeting consisted of updates from HTLN staff on the various monitoring projects. In addition, representatives from the NRSS, Office of Education and Outreach, facilitated a science communication workshop. The MWR chief of interpretation extended the invitation to interpreters on behalf of the HTLN and remained enthusiastic about the opportunities presented by the workshop. The interpreters learned about HTLN projects, participated in a workshop geared towards coupling interpretation efforts with HTLN projects in the respective parks, and allowed time for a meeting of the interpreters with the MWR chief of interpretation. Interpreters and resource managers also met to formulate a joint communication project for each park. The HTLN offered to fund one or two projects that used HTLN monitoring data.

At the close of the annual meeting, the Board acknowledged again the importance of engaging the education and interpretive community in the activities of the HTLN. They encouraged the HTLN coordinator to form a committee composed of park interpreters and resource managers to develop recommendations as to how to continue the momentum generated by the workshop. The HTLN coordinator established a Communication Workgroup by December 2007. The workgroup met by conference call to explore the next steps towards furthering

the HTLN's interpretation and education efforts. The HTLN's communication biologist led the eight-member workgroup.

3.2.5 2008 Interpreters Workshop

The final annual meeting of the HTLN occurred in Springfield, Missouri, in August of 2008. The HTLN invited park interpreters, resource managers, and the Board to participate. The interpreters shared in the program-area updates, learning the results of monitoring within parks. The Communication Workgroup assisted in developing the interpretation portion of the agenda. The workgroup chose to have a session on website writing and design as part of the interpreters' breakout session. Once again, the participants appreciated the opportunity for a joint meeting to learn more about the HTLN and communication opportunities. The communication workshop kicked-off efforts to create links between the park web sites and the HTLN web pages, creating a seamless network of Science in Parks.

During the meeting, the Board expressed strong support for continued interaction with park interpretation and education specialists. The Board recommended that the Communication Workgroup remain active and tasked them to (1) assist with choosing projects for the George Wright Society conference in 2009, and (2) develop a proposal for integrating an interpretive component into the 2010 Biennial Meeting. The proposal for the 2010 Biennial Meeting addressed a training session, justified by the benefit to the HTLN, and with estimated cost to the HTLN. The Board encouraged the workgroup to explore funding alternatives to offset travel expenses for the meeting to the HTLN.

3.2.6 Biennial Meeting 2010

The HTLN invited David Larsen, NPS Interpretation and Education Training Manager, to speak about science and education/interpretation at the 2010 network meeting. The interpreters offered examples of using monitoring information in education and interpretation. Five-minute interpretation presentations were paired with the update for the related monitoring project, making the tie between HTLN data/results and the

presentation of high quality, factual material in education and interpretation.

This meeting also served as the launch of the Invasive Plant Management Plan and Environmental Assessment. The interpreters, resource managers, superintendents, and guests became part of the internal scoping session. The facilitators of this session presented a short workshop on the public engagement portion of the Environmental Assessment process, including introducing a Public Engagement Plan with templates for public notices, letters, newsletters, and press releases for interpreters to use during the process.

3.2.7 George Wright Society

In the August 2008 Board meeting, the Board decided that the HTLN should support attendance at the George Wright Society biennial conferences to share successes of the HTLN and the parks. For the George Wright conference in 2009, the Board approved sponsoring teams of resource managers and interpreters who collaboratively develop a presentation around Vital Sign projects. The Board selected teams from HOCU and HEHO to attend the conference.

The HTLN coordinator, HTLN communication biologist, representatives from the NRSS-OEO, Golden Gate National Parks Conservancy, CSU, and park representatives participated in a panel discussion, *Science Communication: Strategies for Successful Collaboration*, at the 2009 George Wright Society conference (DeBacker, et al. 2009). This session shared the efforts of three different networks in developing and implementing communication strategies to connect interpreters and NPS staff to the wealth of information produced about park resources. The panel presented examples of successful collaboration between scientists, resource managers, and interpretation managers.

The HTLN coordinator and communication biologist chaired a workshop at the 2011 conference of the George Wright Society (DeBacker and Middlemis-Brown 2011). The workshop presented the accomplishments in education within the parks and park-network communication, and the

implications for public engagement as park stewards. Presenters included two partners in education, a specialist from MSU and a science teacher from a Missouri high school, and a resource manager from CUVA. An interpretive ranger from GWCA also contributed to the workshop. The panel provided specific examples of interpreting science in predominantly cultural parks, making scientific information relevant to park visitors and stakeholders, and strengthening the public's connection to park resources.

3.2.8 Education Partnership

The HTLN worked with partners at MSU to design and facilitate a pilot education workshop. Park interpreters, HTLN staff, partners, and selected middle and high school biology teachers worked cooperatively to design park-specific curricula that incorporated scientific information generated by the HTLN with hands-on lessons for students.

Missouri State University hired a retired teacher with experience incorporating scientific data into classroom curriculum to assist HTLN in developing this educational program in 2011. The education specialist, Theresa Johnson, began work in May 2012. Her first activities focused on opportunities to advance the NPS director's *Call to Action* (NPS 2011) education goals. The specialist spent much of 2012 and 2013 on establishing the education specialist position through personal contacts. The specialist traveled to HOSP, ARPO, and GWCA to give presentations and interactive programs that engaged the public with network-generated data, emphasizing the role of science in managing national parks. The specialist built rapport with parks by making additional trips to HEHO, EFMO, TAPR, HOME, and PIPE. These site visits opened the potential for collaboration between HTLN scientists and park education staff. Additionally, the education specialist acted as liaison between partners at MSU and the HTLN.

The education specialist created interactive displays, using network-generated information in the context of a park's specific resources. Coupled with the displays, the education specialist completed aquatic invertebrate and bird-migration programs

for use at park events and celebrations. The education specialist or interpreters can adapt these programs and displays, making them park specific. Local educators have activities and lessons available for use in the classroom and on-site at WICR and GWCA that use HTLN findings and data. A workshop for interpreters and other educators included sharing place-based Project Learning Tree and Project WET activities, customized for OZAR and BUFF. The education project continued progress in developing science programs at TAPR and working with the Teacher-Ranger-Teacher program, during 2013-2014.

3.2.9 Ozarks Research and Learning Center

To build on the momentum created by the HTLN communication efforts, managers at BUFF and OZAR³⁸ proposed an Ozarks Science and Learning Center (ORLC) as a centennial project for BUFF. This proposal, built on an unfunded proposal from 2001, included HTLN and MSU as partners. It also clearly stated that the ORLC would service multiple Ozark Highland parks, and not just OZAR and BUFF, but it did not extend to all parks within the HTLN. The concept of RLCs came out of the Challenge, but HTLN had not received one of the 19 RLCs started during the Challenge.

Initially, the planning had started without Board approval or the HTLN coordinator's involvement. The project came before the Technical Committee and the Board in 2007. The Board supported the concept of an RLC, but requested additional refinement of the proposal to incorporate input from all Ozark Highland parks and to focus on maximizing the education- outreach capacity. The Board submitted the proposal to the NPS associate director for NRSS, the MWR director, and the MWR deputy director for NRSS on September 5, 2007. The center did not receive funding from this proposal.

In August 2008, the Board recommended the establishment of an ORLC Workgroup. The Board tasked the workgroup with fleshing out details of a new proposal for an ORLC. The workgroup addressed questions of

staffing, location, funding, and the role of the Board in oversight of the program. They also addressed maximizing the education and outreach capacity.

The proposed ORLC concept developed as a collaborative undertaking between BUFF, OZAR, HTLN, and MSU without RLC funding from the WASO. It would facilitate research focused on management questions important to parks and decision-making. The ORLC offered facilities at the two parks and a university field station. The MSU College of Natural and Applied Science in Springfield, MO, would provide access to sophisticated equipment and laboratory space. The ORLC has not received funding as an NPS-RLC, but the partners have continued to promote the concept and the site as a location to pursue education and research.

3.3 Assistance to the Parks

Funding limits services that the HTLN can provide to meet park needs. Several parks had priority resources that did not become part of the monitoring program at its initial implementation. In October 2005, park managers expressed a desire to add projects to satisfy specific concerns. Although the HTLN did not reconsider the decision of Vital Signs selected for monitoring, it did concede that it would work with parks to help resource managers augment Vital Sign Monitoring. Integrating park efforts and those of the HTLN would keep parks thinking holistically about complementing Vital Signs with park monitoring programs. Eventually, as the network program became operational, the HTLN employed efficiencies that permitted a broadening of the monitoring applied to parks. The staff felt that they could address some of the previously unsatisfied needs for monitoring.

New initiatives developed within the NPS or old initiatives expanded, providing additional funding for program areas. For instance, fire-effects monitoring, a cooperative effort with the MWR Fire Program, shifted to a broad approach to fire-ecology applications in restoration efforts. The HTLN began coordinating traditional I&M Program implementation with the Natural Resource

38 Initially led by Mark DePoy

Condition Assessment Program, park planning (e.g., Foundation Statements, General Management Plans, and Resource Stewardship Strategy), park-funded monitoring and assessment of natural resource condition, and other research and monitoring efforts. The HTLN even provided expertise and data interpretation that contributed to strategic and implementation planning for programs, such as invasive-plant management and disturbed-land restoration.

The HTLN and the Board actively sought outside funding to leverage operations. The communication plan and subsequent products made operations known. Recognizing the required staff time to write grants, the Board suggested the HTLN staff work with a private grant writer or through the MSU. The Board identified the following sources of funding:

- National Park Foundation
- The Nature Conservancy
- Eastern National (e.g. research projects)
- Natural Resource Preservation Program funding for outsourced projects

Intra-agency Agreements with parks, Inter-agency Agreements within other agencies, and CESU partnerships leveraged funds to improve the service provided to parks.

After applying protocols and collecting Vital Sign data, field crews, program-area and project leaders, data managers, and parks discovered new ways in which they could satisfy the unmet needs for monitoring information. Program areas developed in a continuous manner, relatively unaffected by the administrative changes. In other words, evolution of the program continued in the best interests of quality science that would address resource management issues within the parks. This included the expansion of monitoring in both the Vegetation Program Area and Aquatic Program Area that covers more parks and/or more sampling sites within parks than originally planned in the monitoring plan.

3.3.1 Vegetation Mapping

Vegetation mapping was the last of the core

inventories for the network. The USGS, NatureServe, and the NPS joined forces in the Servicewide Vegetation Mapping Inventory. Once funded from the WASO, the funding model changed to pass funds through the networks to partners, who complete the inventory. The mapping uses the national classification system developed and maintained by NatureServe, a not-for-profit conservation organization providing scientific basis for conservation actions (natureserve.org). This inventory provides complete spatial delineation, classification, and description of plant communities within parks. The maps provide fine-scale descriptions of vegetation that add a welcome dimension to all terrestrial monitoring projects.

The USGS, Upper Midwest Environmental Sciences Center conducted the first three vegetation-mapping projects for EFMO, OZAR, and BUFF, beginning in 2004. Although the HTLN remained involved in the process, the WASO oversaw the projects. The USGS published the final maps for BUFF in 2012. Kelly Kindscher, principal investigator from Kansas Biological Society commenced the second round of Vegetation Mapping Inventory at HOME and TAPR. They completed the work in 2011.

The remaining parks of the HTLN became part of a three-phased approach to vegetation mapping, administered through the HTLN. Missouri Resource Assessment Partnership (MoRAP) with David Diamond as principal investigator began their portion of Phase 1 in 2010, initiating inventories at GWCA, PERI, and WICR. The USGS and NatureServe worked as cooperators to initiate Vegetation Mapping Inventory at CUVA. As of 2013, Phase 1 had been completed, MoRAP had drafted reports for Phase 2 (HEHO, HOCU, LIBO and PIPE initiated by MoRAP in 2011), and MoRAP had conducted all field sampling for Phase 3 (ARPO and HOSP). As part of the agreement between MoRAP and the NPS Vegetation Inventory program, HTLN staff conducts the thematic accuracy assessment portion of the inventory. Thematic accuracy assessment verifies the accuracy of individual map classes (mapped vegetation type). The HTLN will complete the Vegetation Mapping Inventory

and thematic accuracy assessment for all 12 parks in 2015.

Field data collected as part of the vegetation map, thematic accuracy assessment, and terrestrial Vital Sign monitoring are used together to provide park-wide assessment of plant-community condition. The HTLN used the completed vegetation maps to revise reporting of terrestrial vegetation data. The staff set a goal to provide a single, concise summary of vegetation condition for each park, where both breeding-bird and plant-community monitoring occurs. With both projects associated with vegetation maps, monitors can report results by mapped community type, allowing inference of monitoring data to all similarly mapped areas in the park.

3.3.2 Natural Resource Planning

Natural Resource Condition Assessments (NRCAs) evaluate and report on important natural resources in parks. The NRCAs provide a synthesized assessment of current conditions in the park, relying on existing data and expert judgment drawn from a variety of sources. This makes the networks the ideal lynchpin for the process, having already gathered park inventory, monitoring, and research information during data mining and subsequent program implementation.

Staff from the MoRAP, and the HTLN conducted NRCAs for the parks. Basic elements of the methodology include (1) reliance on a framework of essential ecological attributes, (2) development of a list of resource types, indicators, and attributes for assessment, and (3) application of assessments by reporting unit, including parkwide, major terrestrial landscape types, and major streams and tributaries. The investigators assign current condition to indicators using a logic-model framework (James and Guck 2010) with contemporary data and management targets. The integrated analysis was not a quantitative analysis of the park resources; rather it was a method of qualitative reasoning. The MoRAP and HTLN have produced NRCAs for OZAR (2009) and EFMO (2010), and for GWCA, PERI, and WICR (completed in 2011).

Condition Summary Tables

The Natural Resource Condition Summary Table effort is a strategic, long-term framework (over a period of years to decades) to demonstrate the connection of science to management through the planning process. The current condition evaluations for selected Vital Signs contribute to this effort. This enters into the Connect the Dots initiative to coordinate the efforts of the I&M Program networks, Natural Resource Condition Assessments, park planning, park-funded monitoring and research, and other research and monitoring efforts. The I&M Program networks were responsible for completing only a few rows and columns of the Natural Resource Summary Table.

