Vital Signs Monitoring Plan

Upper Columbia Basin Network

Phase I Report

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Phase I Vital Signs Monitoring Plan

Upper Columbia Basin Network

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Executive Summary

Knowing the condition of natural resources in national parks is fundamental to the Service's ability to manage park resources "unimpaired for the enjoyment of future generations". The National Park Service has implemented a strategy designed to institutionalize natural resource inventory and monitoring on a programmatic basis throughout the agency. The effort was undertaken to ensure that the approximately 270 park units with significant natural resources possess the resource information needed for effective, science-based managerial decision-making and resource protection. The national strategy consists of a framework having three major components: 1) completion of basic resource inventories upon which monitoring efforts can be based; 2) creation of experimental prototype monitoring programs to evaluate alternative monitoring designs and strategies; and 3) implementation of ecological monitoring in all natural resource parks.

Parks with significant natural resources have been grouped into 32 monitoring networks linked by geography and shared natural resource characteristics. The network organization will facilitate collaboration, information sharing, and economies of scale in natural resource monitoring. Parks within each of the 32 networks work together and share funding and professional staff to plan, design, and implement an integrated long-term monitoring program. The Upper Columbia Basin Network is made up of 9 National Park Service units located in western Montana, Idaho, eastern Washington, and central Oregon.

The complex task of developing ecological monitoring requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs and produce ecologically relevant and scientifically credible data that are accessible to managers in a timely manner. Network monitoring programs are being developed over a four-year timeframe with specific objectives and reporting requirements for each of three planning phases. This document is the first of three scheduled reports. Its purpose is to 1) outline UCBN monitoring goals and the planning process we will use to develop the monitoring program, 2) summarize existing information concerning park natural resources and identify the most significant resources, resource concerns and issues across the network, and 3) introduce the ecological context and provide a conceptual model framework for Columbia Basin ecosystems.

Over the next year, UCBN staff, park managers and scientists, and collaborators from the scientific community will be engaged in the process of prioritizing selected vital signs as candidates for monitoring. This prioritization process will be based on the ecological significance, management significance, and cost of implementation for proposed vital signs. Once monitoring vital signs are selected by the UCBN (June 2005), the network team will develop and test detailed monitoring protocols for implementation in network parks.

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Chapter 1: Introduction and Background

I. Scope of Phase One Report

In 1999, the National Park Service (NPS) launched the Natural Resource Challenge, a 5-year program designed to strengthen natural resource management in the nation's national parks (National Park Service 1999). The single biggest undertaking of the Challenge was to expand ongoing park inventory and monitoring efforts into an ambitious comprehensive nationwide program. The Servicewide Inventory and Monitoring (I&M) program was introduced to 270 parks identified as having significant natural resources. Under this program, parks have been organized into 32 networks to conduct long-term vital signs monitoring. Each network links parks that share geographic and natural resource characteristics, allowing for improved efficiency and the sharing of staff and resources. A map of the vital signs networks can be found at the following I&M website: http://science.nature.nps.gov/im/monitor/networks2.htm. Funding for development and implementation of the I&M program has been allocated to groups of networks, beginning with 12 networks that contained protocol parks. To date, 22 networks have been fully funded. The Upper Columbia Basin Network (UCBN), formerly called the Northern Semi-Arid Network, is part of a group of six networks that have already received funds to conduct inventory and planning activities and are expected to be fully funded for the monitoring program in FY 2005.

The UCBN Vital Signs Monitoring Plan is being developed over a multi-year period following specific guidance from the NPS Washington Office (WASO) (National Park Service 2003a). Networks are required to document monitoring planning progress in three distinct phases (see Table 1) and to follow a standardized reporting outline. Each phase of the report requires completion of specific portions of the outline.

The Phase I Report includes Chapter One (Introduction and Background) and Chapter Two (Conceptual Models) of the monitoring plan. Other chapters will be developed for the Phase II and Phase III Reports. This document presents the UCBN framework and approach to planning for vital signs monitoring and sets the stage upon which the program will be developed. Specifically, this report:

- introduces network monitoring goals and describes the process we will use to select key resources and monitoring questions;

- summarizes existing information concerning park natural resources and identifies the most significant resources and resource threats for each park across the network;

- introduces the ecological context of the Columbia Basin and provides conceptual models of significant Columbia Basin ecosystems.

- introduces a list of potential vital signs and associated monitoring objectives identified for the UCBN through a series of scoping workshops and a comprehensive literature review.

The Phase II Report will describe in detail the working list of vital signs and associated monitoring objectives, as well as the process taken by the network to identify and prioritize vital signs. The Phase III Report will constitute the first full working version of the UCBN Monitoring Plan and will present results of the monitoring design work and planning for implementation.

Table 1. Three-phase planning process for Vital Signs development.

	Goals and Tasks	UCBN Deadlines
Phase I	Description of Monitoring Objectives and Needs, Data Mining Results and Conceptual Model Development	October 2004
Phase II	Vital Signs Prioritization, Selection, and Rationale	October 2005
Phase III Initial Draft	Monitoring Design	December 2006
Phase III Peer-review	Monitoring Design	October 2007

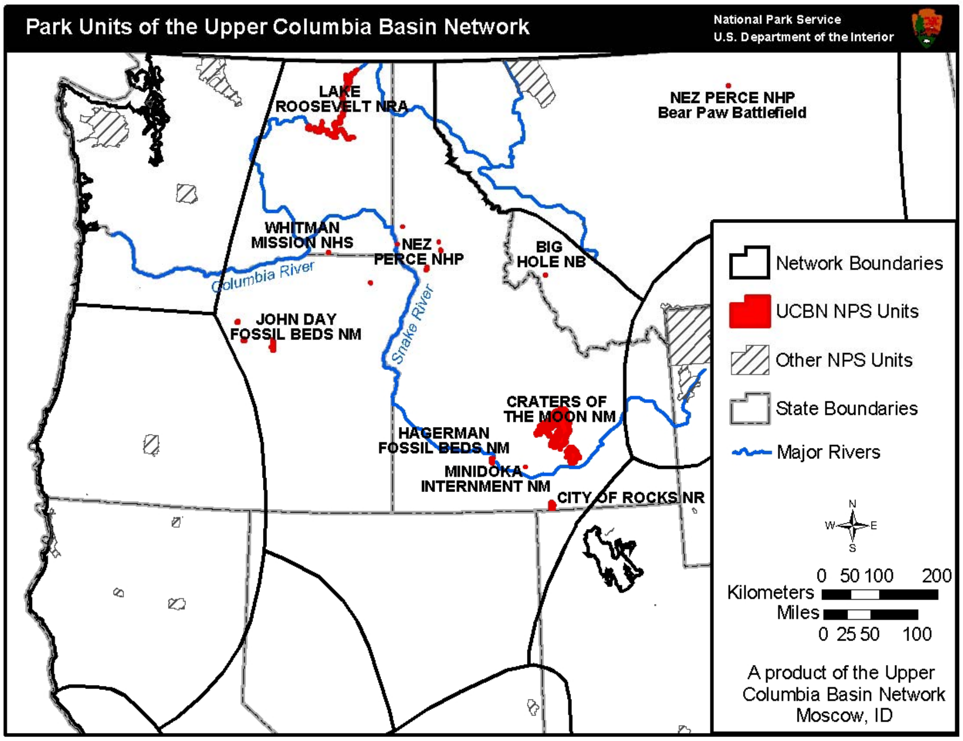
II. Network Overview

A critical component of the I&M program has been the organization of each of the 270 parks with significant natural resources into monitoring networks. The network organization will facilitate collaboration, information sharing, and economies of scale in natural resource monitoring. Each of the networks is guided by a Board of Directors who specify desired outcomes, evaluate performance for the monitoring program, and promote accountability. The level of funding available through the Natural Resource Challenge will not allow comprehensive monitoring in all parks, but will provide a minimum infrastructure for initiating natural resource monitoring in all parks that can be built upon in the future.

Parks within each of the networks work together and share funding and professional staff to plan, design, and implement an integrated long-term monitoring program. The complex task of developing a network monitoring program requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs of each park and produce scientifically credible data that is accessible to managers and researchers in a timely manner. The investment in planning and design also ensures that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of leveraging and partnerships with other agencies and academic institutions.

The UCBN is made up of nine widely separated National Park Service units located in western Montana, Idaho, eastern Washington, and central Oregon. Figure 1 shows the location of the nine UCBN parks and the boundary of the network. Note that one of the units of the Nez Perce National Historical Park (NEPE), Bear Paw Battlefield, is actually located outside of the network boundary in eastern Montana. This unit and one other network park, Big Hole National Battlefield (BIHO), lie outside the Columbia River Basin. The remainder of the network parks lie within the upper Columbia Basin. While all of the UCBN parks have been identified as having significant natural resources, the majority of parks were actually established to protect cultural and paleontological resources. The upper Columbia Basin holds a rich and fascinating cultural history, and several UCBN parks provide the nationally significant service of chronicling the pre-contact and contact cultures of the Nez Perce and Cayuse people, early pioneer and mission culture, and the tragic conflicts that arose between them. Two UCBN parks also protect and interpret globally significant fossil localities. Most UCBN parks also have some level of natural resource protection language included in enabling legislation or other guidance documents.

Figure 1. Map of UCBN park units.



The network organizational structure will be very important to the UCBN. Parks within the UCBN vary in size from 14 hectares to more than 500,000 hectares, and all but two parks are less than 6,000 hectares (Table 2). These small parks are not able to staff and provide resources for many of the natural resource issues they face. The resources available at the network level will greatly increase their capacity to meet the increasingly complex resource management environment found in the upper Columbia Basin.

Table 2. National Park Service Units in the Upper Columbia Basin Network.

					Originally Established For	
Park	Park Code	State	Acres	Hectares	Cultural Resources	Natural Resources
Big Hole National Battlefield	BIHO	MT	655	265	X	
City Of Rocks National Reserve	CIRO	ID	14,107	5,708	X	X
Craters of the Moon National Monument and Preserve	CRMO	ID	469,711	190,081	X	X
Hagerman Fossil Beds National Monument	HAFO	ID	4,351	1,760	X	
John Day Fossil Beds National Monument	JODA	OR	14,056	5,688	X	X
Lake Roosevelt National Recreation Area	LARO	WA	100,390	40,625	***	***
Minidoka Internment National Monument	MIIN	ID	73	30	X	
Nez Perce National Historical Park	NEPE	ID	2,122	858	X	
Whitman Mission National Historic Site	WHMI	WA	98	40	X	

***Lake Roosevelt NRA was established to "…provide for outdoor recreation use of Lake Roosevelt…" and to "…preserve the scenic, scientific, and historic features…of the area."

III. Purpose

A. Justification

Knowing the condition of natural resources in national parks is fundamental to the Service's ability to manage park resources "unimpaired for the enjoyment of future generations". NPS managers across the country are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends of park resources as a foundation for making decisions and working with other agencies and the public for the benefit of park resources. For years, managers and scientists have sought a way to characterize and determine trends in the condition of parks and other protected areas to assess the efficacy of management practices and restoration efforts and to provide early warning of impending threats. The challenge of protecting and managing a park's natural resources requires a multi-agency, ecosystem approach because most parks are open systems, with threats such as air and water pollution, or invasive species, originating outside of the park's boundaries. An ecosystem approach is further needed because no single spatial or temporal scale is appropriate for all system components and processes; the appropriate scale for understanding and effectively managing a resource might be at the population, species, community, or landscape level, and in some cases may require a regional, national or international effort to understand and manage the resource. National parks are part of larger ecosystems and must be managed in that context.

Natural resource monitoring provides site-specific information needed to understand and identify change in complex, variable, and imperfectly understood ecosystems and to determine whether observed changes are within historic levels of variability or may indicate unwanted human influences. Thus, monitoring data help define the typical limits of variation in park resources and when put into a landscape context, monitoring provides the basis for determining meaningful change in ecosystems. Monitoring results may also be used to determine what constitutes impairment and to identify the need to initiate or change management practices. Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making aimed to maintain, enhance, or restore the ecological integrity of park ecosystems and to avoid, minimize, or mitigate ecological threats to these systems (Roman and Barrett 1999).

The intent of the NPS monitoring program is to track a subset of valued resources and indicators of park ecosystems known as “vital signs.” Vital signs, as defined by the National Park Service for the purposes of the I&M program, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. Vital signs are part of the total suite of natural resources that park managers are directed to preserve “unimpaired for future generations,” including water, air, geological resources, plants, and animals, and the various ecological, biological, and physical processes that act on these resources. In situations where natural areas have been so highly altered that physical and biological processes no longer operate (e.g., control of fires and floods in developed areas), information obtained through monitoring can help managers understand how to develop the most effective approach to restoration or, in cases where restoration is impossible, ecologically sound management. The broad-based, scientifically sound information obtained through natural resource monitoring will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources.

B. Legislation, Policy and Guidance

In establishing the first national park in 1872, Congress “dedicated and set apart (nearly 1,000,000 acres of land) as a … pleasuring ground for the benefit and enjoyment of the people” (16 U.S.C. 1 § 21). By 1900 a total of five national parks had been established, along with additional historic sites, scenic rivers, recreation areas, monuments, and other designated units. Each unit was to be administered according to its individual enabling legislation, but had been created with a common purpose of preserving the “precious” resources for people’s benefit. Sixteen years later the passage of the National Park Service Organic Act of 1916 (16 U.S.C. 1 § 1) established and defined the mission of the National Park Service, and through it, Congress implied the need to monitor natural resources and guarantee unimpaired park services:

> “The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified … by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, *which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*”

Congress reaffirmed the declaration of the Organic Act vis-à-vis the General Authorities Act of 1970 (16 U.S.C. 1a-1a8) and effectively ensured that all park units be united into the ‘National Park System’ by a common purpose of preservation, regardless of title or designation. In 1978, the National Park Service's protective function was further strengthened when Congress again amended the Organic Act to state "…the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…” thus further endorsing natural resource goals of each park. A decade later, park service management policy again reiterated the importance of this protective function of the NPS to “understand, maintain, restore, and protect the inherent integrity of the natural resources” (National Park Service 2001).

More recent and specific requirements for a program of inventory and monitoring park resources are found in the National Parks Omnibus Management Act of 1998 (P.L. 105-391). The intent of the Act is to create an inventory and monitoring program that may be used “to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources.” Subsequently, in 2001, NPS management updated previous policy and specifically directed the service to inventory and monitor natural systems in order to inform park management decisions:

> “Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions” (National Park Service 2001).

In addition to the legislation directing the formation and function of the National Park System, there are several other pieces of legislation intended to not only protect the natural resources within national parks and other federal lands, but to address general concerns over the environmental quality of life in the United States. Many of these federal laws also require natural resource monitoring within national park units. As NPS units are among some of the most secure areas for numerous threatened, endangered or otherwise compromised natural resources in the country, the particular guidance offered by federal environmental legislation and policy is an important component to the development and administration of a natural resource inventory and monitoring system in the National Parks.

Legislation, policy and executive guidance all have an important and direct bearing on the development and implementation of natural resource monitoring in the National Parks. Relevant federal legal mandates are therefore summarized in Appendix A.

Of particular importance is the Government Performance and Results Act (GPRA) which is central to NPS operations, including the I&M program. The National Park Service has developed a national strategic plan identifying key goals to be met (National Park Service 2001). A list of the national GPRA goals relevant to UCBN parks is located in Table 3. In addition to the national strategic goals, each park unit has a five-year plan that includes specific park GPRA goals. Many of these park specific goals are directly related to natural resource monitoring needs.

C. Purpose of UCBN Parks

The UCBN includes a National Monument, a National Monument and Preserve, a National Historic Site, a National Historical Park, a National Recreation Area, a National Battlefield, a National Reserve and 2 Fossil Bed National Monuments. In 1970, Congress elaborated on the 1916 NPS Organic Act, saying all of these designations have equal legal standing in the National Park system. Definitions of park designations are found in Appendix B.

The enabling legislation of an individual park provides insight into the natural and cultural resources and resource values for which it was created to preserve. Along with national legislation, policy and guidance, a park’s enabling legislation provides justification and, in some cases, specific guidance for the direction and emphasis of resource management programs, including inventory and monitoring.

The enabling legislation for several UCBN parks is difficult to interpret because of the legal language used. At least one park, Lake Roosevelt National Recreation Area (LARO), does not have enabling legislation. The network staff assembled information on the purpose of each park from various park documents, including general management plans, resource management plans, and strategic plans. This does not represent the comprehensive goals and objectives for each park but represents subsets that are most relevant to natural resource monitoring. Park goals and objectives stated in resource management and general management plans are presented in Appendix C.

The purpose of designation for UCBN parks varies from preservation of cultural resources to the protection of natural resources. The following five categories encompass the network perspective on the purpose of UCBN parks: 1) interpreting the culture and history of a place or people, such as the Nez Perce tribe, 2) preserving and protecting the uniqueness of an area, such as the geologic resources, the natural quiet, or the paleontological resources, 3) encouraging and supporting scientific research, 4) managing and protecting recreational resources, and 5) preserving and enhancing riparian and wetland areas.

Table 3. GPRA goals specific to UCBN parks and relevant to the monitoring plan for the Upper Columbia Basin Network.

GPRA Goal	Goal #	Parks with this goal
Natural and cultural resources and associated values are protected, restored, and maintained in good condition and managed within their broader ecosystem and cultural context.	Category Ia	BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI
Disturbed lands restored	Ia1A	BIHO, CIRO, HAFO, LARO, NEPE, WHMI
Exotic vegetation contained	Ia1B	BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI
Threatened and Endangered species	Ia2B, Ia2X	JODA, LARO, MIIN
Air quality and wilderness values	Ia3	CRMO
Water quality unimpaired	Ia4	BIHO, CIRO, JODA, LARO, NEPE
Cultural landscapes in good condition	Ia7	BIHO, HAFO, JODA, MIIN, NEPE, WHMI
The National Park Service contributes to knowledge about natural and cultural resources and associated values; management decisions about resources and visitors are based on adequate scholarly and scientific information.	Category Ib	BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI
Natural resource inventories	Ib1	BIHO, CIRO, CRMO, HAFO, JODA, NEPE
Vital signs for natural resource monitoring identified	Ib3	BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, WHMI
Geologic resources inventory	Ib4A	CRMO, HAFO, JODA
Geologic resources mitigation and protection	Ib4B	CRMO, HAFO, JODA
Aquatic resources	Ib5	JODA

D. Role of Monitoring

Historically, inventory and monitoring in most parks was subject specific and primarily driven by the need to deal with specific environmental or management problems. However, over the past decade the NPS has broadened the scope of inventory and monitoring to include all aspects of the ecosystem. The current program is driven as much by the need to fill in gaps in ecological knowledge of the area as by the need to provide information for specific management problems.

Monitoring is a central component of natural resource stewardship in the National Park Service, and in conjunction with natural resource inventories and research, provides the information needed for effective, science-based managerial decision-making and resource protection (Figure 2). Ecological monitoring establishes reference conditions for natural resources from which future changes can be detected. Over the long term, these “benchmarks” help define the normal limits of natural variation, may become standards with which to compare future changes, provide a basis for judging what constitutes impairment, and help identify the need for corrective management actions.

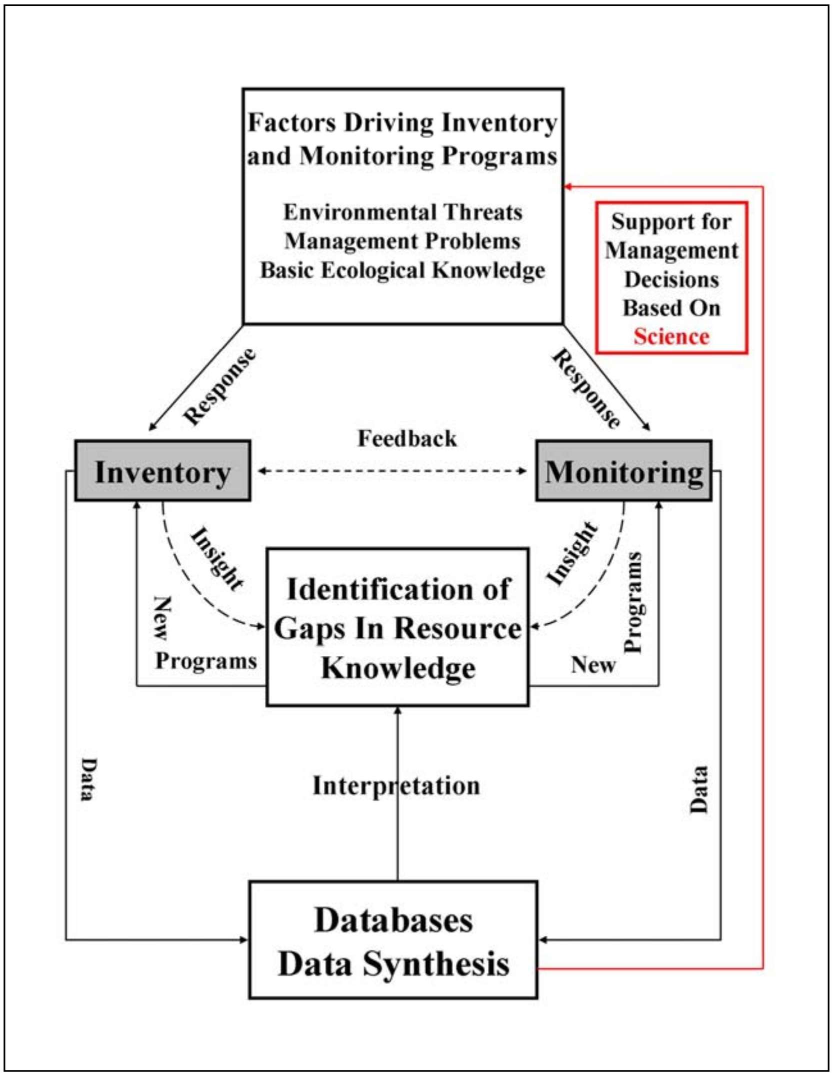
The overall purpose of natural resource monitoring in parks is to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage park resources. Results from monitoring will allow managers to confront and mitigate threats to the park and operate more effectively in legal and political arenas. To be effective, the monitoring program must be relevant to current management issues as well as anticipate future issues based on current and potential threats to park resources. The program must be scientifically credible, produce data of known quality that are accessible to managers and researchers in a timely manner, and be linked explicitly to management decision-making processes.

The American people expect the National Park Service to preserve the nation's heritage, including living and non-living features of ecosystems in all units of the National Park System. Possessing the knowledge of the condition of natural resources in national parks is fundamental to the Service's ability to protect and manage parks. National Park managers across the country are confronted with increasingly complex and challenging issues, and managers are increasingly being asked to provide scientifically credible information to defend management actions. The National Parks Omnibus Management Act of 1998 includes a Congressional mandate to provide information on the long-term trends in the condition of National Park System resources.

Management of the national parks is an extremely complicated and difficult task. Many of the threats to park resources, such as invasive species and air and water pollution, originate outside park boundaries and require an ecosystem approach to understand and manage the park's natural resources. Managers must be capable of determining whether the changes they are observing in park ecosystems are the result of natural variability or human activities. If the latter, then resource managers must understand park ecosystem processes and mechanisms well enough to know what actions are needed to restore natural conditions. Such knowledge can only be gained through long-term research and monitoring. Short-term, parochial methods provide a useful beginning but cannot by themselves provide the needed knowledge and understanding. In the words of Ralph Waldo Emerson, “the years teach much which the days will never know.”

The source for the preceding information on justification, legislation, policy and guidance, and the role of monitoring can be located at: (http://science.nature.nps.gov/im/monitor/vsmAdmin.htm#ProgramAdmin)

Figure 2. Information Pathways for Inventory and Monitoring



IV. Network Monitoring Objectives and Vital Signs Selection Process

A. Servicewide Monitoring Goals

As UCBN staff plans, designs, and implements an integrated natural resource monitoring program it is guided by the five NPS servicewide goals in Table 4. By adopting the servicewide monitoring goals, certain aspects of the UCBN program scope and direction become apparent. The program will include retrospective or effects-oriented monitoring to detect changes in the status or condition of selected resources, retrospective or stress-oriented monitoring to meet certain legal mandates (e.g. Clean Water Act), and effectiveness monitoring to measure progress toward meeting performance goals (National Research Council 1995, Noon et al. 1999). Through the servicewide goals, the UCBN also acknowledges the need to understand inherent ecosystem variability in order to better detect and interpret human-caused change. It recognizes the potential role of NPS ecosystems as reference sites for more impaired systems and will address these issues of intrinsic variability and reference site comparison through the vital signs selection process and monitoring protocol development.

Table 4. Servicewide Vital Signs Monitoring Goals

NPS Servicewide Vital Signs Monitoring Goals

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.

2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.

3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.

4. Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.

5. Provide a means of measuring progress toward performance goals.

B. UCBN Monitoring Objectives

The importance of clearly defining the objectives of a monitoring program has been stressed by many authors (Goldsmith 1991, Silsbee and Peterson 1991). Clear objectives help define all aspects of a program including the choice of vital signs to be monitored. The most commonly stated objective for NPS programs is to generate information that will help managers make better informed management decisions (Quinn and Van Riper 1990). This is clearly reflected in the first and second servicewide goals presented above. The objectives of the UCBN monitoring program reflect the network's commitment to this, but also include the ability to document threats or the effects of activities outside of park boundaries. Some authors have suggested that monitoring programs are important simply to document changes just for the sake of familiarity with the resources, to gain insights into how the ecosystem works, or to provide a reference point to which less pristine areas can be compared (Croze 1984, Silsbee and Peterson 1993). The objectives of the UCBN program also reflect this intent. Three broad programmatic monitoring objectives have been identified for the UCBN:

1) Effectiveness Monitoring

- To monitor the effects of management activities on target populations, communities and biophysical properties.

2) Stressor Effects Monitoring

- To monitor the status and trends of selected park vital signs vulnerable or potentially vulnerable to stressors.

3) Baseline Monitoring

- To develop long-term data sets of fundamental ecosystem attributes that provide the critical context within which effectiveness and stressor-effects monitoring will occur.

Each of the preliminary vital signs identified for the UCBN have been assigned to one of the three monitoring objective categories identified above and are presented in Appendix M. Specific monitoring objectives have been developed in association with the vital signs and these are also included in Appendix M. The UCBN has incorporated its preliminary list of vital signs into the national framework developed in 2004 in order to provide consistency between networks. Table 5 presents a condensed version of the table in Appendix M, showing the UCBN's primary monitoring objectives paired with the national I&M program's level 1 and 2 vital signs categories.

Table 5. The primary UCBN monitoring objectives organized within the servicewide Inventory and Monitoring Program's national vital signs framework.

Level 1	Level 2	Monitoring Objective
Air and Climate	Air Quality	Determine status and track trends in ozone injury occurring in ozone-sensitive plant species across the UCBN.
	Air Quality	Track trends in atmospheric pollutant emissions and deposition.
	Air Quality	Track trends in UCBN viewsheds.
	Weather	Monitor trends in precipitation, temperature, and snowpack in and adjacent to UCBN parks.
Geology and Soils	Geomorphology	Track changes in morphology of stream bank and other riparian features in the UCBN.
	Geomorphology	Determine the type, rate, and extent of visitor impacts on UCBN geologic and paleontologic features.
	Soil Quality	Track physical, chemical, and biological changes in soils.
Water	Hydrology	Determine the status and trend of surface water quantity in the UCBN, including flow in streams, springs, and seeps.
	Water Quality	Track spatial and temporal changes in water quality.
Biological Integrity	Invasive Species	Document changes in established populations of invasive plant and animal species.
	Invasive Species	Use monitoring data for early detection & predictive modeling of incipient invasive species.
	Infestations and Disease	Determine trends in incidence of disease and infestation in selected plant communities and populations.
	Focal species or Communities	Determine trends in composition and structure of selected focal populations and communities.
	At-Risk Biota	Determine status and trends of at-risk biota, including relict and peripheral species, and T&E species.
Human Use	Point Source Human Effects	Conduct pre and post control monitoring of plant communities in weed treatment areas in the UCBN.
	Non-point Source Human Effects	Use monitoring data to track the impacts of permitted livestock grazing in vulnerable ecosystems of CIRO, NEPE, and LARO.
	Visitor and Recreation Use	Determine spatial and temporal patterns of visitor use of park resources.
Ecosystem Pattern and Processes	Fire	Track spatial and temporal changes and variability in wildfire events across the UCBN.
	Fire	Determine spatial and temporal patterns and effects of fire on plant and animal communities.
	Land Use and Cover	Document changes in land use/land cover within and adjacent to UCBN park boundaries.
	Land Use and Cover	Track changes in the cultural and natural viewsheds of the UCBN.

C. Vital Signs Selection Process

The overall goal of the UCBN vital signs selection process is to develop as comprehensive a program as possible such that it will yield information that is “greater than the sum of its parts”. However, we recognize that no monitoring program can monitor everything and that monitoring is less expensive, easier, and ultimately more successful when the techniques are simple to use and when they focus on specific components of the ecosystem. Techniques which are easy to use will facilitate collection, analysis, and interpretation of data, and lessen the problems associated with handing over program responsibility to subordinates (Wright 1993). The latter point is important in parks because as a long-term exercise, monitoring frequently involves many different people, each possibly for only a few years (Usher 1991). The UCBN feels that an emphasis in parsimony is critical to development of a successful long-term monitoring program and will undertake vital signs selection within this context.

In order for a monitoring program based on simple, discrete indicators, objectives, and measures to be truly comprehensive, however, the program must be well integrated both ecologically and programmatically. Following recommendations by Noss (1990) and others, the UCBN aims to develop an ecologically integrated program by selecting vital signs that span a range of spatial and temporal scales and span multiple levels of ecological hierarchy, from the genetic to the landscape level. Programmatic integration will require the consideration of other programs and projects ongoing within UCBN parks as well as other NPS networks, and in other partnering agencies. A comprehensive and well integrated monitoring program requires careful crafting of vital signs and objectives, knit together with other existing programs. The preliminary list of UCBN vital signs presented in Appendix M represents a coarse first step in this process. The selection process will be completed during Phase II of the program development and will select and prioritize an integrated list of vital signs based on the following three criteria: ecological significance, management significance, and legislative significance.

To date, the UCBN has taken several steps to identify a comprehensive preliminary list of vital signs and associated monitoring questions and objectives. In 2002, the UCBN hosted a vital signs scoping workshop held at the University of Idaho in Moscow, Idaho on April 16-17. The report from this workshop is located in Appendix D. In preparation for this first workshop, the network staff completed a computerized resource database documenting all natural resource studies pertaining to each park site, species lists for each park in the network and information on existing natural resource data. To avoid a “death by models” situation, a simple, straightforward conceptual model was developed before the workshop, providing a starting point and framework for addressing and evaluating vital signs and monitoring strategies at the network level. The workshop was organized to identify and validate vital signs common to each park site, substantiate the premises of the conceptual model, further develop the monitoring focus, and identify preliminary measures and methods.

Prior to the workshop, resource managers were sent a questionnaire examining the following points as preparation for workshop discussions:

- What are your park’s most significant resources for which information about status and trends is needed?

- What park resources have regional or even national significance due to their unique nature or because they serve as indicators of regional trends?
- Are there particular resources that the park has special mandates or commitments to protect either by park legislation, in a general management plan, or in other planning documents? (e.g., Federally listed species at all parks)
- What, in your opinion, are the greatest current or prospective internal threats to significant park resources? (e.g., climbing at CIRO, trail impacts at JODA)
- What are the greatest external threats? (e.g., irrigation at HAFO)
- Are there significant current or future ecosystem restoration projects in the park for which long-term monitoring is needed? (e.g., vegetation restoration projects at WHMI)
- What long-term natural resources monitoring projects have been undertaken in the past or are ongoing now?

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Resource Managers responded to the questionnaire in writing and a summary of their responses is contained in Appendix E. Park summaries were prepared for this workshop that contained information on the size of the park, designation date, park history and purpose, location, elevation, climate, fauna, flora, unique features and species of special concern and resource management concerns (Appendix F).

The conceptual model developed for the workshop was altered to best reflect workshop findings (Appendix G). The final column of the model listed the vital signs considered by workshop participants to be the most important to monitor in the Network. Vital signs included riparian/wetlands community, grassland/shrub-steppe community, herpetofauna, avifauna, small mammal community, invertebrate community and soil properties.