The HTLN developed a draft of a Vital Sign Supporting Table for each park, which fed into the larger Natural Resource Summary Table. This simple summary of the current condition estimates for selected Vital Signs is one of the products at the top of the information pyramid, promoted by the Service-wide program, and is part of communicating estimated conditions to parks. In 2013, the HTLN staff updated both the format and content (status/trend and reference condition) to match the national I&M Program template. Each program-area leader updated tables by mid-January 2014, in order to meet the January 31, 2014 deadline for FY2013 reporting. The tables play a role in the future State of the Park reports.

Park Planning Activities

The HTLN staff has assisted in park management planning activities. The staff ensures that recent understanding of resource status and trends become part of the planning process. Additionally, reports from monitoring usually include recommendations for management activities that may improve resource conditions (e.g. recommendations for riparian buffers along park streams). Rarely do these recommendations become specific prescriptions for actions, because management actions require a planning process that analyzes the impacts of the action to the entire human environment. Recommendations for invasive-plant management

have taken on greater specificity than those for general plant-community management. Some of these recommendations informed the IDT of the type of actions to consider in the programmatic IPMP/EA (Middlemiss-Brown and Young 2013). The HTLN staff has served on IDTs for Environmental Assessments related to natural resource management, such as a vegetation management plan for PERI, and on Resource Stewardship Plan workgroups.

The HTLN, through its planning and EPMT operations, has engaged several parks with limited natural resource management capabilities. The HTLN assisted Fort Scott National Historic Site, a park outside of the network, in developing a vegetation management study in 2011. The EPMT subsequently assisted the park in managing invasive plants within its small, restored prairie. The EPMT located at CUVA has also assisted James A. Garfield National Historic Site, also outside of the network, in the control of garlic mustard in park forests.

3.3.3 Special Projects

The HTLN undertook several special, vegetation projects to address particular needs of parks with focal resources. These projects often occurred in tandem with scheduled monitoring or inventories, maximizing the time investment by HTLN biologists.

In 2000, HTLN botanist, Karola Mlekush, conducted a study of the overstory trees in Bloody Hill glade at WICR. One study documented the size, condition, and location of Chinquapin oaks (*Quercus muehlenbergii* Engelm) at an important site for the Missouri bladderpod. The question of how changes in the sentinel trees, some hundreds of years old, may affect habitat for the Missouri bladderpod came out of a baseline study and drove a subsequent study (Mlekush 2011) specifically on the condition of Chinquapin oaks across Bloody Hill.

Early vascular plant studies at HOME focused on the restored tallgrass prairie and applied little effort in the forested areas. An HTLN inventory, including forested areas of the park identified the existence of a mature stand of rare, mesic bur oak (*Quercus macro-*

carpa) community. The HTLN staff completed the forest inventory, but then consulted with local experts to determine the community's classification by the Nebraska Natural Heritage Program. A further study ensued to evaluate the quality of the stand and to generate management recommendations for the site (Mlekush and DeBacker 2003).

The HTLN began a prairie and thicket-mapping project at HOME to assist the park in decisions regarding thicket management in the summer of 2000. Although some shrub thickets in the park have a historical significance, thickets have spread over the years and may affect prairie integrity. Staff conducted thicket mapping in 2001 in conjunction with treatment efforts to contain or reduce thickets and they have continued remapping every five years (2005 and 2010). The park wishes to take a long-term view of the success of management practices in reducing thicket colonies, and focuses attention on the total area occupied by woody shrub species in the restored prairie.

In 2003, a tornado struck the Manley Woods area of WICR affecting 148 acres of timbered land. The affected area included long-term monitoring sites sampled in three years both pre- and post-tornado. In the post-tornado years, three additional disturbances occurred, but each disturbance differentially affected each of the sites:

- In 2005, a contractor removed salvageable timber from Manley Woods.
- In 2006, the park applied prescribed fire to Manley Woods.
- In 2007, an ice storm further affected communities in Manley Woods.

A special study determined the effectiveness of the fuel-reduction activities and described the composition of plant communities inhabiting Manley Woods (Leis and James 2008).

Herbert Hoover National Historic Site had a unique set of monitoring data resulting from 21 years of work by Paul Christiansen, prairie ecologist associated with Cornell College, Iowa. In 2007, the HTLN used prescribed

fire records and this monitoring data to evaluate fire effects on a prairie restoration in the park (Williams, et al. 2007). The HTLN staff also integrated data from the Christiansen monitoring with the data collected by the HTLN, using three of Christiansen's monitoring sites as new HTLN plant-community sites.

3.3.4 Fire Ecology Program Area

In June 2002, the MWR Fire Program and Prairie Cluster had begun collaboration on fire-effects monitoring and plant-community monitoring. The MWR fire ecologist, Jim DeCoster, asked for funding from the National Fire Management Program Office to hire a permanent fire ecologist, stationed with the HTLN. The FIREPRO did not fund a fire ecologist position at that time. According to the FIREPRO Steering Committee and the Fire Ecology Steering Committee, the conditions within tallgrass prairie parks justified having a moderate-sized fire-ecology program. As a result, the MWR Fire Program provided financial support to HTLN to enhance monitoring with seasonal technicians for TAPR and EFMO in 2003. The MWR fire ecologist expressed the benefits of this collaboration in the 2004 Fire Ecology Annual Report (DeCoster 2004):

"Through this collaboration [between the HTLN and Midwest Fire Management Program], the Midwest Fire Management Program is receiving a vast amount of vegetation data with a very modest financial contribution. The lack of a fire ecologist to specifically analyze this data for fire-effects information is a major impediment preventing the use of this data in adaptive management decisions. The Midwest Fire Management Program will continue to provide funding for seasonal positions, with the hope that the Fire Management Program Center will eventually provide funding for permanent positions."

"It has been the hope that FIREPRO will eventually fund a full time fire ecologist and a subject to furlough lead fire-effects monitor. With such funding, the following could be accomplished for these seven parks [WICR, HOME, PIPE, EFMO, TAPR, GWCA, and HEHO]:

- quantitative prescribed fire objectives could be written*
- fire-effects monitoring plans could be written*
- data analysis on fire effects could be performed*
- immediate post-burn reads could be performed*
- fire-effects monitoring could be expanded in the existing parks*
- better fire-ecology support could be provided to the parks*

Moreover, the hiring of permanent personnel would allow fire-effects monitoring programs to be established at Fort Larned National Historic Site and Fort Scott National Historic Site."

(Jim DeCoster 2013)

Over the next several years however, the WASO delivered no funds for hiring new, permanent fire ecologists. This left seven of the parks in need of additional monitoring and support to evaluate the efficacy of their prescribed fire goals. The HTLN submitted a proposal to fund a fire ecologist, lead monitor, and assistant monitor for 36 pay-periods to collaborate with the NPS Fire Management Program during FY 2005 and FY 2006. The Midwest Fire Management Program worked with National Fire Ecology Program staff to use year-end funding from FY 2006 to fund a term fire ecologist through a CESU. Finally, a collaborative effort between the

NPS, Fuels Program, MWR Fire Ecology Program, the HTLN, and MSU permitted MSU to hire a fire ecologist dedicated to the HTLN beginning in 2007.

A funding modification to the Cooperative Agreement, facilitated by the NPS Fire Ecology Program, allowed MSU to hire a lead monitor and project graduate student, dedicated to HTLN fire-effects monitoring in FY 2009. This allowed deployment of full scale monitoring in spring of 2009, and the fire monitoring staff completed several focus projects and reports that year. The fire ecologist tested methodologies and developed a protocol in 2010 (Leis, et al. 2011). The HTLN acquired funding that allowed modification to the agreement with MSU that made the lead monitor a full time, GS-7 (equivalent) position and upgraded the fire ecologist to GS-11 (equivalent), starting January 2011. In that same year, two additional opportunities surfaced. The first connected the fire ecologist with park condition assessments. The second created a plan for the Great Plains Fire Science Exchange (GPFSE), submitted to the Joint Fire Science Program for funding. The GPFSE received funding in 2012.

The NPS Fire Ecology Program has provided funds to expand Vital Sign Monitoring in parks with active fire programs, conduct focused analysis of Vital Sign data for fire effects, and collect fire-effect data on specific fires. The collaboration with MSU provides scientific and administrative support. The successful operation of the GPFSE broadens the scope of expertise available to the fire ecologist through collaboration with other fire science organizations. The HTLN fire-ecology team seeks to integrate ecosystem data with fire-ecology data, and apply the broad understanding to park management. The team collaborates with parks and acts as a liaison with the MWR Fire Program to create a multifaceted fire-effects program.

Participation in Prescribed Fire

Ozark National Scenic Riverways inquired about the availability of the HTLN Fire Ecology Team (FET) for wildland-fire duty in

their area. The Cooperative Agreement with MSU did not address participation in wildland fire as a duty of the fire-ecology team, and so the FET could not assist. The issue became more complicated, when considering the response to a prescribed fire going out of prescription. If the FET may not assist to suppress an escaped fire, the result may pose a threat to health and safety. After consultation with park and regional fire staff, the HTLN requested a modification to the existing Cooperative Agreement with MSU, stating that in the event of the FET working on a prescribed fire that escapes, the FET would continue work on the incident until released by the burn boss/incident commander. This change went into effect in August 2011.

The Ozarks Area Fire Management Officer (FMO) rejected the agreement, because the FET lacked wildfire experience. The FMO would not allow fire-effects work during prescribed fires under his command, despite the FET's certification to work on prescribed fires. This decision hindered operations of the FET to integrate fire-effects monitoring with Vital Sign Monitoring and the ability to provide a quality service to the parks.

Great Plains Fire Science Exchange

The GPFSE, part of the Joint Fire Science Program³⁹, exchanges knowledge and distributes research results about fire dependent, grassland ecosystems of the Great Plains region among a consortium of landowners, land managers, practitioners, and scientists. Through an information sharing process, the GPFSE hopes to strengthen collaboration within the fire community, and make science-based information available for land managers, decision makers, and others in the Great Plains Fire Community. Successful funding of the GPFSE resulted in the fire ecologist taking a leadership role in the program. This necessitated altering the fire ecologist's appointment to 50% for HTLN and 50% for GPFSE. The GPFSE is a close partner of the HTLN monitoring program.

3.3.5 Invasive Plant Management

As with all monitoring, monitoring invasive

³⁹ Joint Fire Science Program is a nationwide program that funds scientific research on wildland fires and distributes results to help policymakers, fire managers and practitioners make sound decisions. Found at <http://www.firescience.gov/>, December 9, 2013.

species provides the information needed for efficient and effective management. In 2000, a proposal, led by Technical Committee members, did not receive funding as part of the Challenge. In 2006, a workgroup of Technical Committee members once again began to address this need. After engaging the resource managers from the parks in a survey about invasive-plant management needs and receiving the Board's enthusiastic support, EFMO submitted a proposal on behalf of all the network parks to establish an EPMT using ONPS funds instead of Challenge funding. The request for ONPS funds was successful, and the NPS had scheduled EFMO to receive funding in 2010.

Anticipating funding in 2010, the MWR I&M Program and EPMT coordinator (Carmen Thomson), HTLN coordinator (Michael DeBacker), and EFMO superintendent (Phyllis Ewing) asked the MWR director for contingency funding to support a trial run at EPMT operations in 2009. This resulted in the MWR director providing support for SCA interns to work on invasive-plant treatment recommendations for the parks. Concurrently, at the Board's recommendation, the HTLN reestablished the EPMT Workgroup to prepare for the influx of EPMT funds. The Board charged the workgroup with updating the proposal, specifically (1) to provide more detailed implementation planning, (2) to flesh-out a data management plan, and (3) to describe the oversight role of the Board. The workgroup developed a five-year, phased plan for creating an EPMT.

The five-year plan considered three alternative approaches for organizing the EPMT:

1. The first alternative proposed hiring staff to manage and operate two four-person strike teams, with host parks providing oversight and administration.
2. The second alternative proposed combining the position of the EPMT coordinator and the HTLN invasive-plant biologist (i.e., HTLN botanist, Craig Young) with program supervision from WICR. The resource manager at a park receiving services would provide day-to-day oversight of the crew boss and technician to ensure compliance with

all park procedures and practices. The workgroup preferred this alternative because it balanced a core permanent infrastructure, and it integrated monitoring and management capabilities.

3. The third alternative was similar to the second alternative, except that the EPMT would not hire a crew technician and temporary work crews would locate at various parks.

In 2010, the EPMT submitted to MWR the five-year start-up plan for EPMT implementation in two phases. Phase 1 recommended establishing a core EPMT staff, as detailed in the second alternative. Phase 2 detailed budget, administration, and data management over the start-up period. The internal document, *Organization of an Exotic Plant Management Team to Serve Parks Cooperating as the Heartland Inventory and Monitoring Network: A Recommendation (Phase 2)*, summarized Phase 2 in January of 2010.

Efforts to obtain funding resulted in the MWR providing \$741,000, beginning in FY 2010, through an ONPS increase to EFMO. The invasive-plant biologist also served as the EPMT coordinator, and worked with the parks to develop a work plan for management activities in 2010. For the first year of work, the EPMT continued to rely on interns and Conservation Corps to provide field labor as it fleshed out a staffing plan, and because it had no travel allocations for a centralized crew. Instead, the EPMT provided funding for staff and equipment to compete projects, as outlined in the work plan, at each park. The EPMT hired biological interns and seasonal technicians using Intra-agency Agreements or NPS temporary hiring processes as specified in the work plan (Intra-agency Agreements, Appendix 3). The EPMT executed contracting and provided training, support, quality control, and data consolidation and reporting. The parks hired, oriented, supervised, and ensured safety of daily activities of seasonal biological technicians, interns, and work crews. Some parks used a variety of local partnerships, youth-service providers, and contractors to carry out invasive-plant management. The parks provided suitable workspace, vehicles, and computers, and took responsibility for

completion of environmental compliance required to conduct invasive-plant control with assistance from the EPMT.

The first year of operation went smoothly, largely because of strong cooperation and coordination among all partners. The HTLN Board noted that with staff attached to both WICR and EFMO the EPMT incurred (1) duplication in effort and services provided by the administrative staff at two parks, and (2) complexity in budgeting with multiple base accounts through different points-of-contact. The Board tasked the HTLN coordinator to investigate alternatives to simplify program administration. After conferencing on the regional level, requesting input from both parks, considerable deliberation, and proposing a recommendation to all park superintendents for concurrence, the Board decided to consolidate administrative support and funding through WICR, as approved by the MWR director (NPS Memorandum, November 18, 2010). The Board approved hiring a term EPMT crew leader, Adam Throckmorton, based at WICR, in July 2010.

The MWR had assured the HTLN of modest travel ceiling increases to the host park to accommodate the EPMT. In 2011, the second year of operation, MWR had not yet provided additional travel allowance for EPMT activities. The EPMT developed local projects in which the EPMT and parks cooperated in logistics, and staffing. The EPMT used innovative outsourcing to minimize the travel charged to the NPS, limiting travel to only 140 days for the year. Still, the core crew of the EPMT needed some travel ability to oversee operations and conduct inherently governmental tasks.

Anticipated travel for FY 2012 and FY 2013 was higher than that for FY 2011. Contract inspections, data collection and training in parks, and training for staff were required. The HTLN requested increases in the FY 2012 and FY 2013 to the WICR travel ceilings to accommodate the mandates of this program. The MWR approved \$15,000 of travel allowance for these years, but travel ceilings still severely limited the quality and quantity of service provided directly to the

parks.

Strategic Plan

An EPMT representative, Sherry Middlemis-Brown, coordinated with parks to prepare the required National Environmental Policy Act of 1969 (NEPA) documentation for work plans requiring management actions. The NPS allows the use of Categorical Exclusions (CE) for invasive-plant management actions that are consistent with plans that underwent NEPA process and that meet certain criteria (NPS 2006). Thus, fire management plans or vegetation management plans sometimes sufficed as implementation plans for invasive-plant management.

In creating work plans, the EPMT found that relying on CEs could limit the scope of treatment, thus preventing a long-term solution to invasive species management. Because of the wording of the NPS policies concerning invasive plants and CEs, using CEs could hamper early detection and immediate response for eradication of small infestations of invasive plants. Parks within the HTLN recognized a need for an integrated, invasive-plant management strategy that defined specific goals, objectives, and strategies that would apply across all 15 parks. Therefore, a project began in 2010 to develop a programmatic strategy and appropriate NEPA compliance documents that would act as a program level, strategic plan in all 15 parks.

Developing a Heartland Invasive Plant Management Plan and Environmental Assessment (IPMP/EA) took more than two years. Internal scoping began in July 2010 at the HTLN Biennial Meeting, where park resource managers, lead interpreters, several superintendents, and MWR representatives met with HTLN staff. External scoping began October 26, 2010, when the EPMT entered the project into the NPS software system, PEPC, and established the Interdisciplinary Team (IDT). The IDT initially consisted of a resource manager from each park, two cultural resource representatives from MWR, a planner from MWR, the EPMT coordinator, and the document's author/facilitator. As interest in the IPMP/EA swelled, additional NPS staff requested to join the IDT. This increased the membership from 19

to 30 members. The IDT met by conference calls, where the facilitator explained IDT tasks and updated members on progress.

The EPMT sent approximately 80 letters of intent to partner agencies and stakeholders in November 2010, requesting consultation. The EPMT created a guide to civic engagement for park use with templates for notification of stakeholders and tribes during external scoping, consultation, and public comment. Each park engaged their stakeholders and their public according to park policy. Because of the sensitive nature of tribal-federal communications, each park engaged their associated tribes with the support of the EPMT, rather than having the EPMT consult with tribes directly. The external scoping period ended in PEPC on March 1, 2011 after parks contacted all tribes and requested consultation, but remained open throughout the process by phone or letter.

Writing of the IPMP/EA began in early 2011. The primary author, Sherry Middlemis-Brown, facilitated the NEPA process and completed most of the writing. The EPMT coordinator provided technical assistance. The need to collaborate with 15 parks made the process slow and arduous. The author completed writing the draft document in 2011 with the final park review completed by August 2012. The draft went to the MWR for review in October 2012. Because of the sensitive resources in the 15 parks, the EPMT held an early consultation on the draft EA for all partner agencies, beginning December 2, 2012. Public comment began February 5, 2013 on a draft, containing minor revisions recommended in agency consultations submitted before January 30, 2013. Public comment and agency consultation remained open until March 30, 2013.

The resulting IPMP/EA (Middlemis-Brown and Young 2013) assessed impacts of invasive-plant management on the environment. The programmatic strategy used a decision tree to select various treatments to achieve the most effective invasive-plant management feasible, and defined best practices and mitigations to limit environmental impacts to minor or negligible levels and short duration.

The EPMT and IPMP/EA provides parks with consistent and continuous management of invasive plants that minimizes potential impacts and maximizes overall management success. The IPMP/EA encourages collaboration between parks and invasive-plant experts, training of staff, prevention, early detection, and rapid response to invasive plants, and it requires use of best practices to manage established invasions.

The extent of the external scoping and early consultation provided an understanding of agency and public concerns before writing the IPMP/EA. This contributed to the ease with which the document went through reviews, consultation on the draft, and public comment. The final document differed little from the initial draft.

The author completed a Finding of No Significant Impacts (FONSI), based on the final IPMP/EA. The FONSI went through internal and external review. The acting MWR director signed the FONSI on July 19, 2013 (Middlemis-Brown 2013).

The EPMT

During the programmatic planning process, parks and the EPMT continued to take action to control invasive plants under CEs. Each year, the EPMT coordinator collaborated with park managers to develop a work plan that describes actions to manage specific target species. Parks complete compliance documentation for actions, as required by regulation or NPS policy. Compliance documentation usually involves filling out an Environmental Screening Form, determining additional NEPA compliance documentation required, submitting National Historic Preservation Act, Section 6 review forms as needed, and submitting requests for permission to use herbicides, as applicable, through the Pesticide Use Proposal System.

With the execution of the IPMP/EA, the EPMT requires that parks complete annual compliance on work plans prior to management actions. The potential exists for the EPMT to move forward with execution or funding of a project in good faith that the park has completed compliance, when, in fact, compliance is not yet complete.

To prevent this problem from arising, the EPMT decided that it would only carry out those projects for which the superintendent has signed the Letter of Compliance Completion.

The HTLN administers a unique EPMT in that it is (1) the only ONPS funded EPMT, (2) the first EPMT to be fully integrated within the administrative framework of an I&M Program network, and (3) the only EPMT to cover an unprecedented physical range of 757 latitudinal miles and 777 longitudinal miles with 15 parks in 8 states. The EPMT relied on a variety of partnerships to carry out 90% of invasive-plant management in lieu of using NPS travel, when first implemented. Park staff, EPMT, or Conservation Corps in partnership with NPS personnel implemented management actions. An Intra-agency Agreement with PERI staffed small a crew that served several parks in 2010. The crew leader stationed at WICR could not easily serve the eastern portion of the HTLN (CUVA, HOCU, and LIBO), because of the cost and logistics of travel. The Board approved establishing an EPMT module in cooperation with CUVA, October 2011. Cuyahoga Valley National Park entered into an agreement with HTLN that brought consistency in service to these parks. The CUVA-HTLN Intra-agency Agreement supported a Subject-To-Furlough crew leader and a field crew to serve these parks and assist with other EPMT projects, when needed.

3.3.6 Disturbed Lands Initiative

Disturbed land restoration is the process of restoring lands, where human actions have influenced the natural conditions and processes, causing unwanted and long-lasting problems that affect other resources. Within the parks, these actions exacerbate the invasion of exotic plants, affect water through erosion and sedimentation, and disrupt ecosystem functions or physical processes. Vital Sign Monitoring plays an integral process in determining the status and trends of systems that might or are undergoing restoration. The restoration results in improvements to native and natural habitats, and natural processes. Thus, managers can measure long-term success through Vital Sign Monitoring.

The HTLN and the parks collaborated to summarize the restoration projects already identified by parks in project plans, Cultural Landscape Reports, and Resource Management Plans, and describe other areas requiring restoration. Vegetation maps were used in parks, where available, to locate potential areas not yet identified. The HTLN also sought to develop this effort into a comprehensive project proposal, satisfying the justifications for requesting park-base funding for a permanent disturbed-land restoration and vegetation-adaptation project affiliated with the HTLN. The HTLN established an Intra-agency Agreement with EFMO to detail an employee, Jessica Salesman, for this purpose. The employee completed the initial work in 2013, but the HTLN does not know the future viability of the project.

3.4 A Fully Implemented Program

The HTLN became fully operational in 2005, but continued to evolve to accommodate needs as staff continued acquisition and analysis of data and as managers received reports on resource status. Additionally, as the HTLN evolved, the Network Charter underwent revisions to accommodate some concerns expressed by the HTLN staff, the MWR director, and the Technical Committee. The revision done in 2007 addressed the role of the Technical Committee and brought the prototype program out from behind a curtain, acknowledging its continuing value to the combined program.

3.4.1 Safety First

The HTLN completed the initial safety plan in 2006, and revised it in 2008. After completing operational leadership training in 2011, the HTLN initiated another revision of the safety plan to incorporate concepts of operational leadership. The Board and Technical Committee reviewed the safety plan in 2012, providing comments. The Board approved the final safety plan in April 2012.

3.4.2 Program Reviews

A memo of February 28, 2008 from the NPS associate director for NRSS to the regional directors contained a document updating guidance to the networks for the operation and maintenance of Vital Sign Monitoring

networks. The guidance clarified core duties, operations, and expectations for the I&M Program networks. The memo summarized key policy and guidance, issued previously in various documents, and provided supplemental guidance on new activities and emerging issues. This guidance would enter into subsequent program reviews.

The HTLN's three-year, program review, August 18-21, 2008 in Springfield, Missouri, included five reviewers:

- MWR chief of natural resources, retired (Steve Cinnamon)
- National I&M Program director (Steve Fancy)
- Chief of natural resources, BUFF, retired (George Oviatt)
- MWR I&M Program coordinator (Carmen Thomson)
- Great Lakes Network coordinator (William Route)

The review panel members with the consensus of all of the superintendents and park resource managers, who attended the August 2008 review, agreed that the HTLN had made an excellent start. Network staff had produced an impressive number of protocols, technical reports, and data sets. The NPS considered HTLN a model I&M Program network.

The invited panel also addressed specifics on the state of the HTLN after the first three years of operation. The review panel reported that the HTLN operated on a "razor-thin margin" with little opportunity for making adjustments in the event of staff turnover, equipment failures, poor weather, or other events, expected with any long-term monitoring program. The panel concurred with the HTLN's efforts to trim costs and make some of the field efforts more efficient. They recognized that the recent scheduling changes that consolidated several terrestrial projects would reduce some demands on the Vegetation Program Area and the Wildlife Program Area. Some specific recommendations for the Aquatic Program Area were:

- Do not implement the geomorphic pro-

tol and add a few simple geomorphic measures into the aquatic invertebrate and/or fish protocols.

- Defer the monitoring of Ozark hellbenders by HTLN staff to other investigators.
- Evaluate staffing for the Aquatic Program Area, which was stretched too thin and behind schedule in routine reporting. The HTLN should consider cutting sample size or number of measurements for some of the aquatic protocols until funding or added staff can alleviate the backlog.

The HTLN asked representatives from parks with aquatic sampling to review protocols for invertebrate and fish monitoring, reply to a questionnaire, and craft ideas for reducing the current workload of the Aquatic Program Area, while maintaining scientific integrity of data and addressing information needs. In a memorandum dated May 10, 2010, the HTLN coordinator called for the establishment of an ad-hoc committee to deliberate the scaling back of monitoring at Ozark River parks (i.e., BUFF and OZAR) to a sustainable level. The program area implemented sampling revisions in the Fall/Winter 2012 field season.

3.4.3 Considering the Future

The HTLN staff has learned many lessons over the years. They tried various techniques that did not succeed in attaining desired results and adopted many innovative techniques and approaches that exceeded expectations. The lessons learned, successes gained, and visions of what the I&M Program could accomplish has led to the following ideas for the future.

Nationally, I&M should strive to:

- Leverage the networks' 'brains & boots on the ground,' and their administrative infrastructures to better coordinate activities of all field based NRSS staff.
- Dissolve the artificial dichotomy between job 'one' – the collection and analysis of long-term monitoring data; and everything else that information can be used for (e.g. planning, education, decision support). Focus on problems solved, resources stewarded, and the

core mission of ‘preserving resources unimpaired.’ Avoid traditional metrics (e.g. # protocols, # reports) for defining success.

- Fully embrace the networks as an NPS organizational entity aligned through regions and comprised of related park units. After 10 years, we still argue over administrative care and feeding of the networks. Currently, supervision, fiduciary control, and administrative support functions are inconsistent throughout the NPS.
- Integrate network expertise into the Solutions for Technical Assistance Requests (STAR) process. Consider networks as primary sources of information and expertise to address STAR requests. Incentivize networks to take a larger, collaborative role in STAR projects than they do currently.

Networks should strive to:

- Carefully blur the line between objective consultant and park advocate. The model of the USGS as the objective scientific organization does not fit the roles and responsibilities of the networks to

their parks. Networks serve the parks as partners in problem solving. Parks come to the networks with questions that would not have the level of nationwide, scientific merit to appeal to a pure-science division. The NPS is in the business of stewardship and management, creating a bias towards decision making that preserves park resources unimpaired for current and future generations.

- Embrace the responsibility of being the institutional knowledge of many park natural resource programs. Networks should look for opportunities to mentor young resource managers. Networks can fill the void created by the loss of the natural resource managers’ training program.
- Serve as facilitators of multi-park collaborations. Networks are positioned uniquely to align disparate park-based efforts to address common natural resource issues. Networks can be entrepreneurial in fostering partnerships.
- Aspire to be the first stop for advice and information for natural resource managers.