A second Network-wide workshop was held at the University of Idaho in Moscow, Idaho on March 9-10th, 2004. The report from this workshop is located in Appendix H. The purpose of this workshop was to continue to solicit input from park managers and regional scientists on potential vital signs and associated monitoring questions. Heavy emphasis was placed on the development of monitoring questions, since it was becoming clear to the UCBN that vital signs were of limited value without an associated set of status-and-trend type questions. The outcomes from this workshop included: 1) the creation of a network of stakeholders, 2) a review of technical information developed by the science advisory committee, and 3) the development of a list of vital signs and associated monitoring questions that will help track a subset of the total suite of natural resources that park managers are directed to preserve.

A network of stakeholders was established by contacting resource professionals from agencies that have land adjacent to park lands and by speaking to references provided by park resource managers. Potential partners were identified (Appendix I) and scientists from many different natural resource disciplines and agencies participated in the 2004 Network workshop.

A primary emphasis of UCBN efforts in FY2004 has been to define the most significant resources, resource concerns and stressors within UCBN parks. Information from questionnaires sent to Network resource managers before the workshop was presented to workshop participants in 3-ring binders. This information included a list of species of concern (Appendix J), a noxious weed list (Appendix K), and a list of prioritized stressors affecting park natural resources (Appendix L).

Following the 2004 workshop, a vital signs ranking website was launched and workshop participants and other stakeholders were solicited to complete individual ranking exercises for the list of vital signs and questions developed during the workshop (see http://www.cnr.uidaho.edu/wilderness/UCBNVitalSPriorities.htm). Ranking was done on the ecological and management significance of each question and new questions were offered by some participants. Thirty-four stakeholders participated in the ranking exercise and the 19 top ranked questions are presented in Appendix N. The UCBN staff then conducted an additional review of the survey results and further refined the preliminary list of vital signs which is included in Appendix M. The UCBN will proceed with this list into the phase II prioritization process.

An important component of the vital signs selection process has been the conceptual modeling efforts conducted during the previous vital signs scoping workshops and more recent efforts detailed in Chapter 2 of this report. Following the 2nd vital signs workshop, the UCBN staff identified 5 broad ecosystem categories into which most vital signs and questions developed in the workshop could be placed: cultural landscapes, sagebrush-steppe ecosystems, forest and woodland ecosystems, riparian and wetland ecosystems, and aquatic resources. These five focal systems are primarily defined by land cover and vegetation type and encompass the suite of significant ecological resources of concern from which measurable information-rich indicators will be developed. An extensive literature review and a suite of updated conceptual models reflecting the network's progress in vital signs selection is presented in Chapter 2.

In FY 05, the Network team will convene small, focused workgroups to determine what questions address the five focal systems across temporal and spatial scales. These workgroup meetings will provide a small-group format to solicit input and review from invited experts, and to promote discussion of how to integrate monitoring across ecosystems or subject areas. Background materials for the five focal workgroups will include this report, and literature review/conceptual models from Chapter 2. Prior to the workgroup meetings, UCBN staff, SAC members and contributing scientists will evaluate vital sign sets according to I & M program selection criteria. Their recommendations and comments will be forwarded to workgroups for discussion and possible refinement.

Workgroups will be asked to recommend monitoring questions, objectives and measurements for each focal system and to propose two to three options (i.e., monitoring at basic, moderate, and optimal funding levels) for proposed vital signs.. Workgroup meetings will include several outside scientists with ecosystem, taxa, or monitoring expertise. A lead author (UCBN staff, cooperator or park scientist) will be identified for each workgroup. In some cases, we will consolidate related workgroups in a single meeting, in part to hold down travel costs and time commitments, but also to promote discussion and potential integration across related topic areas. Each workgroup will produce a report that proposes "strawman" vital signs sets for their assigned ecosystem(s) or focal area(s) and an accompanying rationale for their selection. The report will contain supporting documents that provide justification (or ranking criteria) for why certain vital signs were selected, and show how they fit with the conceptual ecosystem model.

The report will also list the vital signs that were considered but not selected for monitoring and the reasons why they were not selected. The reports will be circulated to UCBN parks to ensure that park staff who could not attend the meetings will have an opportunity to review and comment on the resulting products.

When all the workgroup reports are complete, the UCBN team will meet with the SAC to determine the list of prioritized vital signs and associated monitoring questions. This list will be used to develop and write Phase II of the UCBN monitoring plan.

The Network team will list the specific, measurable objectives for each vital sign selected for monitoring, and wherever possible, give the threshold value or "trigger point" at which some action will be taken. The statistical "detection limits," given typical sample variability and chosen sample sizes, shall be low enough to ensure that such threshold values or trigger points can be detected whenever possible.

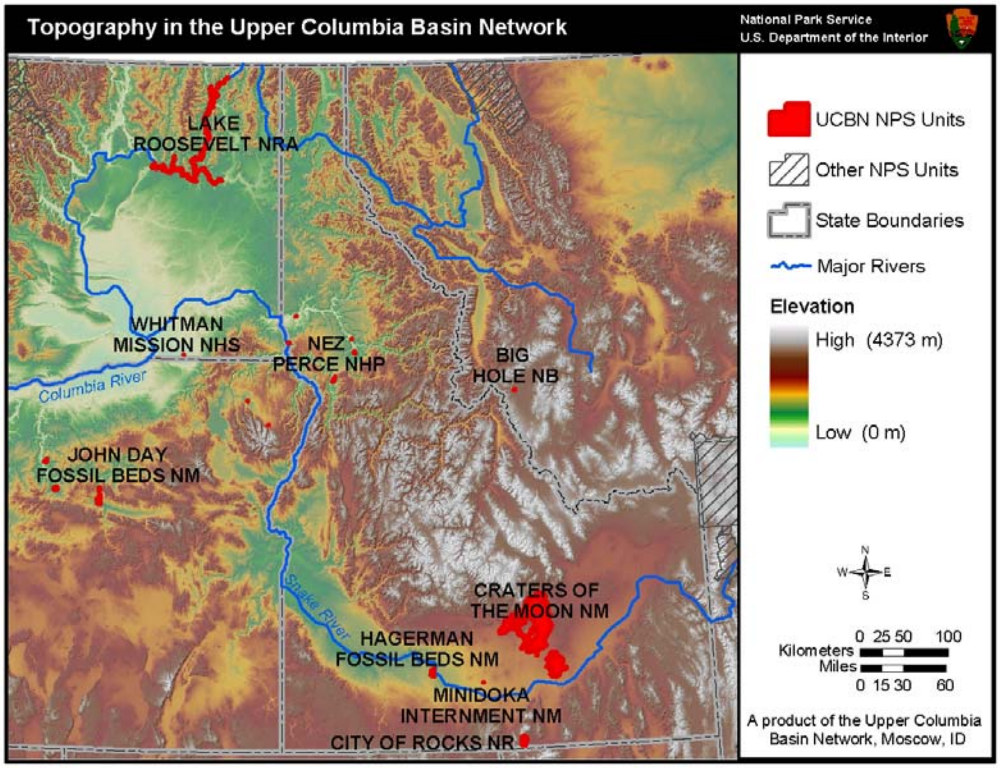
At the conclusion of the prioritization of vital signs a Phase II report will be written. The projected completion date for this report is June 1, 2005.

V. Ecological Context

A. Introduction

The nine parks in the UCBN are spread across four states and occupy portions of the Columbia Plateau and Snake River Plain geographic regions. All parks are located within the Columbia River Basin except BIHO and the Bear Paw Battlefield unit of NEPE. UCBN park units include a total of over 245,000 hectares of land area, span 850 kilometers from east to west, 765 kilometers from north to south, and cover 2506 meters of vertical relief (Figure 3). The lands contained in the UCBN are highly diverse. This section attempts to describe the range of physical and biotic variation across the network. All scientific names of species mentioned in the following text and in chapter 2 are presented in Appendix Q.

Figure 3. Topography in the UCBN.

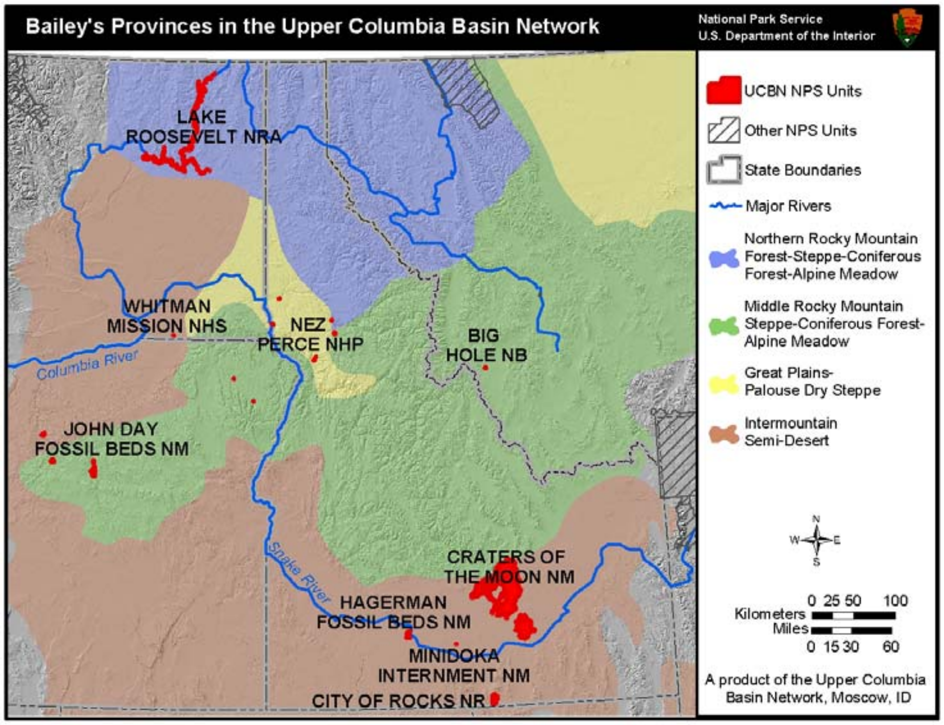


The network adopted a land classification system to better understand the similarities and relationships between park units. The idea of ecoregions emerged as the most useful land classification system for supporting sustainable resource management practices (Bailey 1995, 1998). The ecosystem concept underlies the ecoregion system of land classification because it effectively brings together the biological and physical worlds into a framework by which natural systems can be described, evaluated, and managed (Rowe 1992).

The National Hierarchical Framework of Ecological Units developed by the USDA Forest Service (Bailey 1995, McNab and Avers 1994, ECOMAP 1993) provides a useful means of integrating factors such as regional physiography and climate to assess broad-scale differences and similarities among UCBN parks. Ecological types are defined and combined into ecological units, then described and mapped based on the National Hierarchical Framework of Terrestrial Ecological Units (ECOMAP Framework). The ECOMAP Framework is a regionalization, classification and mapping system for stratifying the Earth into progressively smaller areas of increasingly uniform ecological potential.

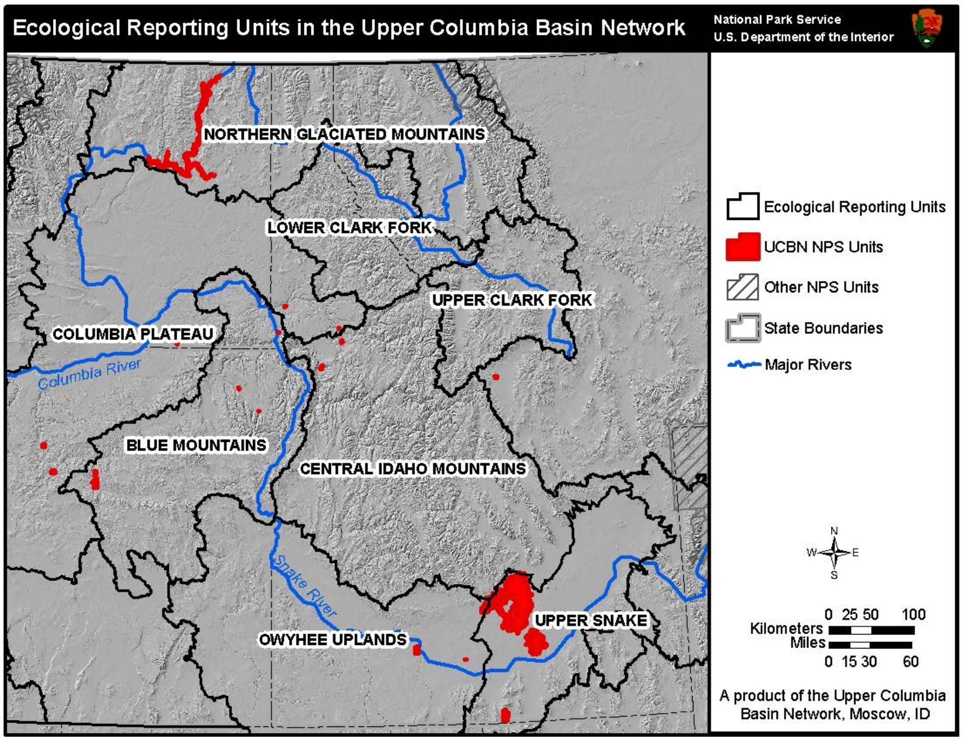
There are three levels of ecological units delineated in the hierarchical framework that is used for understanding UCBN parks' resources. The *province* has broad applicability to management on an ecoregion scale (Figure 4), the *section* unit is more pertinent for the strategic, subregional effort of monitoring park resources, and the *subsection* level identifies unique geoclimatic environments. Units in the hierarchy are designed on the basis of similarity for: 1) potential natural communities, 2) soils, 3) hydrological function, 4) topography and landforms, 5) lithology, 6) climate, 7) air quality, and 8) ecological processes like nutrient cycling, productivity, and natural disturbance regimes, including succession and fire (Cleland et al. 1997).

Figure 4. Bailey's Ecoregion Provinces in the UCBN.



We have also used the ecological reporting unit (ERU) adopted by the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The ICBEMP divided the basin area (Figure 5) into 13 ERUs . ERUs were defined by the landscape ecology, terrestrial, and aquatics staff of the science integration team (SIT) working on the ICBEMP. In the ICBEMP reports, ERUs provide the basis for the descriptions of biophysical environments, the characterization of ecological processes, the discussion of effects of land management activities and observed trends from past management, and the discussion of the complexities of managing landscapes in the future (Quigley and Arbelbide 1997).

Figure 5. Ecological Reporting Units (ERUs) of the UCBN.



A total of 4 provinces occur within the landscape ecology characterization area of the Upper Columbia Basin Network. The UCBN is also contained within 6 ERUs described by the ICBEMP (Table 6).

The four provinces that contain the UCBN parks share many similarities. The most fundamental is the profound alteration and disturbance of their landscapes. Lands undisturbed by human activities are rare in the region and an even smaller proportion of the remaining undisturbed lands are formally protected. Land use change, habitat alteration, and fragmentation are some of most important agents of change and source of resource stress in UCBN parks. The scarcity of protected lands within these provinces was illustrated in a survey that assessed the degree to which units of the national park system contained a representation of all natural regions in the country (National Park Service 1972).

This assessment found that the various landscapes within the Columbia Plateau and Great Basin natural regions had the poorest representation within the national parks. Evidence of the lack of protection in these regions can also be found in the research of the Gap Analysis Program and by Wright et al. (2001) that has characterized the Snake River Plain and the Columbia Plateau - Palouse ecoregion as one of the least protected landscapes in North America. Conservation biologists have also characterized this region as an endangered ecosystem (Noss et al. 1995).

An overview of the biophysical environment of the Upper Columbia Basin Network sets the stage for conceptual models described in Chapter 2. This section introduces key physical and biotic qualities that characterize the park sites located in the UCBN.

Table 6. Ecological Characterizations of Upper Columbia Basin Network Parks.