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Appendix 1: Glossary

Glossary

A	
AARWP	Annual Administrative Report and Draft Work Plan
ARPO	Arkansas Post National Memorial
Adaptive management	A systematic process of learning from experience and subsequent improvement of management policies and practices by implementing management actions explicitly designed to generate information useful for evaluating alternative hypotheses about the system being managed.
Annual Work Plan	The HTLN coordinator presents an Annual Work Plan proposal to the Board, identifying projects, implementation, and funding for each fiscal year.
Attributes	Any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem.
B	
Board	Board of Directors; the governing body for the Heartland Network and later for the HTLN, as established in the Network Charter.
BRD	Biological Resources Division, U.S. Geological Survey; developed from the National Biological Survey (bureau created in 1993) and incorporated into the U.S. Geological Survey in 1996.
BUFF	Buffalo National River
C	
CA	Cooperative Agreement, an official agreement between NPS and a partner under a Memorandum of Understanding.
CE	Categorical Exclusion is an action, related to an existing implementation plan, having no significant impact on the environment, and therefore is excluded from further environmental effects analysis.
CESU	Cooperative Ecosystem Studies Unit; one of a network of units that provide research, technical assistance, and education to federal land management, environmental and research agencies, and their potential partners to address critical and natural and cultural resource management and stewardship issues. The network was established by Memorandum of Understanding.
COLA	Cost of Living Adjustment is a wage-indexed increase in pay, intended to keep pace with inflation.
CSU	Colorado State University is a CESU member.
CUVA	Cuyahoga Valley National Park
Challenge	Natural Resource Challenge Program of 1999 encouraged resource management based on scientific knowledge and funded programs for seven years, starting in fiscal year 2000.
Clean Air Act (1970)	[42 USC 7401 et seq.; 84 Stat. 1676, P.L. 91-604] an extension of the Air Quality Act of 1967, the 1970 act (CAA, as amended) protects and enhances the nation's air quality to promote the public health and welfare.
Clean Water Act (1972)	Federal Water Pollution Control Act. [33 U.S.C. 1251 et seq.], passed in 1972, strove to reduce toxic substances released into the nation's surface waters from point sources. Amendments broadened the scope to cover standards for various stream uses (e.g., wildlife purposes and human recreation). The act is administered by the Environmental Protection Agency, working with states.
Conceptual models	Purposeful representations of reality that provide a mental picture of how something works to communicate that explanation to others.
Cooperating agency	An agency other than the lead agency with an interest in an action, resource, or park because of law or special expertise. Federal, state, or local governments, and Indian tribes, may be designated cooperating agencies.
Cooperative Agreement	Specify particular tasks and compensation to be fulfilled under an established Memorandum of Understanding.
Core Park Vital Signs Monitoring Program	An early version of the Vital Signs Program that intended to establish core indicators for monitoring in parks.
D	
DOQQ	Digital Orthophoto Quarter Quad; aerial photography or satellite imagery that is aligned with latitude and longitude at a scale of 1:12,000.
Dataset Catalog	A desktop tool for keeping an inventory of and providing abbreviated metadata about natural resource data sets.
DataStore	An NPS application that shares Geographical Information System data and metadata associated with natural resources and generated by or for the NPS.
Driver	The major external driving forces that have large-scale influences on natural systems. Drivers can be natural forces or anthropogenic.

E

EFMO	Effigy Mounds National Monument
EPMT	Exotic (invasive) Plant Management Team; a project team and subunit of the HTLN that assists parks with invasive plant management.
Ecological integrity	The degree to which the physical, chemical, and biological components and relationships of an ecosystem functioning and sustainable.
Ecosystem drivers	Major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large-scale influences on natural systems.
Endangered species	[16 USC §1532(6)] Any species that is in danger of extinction throughout all or a significant portion of its range. Endangered Species Act 1973 requires federal agencies to insure that any actions with a federal nexus do not jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modifications of critical habitat.

F

FET	Fire Ecology Team of the HTLN.
FFI	FFI (FEAT/FIREMON Integrated) is a monitoring software tool for collection, storage, and analysis of fire ecology data. The initials are used as the software name without the originating software names.
FIREPRO	Funding to fire offices and parks from the National Fire Management Program.
FMO	Fire Management Officer
FONSI	Finding of No Significant Impacts is an official document under the National Environmental Policy Act regulations for NPS.
FTE	Full Time Equivalent refers to one person working full time. Allocations of human resources are expressed in FTEs.
FY	Fiscal Year, the federal government's fiscal year, running from October 1 to September 30.
Fire Program	The NPS fire program operation is referred to as Fire Management Program
Five Year Program Review	The Prairie Cluster had a program review in 2001 and every 5 years thereafter to evaluate accomplishments, products, protocols, data management, fiscal management, and staffing.
Focal resources	Park resources that, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring.

G

GIS	Geographical Information System; software that assists in collection, management, display, and analysis of spatial data, often associated with processing data collected on a GPS receiver.
GPRA	Government Performance and Results Act of 1993 sets management goals for parks.
GPS	Global Positioning System; a navigation system, using satellites to triangulate location information.
GRTS	Generalized Random Tessellation Stratified sampling
GWCA	George Washington Carver National Monument
Geodatabases	Relational database management system used in conjunction with GIS, incorporating location and metadata with other datasets.

H

HEHO	Herbert Hoover National Historic Site
HOME	Homestead National Monument of America
HOCU	Hopewell Culture National Historical Park
HOSP	Hot Springs National Park
HTLN	Heartland Inventory and Monitoring Network combined the Heartland Network and the Prairie Cluster Long-term Ecological Monitoring into one I&M Program network.
Heartland Network	The name given to the I&M Program network prior to integration with the Prairie Cluster.

I

IDT	Interdisciplinary Team assists in an Environmental Assessment or Environmental Impact Statement.
I&M Program	Inventory and Monitoring Program, Natural Resources Stewardship and Science, National Park Service
Interagency Agreements	Agreements made between agencies of the federal government, usually to implement certain tasks with a set compensation.
Interior	Department of Interior, United States government
Intra-agency Agreement	Agreements made between the units or offices within the NPS.

IRMA	Integrated Resource Management Applications, a 'one-stop' portal, where the investigator can search, view, and download documents, reports, publications, data sets, park species lists, and links to additional data sources.
Impaired water	A body of water with chronic or recurring violations of water quality criteria.
Indicators	A selected subset of the physical, chemical, and biological attributes, including processes that represent the overall health or condition of the system.
Integrity	See Ecological Integrity
Interior	United States Department of Interior
Inventory	A point-in-time determination of location or condition of a resource. For I&M, at least 90% of the vertebrates and vascular plants in the parks were documented with distribution and abundance information on a subset of those species, becoming the initial set of observations for a monitoring program.
K	
KU	Kansas University; the Heartland Network worked with the Central Plains Center.
Konza LTER	Konza Prairie Long-term Ecological Research program of Kansas State University.
L	
LIBO	Lincoln Boyhood National Memorial
LTEM	Long-term Ecological Monitoring of the Inventory and Monitoring Program, National Park Service.
Landsat 5	Low orbiting satellite used to record the earth's surface as imagery.
M	
MoRAP	Missouri Resource Assessment Partnership, University of Missouri.
MSU	Missouri State University, formally known as Southern Missouri State University.
MU	University of Missouri
MWR	Midwest Region, NPS; the MWR has an office and staff that supports NPS programs.
MWR Fire Program	Midwest Fire Management Program, the Midwest Region's office of the National Fire Management Program
Measures	Specific feature(s) used to quantify an indicator, as specified in a sampling protocol. For example, pH, temperature, dissolved oxygen, and specific conductivity are all measures of water chemistry.
Metadata	Describes content, quality, condition, and other characteristics of data, particularly in spatial data, and provides information to process and interpret data received from external sources.
Monitoring	The repeated collection and analysis of observations to evaluate changes in status of conditions and to detect changes or trends in a resource conditions.
Monitoring plan	An overall strategic design that identifies the management and scientific issues of concern, objectives of monitoring, Vital Signs to monitor, locations of monitoring, staffing requirements, and data management.
N	
NatureBib	Once called NRBib, this updated, a centralized, online catalog of natural resource information on parks.
NAWQA	National Ambient Water Quality Assessment Program of the US Geological Survey.
NBS	National Biological Survey; a Department of Interior bureau with biological research functions, created in 1993 when the department removed biological research units from other bureaus and attached them to the NBS. It lost status as a bureau in 1996 and became the Biological Research Division of the US Geological Survey.
NEPA	National Environmental Policy Act of 1969 [42 U.S.C. §4321 et seq.]; the law requires that decision-makers and the public know the consequences of an action before taking it.
NGPN	Northern Great Plains Network; a network of the I&M program, located northwest of the HTLN and implemented after the HTLN; two Prairie Cluster parks joined the NGPN once that network became fully operational.
NHPA	National Historic Preservation Act of 1966, as Amended; laws regarding the protection of cultural and historical resources and values.
NLCD	National Land Cover Database; a land cover classification system with 16-classes for the contiguous United States, and applied at 30-meter resolution.
NPS	National Park Service; a bureau of the Department of Interior.
NPSpecies	The NPS database with records of species occurrence and status in parks.
NRBib	The NPS bibliographic citations for all reports, papers, and documents relating to natural resource studies and investigations in parks.
NRC	National Research Council, a section of the National Academy of Sciences dedicated to advance science in government function.
NRCA	Natural Resource Condition Assessments is a project of the Water Resources Division to determine current resource conditions within watersheds.

NRDT	Natural Resource Database Template, a set of relational database tables that parks and networks use for inventory and monitoring data.
NRI	Natural Resource Initiative, precursor to the Natural Resource Challenge, and also the continued program to support natural resource science after the Challenge.
NRInfo	Natural Resources Information Portal, the precursor to IRMA
NRMAP	Natural Resources Management and Assessment Program a system of quantification of natural resources within the parks.
NRPC	Natural Resource Program Center, a division within NPS.
NRSS	Natural Resource Stewardship and Science, a division of the National Park Service with hierarchical offices at Service-wide and regional levels.
NRTR	Natural Resource Technical Reports of the National Park Service.
NVCS	National Vegetation Classification Standard; facilitates a consistent national classification of existing vegetation, simplifying application of classes across the nation.

O

ONPS	Operation of the National Park Service; a funding stream that supports park base-funds.
ORLC	Ozarks Science and Learning Center
OZAR	Ozark National Scenic Riverways
1998 Omnibus Act	1998 National Parks Omnibus Management Act enhanced management and protection of resources through authorizing and directing the conducting of scientific study to be used in management decision-making.
Organic Act	National Park Service Organic Act of 1916; established the National Park Service as a bureau tasked to conserve resources within units in an unimpaired state for future generations.

P

PDF	Portable Document Format files represent documents independently of the software in which they were created, with a fixed layout that can be read with readily available, free software.
PEPC	Planning, Environment & Public Comment, online planning system
PERI	Pea Ridge National Memorial Park
PIPE	Pipestone National Monument
PMIS	Project Management Information System; an NPS intranet application to manage information for project funding requests. It also functions as a project proposal system to request funding.
Pay period	A two-week period established by the Office of Personnel Management for reporting work hours, resulting in payment of salary. Pay periods are often used to indicate duration of temporary employment, such that 13 pay periods of employment represents a six-month term of employment.
Prairie Cluster	Prairie Cluster Long-term Ecological Monitoring, prototype cluster of parks in the I&M Program, prior to integration with the Heartland Network as part of the HTLN.
Program	Refers to the Inventory and Monitoring Servicewide structure and to the prototype component of the Servicewide structure, the LTEM Program.
Program Area	Each resource issue monitored by the prototype or each grouping of Vital Signs by type (e.g., aquatic program area, vegetation program area, wildlife program area) constitutes a program area. Monitoring within a program area is done by project (e.g., whitetail deer, breeding birds within the wildlife program area).
Protocols	As used by this program, are detailed study plans that explain how data are to be collected, managed, analyzed and reported and are a key component of quality assurance for natural resource monitoring programs (Oakley et al. 2003).

Q

QA/QC	Quality Assurance and Quality Control, a method of ensuring integrity and validity of data entry.
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R

RLC	Research Learning Center, one of the products of the Natural Resource Challenge, intended to combine research and education through collaboration with educational institutions to protect and preserve park resources.
Research	The collection of data to enhance understanding of ecological processes and determine the cause of changes observed by monitoring.

S

SCA	Student Conservation Association is an organization that provides opportunities for students to contribute to environmental conservation through participation in public service. SCA volunteers assist in many national parks.
STF	Subject to Furlough employment condition permits temporary lay off.
SOW	Scope of Work

STORET	Storage and Retrieval, a water-quality, data warehouse managed by the Environmental Protection Agency.
Scoping	The procedure by which an agency identifies important issues and determines the extent of analysis necessary for an informed decision on a proposed action.
Servicewide	Refers to all National Park Service units and offices, or the national level of a National Park Service program
Stressors	Physical, chemical, or biological perturbations (unnatural or excessive influences) to a system that cause significant changes in the ecological components, patterns, and processes in natural systems.
T	
TA	Task Agreement, an agreement with specific expectations named, falling under a Cooperative Agreement.
TAPR	Tallgrass Prairie National Preserve
Threatened and endangered species	Any species of fish, wildlife, or plant that is listed as threatened or endangered by the U.S. Fish and Wildlife Service under the authority of the Endangered Species Act [16 USC §1532(6)] of 1973. The Endangered Species Act requires federal agencies to insure that any actions with a federal nexus do not jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modifications of critical habitat.
Trend	As used by this program, monitoring results that establish a directional change in resource condition over time.
Threshold	In monitoring, a point at which change is considered significant. Threshold should be identified within the monitoring plans, such that levels of detection are sensitive enough to perceive the significant change. Threshold may also refer to the point at which management action will be taken.
U	
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service, a bureau of the US Department of Interior
USGS	United States Geological Survey; a bureau of the US Department of Interior
V	
Vegetation Mapping Inventory	One of the 12 core inventories.
Vital Signs	A subset of physical, chemical, and biological elements and processes in park ecosystems that represent the condition of park resources, effects of stressors, or elements of important human values. They represent natural resources that park managers must preserve “unimpaired for future generations.”
W	
WASO	Washington Office, headquarters for the National Park Service and associated programs, referenced as an entity, rather than a location, since WASO offices are located across the nation
WICR	Wilson’s Creek National Battlefield
WRD	Water Resources Division of the National Park Service
WUI	Wildland/Urban Interface is a National Fire Management Program initiative to remove hazard fuels from land near populated areas, thus the wildland-urban aspect of the initiative.
Wild and Scenic Rivers	Wild and Scenic Rivers Act of 1968 (Public Law 90-542; 16 U.S.C. 1271 et seq.) to preserve certain free-flowing rivers with outstanding natural, cultural and recreational values.

Appendix 2: Timelines for Program Areas

Table 2a. Timelines for Program Areas: Pre-1998 to 2006

Project Area	Pre-1998	1999	2000	2001	2002	2003	2004	2005	2006
Aquatic Program Area	Initial protocol (Boyle, et al. 1990). Harris et al. (1991) inventories on 6 parks. Protocol published (Peterson 1996).		Peitz joins Prairie Cluster Began fish protocol developmen	Began stream as- sessment protocol developm	Fish inventories at 4 parks. Stream reach assessment monitoring began PIPE, HOME, WICR & TAPR.	USGS helped to refine Peterson et al. 1999.	Implement prairie fish protocol Expand to HOME. Begin BUFF and OZAR fish protocol (McDonald). Bowles joins staff. Luraas on staff 2004-2006.	GWCA monitoring resumes. Dodd joins staff. Petersen inventories at 5 parks (Peterson and Justus 2005). Begin pilot at OZAR springs.	OZAR and BUFF pilots continue. Morrison and Bowles propose modifying prairie-park invertebrate protocol. Ciak on staff 2007-2008. Hinsey as SCEP ¹ .
						Agreement for geomorphology protocol begins in September, due November 2004.			
				Initiated annual fish monitoring at PIPE and TAPR, assessing status of Topeka shiner.			Agreement for protocol for Ozark Hellbender at OZAR begins with final report due December 2006.		
	Publish invertebrate protocol (Peterson et al. 1999) and implemented in 4 prairie parks by Peitz. Rabini (MU) processed benthic samples until 2005.								
Data Management			Witcher joins Prairie Cluster			Implemented DMP ² . Developed databases for birds, Topeka shiner; revised Missouri bladderpod. Integrated Access® databases with ArcGIS®.	New server to house program merger. Revised DMP and wrote SOP ³ for protocols.	Developed databases: deer, MO bladderpod, invasive plants, aquatic invertebrates. Developed server archive.	Developed databases: fish, invertebrate, and spring communities. Obtain new imagery.
Breeding Bird			Peitz joins Prairie Cluster. Began protocol development.	Initiated breeding bird surveys at TAPR and AGFO		Protocol finalized in 2003 - example to other networks.		Added bird monitoring at HEHO and HOCU.	Last year of survey in AGFO.
Fire Ecology / Fire Effects				Fire Effects monitoring at TAPR begins		Fire Effects monitoring at EFMO begins.	Fire Effects monitoring at EFMO & TPR continue; Original fire ecology proposal approved	Burning began at EFMO. Established new monitoring sites.	Acquired grant funding through the NPS Fuels Program to hire a fire ecologist through cooperative agreement.

¹ Student Experience Career Program – student-hiring program through the federal government.

² Data Management Plan

³ Standard Operating Procedures

Table 2a. (continued) Timelines for Program Areas: Pre-1998 to 2006

Project Area	Pre-1998	1999	2000	2001	2002	2003	2004	2005	2006
Land Cover						Hansen and Gyskiewicz report.			
					JAYA Corporation- contract: Landcover Analysis for Four National Parks.	Begin University of Arkansas research proposal: The Interpretation of Land Use Change and Development of Monitoring protocol for the Heartland Network Hot Springs National Park. (continued 2007-2009)			
				Calmit- produced for Prairie Cluster maps and report Land Use/ Land Cover Interpretation and Analysis for Three National Monuments.					
Vegetation	NBS-NPRC botanist (DeBacker) start, post-doc, and technician test field protocols. 1998, Botanist transferred from USGS to NPS. First draft of protocol completed	Mlekush joined Prairie Cluster as botanist. Began herbarium.	Second draft of vegetation monitoring protocol completed. Special project in Bloody Hill Glade, WICR.	Monitoring expanded to TAPR, building on baseline data (Eddy, Emporia State Univ.). Buck leaves.	Protocol through USGS, Northern Prairie Wildlife Research Center. Woodland inventory at HOME (report, 2002).	Alicia Sasseeen joined the Heartland Network as Plant Ecologist.	Established seven monitoring sites in restored prairie at GWCA. Revised Vegetation Monitoring protocol completed.	Established 4 new sites at HEHO and 3 existing sites (Christensen); 13 new fire effects sites in woodland units, N2, N3, S1 and S2 at EFMO.	James as plant ecologist. Added sites at TAPR, Big Pasture.
		Shake-up in USGS, BRD personnel and U-Mo. Jenkins leaves; Grabner starts MS; Buck (U-Mo) and Rizzo (BRD) work on protocol.							
Wetlands						CUVA contributed toward the study of indicators in CUVA; 48 wetlands evaluated.		Frazer (University of Akron) drafted protocol; the study recommends a permanent wetland staff at CUVA.	
Whitetail Deer			Peitz joins Prairie Cluster.					Monitoring initiated at ARPO, PERI & WICR in winter. Hemorrhagic fever struck PERI & WICR in fall.	
Invasive Plants					Preliminary work on protocol.		Pilot sampling at PERI and CUVA		Contract to implement protocol at 6 parks.

Table 2a. (continued) Timelines for Program Areas: Pre-1998 to 2006

Project Area	Pre-1998	1999	2000	2001	2002	2003	2004	2005	2006
Western Prairie Fringed Orchid			First protocol published and used between 2000 – 2006.	Prairie Cluster staff uses GPS. Demographic monitoring attempted, but dropped.	Established a spatial search area. Created MS Access® database.			Added seed capsule monitoring and height to inflorescence measure.	Geodatabase created. Single orchid located outside of search area.
Missouri Bladder-pod	Thomas and Jackson at WICR (1987-1990). Bloody Hill Glade (BHG) demographics (1996). USGS initiated protocol (1995). Establish grid at BHG. Core stratified. Kelrick implemented protocol.		Boetsch joins Prairie Cluster.	24 additional stratified random cells selected.		Beaulac, Truman State Univ. implements protocol.		Implement GIS-based (grid) at Manley Woods, Walnut, No. Bloody Hill, NW Bloody Hill, Terrell Creek, and Wire Road.	
			Adaptive sampling implemented as an alternative to grid sampling						

Table 2b. Timelines for Program Areas: 2007 to 2015

Project Area	2007	2008	2009	2010	2011	2012	2013	2014	2015
Aquatic Program Area	Proposed protocol changes to include the addition of 6 parks.	Ozark hellbender protocol beyond HTLN capacity. Geomorphic monitoring dropped. Program review says aquatic staffing too thin. Cribs and Hisney join staff.		Invertebrate monitoring at AGFO ended.					
	All Aquatic Program Area protocols written or revised			Team investigated various ways to scale-back big river monitoring and to reduce workload. Recommendations led to revised monitoring at OZAR and BUFF, implemented in 2012.					
Data Management	NRDT ⁴ guidelines published. Actively maintaining core ArcGIS® and Access® databases.	Acquired MSU server; establish SOP for backup and file transfer. 12% increase in data quantity from 2007.	New server at WICR. Transferred AGFO and SCBL databases to NGPN.	WASO Self Evaluation survey. 34% increase in records since 2008. Develop fire ecology databases.	Record count exceeds 750,000 in 20 databases and geodatabases. Integrated EPMT with SOPs.	Explored data visualization techniques and SQL® server databases.			
Breeding Bird	Began current schedule, 1 in 4 years; habitat is sampled in same years	New protocol to include added parks. Volunteers sample birds at HEHO, HOCU, & TAPR.					Volunteers and staff sample birds in all 11 parks included in monitoring protocol.		
Fire Ecology / Fire Effects	Hired fire ecologist. HEHO contributes to completion of long-term report on 21 years of data. Vegetation community report for TAPR completed.	Acquired a funding modification to add a lead monitor and a project oriented graduate student. Prescribed fire Resource Kit published.	Reports published. Full scale fire monitoring deployed. Students worked on several projects. Hired lead monitor at 74% FTE ⁵ . Upgraded fire ecologist to GS-9/5.	Lead Monitor becomes full time and upgraded Fire Ecologist to GS11. Five-year contract granted.	Protocol published. First reports published in NRSS ⁶ series. HTLN vegetation database converted to FFI. Initiated 2-year woody shrub belt surveys at GWCA.	Protocol revised to correct errors in datasheets. Grant for GPFE ⁷ acquired. Lead monitor position at 75% FTE. Fire ecologist shared 50% with GPFE.	Lead monitor position vacant. Database posted to IRMA ⁸ .		

4 Natural Resource Database Template

5 Full Time Equivalents – one FTE equals on employee working full time.

6 Natural Resource Stewardship and Science – refers to a division of the NPS and to the publication series emanating from that division.

7 Great Plains Fire Science Exchange

8 IRMA – Integrated Resource Management Applications , the NPS portal to data, documents, publications, and public and agency systems.

Table 2b. (continued) Timelines for Program Areas: 2007 to 2015

Project Area	2007	2008	2009	2010	2011	2012	2013	2014	2015
Land Cover			HTLN processed land cover supervised classification for HOCU.			Draft Protocol receives peer review. Changed accuracy methods in protocol after review.		Protocol published; first NRSS reports published.	
	(continued from 2006) Begin University of Arkansas research proposal: The Interpretation of Land Use Change and Development of Monitoring protocol for the Heartland Network Hot Springs National Park.			Wrote Draft Land Cover/Use Protocol.					
Vegetation	7 new sites added at each HOSP and PERI in woodlands.	4 new sites in restored prairie management units were established at WICR. Began archival digital photos of sites (complete by 2015). MoRAP co-operator, initiated Natural Resource Condition Assessments (NRCA)	Revised vegetation protocol; revisit schedule changed. Sites added to HOME and PIPE. Final sampling at AGFO and SCBL with final report to NGPN. NRCA deliverables in 2009 (OZAR) and 2010 (EFMO)	Initiated VMI ⁹ at HOME and TAPR, Kansas Biological Society; completed in 2011. MoRAP begins VMI of phase 1 parks. USGS/ NatureServe initiate VMI for CUVA. Special Chinquapin oak study conducted at Bloody Hill Glade, WICR (NRDS report, 2010).	Established 4 new sites in woodland at LIBO. MoRAP begins VMI of phase 2 parks. USGS co-operators completed VMI for BUFF.	HTLN conducts thematic accuracy assessment of VMI phase 1 parks.	HTLN conducts thematic accuracy assessment of VMI phase 2 parks. MoRAP begins VMI of phase 3 parks. Deliverables of VMI phase 1 and CUVA completed.	HTLN thematic accuracy on VMI phase 3 parks	Deliverables on VMI complete for phase 3.
Wetlands	SCEP hired to rework protocol from Ohio EPA's VIBI. Completed desktop Hydrogeomorphic (HGM) class determinations.	Research and Procurement -- delineated sites; began vegetation survey and installed monitoring wells; verified HGM classification.	Began Frazer protocol overhaul and Standard Operating Procedure (SOP) development.	Surveyed and delineated 20 wetland sites and selected 8 permanent reference sites. Completed draft protocol.	"Wetland monitors" became volunteer group. Preparation for Survey Site sampling. Completed a soil survey analysis. Designed an Access@ database.	Initiate water chemistry monitoring and breeding bird surveys. Install staff gauges. Wetland Monitors monitored 26 wells and 4 staff gauges.	Finished vegetation survey at Sentinel Sites. Final, survey geodatabase developed. Protocol and SOPs in working draft form.		
Whitetail Deer	Protocol finalized in 2007.		Began reporting data in interactive PDFs.		Data analysis determined habitat in sample areas is similar throughout park for each park.	Winter of 2012-2013 project to determine if deer were clumped, using infrared cameras (collaboration with College of the Ozarks).			

Table 2b. (continued) Timelines for Program Areas: 2007 to 2015

Project Area	2007	2008	2009	2010	2011	2012	2013	2014	2015
Invasive Plants	Draft of protocol (Geissler and Bradley 2007). Completed target species lists and reference frames. Finalized protocol. Published Park Science article.		Unique approach for HOSP. Initiated Big Springs at OZAR, off-protocol project.		Powder Mill Natural Area, OZAR, off-protocol projected initiated.				
Western Prairie Fringed Orchid	Vegetation profile and soil probe added (soil probe sporadically used in subsequent years). Protocol revised.				Main search area enlarged, and new area added. Record number of orchids observed.	New area becomes a permanent site. New Access® database to accommodate all data.			
Missouri Bladder-pod		New protocol published.							

Appendix 3: Agreements

The following list includes partners, cooperators, CESU institutions, and contractors completing inventories.

Type of Agent	Agent	Inventory related activities
Universities	Arkansas State University Jonesboro, AR	ARPO, GWCA, HOSP, OZAR, WICR Herpetofauna Inventories; PERI Bat Inventories; ARPO, GWCA, HOSP, OZAR, WICR Herpetofauna NPSpecies Certifications.
	Arkansas Tech University Russellville, AR	BUFF Bird Inventory; BUFF Bird NPSpecies Certification
	Cornell College Mount Vernon, IA	HEHO Vascular Plant NPSpecies Certification
	Drake University Des Moines, IA	EFMO Herpetofauna and Mammal NPSpecies Certification
	Indiana State University Terre Haute, IN	LIBO Mammal NPSpecies Certification
	Missouri State University Springfield, MO	GWCA Exotic Plant Inventory; GWCA, HEHO, HOME, TAPR, WICR Mammal Inventories; HEHO, HOCU, HOME, TAPR Bat Inventories; GWCA, HEHO, HOCU, HOME, TAPR, WICR Mammal NPSpecies Certifications
	Mount Mercy College Cedar Rapids, IA	HEHO Herpetofauna Inventory
	Southeast Missouri State University Cape Girardeau, MO	OZAR Upland Bird Inventory; OZAR Bird NPSpecies Certification
	University of Arkansas Monticello, AR	ARPO Bat and Bird Inventories
	University of Arkansas Fayetteville, AR	ARPO, BUFF, HOSP, PERI Vascular Plant NPSpecies Certification
	University of Kansas Lawrence, KS	OZAR Riparian Bird Inventory
	University of Nebraska Omaha, NE	HOME, PIPE, TAPR Herpetofauna Inventories; TAPR Deer Inventory; HOME, PIPE, TAPR Herpetofauna NPSpecies Certifications
	University of Southern Indiana Evansville, IN	LIBO Herpetofauna NPSpecies Certification
State and Federal Agencies	University of Wisconsin Madison, WI	EFMO Vascular Plant Inventory; EFMO Vascular Plant NPSpecies Certification
	Chipper Woods Bird Observatory Indianapolis, IN	LIBO Bird NPSpecies Certification
	Iowa Department of Natural Resources Des Moines, IA	EFMO Fish NPSpecies Certification
	Missouri Department of Conservation Columbia, MO	OZAR Mammal NPSpecies Certification; PERI Herpetofauna NPSpecies Certification.
	The Nature Conservancy Ohio	HOCU Vascular Plant NPSpecies Certification
	USGS-Great Lakes Science Center Porter, IN	LIBO Vascular Plant Inventory; LIBO Vascular Plant NPSpecies Certification
	USGS-WRD Little Rock, AR	BUFF, GWCA, HOSP, PERI, WICR Fish Inventories; ARPO, BUFF, GWCA, HOSP, PERI, WICR Fish NPSpecies Certifications