Park	**Bailey's Divisions**	**Bailey's Province**	**Ecological Reporting Unit (ERU) (from ICBEMP)**
CIRO	Temperate Desert	Intermountain Semi-Desert (342)	Upper Snake
CRMO	Temperate Desert	Intermountain Semi-Desert (342)	Upper Snake
HAFO	Temperate Desert	Intermountain Semi-Desert (342)	Owyhee Uplands
MIIN	Temperate Desert	Intermountain Semi-Desert (342)	Owyhee Uplands
WHMI	Temperate Desert	Intermountain Semi-Desert (342)	Columbia Plateau
JODA (Clarno)	Temperate Desert	Intermountain Semi-Desert (342)	Columbia Plateau
JODA (Painted Hills)	Temperate Steppe Regime Mtns.	Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province (M332)	Columbia Plateau
JODA (Sheep Rock)	Temperate Steppe Regime Mtns.	Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province (M332)	Blue Mountains
BIHO	Temperate Steppe Regime Mtns.	Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province (M332)	NA
LARO (North)	Temperate Steppe Regime Mtns.	Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Province (M332)	Northern Glaciated Mountains
LARO (South)	Temperate Steppe Regime Mtns.	Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Province (M332)	Northern Glaciated Mountains
NEPE Spalding	Temperate Steppe	Great Plains –Palouse Dry Steppe Province (331)	Columbia Plateau
NEPE Whitebird	Temperate Steppe	Great Plains –Palouse Dry Steppe Province (331)	Central Idaho Mountains

B. Regional Context

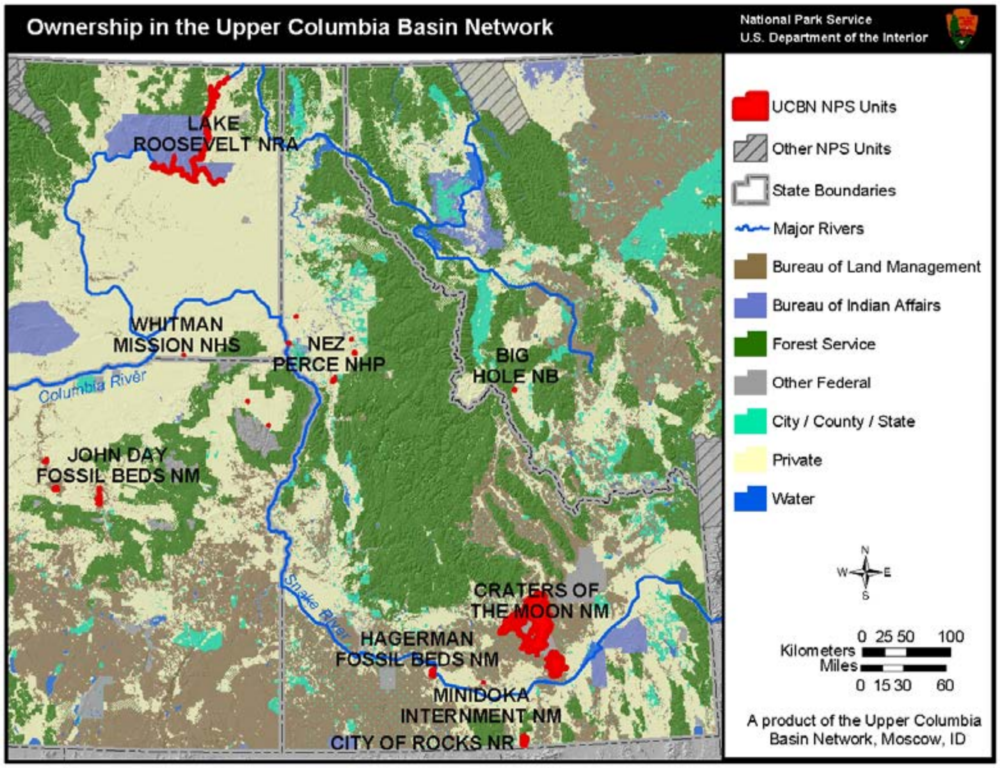
The quality of the landscape matrix in which national park units are embedded is vital to the long-term integrity of the units themselves. Attributes of the surrounding landscapes contribute to both abiotic and biotic dynamics of remnant areas (Saunders et al. 1991, Meffe and Carroll 1997) and are major determinants of both short-term and long-term protection effectiveness (Schonewald-Cox 1988). In many cases, national park units are dependent on adjacent lands simply because their boundaries fail to encompass habitats necessary to maintain complete species communities (Myers 1972, Western 1982, Curry-Lindahl 1972, Garratt 1984). For example, studies in the Greater Yellowstone Ecosystem have shown that some species cannot persist in Yellowstone National Park without access to habitat on adjacent lands, and species dependent on low elevation, riparian, or grassland habitats may be most vulnerable (Hansen and Rotella 2002).

Concerns over external influences on National Parks date as far back as 1933 (Wright et al. 1933), and management of adjacent lands has been identified as one of, if not the most, serious challenge facing park managers over the last 25 years (Shands 1979, National Parks and Conservation Association 1979, National Park Service 1980, Buechner et al. 1992). In 1963, the National Academy of Sciences Advisory Committee recommended that specific attention should be given to assessing changes in land use, resource use and economic activities on areas adjacent to national parks that likely affect those parks (Robbins et al. 1963). Ten years ago, the National Park System Advisory Board recommended that “resource management should be addressed in broader context” and specifically recognized the impact of activities outside park boundaries (National Park Service 1993). Again, in 2001, the National Park System Advisory Board indicated the need for broad-scale research and management when they suggested restoring landscape-, regional-, and continental-scale habitat corridors and establishing new parks or modifying existing park boundaries (National Park Service 2001).

Threats or stresses originating from outside park boundaries can, and are, significantly modifying biodiversity and other valued components of park ecosystems (National Parks and Conservation Association 1979, Garratt 1984, Machlis and Tichnell 1985, Sinclair 1998). In 1980, greater than 50% of threats reported across the National Park Service system were from external sources, with development on adjacent lands, air pollution, urban encroachment and roads and railroads most frequently cited (National Parks Service 1980). More recently, land use change (Hansen and Rotella 2002), fragmentation (Ambrose and Bratton 1990), and human population density (Newmark et al. 1994), have been documented as threats to individual parks. In addition, climate change is likely to exert a strong influence on biodiversity within parks. It has been hypothesized that only protected areas with adequate expanses of surrounding habitat and linkages to other protected areas will be able to support current levels of biodiversity into the future (Hansen et al. 2001).

The UCBN team is committed to complementing existing and fostering new regional collaborations that will benefit natural resource management within UCBN parks. The 9 park units of the UCBN occur over a 4-state area and are subject to a variety of adjacent land management strategies. Like many park units across the US, parks in the UCBN tend to be “islands” in a sea of multi-use lands. For 8 of the 9 park units, the greater part of land within 5 miles of park boundaries is in private ownership (Figure 6). Only Craters of the Moon is surrounded by a majority of public lands, primarily BLM. The BLM manages >20% of the lands around 3 additional parks in southern Idaho (MIIN, HAFO, CIRO) and 1 park in Oregon (JODA). The USFS manages just over 40% of the land around BIHO in western Montana and also has important land holdings around CIRO, NEPE, and LARO. Small, but valuable portions of state lands occur within 5 miles of park units in all 4 states. Three of the parks in the network (CIRO, JODA, NEPE) are composed of multiple subunits. The most extreme case is NEPE, which consists of 38 subunits spread over 4 states.

Figure 6. Land Ownership in the UCBN.



Many of these surrounding land management agencies also designate areas for the long-term conservation of resources. At least 32 of these conservation areas occur within 10 miles of UCBN park units (Table 7). Federal agencies manage 19, state agencies manage 10 and 3 are owned by The Nature Conservancy. Partnering with these entities as well as tribal and private landowners is essential for the long-term integrity of natural resources in UCBN parks (see Appendix I for list of potential partners).

Table 7. Areas within 10 miles of National Park Service units in the Upper Columbia Basin Network that are managed for the long-term maintenance of biodiversity.

PARK	NEARBY CONSERVATION AREA[1]	MANAGING AGENCY[2]	DISTANCE (MI)
Hagerman Fossil Beds NM	Thousand Springs Ranch and Preserve	TNC	< 5
	Hagerman Wildlife Management Area	IDFG	< 5
	Box Canyon / Blueheart Springs ACEC	BLM	< 10
Minidoka Internment NM	Vineyard Creek ACEC	BLM	< 10
City of Rocks NR	Jim Sage Canyon Research Natural Area	BLM	< 10
Craters of the Moon NM and Preserve	Bear Track Williams Recreation Area	IDFG	< 5
	Preacher Bridge Access Area	IDFG	< 5
	Carey Lake Wildlife Management Area	IDFG	< 5
	Minidoka National Wildlife Refuge	USFWS	< 5
	Silver Creek Access Area	IDFG	< 10
	Silver Creek Easements	TNC	< 10
	China Cup Butte Research Natural Area	BLM	< 10
	Idaho National Engineering and Environment Laboratory	DOE	< 10
Nez Perce NHP (Idaho portion)	Lower Salmon River ACEC	BLM	< 5
	Hells Canyon National Recreation Area	USFS	< 10
	Lower Lolo Creek ACEC	BLM	< 10
	Middle Fork Clearwater Wild River	USFS	< 10
	Craig Mountain Wildlife Management Area	IDFG	< 5
	Redbird Creek Research Natural Area	BLM	< 5
	Captain John Creek Research Natural Area / ACEC	BLM	< 5
	Craig Mountain ACEC	BLM	< 5
	Garden Creek Preserve	TNC	< 10
	Chief Joseph Wildlife Recreation Area	WDFW	< 10
Nez Perce NHP (Oregon portion)	Eagle Cap Wilderness Area	USFS	< 5
	Hells Canyon National Recreation Area	USFS	< 5

PARK	NEARBY CONSERVATION AREA[1]	MANAGING AGENCY[2]	DISTANCE (MI)
Lake Roosevelt NRA	Northup Canyon State Park	WA STATE	< 5
	Sherman Creek Wildlife Area	WA STATE	< 5
John Day Fossil Beds NM	Spring Basin Wilderness Study Area	BLM	< 5
	Pine Creek Ranch	CTWS	< 5
	Bridge Creek Wilderness Area	USFS	< 10
	Aldrich Mountain Wilderness Study Area	BLM	< 10
	Murderer's Creek Wildlife Area	ODFW	< 10
	Black Canyon Wilderness Area	USFS	< 10

[1] ACEC = Area of Critical Environmental Concern

[2] Managing agencies include The Nature Conservancy (TNC), Idaho Department of Fish and Game (IDFG), Bureau of Land Management (BLM), US Fish and Wildlife Service (USFWS), Confederated Tribes of Warm Springs (CTWS), Department of Energy (DOE), US Forest Service (USFS), Washington Department of Fish and Wildlife (WDFW), Washington state (WA STATE), and Oregon Department of Fish and Wildlife (ODFW).

C. Climate and Air Quality

Bailey (1995, 1998) describes *climate* as a source of energy and water operating at the broadest spatial and temporal scales, and thus serving as a prime controlling factor for ecosystem distribution. The major controls on climate are latitude and topography, along with continental position for terrestrial regions. Continental position is important because it relates to prevailing winds and moisture regimes largely determined by global atmospheric conditions. Therefore, oceanic conditions must be taken into account when trying to understand macroclimates of the continental landscape.

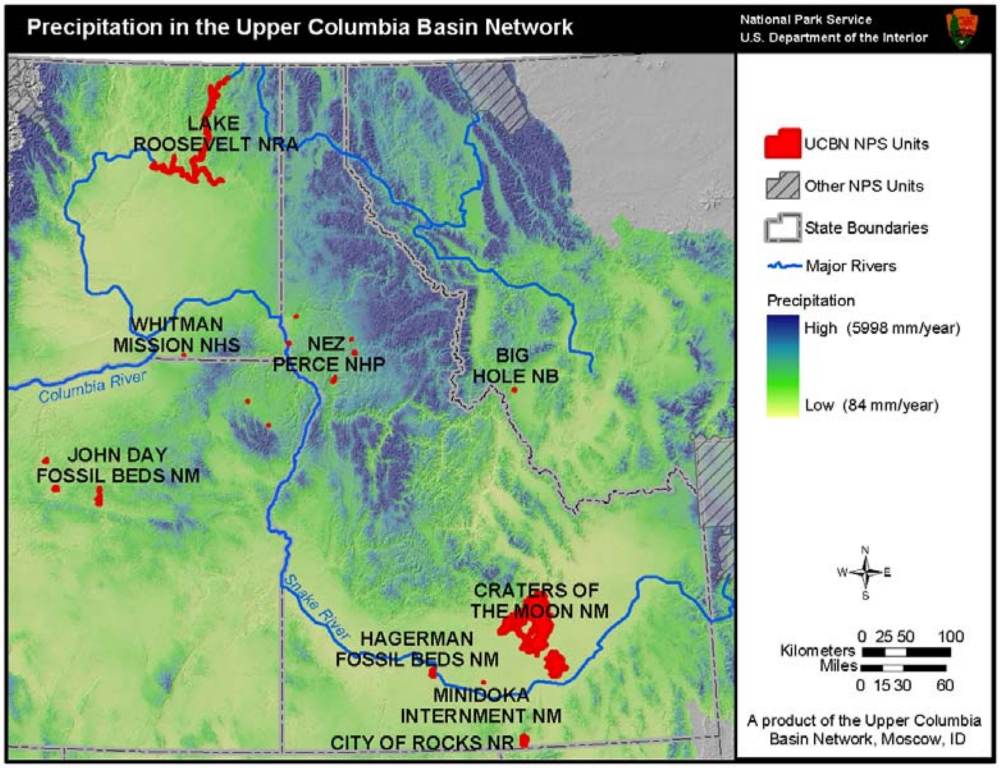
Climate strongly affects landforms and erosion cycles. Therefore, at the next level of controlling factors (for terrestrial regions) we find *landform* and geomorphic processes, which relate to geological substrate, surface shape, and relief. At the meso and microscales, soil and vegetation patterns derive from landform, because landform controls key factors affecting soil development and plant growth. Within this context, slight differences in slope and aspect determine *soil moisture availability* that in turn determines vegetation community. Soil moisture availability refers to the amount of soil moisture that is available to plants and, in the upper Columbia Basin, occurs along a *topographic moisture gradient* in which soil moisture increases with increasing elevation, decreasing slope, and northerly aspects (Peet 2000).

The Columbia basin is in a transition-type climate zone, and climate patterns are dominated by topographic features (Ferguson 1999, Quigley and Arbelbide 1997). Vegetation type and distribution varies depending on the soils, long-term precipitation patterns, and climate. Climate at park sites is influenced by three distinct air masses: 1) moist, marine air from the west that moderates seasonal temperatures; 2) continental air from the east and south, which is dry and cold in winter and hot with convective storms in summer; and 3) dry, arctic air from the north that brings cold air to the basin in winter and helps to cool the basin in summer (Ferguson 1999).

Most precipitation accumulates during winter (20-40 cm, 8-16 inches) in the central Columbia and Snake River Plateaus. The mountain snowpack acts as a natural reservoir and supplies the basin with most of its useable water. Summer precipitation through the basin ranges from about 20-50 cm (8-20 inches) (Figure 7). Trends in the last 50 to 100 years indicate a general decrease in winter precipitation and increase in summer precipitation (Ferguson 1999).

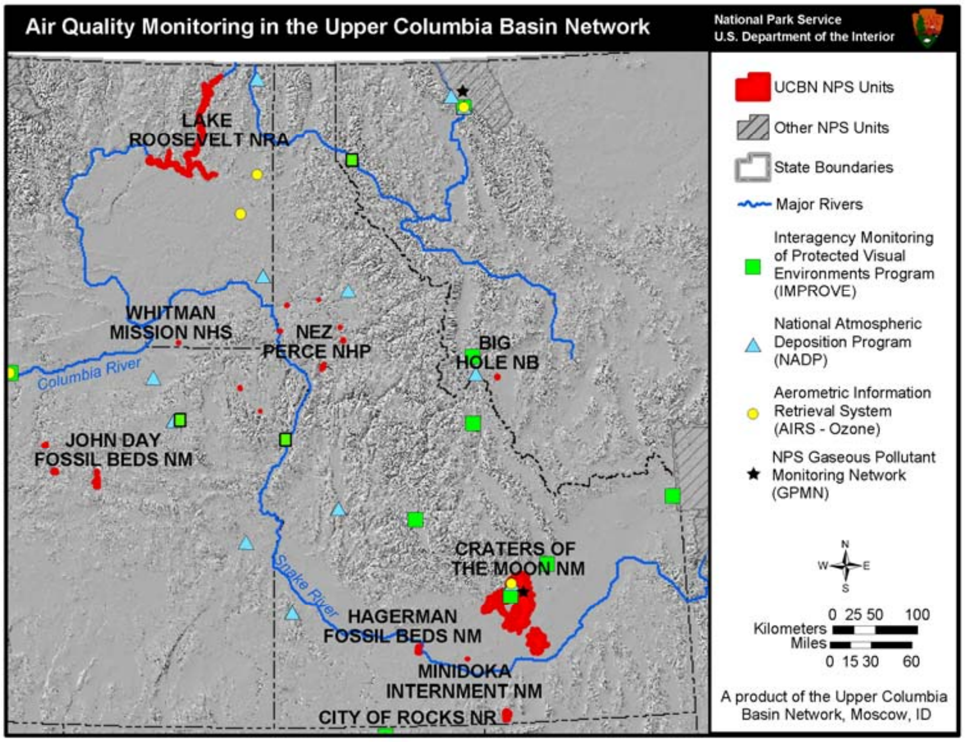
Temperatures are generally mild in the basin because of the periodic influxes of moderating Pacific moisture. Winter mean monthly temperatures range from -10 to -3^{0}C (-50 to 27^{0}F) and summer temperatures ranges from 10 to 15^{0}C (50 to 59^{0}F). Trends in the last 50 to 100 years indicate a slight increase in winter temperatures and slight decrease in summer temperatures (Ferguson 1999). Climate change scenarios identified by the US Global Change Research Program (USGCRP) for the Rocky Mountain/Great Basin region, which includes the UCBN area, are complex but include a reduction in snowpack and an overall aridifaction of the region, with increased evapotranspiration negating the effects of potential increased summer precipitation (Wagner et al. 2003). A number of vital signs have been proposed that would address climate change in the UCBN region (see Appendix M).

Figure 7. Precipitation Map of the UCBN



Air quality monitoring stations are located near several UCBN parks (Figure 8). The only park unit in the UCBN that has air quality monitoring on site is the Craters of the Moon National Monument and Preserve. Craters of the Moon is considered a Class I airshed under the Clean Air Act, which requires that the airshed receives the highest level of air quality protection. Consequently, Craters of the Moon National Monument and Preserve (CRMO) participates in the National Park Service's comprehensive air resources management program, designed to assess air pollution impacts and protect air quality related resources. The National Park Service operates monitoring instruments near the Monument’s Visitor Center, which record concentrations of ozone, fine particles which effect visibility, and acid precipitation. These sites are part of national monitoring networks which record existing conditions, detect trends, and help in the development of predictive models for air quality used throughout the country.

Figure 8. Air quality monitoring in or near UCBN parks.



D. Landforms and Geology

The USGS, in cooperation with NPS, have placed NPS sites into geologic provinces and sections that follow closely the boundaries of the ERUs developed by the ICBEMP (see figure 5 and http://www2.nature.nps.gov/geology/usgsnps/province). The majority of UCBN parks are contained within the Columbia Plateau geologic province (see figures 9 and 10). BIHO and the northern portion of LARO are considered within the Rocky Mountain System. The Columbia Plateau province is sub-divided into 5 geologic sections (see figure 10). The Walla Walla Plateau contains three of the northern most network parks – the southern portion of Lake Roosevelt NRA (LARO), Whitman Mission NHS (WHMI), and portions of NEPE. The Snake River Plain contains four of the southern most parks including Hagerman Fossil Beds NM (HAFO), Minidoka Internment NM (MIIN), CRMO, and City of Rocks NR (CIRO). City of Rocks straddles the border between the Snake River Plain and the Great Basin province. The John Day Fossil Beds (JODA) straddle the border of the border of the Blue Mountains and the southern Walla Walla Plateau. BIHO and the northern portion of LARO are considered in the Northern Rocky Mountains of the Rocky Mountain System.

A table of geoclimatic characteristics compiled by the ICBEMP for ecological reporting units is presented in Table 8 (Quigley and Arbelbide 1997). Refer to figure 5 to locate UCBN parks within ICBEMP ecological reporting units.

Table 8. Geoclimatic characteristics of ecological reporting units (Quigley and Arbelbide 1997).

ERU	Landforms	Bedrock & Surficial Material	Elevation Range (m)	Mean Annual Precip. & Temp.	Major Potential Vegetation Groups
Columbia Plateau (NEPE, WHMI, JODA)	Plateaus, hills, and plains	Basalts and volcanic rocks; loess, glacial outwash, and flood deposits	61-1,220	180-450 mm 4 to 14^0C	Sagrebrush, Bluebunch wheatgrass, and Idaho fescue
Northern Glaciated Mtns. (LARO)	Glaciated mountains, foothills, basins, and valleys	Granitic, gneiss, schist, siltite, shale, quartzite, carbonate; glacial till, and outwash	244-3,081	410 to 2,540 mm -1 to 14^0C	Douglas-fir, ponderosa pine, grand fir, western hemlock, and subalpine fir.
Owyhee Uplands (HAFO, MIIN)	Dissected mountains, plains, plateaus, and foothills	Volcanic basaltic flows and pyroclastic rocks	641-2,501	200 to 400 mm 2 to 8^0 C	Salt desert shrub, sagebrush, and juniper
Upper Snake (CIRO, CRMO)	Basins, valleys, mountains, plateaus and plains.	Volcanic-basalt to rhyolite: and carbonate, phosphate, clastic sedimentary rocks	397-2,288	100 to 790mm 4 to 13^0 C	Salt desert brush, sagebrush and juniper
Central Idaho Mountains (NEPE)	Dissected mountains, breaklands, canyons, basins, foothills, and valleys, and some alpine glaciation	Granitics, gneiss, schist, shale, carbonate rocks, and volcanic rocks	427-3,861	250 to 2,030mm 3 to 10^0 C	Douglas-fir, grand fir, sagebrush, grasslands, and subalpine fir
Blue Mountains (JODA, NEPE)	Low to moderate relief plains, foothills and mountains with narrow valleys and breaks	Paleozoic and Cenozoic sediments, Cenozoic basalts	762-3,048	250-1270 mm 3 to 14^0 C	Douglas-fir, grand fir, sagebrush, grasslands, and subalpine fir

Figure 9. Geologic provinces of the western United States (see http://wrgis.wr.usgs.gov/docs/parks/province/columplat.html).

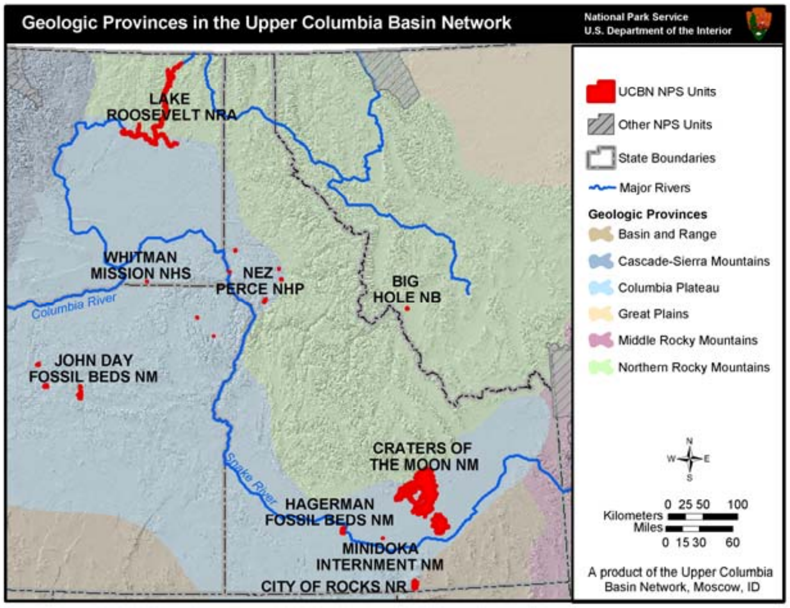
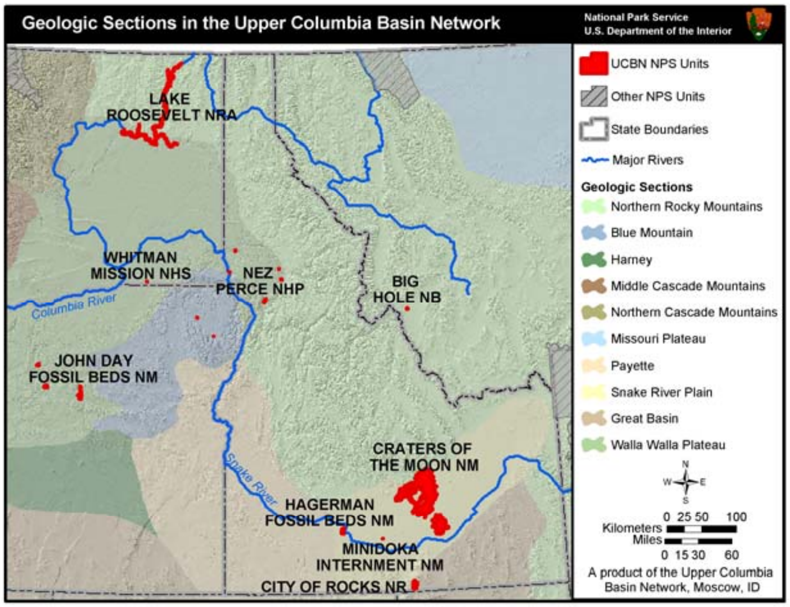


Figure 10. Geologic sections of the Columbia Plateau (see http://wrgis.wr.usgs.gov/docs/parks/province/columplat.html).



Columbia Plateau

The Columbia Plateau is the most significant geologic province of the UCBN and its unique volcanic geology dominates much of the present day landscape in the UCBN. The plateau contains one of the world's largest accumulations of lava. The topography here is dominated by geologically young lava flows that inundated the countryside with amazing speed, all within the last 17 million years. Over 170,000 cubic kilometers of basaltic lava, known as the Columbia River basalts, covers the western part of the province. These tremendous flows erupted between 17 and 6 million years ago. Most of the lava flooded out in the first 1.5 million years—an extraordinarily short time for such an outpouring of molten rock. Over 300 high-volume individual lava flows have been identified, along with countless smaller flows. Numerous linear vents, some over 150 kilometers long, show where lava erupted near the eastern edge of the Columbia River Basalts, but older vents were probably buried by younger flows. Similar flood basalts occurred further east in the Snake River Plain. Following this period of intense volcanism were the repeat events of glaciation during the Pleistocene Epoch that reshaped much of the Columbia Plateau. Continental ice sheets reached as far south as the Spokane area in eastern Washington, and montane glaciers reached farther south down the Rocky Mountain and Cascade chains. Massive pluvial lakes and ice dams drove repeated flood events that continue to have a tremendous effect on modern day geomorphology as well as land use practices.

Snake River Plain – City of Rocks NR, Craters of the Moon NM, Hagerman Fossil Beds NM and Minidoka Internment NM

The Snake River Plain stretches across southern Idaho, includes portions of eastern Oregon and northern Nevada, and ends at the Yellowstone Plateau in Wyoming. Looking like a great spoon scooped out of the Earth's surface, the smooth topography of this province forms a striking contrast with the strong mountainous fabric around it. The Snake River Plain lies in a distinct depression. At the western end, the base has dropped down along normal faults, forming a graben structure. Although there is extensive faulting at the eastern end, the structure is not as clear there.

Like the Columbia River region to the west, volcanic eruptions dominate the story of the Snake River Plain in the eastern part of the Columbia Plateau province. The earliest Snake River Plain eruptions began about 15 million years ago, just as the tremendous early eruptions of Columbia River Basalt were ending. Most of the Snake River Plain volcanic rock is of Pliocene age (5-1.6 million years ago) and younger.

In the west, the Columbia River Basalts are almost exclusively made of black basalt. In the Snake River Plain relatively quiet eruptions of soupy black basalt lava flows alternated with tremendous explosive eruptions of rhyolite, a light-colored volcanic rock.

Cinder cones dot the landscape of the Snake River Plain. Some are aligned along vents and fissures that fed flows and cone-building eruptions. Calderas, great pits formed by explosive volcanism, low shield volcanoes, and rhyolite hills are also part of the landscape, but many are obscured by later lava flows.

Craters of the Moon lava field lies along the northern border of the Snake River Plain, midway between Arco and Carey, Idaho. It consists of Holocene to Pleistocene lava flows, cinder cones, spatter cones, lava tubes, and other features typical of basaltic volcanism. Much of the field lies within CRMO. The land cover of CRMO is over 80% lava (see table 9).

The landscape of CIRO has been sculpted from the upper parts of the Cassia batholith. Some of the oldest rocks in the western United States are found here. CIRO was designated a national natural landmark in recognition of the nationally significant geological and scenic values of its rock formations. Rock formations in the reserve developed through an erosion process called exfoliation, during which thin rock plates and scales sloughed off along joints in the rocks. The joints, or fractures, probably resulted from contractions when the rock cooled or from expansions when overlying materials eroded away and eliminated confining pressure. The granite has eroded into a fascinating assortment of domes and spires, some of which stand 200 feet or more above the surrounding landscape. Shallow depressions, called panholes, are scattered along the flat tops of many of the domes. The most notable panhole is located on top of Bath Rock and frequently fills with water from rain or snow melt. The degree to which wildlife depend upon these seasonal water holes is not known, nonetheless, these panholes contribute to the striking natural beauty of the reserve.

Hagerman Fossil Beds National Monument is located in Hagerman Valley in the central Snake River Plain. The Snake River, which flows west, then north, through the valley, forms the eastern boundary of the monument. On the monument side of the river, the valley wall rises steeply and abruptly about 550 feet above the river. Much of this steep terrain forms badland-type topography characterized by bluffs, landscape scarps, and hummocky deposits. The steep slopes consist of bluffs of the Glenns Ferry Formation. The bluffs, known locally as the Hagerman Cliffs, are composed primarily of unconsolidated lake, floodplain, and stream deposits, volcanic ash, and thin basalt flows deposited during the Pliocene and Pleistocene eras about 3.5 million years ago. On the eastern side of the river, where the monument headquarters is located, large basalt rimrock features define the valley wall, and large rounded boulders, called “melon gravel”, are scattered across the valley bottom. The melon gravel were deposited by pleistocene flood events caused by ice dams associated with glacial Lake Idaho.

<u>Walla Walla Plateau</u> – Nez Perce NHP, Lake Roosevelt NRA, and Whitman Mission NHS

The Walla Walla Plateau is a part of the Columbia Plateau and experienced much of the same flood basalt volcanism. Beginning about 15,000 years ago and continuing for about 2,800 years, periodic melting of glacial ice dams caused giant floods every 35 to 55 years (the last flood happened about 12,800 years ago). Geologists have documented up to 50 of these outbursts associated with glacial Lake Missoula and known as the Missoula Floods. These floods, documented as the largest in geologic history, each drained as much as 10 times the total combined volume of water carried today by all of the rivers in the world. When these walls of water hit the Wallula Gap, a narrows in the Columbia River downstream from the mouth of the Walla Walla River, water backed up and formed lakes in adjacent valleys and lowlands. In the Walla Walla Valley, the water deposited fine-grained slackwater sediments created by the grinding layers of glacial ice that spread as far south as the current city of Spokane, Washington. These sediment depositions have been moved by wind (commonly called loess) and now cover the Palouse region of Washington and Idaho in rolling hills of deep loess soils. Geologists have recorded layers of volcanic deposits from eruptions of Mt. St. Helens interspersed between the layers of loess. The loess in the region is young from a geologic standpoint and quite rich in minerals. This mineral-rich deposit of loess, interspersed with volcanic ash, has led to the region becoming a highly productive agricultural region.

<u>Blue Mountains Section</u> – John Day Fossil Beds NM, Nez Perce NHP

The John Day Fossil Beds lie along the western edge of the Blue Mountains and share characteristics of both the Blue Mountains and the southern Columbia Plateau. Much of the Blue Mountains and Wallowa Mountains of northeastern Oregon and southeastern Washington are made of ancient accreted terrains that were smashed into the North American continental plate during eons of continental drift. During the Cretaceous Period, the Pacific Ocean extended east into central Oregon and deposited marine sediments. Subsequent subduction-related volcanism during the Eocene and Oligocene are largely responsible for the rich fossil resources in the region. These fossils record a much wetter and warmer climate that existed prior to the rise of the Cascade Range. Columbia flood basalts covered much of the region approximately 15 million years ago, and more recent volcanism, faulting, and water driven erosion have created a rugged modern-day landscape of deep rocky canyons, rimrock lined plateaus, and deeply eroded hills and gullies of pyroclastic sedimantary rocks and volcanic ash-derived clay soils. The plateaus along the lower reaches of the John Day Valley near the Columbia River were formed from the loess exposed by the Missoula Floods during the Pleistocene Epoch. Further south in the vicinity of JODA, Pleistocene influences are much less evident, and in this way the region differs considerably from the Walla Walla Plateau to the north. Mountain glaciers have been important further east in the Wallowa and Blue Mountains, carving out deep valleys, including the Wallowa Valley, the ancestral homeland of the Nez Perce and the burial site of Chief Joseph, an important part of NEPE.