Type of Agent	Agent	Inventory related activities
Non-governmental Organizations	Allergen Inc. Cartersville, MO	GWCA Vascular Plant Inventory; GWCA Bird and Vascular Plant NPSpecies Certifications
	Audubon Upper Mississippi River Campaign McGregor, IA	EFMO, HEHO Bird Inventories; EFMO, HEHO Bird NPSpecies Certifications
	Christina Wieg Cincinnati, OH	HOCU Herpetofauna Inventory; HOCU Herpetofauna NPSpecies Certification
	Ecological Contract Services Meta, MO	BUFF Vascular Plant Inventory
	Institute of Botanical Training Indianapolis, IN	OZAR Vascular Plant NPSpecies Certification
	Janene Lichtenberg Pablo, MT	HOME, PERI, WICR Bird NPSpecies Certifications
	Anthony C. Minamyer Logan, OH	HOCU Fish Inventory; HOCU Fish NPSpecies Certification
	Hinterthuer Botanical Clearance Fayetteville, AR	PERI Exotic Plant and Vascular Plant Inventories
	Nature's Keeper Consultants Montreal, MO	HOSP Exotic Plant Inventory
	TetraTec Environmental Geneseo, IL	CUVA Exotic Plant Inventory
	Theo Witsell Little Rock, AR	HOSP Vascular Plant Inventory

Projects conducted in-house by National Park Service Staff

BUFF, PERI, WICR Bat Inventories;
HOCU, PIPE, TAPR Bird Inventories;
HOME Deer Inventory;
HEHO, HOME, LIBO Exotic Plant Inventories;
HOCU, HOME, PIPE, TAPR Fish Inventories;
BUFF Herpetofauna Inventory;
HOME Vascular Plants Inventory;
HOCU, HOSP Bird NPSpecies Certifications;
HOCU, OZAR Fish NPSpecies Certifications;
BUFF, HEHO Herpetofauna NPSpecies Certifications;
ARPO, BUFF, HOCU, HOSP, PERI, PIPE Mammal NPSpecies Certifications;
HOME, PIPE, TAPR, WICR Vascular Plants NPSpecies Certifications.

Intra-agency Agreements – Phase III and Implementation

The following is an incomplete list and explanation of the agreements made between the network and parks or offices within the NPS.

HTLN-BUFF () – Aquatic Invertebrate Protocol

The agreement was for development of a protocol that would address quantitative and qualitative sampling procedures for long-term monitoring of invertebrates, integrating the qualitative and semi-quantitative sampling techniques recommended by Doisy and Rabeni (1999) and USGS- National Ambient Water Quality Assessment Program with the quantitative sampling recommended by Mathis (2000). Developing one protocol allowed the HTLN staff to deal with only one set of SOPs rather than two. The differences between OZAR and BUFF were integrated into a comprehensive protocol with the same general approach and sampling design for both river systems. The protocol development took place in the spring through fall 2004 with field-testing during winter 2005. A second task within

this agreement led to development of the aquatic invertebrate database for the network and the transfer of legacy data from BUFF to the database.

HTLN-BUFF-CUVA-OZAR (multiple-parks G2106000002004) – Biologists at Parks

The HTLN staffing plan identified three GS-7, Subject to Furlough (STF) biologist positions to be duty stationed at BUFF, CUVA, and OZAR. The roles and responsibilities of the network and the host park were established. The Board approved the agreements in 2006. The position at BUFF was never established. The position at OZAR¹ moved to WICR. The wetland project leader² still resides at CUVA.

HTLN-CUVA-EPMT (G2106000008) – Hosting EPMT

In FY 2010, the HTLN EPMT received funding to begin serving parks. The EPMT could not easily serve the eastern portion of the network (CUVA, HOCU, and LIBO), because of the cost and logistics of travel. The park entered into an agreement with HTLN that brought consistency in service to these parks. Under this agreement, the EPMT provided funding for a GS-9 biologist as a field-crew leader for 13 pay periods per year. The biologist provided a higher level of biological expertise, park knowledge, planning and operational capability, and supervisory skills than could seasonal staff at a location distant from the EPMT coordinator's location. The park provided seasonal staff for a work crew. These workers were available to serve HOCU and LIBO, and other parks as needed. The park handled all administrative responsibilities for the hiring, supervision, and maintenance of the position.

HTLN-EFMO-EPMT (G2106000005) Hosting EPMT

The network developed a proposal to fund an Exotic Plant Management Team (EPMT). Effigy Mounds National Monument submitted the proposal on behalf of the network and parks in December 2006. In FY2010, EFMO received a base increase of \$667,000 for operations of the EPMT. The EPMT operated as a division of the HTLN under the direction of the EPMT coordinator. The EPMT coordinator, located at WICR, was responsible for Vital Signs monitoring of invasive species and for oversight of the HTLN EPMT. A field-crew leader position was slated to be located at EFMO. The term of the agreement was ongoing, unless terminated by both parties.

This agreement was terminated, because of administrative problems at EFMO. The EPMT home base moved to WICR and funding became part of WICR base-funding.

HTLN-EFMO (G2016000007) - Restoration Agreement

The HTLN wished to develop a proposal to fund a Vegetation Restoration/Adaptation Program and sought a temporary detail to assist with planning. The HTLN developed an agreement with EFMO to fund an employee for one day per pay period, purchase equipment and supplies for the work, and cover travel costs associated with the detail related work.

HTLN-PERI-EPMT (G2106000006)

In FY 2010, the HTLN EPMT received funding to begin serving parks. The EPMT collaborated with parks to build their capacity to manage invasive plants. Existing staff included supervisory and data management personnel, shared with the HTLN staff, and a term, field-crew leader position. The EPMT required staging locations that would serve the widely distributed parks. The HTLN stationed two seasonal employees at PERI for at least six pay-periods, not to exceed 13 pay-periods. The HTLN provided all operating and equipment funds for office and fieldwork relating to the EPMT and covered costs of travel. The park assisted with administrative responsibilities and provided suitable space and vehicle use.

HTLN-WICR Agreement (G2106000001; G2106000006B) – Host Park

At the annual meeting of the Board in 2005, participants discussed proposed changes to the overhead cost paid to the host park, WICR. The WICR superintendent described a new 'cost recovery' plan, where all expenses accrued by WICR for hosting the network would be itemized and billed to the network. After considerable negotiation, the Board and WICR came to an agreement that resolved the cost recovery issue and brought stability to base funding for

1 First held by Jessica Luraas and then by Catherine Ciak. Prairie Cluster Coordinator GS-12.

2 Sonia Bingham

the park and program. This agreement was G2106000001 of 2006.

The agreement between HTLN and WICR was updated in April 2011.³ The agreement described the relationship between WICR and the HTLN. The agreement identified specific requirements to be fulfilled and duties to be performed by all parties to support operations of the program. It incorporated policies governing support services and apportioning base funding increases and assessments. This agreement replaced terms of previous agreements.

Interagency and CESU Agreement Descriptions

The Heartland Network and HTLN established the following agreements with partners or cooperators, and specified particular tasks to be fulfilled under an existing Memorandum of Understanding. Cooperative Agreements may have subordinate agreements called Task Agreements that specify a task within the larger agreement. The Task Agreement (T.A.) may indicate a special due date for a portion of the Cooperative Agreement. The following represent only those agreements with a description. Other agreements were made by the Heartland Network and HTLN.

HTLN-University of Missouri, (C.A. H6000030300) – Spring Protocol

This agreement from 2000 resulted in development of a monitoring protocol for aquatic habitats within springs in the Ozark National Scenic Riverways. The monitoring would track success of management that maintained the condition of spring habitats between years 2005 and 2025. The project would (1) conduct a literature review of methods for assessing spring integrity, particularly using invertebrate species assemblages, (2) inventory baseline status of species distribution, abundance, and population characteristics, (3) draft and test monitoring protocols to assess spring integrity, and (4) provide a final monitoring protocol. Dr. Charles Rabeni and Kathy Doisy engaged the project.

HTLN-MWR-University of Wisconsin (C.A.) – GIS Support Agreement

This agreement covered a cooperative project with the MWR-GIS Support Office at the University of Wisconsin for the development of geodatabases and compilation of metadata from the inventory data. The geodatabases combined the spatial and tabular data into a single MS Access® file that loaded directly into ArcGIS®.

HTLN-University of Kansas (C.A.) – Water Quality

The original contract (signed in 2001) with the Central Plains Center for Bioassessment, KU, would last until September 2002. It included three tasks, (1) summarize state and federal water quality standards applicable to each of the 15 HTLN parks, (2) compile and review state biological assessment methodologies for states in the network, and (3) recommend monitoring designs for the network. The Heartland Network modified the agreement in September 2002, allowing continuation of the initial work along with additional tasks. These additional tasks included updating baseline, water-quality databases (NPS Water Resources Division Horizon Reports) for each park, statistically analyzing these data for trends, and linking this database to an aquatic resource GIS. The modification also re-sequenced the tasks giving high priority to the added tasks. Task completion was expected by September 2003.

At the time of the agreement (Summer 2001), the network considered biomonitoring possible at most HTLN parks. In the third Aquatic Workshop, the aquatic workgroup selected a subset of parks rather than all HTLN parks for monitoring.

HTLN-Illinois Natural History Survey, Chris Phillips (C.A.) – Hellbender Pilot

The hellbender is a federal candidate for listing as threatened or endangered. A coalition of public and private agencies interested in the protection of hellbender populations has accomplished the preliminary phase of sampling protocol development for the species. The HTLN initiated a CESU agreement for protocol development with Dr. Christopher A. Phillips, Illinois Natural History Survey at the University of Illinois, Urbana-Champaign. The protocol was never completed because the draft indicated that the network would have to expend considerable resources to implement the protocol. The draft product was submitted to the Missouri Department of Natural Resources, a partner in hellbender management, for consideration.

HTLN-PIPE-Pipestone County (C.A.)

The State of Minnesota, Pipestone County, and PIPE worked cooperatively to collect and analyze water samples and

³ Board meeting conference call April 2011.

to perform the statistical analyses needed to determine if enough data had been collected to establish the TMDLs. The HTLN contribution came from NPS WRD funding.

HTLN-U.S. Geological Survey, Chris Schmidt (C.A.) – Lead, Heavy Metals

Columbia Environmental Research Center, University of Missouri engaged in the development of a protocol for sampling heavy metals with a particular emphasis on lead and mercury, beginning in 2004. The protocol was completed and implemented on a five-year rotation for BUFF and OZAR.

HTLN-U.S. Geological Survey, Bob Pavlowski (C.A.) – Geomorphology / Physical Habitat

The BUFF hydrologist worked with Robb Jacobsen, BRD, to develop a work plan for this project. Bob Pavlowski, USGS, located at Southern Missouri State University (later SMU) submitted a proposal for complete sampling and analysis protocols for geomorphology monitoring. A final protocol was expected in May of 2005. The protocol was never finalized because the network felt it beyond their capabilities.

HTLN-OZAR-U.S. Geological Survey

The NPS Water Resources Division funded basic water quality measurements coupled with sampling indicator bacteria. This was in response to high bacteria levels in Jack's Fork that led to listing of a segment of the river within the park as Clean Water Act, §303d, Impaired Waters.

HTLN-HEHO-U.S. Geological Survey

The HTLN worked in cooperation with the USGS Iowa District to deploy a continuous water quality probe to log conductivity, temperature, DO, pH, and turbidity. The stream was listed as impaired water, Clean Water Act, Section 303d, for fecal bacteria levels.

HTLN-U.S. Geological Survey, Jim Petersen (C.A.) – Fish Community Protocol

The agreement would lead to development of protocols for monitoring fish communities in streams within BUFF and OZAR. The cooperator would base the protocol on the National Ambient Water Quality Assessment Program protocols, but modify those protocols to reflect NPS monitoring objectives and the environmental setting of the Ozark Plateaus. The protocols were designed specifically for BUFF and OZAR, but would have application elsewhere. The protocols presented methods for collecting representative samples of the fish community, but did not estimate fish density. Protocols addressed preparation, training, site selection, fish community sampling, equipment maintenance, data management, data analysis, data reporting, and protocol revision.

HTLN-HOSP-U.S. Geological Survey, Arkansas WRD – Hot Springs Temperature

In 2004, HOSP had little information on the origins of hot water in springs, the mixing rate of cold water into the hot springs, the recharge areas for the cold water, and the potential for contaminants from cold water to affect water quality in the hot springs. The USGS placed thermal loggers on the hot springs and monitored precipitation in potential recharge areas for the cold groundwater that mixes with the hot water. They related precipitation with water temperature changes, attempting to determine the rate of recharge and its potential impacts to hot springs.

HTLN-University of Kansas, R.L. McGregor Herbarium

The NPS obtained TAPR during the early years of the I&M Program. As a new unit of the NPS it needed extensive inventory of resources on site. This Cooperative Agreement from 2004, resulted in the curation of the vouchers from the vascular plant inventory.

HTLN-USGS, Rolla, Jerri Davis

This agreement from 2005 sought to validate the Total Maximum Daily Limit (Clean Water Act, §303d, Impaired Waters) of pollutants in the impaired segments of Jack's Fork in OZAR

HTLN-Colorado State University

In 2005, a Cooperative Agreement with Colorado State University (CSU) resulted in the development of a communication plan designed to meet the needs of the HTLN and network parks. The CSU cooperators worked with the HTLN to develop an approach to enhance communication between scientists and resource and interpretation managers at parks. The project addressed how to develop clear and concise messages about the efficacy of the I&M

Program and disseminate findings to internal and external audiences.

HTLN-Missouri State University, Wanda Brandon – Publication Layout

This project accessed publication design and layout for the Vital Signs Monitoring Plan publication.

HTLN-Missouri State University, Steve Jensen – Monitoring Partnership

The first attempt to accommodate the burgeoning HTLN staff in permanent quarters outside of parks resulted in a request for proposals to house the Aquatic Program Area at a park or partner's location. Missouri State University offered the best proposal in terms of proximity, and access to university faculty, students and resources. The Board approved the recommendation during a conference call on January 26, 2004. The Heartland Network revised its charter, so that it reflected the decision. The Cooperative Agreement was finalized in 2005 and has expanded to include additional HTLN staff.