<u>Northern Rocky Mountains</u> – Big Hole NB, Lake Roosevelt NRA

The Rocky Mountains took shape during a period of intense plate tectonic activity that formed much of the rugged landscape of the western United States. Three major mountain-building episodes reshaped the west from about 170 to 40 million years ago (Jurassic to Tertiary Periods). The last mountain building event, the Laramide orogeny, (about 70-40 million years ago) the last of the three episodes, is responsible for raising the Rocky Mountains.

During the last half of the Mesozoic Era, the Age of the Dinosaurs, much of today's California, Oregon, and Washington were added to North America. Western North America suffered the effects of repeated collision as slabs of ocean crust sank beneath the continental edge. Slivers of continental crust, carried along by subducting ocean plates, were swept into the subduction zone and scraped onto North America's edge. About 200-300 miles inland, magma generated above the subducting slab rose into the North American continental crust. Great arc-shaped volcanic mountain ranges grew as lava and ash spewed out of dozens of individual volcanoes. Beneath the surface, great masses of molten rock were injected and hardened in place.

For 100 million years the effects of plate collisions were focused very near the edge of the North American plate boundary, far to the west of the Rocky Mountain region. It was not until 70 million years ago that these effects began to reach the Rockies. The growth of the Rocky Mountains has been one of the most perplexing of geologic puzzles. Normally, mountain building is focused between 200 to 400 miles inland from a subduction zone boundary, yet the Rockies are hundreds of miles farther inland. Although geologists continue to gather evidence to explain the rise of the Rockies, an unusual subducting slab is believed to have largely driven the Laramide orogeny. At a "typical" subduction zone, an oceanic plate sinks at a fairly high angle. A volcanic arc grows above the subducting plate. During the growth of the Rocky Mountains, the angle of the subducting plate may have been significantly flattened, moving the focus of melting and mountain building much farther inland than is normally expected.

It is postulated that the shallow angle of the subducting plate greatly increased the friction and other interactions with the thick continental mass above it. Tremendous thrusts piled sheets of crust on top of each other, building the extraordinarily broad, high Rocky Mountain range

Both the Big Hole Valley and the Okanagan Highlands of upper Lake Roosevelt have experienced extensive reshaping from Pleistocene glaciation. Beginning about 2.5 million years ago and lasting until about 10,000 years ago, lobes of continental and cordilleran ice sheets ground across the Northern Rockies and the northern edge of the Columbia Plateau. The Big Hole Valley itself is a broad "U"-shaped valley carved by glaciers and the Okanagan Highlands were repeatedly smoothed over from periodic glacier movements.

E. Soils

UCBN parks contain hundreds of soils that very widely in their age and parent material, occur across a range of climatic conditions and topography, and support a wide variety of vegetation types. This variation results in a broad range of productivity. Soils descriptions are grouped by the province in which a park occurs. The accompanying descriptions are from the ICBEMP (Quigley and Arbelbide 1997).

LARO

Province M333 Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow—Province M333 occurs in northeastern Washington, northern Idaho, and northwestern Montana. It is mountainous with elevations that range from approximately 370 to 3,000 meters. This area has a maritime-like climate, except in the east where a continental climate prevails. The average annual precipitation varies from about 400 to 2,500 millimeters. The dominant vegetation types are cedar hemlock pine, western white pine, and Douglas-fir forests. Volcanic ash covers most of the area. Soil productivity of Province M333 is generally good because of the volcanic ash soils (Geist and Cochran 1991) and the presence of favorable temperatures and precipitation (maritime climate and low-to-moderate elevations). The most productive areas are the low- to mid-elevation sites where neither temperature nor moisture are considered limiting. The least productive soils occur west of the Columbia River and are shallow and stony, and lack volcanic ash. Northern Rocky Mountain forests have generally low susceptibility to surface fuel accumulations because of their long fire cycles and relatively high productivity. Fuel accumulations remain close to historical norms. These systems are also more capable of replacing soil organic matter, coarse woody debris (larger than 10 cm in diameter), and nitrogen losses than lower productivity systems. In most cases, these forests can be considered moderately buffered against soil damage and in relatively good condition. However, where western white pine mortality from blister rust has been high and large amounts of dead material have accumulated, these fuels can represent a substantial risk for causing soil damage if the site were to burn when fuels are dry.

BIHO, NEPE

Province M332 Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province—Province M332 occurs in central Idaho, westcentral and southwestern Montana, and northeastern Oregon. Elevations generally range from approximately 300 to 3,700 meters. This province includes mountains with narrow valleys, basins, alpine meadows, and breaklands. Most of the higher elevations have been glaciated. Maritime climate, westerly winds, and orographic precipitation yields less than 500 millimeters at the lowest elevations to over 750 millimeters in mountainous areas. Vegetation is dominated by Douglas-fir, ponderosa pine, grand fir, sagebrush steppe, and fescue/wheatgrass grassland. The soils of Province M332 are only moderately productive because of their shallow depths associated with mountain locations, cold temperatures, and low precipitation in some areas. The most productive soils occur in valleys and basins where they are often deep, have high volcanic ash content, and receive higher precipitation. Heavy fuel accumulations and dense stand conditions in some areas place long- and short-term soil productivity potential at risk from wildfire. In contrast, where high fuel and/or dense stand conditions are absent, the risk of potential damage to soils from wildfire is minimal. Where heavy fuels exist (especially on the most sensitive soils), future soil conditions are likely to degrade when wildfires do occur.

CIRO, CRMO, HAFO, MIIN, NEPE, JODA, WHMI

Province 342 Intermountain Semi-Desert—Province 342 consists of plains, tablelands, and plateaus in central Washington, southcentral andsoutheastern Oregon, and southern Idaho. Elevations range from approximately 60 to 2,400 meters. This area has a semi-arid, cool climate. Average annual precipitation varies from about 100 to 625 millimeters. Dominant vegetation types are sagebrush steppe and grassland. Low productivity soils are common in Province 342 because of the sparse precipitation and low soil organic matter levels that occur throughout much of the province. Even though moisture is the most limiting factor for these soils, organic matter and nitrogen values are also generally limiting. Organic matter amounts vary with moisture throughout the province. Riparian/wetland areas and high elevation forested and grass/shrub sites have the highest organic matter; the young lava flows, sand dunes, and saline-sodic soils have the least organic matter. In addition, extensive fires in some parts of the province have reduced organic matter and nitrogen contents to critical levels. This situation has often resulted in the expansion of cheatgrass monocultures, which are susceptible to repeated burn cycles that further degrade soil productivity. Although most forests in this area produce low amounts of fuels, high fuel accumulations that contribute to hot fires can occur on more productive sites.

F. Vegetation

Shrub-steppe habitat is the most extensive vegetation type in the Upper Columbia Basin Network parks. However, forested vegetation is also widespread, especially in the northern portion of the network. Forest types present in the Network include ponderosa pine forest, pinyon-juniper woodlands, lodgepole pine forest, isolated stands of douglas-fir, and limber pine woodland. Small amounts of wetland and riparian vegetation are also present in most UCBN parks. Figure 11 provides an illustration of the regional vegetation cover types. Table 9 lists the percentages of land cover types found in each UCBN park.

Figure 11. Land Cover in the UCBN.

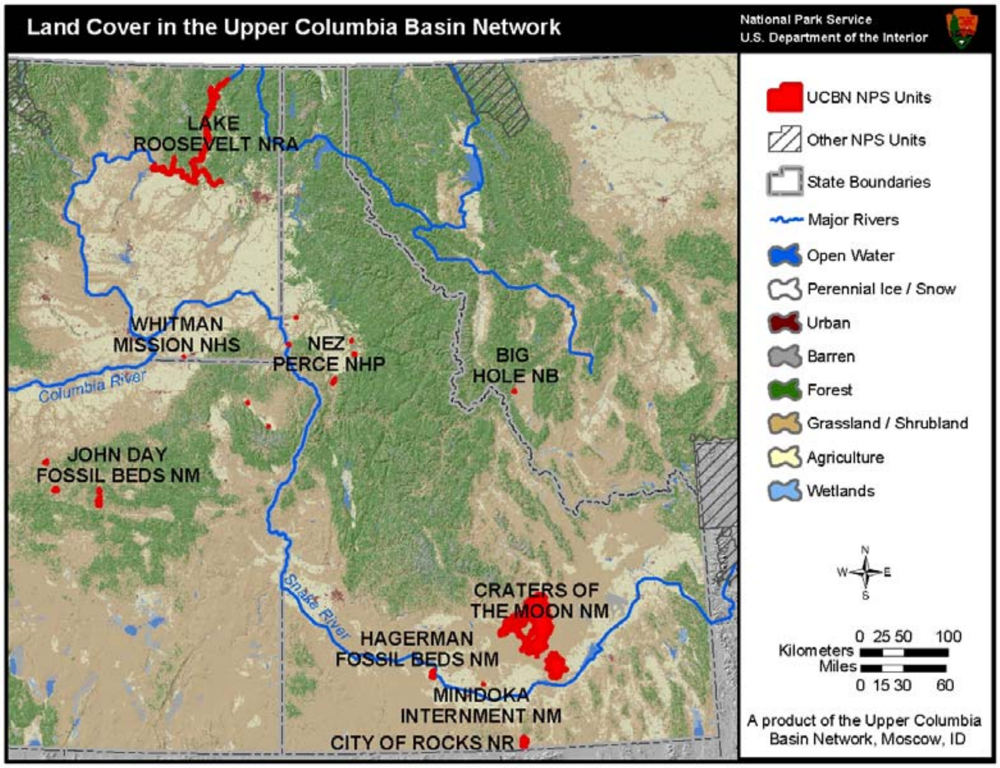


Table 9. Percentage of UCBN park area in each land cover type as determined with the National Land Cover Dataset and the National Park Service digital park unit layer (NPS boundary)

LandCover	BIHO	CIRO	CRMO	HAFO	JODA	LARO	MIIN	NEPE	WHMI
Open Water	0.93%			0.63%	0.45%	74.96%		0.52%	6.28%
Urban			0.05%			1.03%		0.26%	
Bare Rock/Sand/Clay			81.00%	0.33%	1.04%	0.47%			
Transitional	18.35%					0.36%		4.00%	0.47%
Deciduous Forest	0.10%	0.32%			0.01%	0.09%		3.74%	2.33%
Evergreen Forest	22.58%	3.46%		0.18%	20.84%	11.26%		7.14%	
Mixed Forest						0.37%		0.04%	
Shrubland	2.93%	70.90%	18.11%	53.11%	68.02%	5.50%	45.43%	16.50%	3.26%
Orchards/Vineyards/Other						0.14%			4.65%
Grasslands/Herbaceous	32.08%	22.63%	0.76%	40.91%	4.96%	4.31%	28.61%	51.34%	83.02%
Agriculture		2.58%	0.06%	4.65%	4.65%	1.46%	25.66%	16.28%	
Woody Wetlands	20.92%	0.11%	0.01%	0.18%		0.02%	0.29%	0.14%	
Emergent Herbaceous Wetlands	2.10%				0.03%	0.04%		0.03%	

Shrub-Steppe

Shrub-steppe habitat is found to some extent in all 9 network parks. The majority of shrubland habitat presented in Table 9 is shrub-steppe. Characteristic and dominant shrubs in the shrub-steppe vegetation type include several species of *Artemisia* sagebrush, at least three subspecies of *Artemisia tridentata* sagebrush, antelope bitterbrush, and 2 species of rabbitbrush. Each of these species may occur as ecological dominants in a monoculture-type condition, or may occur within a more complex heterogeneous shrub seral condition. Rabbitbrush, especially gray rabbitbrush, is associated with heavily disturbed areas.

A variety of native perennial and introduced annual grasses occur in association with sagebrush shrub species. Depending upon disturbance history, extensive stands of grasses can occur without a shrub component. Dominant grasses in the sagebrush-steppe of the UCBN include bluebunch wheatgrass, Idaho fescue, and Thurber's needlegrass. Sandberg or native bluegrass is often present in between caespitose clumps of the dominant bunchgrasses and basin wildrye often occurs in moist swales and drainages or along roadside ditches. Cheatgrass and other introduced invasive annual grasses are present, and frequently dominant, in many UCBN shrub-steppe habitats today. Ephemeral forb cover in shrub-steppe habitat is highly variable depending on annual precipitation, disturbance history, and other ecological factors. Forbs are always more present in the UCBN during years with average or above average precipitation. Trees may be present in some shrub-steppe habitats, usually as isolated individuals from adjacent forest or woodland habitats. For more information on shrub-steppe habitat descriptions, see the following link: http://www.nwhi.org/ibis/queries/wildhabs/WHDF_H16.asp.

Alteration of fire regimes, fragmentation, livestock grazing, and the addition of numerous exotic plant species have changed the character of shrub-steppe habitat in the UCBN. Overall this habitat has seen an increase in the diversity and abundance of exotic plants and a decrease in native bunchgrasses. More than half of the Pacific Northwest shrub-steppe habitat community types listed in the National Vegetation Classification are considered imperiled or critically imperiled (Anderson et al. 1998). A number of unique and rare forbs are found within sagebrush-steppe habitats in the UCBN and a number are listed as state species of concern, including the picabo milkvetch and obscurre phacelia at CRMO.

Historically, sagebrush dominated shrub-steppe in the Columbia Basin experienced infrequent fires at intervals of 25 years or more (Barrett et al. 1997). Steppe vegetation in the region evolved in the absence of native grazers (i.e. bison), exacerbating the effects of domestic livestock introduction in the late 1800's (Bureau of Land Management 2002). Historic grazing and the introduction of invasive annual grasses has led to accelerated fire return intervals in many parts of the Columbia Basin, particularly in the Snake River Plain (Barrett et al. 1997, West and Young 2000, Wagner et al. 2003). Unlike the "hot" deserts of the southwestern U.S., in which a rich flora of native annuals coexists with the perennials, native annuals are extremely scarce or absent throughout much of the Great Basin and Columbia Basin (West and Young 2000, Wagner et al. 2003). Cheatgrass is one of the most widely distributed of the exotic annuals, currently estimated to dominate 20% of the intermountain shrub-steppe and it's introduction has led to significant changes in UCBN ecosystem structure and function (Mack and D'Antonio 1998, Wisdom et al. 2000, Keane et al. 2002).

Coniferous Forest and Woodland

Ponderosa pine forest only occurs in two of the northernmost parks of the UCBN, although it is widespread in the mesic foothills and montane environments surrounding many of the UCBN parks. Ponderosa pine occurs throughout the northern half of LARO and covers approximately 7% of NEPE (Table 9). Scattered ponderosa pines occur around the margins of the lodgepole pine forest at BIHO and several large ponderosa pines are found in isolated draws in the Sheep Rock Unit of JODA. As in shrub-steppe, fire plays an important role in creating and maintaining the vegetation structure and composition in this habitat. The fire regime most often associated with ponderosa pine systems is the high-frequency/low intensity type described by Agee (1993) and Barrett et al. (1997) although this may not have been as widespread as was once believed (i.e. Baker and Ehle 2001). This fire regime is believed to have maintained ponderosa pine forests in open stands with single-layer canopies and shrub and grass understories (Hessburg and Agee 2003, Long 2003). Timber harvest, heavy livestock grazing, and fire suppression have led to widespread changes in the structure and composition of these forests (Long 2003). In the UCBN, the changes to ponderosa pine forest are most evident in LARO where the vegetation type is widespread in the northern portion of the park. Here, relatively dense stands of young pine occur with sparsely vegetated understories of antelope bitterbrush and other shrubs.

Juniper woodlands occur at JODA, CRMO, and are also present together with pinyon pine at CIRO (see table 9). The vegetation type takes different forms in each of the three parks, occurring in widely scattered savannah-like woodlands in CRMO and parts of JODA, and in dense stands in CIRO and JODA. Pinyon-juniper woodlands often occur with shrub and grass understories. In JODA, many juniper stands have a dense understory of cheatgrass and other invasive annual grasses, including medusahead. Fire suppression, overgrazing, and climate changes are all factors that have apparently led to dramatic expansion of juniper out of fire protected draws and rimrock on to deeper soiled portions of sagebrush-steppe in much of the Columbia Basin (Miller and Rose 1999, Baker and Shinneman 2004, Soulé et al. 2004). This is evident at JODA and presents an ongoing management problem there. Juniper expansion is less evident at CIRO and CRMO and the vegetation type in these parks may more closely resemble historic conditions (Rust and Coulter 2000). Concerns of allelopathy have been raised for western juniper, which often does occur in monoculture-like conditions in some parts of the UCBN (Bureau of Land Management 2002). Efforts to control juniper expansion with fire and mechanical removal have become problematic because of post-treatment vulnerability to weed invasion (D'Antonio 2000). In spite of these concerns over expansion, pinyon-juniper and juniper woodlands provide important habitat for many species of vertebrates and invertebrates in the UCBN. Recent discovery of an outbreak of the pinyon *Ips* beetle at CIRO has presented a new and emerging threat to the pinyon-juniper vegetation there and will require close monitoring in order to determine an effective management strategy.

Lodgepole pine forest covers approximately 22% of the western portion of BIHO and is contiguous with extensive lodgepole and mixed conifer forest in the surrounding mountains of the Beaverhead National Forest. Also a fire-prone forest system, lodgepole forests are believed to have evolved within a high frequency/high intensity fire regime (Agee 1993). The serotinous seed cones of lodgepole pine illustrate this evolutionary relationship. Lodgepole pine seedlings have sprouted in much of the adjacent non-forested portions of the battlefield, and forest succession presents a significant management issue for the cultural landscape of the battlefield. The fire regime of lodgepole pine also implies a difficult and complex management dilemma for the battlefield, as a stand-clearing fire would dramatically alter the battlefield landscape.

Other coniferous vegetation in the UCBN include limber pine at CIRO and CRMO, and small pockets of Douglas fir, western larch, lodgepole pine, and small amounts of subalpine fir in CIRO, CRMO, BIHO and LARO. While these tree species are limited in distribution within the UCBN, they occur widely throughout mesic and montane regions of the Columbia Basin, and have important habitat value for the parks in which they occur. Limber pine occurs on Graham Peak in CIRO but is most significant at CRMO, where it occurs in many, isolated small stands in the northern portion of the monument. This species is considered a pleistocene relict by some investigators but this is not entirely clear (Schuster et al. 1995). Limber pine forms rather monotypic stands along the rocky exposed volcanic flats and north-facing slopes of cinder cones in CRMO. The patchy distribution of limber pine is reflective of its physiological requirements but also because its seeds are primarily dispersed by Clarks's nutcrackers, red squirrels, and other vertebrates (Schuster et al. 1995). Douglas fir occurs in wetter portions of LARO in mixed stands with western larch and ponderosa pine. It also occurs in small pockets along drainages in the extreme northern edge of CRMO, and it co-occurs with lodgepole pine at BIHO. Subalpine fir is present on top of Graham Peak at CIRO. Western larch is a unique component of the landscape at LARO and a species of concern due to its decline throughout the region (Hessburg et al. 2000).

Deciduous Forest and Woodlands

Aspen groves occur in isolated stands in CIRO, CRMO, BIHO, and LARO. These woodlands provide important habitat values and support cavity nesting birds and other vertebrates that would not remain in the parks in the absence of aspen (e.g. Lawler and Edwards 2002, Griffis-Kyle and Beier 2003, Parsons et al 2003). Aspen is a particularly important resource for cavity nesting birds and bats because of the structural characteristics that form in mature stands (Parsons et al. 2003). Marked declines in aspen have been noted throughout the intermountain west and have been the subject of much debate (Peet 2000). Fire suppression has been identified as the most widespread proximal factor, but elk browsing and domestic cattle grazing has also been recognized (Rogers 2002, Larsen and Ripple 2003). The status of aspen in the UCBN is not known, although regenerating suckers are present in many of the stands in CIRO and CRMO.

Other deciduous vegetation types include the cottonwood and willow galleries found along riparian areas in WHMI, NEPE, BIHO, and HAFO. At JODA, a unique wooded riparian habitat occurs along Rock Creek that consists of mountain alder. Throughout the region, these riparian woodlands have declined due to grazing, altered hydrology and stream morphology, and other anthropogenic causes (USDA Forest Service 1996, Quigley and Arbelbide 1997). These ecosystems are typically not subject to fire disturbance but have evolved within the context of floods and exhibit dispersal mechanisms and other characteristics well adapted to this type of disturbance (Knopf et al. 1988, Naiman et al. 2000). Typical of riparian areas in semi-arid biomes, the riparian woodlands of the network provide extremely valuable habitat for many species of vertebrates and invertebrates (Knopf et al. 1988, Knopf and Samson 1994). They also provide important ecological services, including flood control and bank stability (Knopf et al. 1988). Exotic deciduous woodlands, dominated by Russian olive, occur along riparian areas in HAFO and scattered Russian olive trees occur along Bridge Creek in the Painted Hills unit of JODA. While these invasives are generally considered undesirable and are subject to mechanical removal efforts at JODA, they do provide ecological value as well, including bank stabilization and wildlife cover.

Herbaceous Wetlands

Herbaceous wetland environments in UCBN parks make up a small percentage of land cover (see table 9) but are disproportionately important to biological diversity and ecological processes such as water retention and nutrient cycling (Gregory et al. 1991, Kauffman et al. 1997). Small seeps and springs are present in several UCBN parks, including JODA, CIRO, CRMO, and HAFO. A significant proportion of BIHO consists of riparian wetlands along the North Fork Big Hole River dominated by woody species such as willows, but extensive herbaceous wetland vegetation is present there as well. Herbaceous wetland vegetation is also present along riparian areas at NEPE, WHMI, JODA, LARO, and HAFO. No wetlands are present at MIIN. Herbaceous wetland vegetation in the UCBN ranges from small mossy areas in seep environments to extensive stands of sedges and rushes in seasonally inundated areas. In the UCBN, semi-arid climatic conditions prevail and transitions between wetland/riparian and upland areas are abrupt. Woody vegetation, usually willows, cottonwoods, and shrubs, delineate these areas. Sedges, rushes, and other herbaceous emergents dominate seasonally inundated areas within woody borders. American bulrush and various species of spike-rush and sedges are the most common species that occur in these conditions. The larger hardstem and softstem bulrushes also occur in several isolated wetlands in JODA and CRMO. The meander courses of the Big Hole River at BIHO provide for extensive stands of sedge-covered flood plains. Extensive stands of the introduced invasive grass, canary reed-grass, occur in many wetlands in the UCBN. Canary reed-grass is particularly abundant along the seasonally flooded portions of Lake Roosevelt, including the Kettle River arm of the lake, along Doan Creek in WHMI, along the

John Day River in the Sheep Rock unit of JODA, and along the Snake River in HAFO. Canary reed-grass often forms dense monocultures that outcompete native vegetation and negatively affects riparian biodiversity. Canary reed-grass is not yet present in the Weippe Prairie site of NEPE nor along the Big Hole River in BIHO. Monitoring of these sites will be important for early detection and protection of these unique wetland sites.

Grassland

Grasslands in the UCBN primarily occur in conjunction with sagebrush-steppe. Grassland cover percentages in table 9 include areas of cheatgrass and bunchgrass dominated steppe. At HAFO, oldfields of crested wheatgrass occur in portions of the park and large stands of basin wildrye occur along the Snake River. Much of the grassland cover at BIHO consists of Idaho fescue steppe and broad stands of wet sedge meadows along the Big Hole River. In NEPE, highly altered grasslands are dominated by cultivated grasses and, in the case of White Bird Battlefield, converted shrub-steppe dominated by a variety of introduced annual and perennial grasses. WHMI contains the largest percentage of grassland in the UCBN, but the actual acreage represented by this is actually quite small (< 80 acres). The Walla Walla Valley was formerly dominated by Palouse prairie and the Cayuse name for the Whitman Mission site, “Waiilatpu”, has been translated to mean the “people of the rye grass”. The site today consists of areas of restored basin wild rye and perennial bunchgrass as well as extensive stands of canary reed-grass and other invasive species.

Agriculture

Various agricultural and livestock raising activities occur within and/or adjacent to all UCBN parks. Agricultural vegetation in the UCBN differs radically from adjacent native vegetation in structure and function. Vegetable crops are grown adjacent to HAFO, MIIN, and WHMI, and hay and alfalfa are grown within and around JODA, CIRO, NEPE, and portions of CRMO, BIHO, and LARO. Several UCBN parks are nearly surrounded by highly fragmented agricultural lands and they exist as islands of much more stucturally complex vegetation. This is particularly evident at WHMI and HAFO, and fragmentation and connectivity issues will continue to be of concern throughout the UCBN in the future.

G. Fauna

Vertebrates

Vertebrate communities associated with upper Columbia Basin habitats are well represented in UCBN parks. The fauna present in UCBN parks vary widely from site to site due to presence or absence of refugia, type of vegetation communities, and the presence or absence of water. Over 300 terrestrial vertebrate species were identified during the 2000-2003 inventories in the UCBN, including 24 species of reptiles and amphibians, 76 species of mammals, and over 200 species of birds. Current estimates, based on existing information, indicate that approximately 15-20 species of fish are also present in network waters. The bald eagle, bull trout, and middle Columbia ESU summer steelhead are the only confirmed vertebrates species listed as threatened or endangered in the UCBN (see Appendix J). However, there are many vertebrates listed as state and federal species of concern that occur in the UCBN, and many are unique to the semi-arid habitats of the upper Columbia Basin. This list includes unique species such as the greater sage grouse, pygmy rabbit, spotted bat, Columbia spotted frog, and western toad.

As is typically demonstrated by species-area curves, vertebrate richness is highest in the large UCBN parks like CRMO and JODA, but unique habitats, such as the Mill Pond at WHMI and the open water at LARO, attract large numbers of migratory birds. Species richness by park varies most for amphibians and reptiles (Table 10). Amphibian populations may fluctuate widely over time and trends can be difficult to determine. Distribution and abundance of many amphibian species are more closely associated with specific substrates such as downed wood rather than vegetative cover. Also, most amphibian species require water which is scarce in the southern Network parks.

Exotic species, such as bullfrogs, have eliminated amphibian species from some locations in network parks. Examples of this impact are evident at JODA, WHMI, and NEPE.

Table 10. Species Richness by taxon for network parks.

Park	Amphibians	Birds	Mammals	Reptiles
BIHO	2	83 (excluding winter)	31 (excluding bats)	2
CIRO	1	157	35	8
CRMO	4	206	45	10
HAFO	4	153	34	10
JODA	5	155	46	12
LARO	6	182	41	10
MIIN	NA	NA	NA	NA
NEPE	4	84 (excluding winter)	28 (excluding bats)	7
WHMI	3	202	27	5

The effect of livestock grazing or pesticide use on amphibians has not been studied in network parks. Some species of amphibians are known to be intolerant of these impacts. Irrigation is a use that is present in several network parks and it can be beneficial or detrimental, depending on local topography and seasonality of water level fluctuations. Irrigation can provide adequate habitat for egg laying or larval development, but if water is shut off to these areas prior to hatching or metamorphosis, reproduction is lost.

Reptiles in the UCBN are similar to amphibians in that they are not particularly associated with vegetation types. Reptiles require particular topographic conditions, such as a specific slope and aspect, and some species are associated with rock or particular ground cover conditions.

Some reptile species, currently listed as species of concern for network parks (Appendix J), may be associated with substrates or environmental characteristics that are not well distributed in the network. One example is the common garter snake which is widespread in distribution, but appears to be declining in parts of the network, including southeast Idaho (Chuck Peterson, Idaho State University, personal communication).

Disturbance, land use practices, and invasion by exotic vegetation has altered the composition of sagebrush communities or led to extensive fragmentation and loss. The resulting changes in the structure and distribution of vegetation communities have influenced the distribution and abundance of many bird species. Species associated with native grasslands and shrublands, such as sage grouse, have declined dramatically (Paige and Ritter 1999). Sage grouse were historically present at JODA and in the southern portion of LARO, but the species is absent from these parks today (Sharp 1985, Hays et al. 1998). Birds breeding in sagebrush landscapes have been faced with radical and rapid changes in their habitats. Populations of shrubland and grassland birds have had the greatest rates of decline of any groups of birds (US Geological Survey 2002). Loss of reptile diversity may also be associated with the cheatgrass-dominated ground cover in sagebrush-steppe ecosystems. (Alan St. John, herpetologist, personal communication). Similar concern for vertebrate biodiversity have been noted in forested and riparian ecosystems as well (Wisdom et al. 2000). Region-wide changes in the structure and composition of forests have resulted in loss of nesting and roosting substrate for birds and bats (Pierson 1998, Hessburg et al. 2000). Availability of snags and downed wood at the landscape scale is of particular concern for LARO. Loss of riparian and wetlands in the upper Columbia Basin also threaten waterbirds, and the UCBN provides critical habitat for breeding, wintering, and migrating waterbirds (O'Connell 2000). In particular, Lake Roosevelt, the Mill Pond at WHMI, the John Day River at JODA, and the Snake River at HAFO are regularly used by large numbers of wintering and migrating waterfowl.

Range extensions or contractions for some species of vertebrates may be occurring in response to climate changes, climate-induced habitat changes, or other factors (Wagner et al. 2003). Some species of mammals found in the network, especially at CIRO, HAFO, and JODA, are at the northern limit of their range. During 2003 inventory work, the piñon mouse was confirmed in CIRO for the first time since an unvouchered report was made in 1967 (Larrison 1981). City of Rocks is at the northern limit of the range for this unique species. The species was also confirmed for the first time in the Clarno Unit of JODA, and represents the northernmost record for the species in the state of Oregon (Verts and Carraway 1998). In March of 2003, a ringtail was found dead in the Castle Rocks area of the Reserve by Idaho Department of Fish and Game personnel. This was the first record of the species in Idaho and also represents a significant northward range extension. A second dead ringtail was found in the Castle Rocks area in 2004 (Chuck Harris, Idaho Dept. of Fish and Game, personal communication). A similar northward range extension is also occurring for the northern mockingbird in JODA. Nesting mockingbirds in the Clarno Unit of JODA in 2002 represented the northernmost nesting record for that species in Oregon. Relict species at risk of range contractions include the pika at CRMO and the western whiptail at JODA.

Bats have emerged as a vertebrate order of interest in the UCBN because of the high proportion of mammalian diversity represented and because so many bat species are listed by state and federal authorities as species of concern. Although the conservation biology of bats in the Columbia Basin is not well developed (i.e. Marcot 1996), significant information has become available to the UCBN in recent years. Work done by Keller (1995, 1996, 1997) in CRMO and more recently by the UCBN through inventories and additional research (i.e. Rodhouse et al. in press) has demonstrated that several UCBN parks, especially JODA, CRMO, CIRO, and LARO are important centers of bat diversity and bat reproductive activity. In particular, maternity colonies of species such as the Townsend's big-eared bat and the pallid bat, both colonial roosting species sensitive to human disturbance, are concentrated in CRMO and JODA. These and other rock roosting species are likely concentrated at CIRO as well. The potential shortage of snags at LARO is a cause for concern because of the importance of snags as roosts for species like the silver-haired bat and the long-legged myotis.

UCBN parks provide important habitat for both breeding and wintering raptors. CRMO is particularly important, because of its size, for breeding and wintering buteo hawks, especially the ferruginous hawk, Swainson's hawk, and rough-legged hawk. Cooper's and sharp-shinned hawks regularly breed in the aspen and fir stands along the northern edge of the monument as well (Michael Munts, CRMO, personal communication). JODA has also been shown to be an important location for both breeding and wintering raptors. A survey of breeding raptors was conducted in 1977 (Janes unpublished) and the survey was repeated during inventory work in 2002 and 2003. Eight species of raptors, including four species of owls, were confirmed breeding in the monument in 2002 and 2003. The peregrine falcon was not confirmed breeding but sightings of adults were seen near the Cathedral Rock portion of the Sheep Rock Unit in 2002 and 2003, suggesting that a breeding pair may have become established on or near the monument. This would represent the first breeding pair to return to the lower John Day Valley since the era of DDT poisoning during the mid-20th century. Lake Roosevelt also provides important breeding habitat for peregrine falcons, bald eagles, and osprey.