HTLN-Iowa Department of Natural Resources (multiple agreements) – Water Quality

Several agreements were implemented with the State of Iowa. They included:

- Develop Total Maximum Daily Load (TMDL) for Yellow River and install a logging stage gauge at EFMO.
- Monitor Hoover Creek for impairment within HEHO with the intention of isolating the source of fecal bacteria. The cooperator tested water at multiple sites within the park, isolating the stream section where bacteria first appear. They then used incidence of optical brighteners as indicator of bacteria sources.

HTLN- Missouri State University (C.A. H6000030300; T.A. #J-6064-06-0011 and T.A. #J-6064-10-003) – Fire Ecology

A collaborative effort between the NPS, Fuels Program, MWR Fire Ecology Program, the HTLN, and MSU permitted hiring of a fire ecologist⁴, dedicated to the HTLN, in FY 2007. A funding modification (Modification 1) to the Cooperative Agreement, facilitated by the NPS Fire Ecology Program, allowed MSU to hire a lead monitor⁵ and project graduate student, dedicated to HTLN fire effects monitoring in FY 2009. That modification also increased the fire ecologist salary. The HTLN acquired funding that allowed a second modification to the agreement with MSU that made the lead monitor a full time, GS-7 position and upgraded the fire ecologist to GS-11, in line with the grade and salary of NPS fire ecologists. A second Task Agreement for 2012 through 2015 changed the fire ecologist position to half time for the HTLN and half time for the Great Plains Fire Science Exchange in 2012. Modifications may be applied to alter percentage of FTE allocated to the Great Plains Fire Science Exchange.

CUVA-University of Akron (C.A. H61600300001, T.A. # 001) – Wetlands Study

The HTLN selected 60 wetlands at CUVA, based on wetland type, size, and human stressors. The cooperator would monitor a range of ecological properties over most of the growing season. The investigators would determine indicators of wetland type and wetland integrity, based on an analysis, literature review, and CUVA data. The cooperator would place the resulting indicators within the context of assembly rules, which potentially can be used across broad geographical regions to develop strategies for wetland construction, habitat management, and invasive species control. The HTLN and cooperator would enter this information into protocol development, the final phase of the entire wetland project through University of Akron under a separate agreement.

HTLN- Missouri State University (C.A. H6000030300; T.A. #J-2106-11-0083) – Education and Outreach

The HTLN requested assistance to make monitoring results part of educational curriculum. The HTLN had developed an ongoing relationship with the Project WET coordinator⁶ at MSU, placing MSU in an excellent position to assist the HTLN in science education. Therefore, MSU would assist with the recruitment and selection of a science education specialist⁷ and student workers to participate in science-education projects as partners. Much of the work

4 Sherry Leis

5 Maria Gaetani and later Christopher Kopek

6 Erica Cox

7 Theresa Johnson

would focus on developing education and interpretation programs that incorporated a spectrum of network-generated information and attributed it to park specific resources. To do this, the partner would use HTLN findings to develop curriculum for local educators to use in the classroom and on-site. The ultimate goal was to improve overall science literacy and understanding of the role of science in managing National Parks.

Contractors for Invasive Plant Projects

Davey Resources Group, headquartered in Kent, Ohio, provided inventory services for invasive plants at CUVA in 2007 and at HOCU in 2008.

Institute of Botanical Training, L.L.C., a botanical consulting service in Salem, Missouri, implemented invasive plant inventories at HOSP in 2009 and at TAPR in 2010.

Copperhead Consulting of Paint Lick, Kentucky, conducted inventories at ARPO, HOCU, and LIBO in 2011.

Missouri Botanical Garden, working as a subcontractor for ESS, Inc., conducted invasive species monitoring at GWCA, PERI, and WICR in 2013.

Appendix 4: Staffing

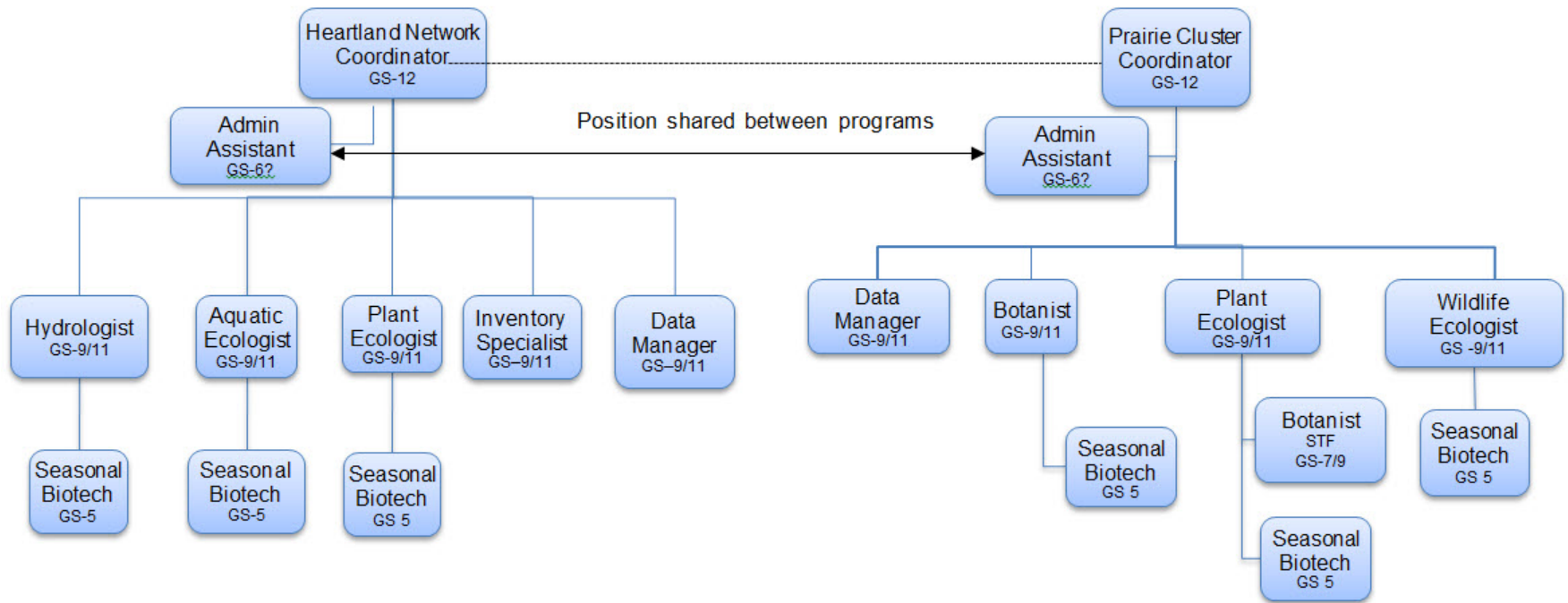


Figure 4.1. The staffing of the Heartland Network and the Prairie Cluster prior to integration of programs in 2003. This organization had been proposed as an alternative for final HTLN, but the Board preferred the alternative organization.

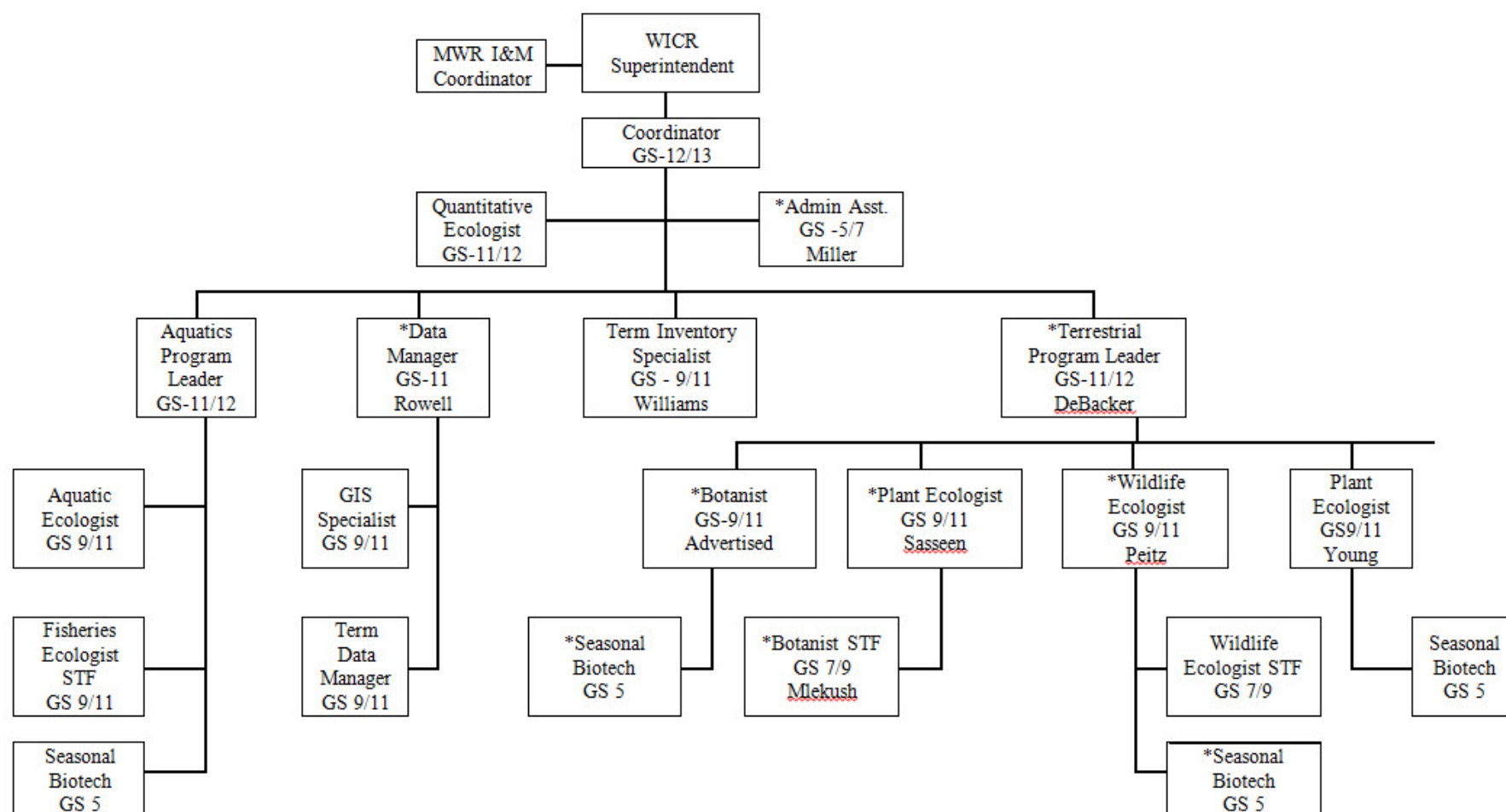


Figure 4.2. The integration alternative preferred by the Board in 2003.

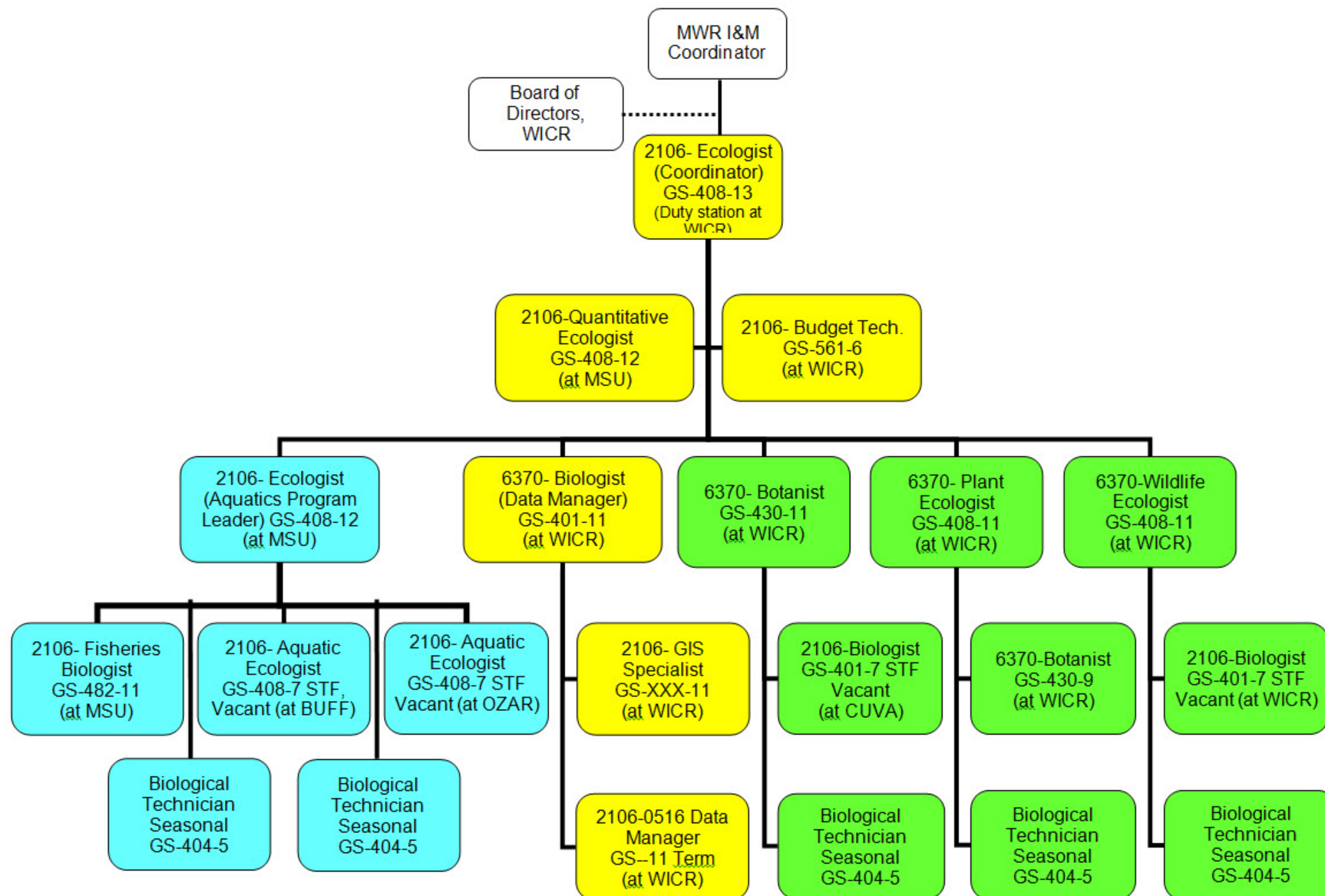


Figure 4.3. HTLN Staffing chart 2005.

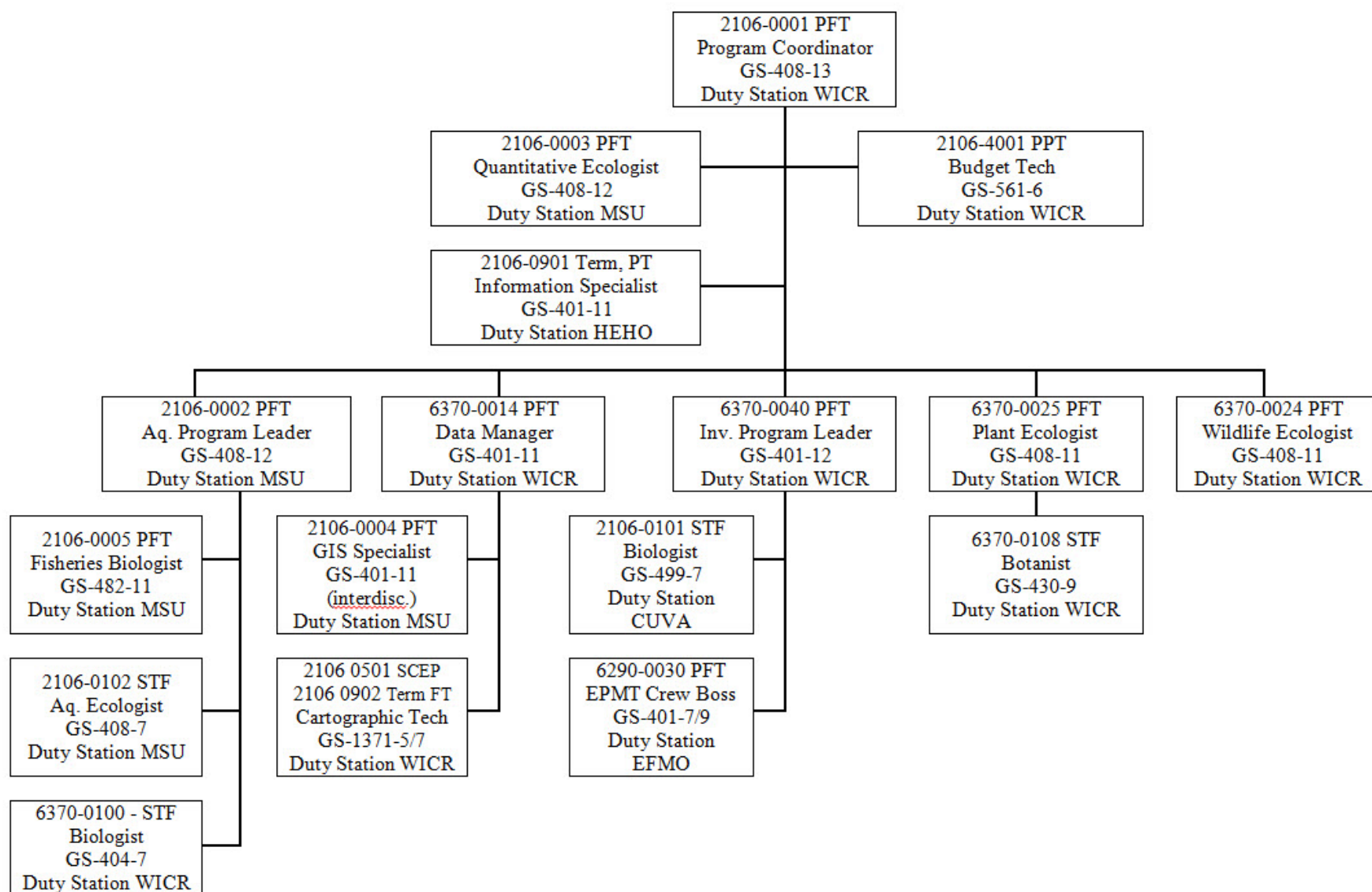


Figure 4.4. HTLN staffing chart April 2010.

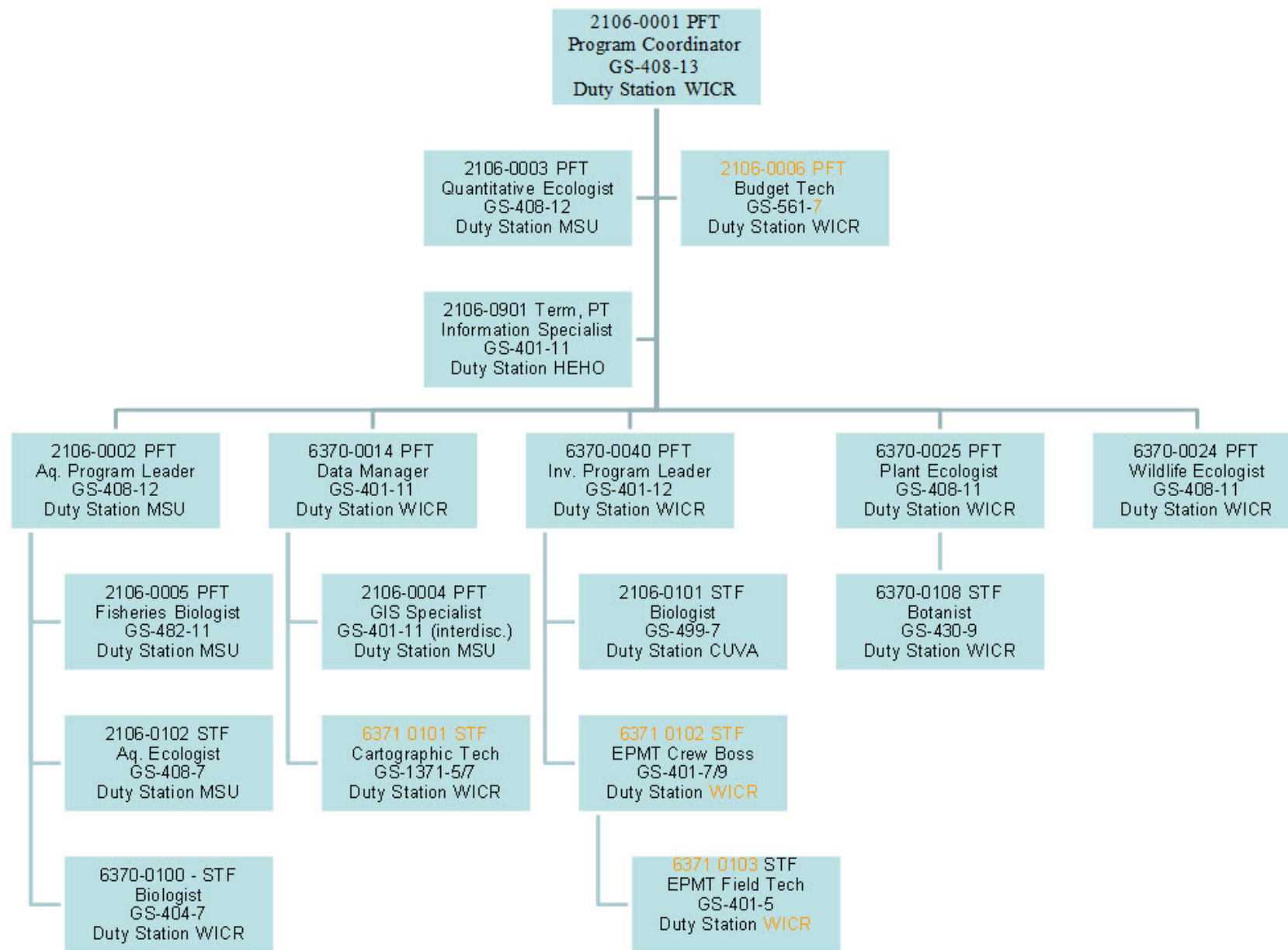


Figure 4.5. April 2011, approved staffing plan

Position Description Summaries

Position	Description
Administrative Assistant / Budget Technician (GS-0303-7, WICR)	The incumbent reconciles orders, invoices, etc., to ensure proper tracking of purchased goods, amounts of expenditures, and available funds. The incumbent tracks "status of funds" in a base budget. The administrative assistant acts as timekeeper, arranges travel, serves as fleet manager, procures routine office needs, maintains property inventories, and maintains the official files.
Aquatic Resources Monitoring Leader (GS-408-12, MSU)	The aquatic ecologist manages the aquatic monitoring program, including planning yearly budgets, hiring and supervising staff, and ensuring objectives. The aquatic ecologist oversees the scientific integrity and implementation of aquatic resource monitoring. The ecologist ensures that results are provided to park managers and to NPS and professional audiences. The expected scope of work included overseeing year-round monitoring of water chemistry, nutrients, contaminants, and bacteria, and seasonal monitoring of amphibians (hellbender) and reptiles (alligator), aquatic physical habitat assessment and monitoring, and monitoring hydrologic regime. Additionally, the position emphasized skills in river, stream, and spring invertebrate community monitoring.
Aquatic Ecologist (GS-408-7, MSU)	The aquatic ecologist is responsible for leading field monitoring trips for aquatic vegetation, invertebrates, fish, and water quality assessments of rivers, tributaries, and springs. Duties include collection and accurate processing and analyses of aquatic invertebrate samples. The aquatic ecologist may be involved in monitoring stream geomorphology and contaminant metals.
Biologist (GS-0401-7, WICR)	The biologist is responsible for leading field monitoring trips for aquatic vegetation, invertebrates, fish, and water quality assessments of rivers, tributaries, and springs. Important tasks include direct support to fisheries biologist for fish community and aquatic invertebrate monitoring. The biologist may be involved in monitoring stream geomorphology and contaminant metals.
Biologist, Data Manager (GS-401-9/11, WICR)	The data manager is responsible for developing and maintaining a comprehensive database management system for physical, biological, and environmental data. The data manager designs databases for projects and writes data management plans and protocols. The data manager works with network and park staff, cooperating scientists, and others to ensure that datasets are fully documented and validated. The data manager contributes to regional and national data management standards and issues.
Biologist, Exotic Plant Program Leader (GS-0401-12, WICR)	The botanist conducts plant ecological monitoring projects for plant species, federally protected under the Endangered Species Act of 1973, plants, invasive plants, and wetlands. The plant ecologist oversees all details related to planning, budgeting, and ensuring appropriate scientific rigor of the projects. The botanist frequently leads field trips. The duties require the botanist to consult with park resource managers and a data management assistant. The botanist is responsible for annual data summary, long-term trend analysis, and report writing.
Biologist, Wetland Specialist (GS-0401-7, CUVA)	The biologist is responsible for implementing wetlands and invasive plant species monitoring at CUVA. The biologist supervises seasonal workers, field procedures, and documentation. The biologist would be responsible for handling and processing monitoring data.
Biologist, Information Specialist (GS-0401-11, Remote)	The information specialist leads scientific communication and environmental compliance. As a technical writer, the information specialist develops project briefs and publishes the network's newsletter. The information specialist also serves as a liaison with park interpreters.
Botanist (GS-0430-7/9, WICR)	The botanist is the plant taxonomy expert for the program, responsible for accurate field identification and identification of material brought to the laboratory. The botanist is responsible for establishing and maintaining a reference collection of plant specimens.
Cartographic Technician – (GS-1371-5/7, WICR)	The cartographic technician procures, maintains GPS units dispersed across parks, and provides training and technical support. The incumbent maintains geodatabases to NPS standards, and posts the data to the web.
EPMT Crew Boss (GS-0401-7/9, WICR)	The crew boss provides field leadership and capability for the EPMT, and serves as the lead trainer and safety officer for EPMT. The crew boss completes project logistics, procurement, and maintenance as needed to support projects. In addition, the crew boss consults with park managers to scope projects and meets work crews, contractors, park staff, and volunteers on sites to safely lead control projects.
EPMT Field Technician (GS-0401-5, WICR)	The crew technician assists the EPMT crew boss. The technician logs daily activities.
Fisheries Biologist (GS-0482-9/11, MSU)	The fisheries biologist serves as the project leader for fish community monitoring. Incumbent oversees monitoring of the federally endangered Topeka shiner, collaborating with FWS recovery team members and state conservation personnel. The fisheries biologist is responsible for annual data summary, long-term trend analysis, and report writing.
HTLN Coordinator (GS-408-13, WICR)	The program coordinator is responsible for all aspects of this base-funded program, including planning, staff supervision, program management, data management and assessment, communicating results and cooperation with other agencies, tribes, and institutions. The program coordinator is responsible for ensuring scientific rigor and oversight to HTLN I&M program development and implementation.
GIS Specialist (Interdisciplinary, 150, 401, 1301-9/11, MSU)	The GIS specialist oversees the program's Geographic Information System, including spatial information and GPS equipment. The incumbent serves as project leader for adjacent land use / land cover monitoring. The GIS specialist interprets aerial photographs, multi-spectral video imagery, satellite data, and remote sensing data. The GIS specialist also provides technical support for microcomputer hardware and software required for GIS and data management functions.

Position	Description
Quantitative Ecologist (Ecologist, GS-408-11/12, MSU)	The quantitative ecologist was responsible for completing the conceptual framework for the monitoring program, developing general sampling design, and ensuring the validity of experimental designs associated with particular projects. The quantitative ecologist provided statistical and analytic support to network projects, and developed sound statistical approaches to analyzing monitoring data, working collaboratively with staff and cooperating scientists to ensure rigorous and integrated collection of quantitative monitoring data.
Plant Ecologist (GS-0408-9/11, WICR)	The plant ecologist serves as the plant community monitoring project leader. The plant ecologist oversees all logistical and programmatic details related to implementing plant community monitoring. The plant ecologist frequently leads field trip. The ecologist is responsible for annual data summary, long-term trend analysis, and report writing.
Wildlife Ecologist (GS-0408-9/11, WICR)	The wildlife ecologist is responsible for developing and implementing a wide range of wildlife projects including monitoring of grassland birds and deer. The wildlife ecologist performs field identification, ensures credible sampling schemes, and supervises staff and volunteers. The wildlife ecologist oversees a citizen scientist program to carry out breeding bird monitoring in network parks and contractors or cooperators contributing to the wild-life project. The wildlife ecologist is responsible for annual data summary, long-term trend analysis, and report writing.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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