While large carnivores do occur in several UCBN parks, large carnivores are not a focus of monitoring planning for UCBN parks because of the wide-ranging nature of these species. None of the network parks have been identified as having large, contiguous blocks of land that would serve as conservation areas for these species, although this may change in the future as fragmentation and land use change increases. UCBN parks are potentially important components of individual carnivore home ranges, and this will likely become more so as fragmentation and habitat loss increases on surrounding lands. Gray wolves occur in the Beaverhead Mountains adjacent to the Big Hole Valley and periodically range down along the North Fork Big Hole River through the battlefield. Gray wolves may also be ranging into the northern portion of CRMO, although this has not yet been confirmed. Wolves are also expected to colonize northeastern Oregon from Idaho during the next few years and JODA and the surrounding matrix of public and tribal land may become occupied by wolves in the future. Mountain lions occur in a number of parks, as do bobcat. Black bear are occasionally seen along the wooded margins and campgrounds of Lake Roosevelt.

<u>Invertebrates</u>

Very little is known about the invertebrate communities in UCBN parks. Lepidoptera and aquatic macroinvertebrate surveys were conducted in JODA in 2003 and 2004. Fifty-five species of butterflies and over 100 species of moths have been confirmed in JODA to date, including several rare species. Results from the macroinvertebrate survey are not yet available. The blind cave leiodid beetle, an Idaho state species of concern occurs in lava tubes of CRMO and two other species of concern, the Idaho pointheaded grasshopper and the Idaho dunes tiger beetle, likely occur in the park as well. Freshwater mollusks have not yet been inventoried in the UCBN but many species likely occur in streams and rivers throughout the network. As many as five species of state and federal mollusk species of concern may occur in the reach of the Snake River adjacent to HAFO, including the desert valvata, and the endemic snake river physa and Bliss Rapids snail (Hovingh 2004). Numerous endemic mollusk species occur throughout the intermountain west and many have shown population declines and reduced distributions over the last 100 years (Hovingh 2004). An invasive non-native mollusk, the New Zealand Mudsnail, occurs in Lake Wolcott, 70 miles upstream from HAFO and poses a serious threat to native mollusks in the Snake River.

Although invertebrates are often overlooked in ecosystem management and planning efforts (i.e. FEMAT 1993, Niwa et al. 2001), the UCBN recognizes the importance of including invertebrates into long-term monitoring. Invertebrates drive many ecosystem processes, including energy and nutrient cycles, and may be excellent indicators of ecosystem health because of short generation times, high diversity, and, in many cases, tight coupling to ecosystem attributes such as vegetation, soils, water quality, and climate (Niwa 2001, Cummins et al. 2001).

H. Aquatic Resources

Except in the case of LARO, aquatic resources represent a very small percentage of total land cover in UCBN parks (see table 9). However, like riparian and wetland vegetation described above, aquatic environments are disproportionately important in terms of biodiversity, biological productivity, and many other ecosystem functions and values (Richardson 1994, Kauffman et al. 1997). Lotic (flowing water) environments in the UCBN include large rivers, perennial tributary creeks, irrigation ditches, and numerous seasonal and ephemeral streams, springs, and seeps. Lake Roosevelt, a large reservoir in the Columbia River, and Lower Salmon Falls Reservoir in the Snake River adjacent to HAFO, also function as lotic environments because of the large inflow and low retention time of water in these reservoirs. Lentic environments in the UCBN include small lakes and ponds, as well as floodplain and depressional wetlands. Table 11 presents the distribution of aquatic environments in the UCBN.

Table 11. Aquatic Resources of UCBN Parks.

Park	Perennial Rivers/Streams/Creeks (no.)	Intermittent Streams (no.)	Irrigation Ditches (no.)	Ponds (no.)	Reservoirs (no.)	Mapped Springs/Seeps (no.)	Unmapped Springs/ Seeps (no.)
BIHO	1		2				
CIRO	5	numerous				5	1+
CRMO	1			1		9	numerous
HAFO			1		1	1+	numerous
JODA	3	1	2	1		8	6
LARO	6				1		
MIIN							
NEPE	3			1			
WHMI	2		1	1			

The variability in climatic and geologic processes within the upper Columbia Basin has resulted in a complex diversity of aquatic habitats. Aquatic habitat heterogeneity is important to biological diversity in both terrestrial and aquatic environments (Gresswell et al 1994, Schlosser 1991). This is especially true in the semi-arid environment of the upper Columbia Basin, and aquatic environments, including the riparian/wetland vegetation "greenline" zone, provide three-dimensional connectivity between the atmosphere, uplands, and upstream/downstream reaches (Gregory et al. 1991). The maintenance of aquatic habitat complexity is critical for biodiversity within the context of increasing human-driven disturbances. Although climatic and geologic processes cannot be managed, human response to them can be planned, and in some cases, human disturbances might be modified to maintain desired habitat complexity in the context of natural disturbance regimes (Reeves et al. 1995). Within the UCBN, because the regional matrix around most parks are highly altered environments, the aquatic resources within parks will take on increasing importance in the future. Because of the productivity of aquatic environments and the natural disturbance regimes of many aquatic environments, they are also highly resilient to and can be quick to recover from many human-caused stressors (Kauffman et al. 1997). Ironically, though, many of the aquatic environments in the UCBN are degraded and in some stage of recovery from historic stressors such as heavy livestock grazing and upstream industrial and agricultural inputs.

I. Cultural Landscapes

The upper Columbia Basin has a rich and fascinating cultural history. This is the land of a highly diverse human landscape, in which many linguistic and cultural traditions sprang up around the great salmon fisheries, wild root crops, and other natural resources of the region. The Nez Perce (Nee-me-poo), Cayuse, Wasco, Yakima, Paiute, Shoshone, and their ancestors have lived in the region for thousands of years and have made an indelible imprint on the landscape. The Columbia Basin was also a central stage in the inexorable and tragic displacement of Native Americans by pioneering European Americans that occurred throughout the west during the 19th century. Beginning with the first encounter between Lewis and Clark's Corps of Discovery and the Nez Perce at Weippe Prairie in NEPE, this period of cultural schism is also remembered in the landscapes of Whitman Mission, Ft. Spokane at LARO, and the many battlefields of the Nez Perce Trail, where Chief Joseph led his brokenhearted Wallowa Band on a 1300-mile exodus from Oregon to northeastern Montana under pursuit by the U.S. Cavalry. Overlaid upon this historical period has been the formation of modern American cultural landscapes during the 20th century, such as the rural agricultural landscape of the Cant Ranch along the John Day River, the Minidoka Internment Center of World War II, and the creation of Franklin D. Roosevelt Lake behind the Grand Coulee Dam. Today thousands of visitors come to see and recreate in these landscapes, preserved and memorialized in UCBN parks. Nez Perce tribal members hold an annual memorial event at the Big Hole Battlefield, and rock climbers come from around the world to challenge themselves on the unique formations of the City of Rocks.

Cultural landscapes are an important component of the parks of the UCBN. While cultural landscapes represent a relatively small proportion of total land area in the network, they are disproportionately important to park mission and visitor experience. Cultural landscapes in the network include historic sites, historic vernacular landscapes, and ethnographic landscapes. A number of cultural landscapes in the UCBN are formally designated through the regional inventory and assessment process coordinated out of the NPS Pacific West regional office. These include the entire Whitman Mission site, the Ft. Spokane parade grounds, and the geologic feature known as "Heart of the Monster" at NEPE. There are many other cultural landscapes in the network that have not been formally designated, including White Bird Battlefield at NEPE and the California Trail area in CIRO. As the regional inventory and assessment process continues, many of these landscapes, sites, and features will be formally designated in the future.

Cultural landscapes are important to the UCBN monitoring program in a number of ways. First, these landscapes and features are highly influential on park ecosystems. It is in these cultural landscapes where much of the visitation and NPS management is concentrated. These sites tend to be highly altered from surrounding landscapes and therefore affect the structure and function of surrounding ecosystems. These areas may be sources of weed invasion and may support non-native vertebrates, such as bullfrogs, which then impact surrounding areas. They also tend to increase the fragmentation of formerly contiguous landscapes. Cultural landscapes also function as discreet ecosystems in and of themselves and therefore represent an important focus for monitoring. The UCBN monitoring program distinguishes cultural landscapes as distinct systems that exhibit unique and important ecosystem processes and interact with surrounding ecosystems in profoundly important ways. It is within this context that the UCBN seeks to explicitly incorporate cultural landscapes into the vital signs monitoring program.

VI. Natural Resources, Resource Concerns, and Issues of UCBN Parks

The most common thread binding all parks in the network is the fact that they are islands located in areas of highly fragmented and often highly disturbed habitat. Most resource problems arise from the impacts caused by the mosaic of land uses around the parks and the legacy of historic land uses within existing park boundaries. Much less of a concern is the current land use and management activities within parks. The impact of current land use practices adjacent to park boundaries is compounded by the fact that all but one of the parks are small and lack external buffer zones that might mitigate impacts coming from lands external to the parks. The end result is that network parks are constantly beset by invasions of exotic plants and inputs from agricultural practices. They confront water and air quality problems due to agricultural and industrial activities on adjacent lands, and suffer from aesthetic impacts and intrusions, e.g., visual and noise pollution adjacent to the units. Along with these ecological problems, these factors disrupt the cultural setting many of the parks seek to portray. Viewsheds and soundscapes of cultural landscapes in the UCBN are at risk of degradation from outside land use changes.

A. Summary of Key Resources

Resource managers were asked to identify the most important significant natural resources in their parks (Table 12). Cultural landscapes, fossil resources, kipukas (islands of vegetation isolated by lava flows at CRMO), riparian communities, and aquatic resources were identified as being the most significant resources in network parks. Vertebrate and plant species of concern were also identified as most significant, including the Townsend’s big-eared bat and sage grouse at CRMO, water birds at LARO, and sensitive plant communities at JODA. Appendix J lists the UCBN species of concern.

Cultural landscapes are the most significant resource in at least 5 of the 9 network parks. At BIHO, NEPE, and WHMI, the entire acreage contained within the park is considered a cultural landscape. Other parks, such as CIRO and LARO, encompass cultural landscapes that are central to park mission

Fossil resources are the reason that HAFO and JODA were designated as National Park sites. The Smithsonian Horse Quarry at HAFO and the numerous fossil beds of JODA are nationally and internationally significant. These beds include some of the world’s richest fossil deposits from the Eocene, Oligocene, and Pliocene Epochs.

Riparian communities were identified by several parks as being a significant resource. Riparian communities support unique plant and animal species and provide important ecological services. Throughout the network these communities have been substantially altered by historic land use, invasive plants, development, and other impacts.

Table 12. Significant resources and management concerns in UCBN parks.

Park	Significant Resources	Management Concerns
Big Hole National Battlefield (BIHO)	Cultural Landscape	Invasive plants, hydrology
City of Rocks National Reserve (CIRO)	California Trail, Indian Grove, riparian communities	Invasive plants, grazing, rock climbing impacts, dust dispersal and sedimentation, erosion
Craters of the Moon National Monument (CRMO	Kipukas, class I airshed, lava tubes, Sage grouse, Townsend's big-eared bats,	Invasive plants, destruction of geologic features by collectors, illegal off-road vehicle use, regional haze impacts on visibility, development impacts on night sky, and white pine blister rust impacts on limber pine
Hagerman Fossil Beds National Monument (HAFO)	Fossils and the associated stratigraphy	Altered hydrological regimes (high water tables, fluctuating reservoir levels, perched aquifers, irrigation) and wind/water erosion pose the biggest threats to slope stability and fossil resources, invasive plants
John Day Fossil Beds National Monument (JODA)	Fossil beds, Research Natural Areas, riparian vegetation, refugia for sensitive flora	Riparian area vegetation, changes in plant communities due to plant invasions and reintroduction of fire
Lake Roosevelt National Recreation Area (LARO)	Aquatic resources, plant communities, raptors and water birds	Industrial pollution, residential development and invasive weeds pose major threats to the landscape
Minidoka Internment National Monument (MIIN)	Not included in survey	Not included in survey
Nez Perce National Historical Park (NEPE)	Cultural Landscape	Invasive plants
Whitman Mission National Historic Site (WHMI)	Cultural Landscape	Invasive plants are a major concern, as is the quality of irrigation water coming into the park

B. Summary of Key Stressors and Resource Concerns

An essential step in the process of selecting vital signs is the gathering of park specific information on natural resources and the significant management issues and concerns facing those resources. In order to narrow the focus, ensure relevance to network parks, and increase efficiencies in the planning process, priorities must be established among focal resources and resource concerns. Network staff used several sources of information to summarize priority resources, stressors and resource concerns for the network. Park planning documents were reviewed and summarized, resource managers were surveyed about the stressors affecting park resources, and information was compiled by questionnaire concerning threats to water quality.

One of the first efforts carried out by network staff was to review resource management plans and general management plans for each park. Resource management plans (RMP) describe park natural and cultural resources, priority resource concerns, and planned actions for maintaining or restoring resource conditions. Park RMPs, if available, were examined and information on natural resources was extracted and summarized. Resource management plans were preferred over other documents because it was easier to determine important resources, goals, objectives, and issues from them than from documents that were created for related but different purposes. If RMPs were not available, recent general management plans (GMPs), which include environmental impact statements, were examined and information on natural resources extracted and summarized (see Appendix C).

A survey of park resource managers was designed to identify and rank the stressors affecting each of the park's resources. Stressors are defined by NPS as physical, chemical, or biological perturbations to a system that are either foreign to that system or natural to the system but applied at an excessive or deficient level (see glossary). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution. We used a matrix of common stressors and resources developed by the Northern Colorado Plateau Network as a starting point and then asked the resource managers to add stressors or resource groups which were not adequately covered in the existing list. Park responses were consolidated to provide a list of stressors of most concern across the network (Appendix L). The ten stressors receiving the highest ranking for all of the network parks are contained in Table 13. Resource managers were asked to list stressors and give the stressor a score of 0 to 3, with 3 being the highest score for an identified stressor that was highly impacting park resources. Exotic plants had the highest score possible (9 parks x 3 = 27) meaning network parks identified this stressor as having the highest negative impact on park resources. Appendix K lists the noxious weed species of greatest concern to UCBN parks.

The information gained from the review of the RMP/GMP for each park, the stressor survey, and the water quality questionnaire yielded a mass of information about UCBN park resources and resource concerns. This information was compiled into narrative form for each park. The park narratives are succinct summaries of each park's significant natural resources, important resource concerns, purpose for the establishment of the park, and general setting (Appendix F). The narratives were reviewed by park resource management staff for accuracy, and will be used throughout the remainder of the selection process.

Table 13. Stressors, listed in order of priority, for UCBN parks.

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Stressors	**Total Ranking Score**
Exotic Plants	27
Agriculture on Adjacent Lands (Water Diversion, Chemical Use, Livestock etc…)	21
Fire Management Practices (NPS and Adjacent Lands)	19
Other NPS Management (Weed Control, Agriculture, Restoration, Reintroductions, etc…)	19
Other Historic Human Impacts (Sagebrush Removal, Irrigation etc…)	18
NPS Development (Facilities, Trails, Campgrounds, Roads, etc...)	16
Historic Livestock Grazing	16
Visitation/Recreation (Boating, Hiking, Climbing, ORV, etc…)	14
Historic Fire Suppression	14
Landscape Fragmentation	14

Water Quality

Assessments of aquatic resources in the Columbia Basin have shown wide-spread habitat degradation, and have identified habitat degradation as a major factor, along with dams, excessive harvest, and introduced non-native gamefish, in the declining fisheries throughout the basin (National Research Council 1996, Quigley and Arbelbide 1997). Extensive grazing caused removal of willow riparian vegetation in many parts of the region as early as 1860 (Elmore and Kauffman 1994). Floodplain irrigation and agriculture altered hydrology and many river and stream channels were straightened and cleaned of wood and other in-stream structures (Quigley and Arbelbide 1997). Beginning in the early 20th century, large dams were constructed along many rivers and streams in the basin for flood control, irrigation, and electricity, resulting in habitat loss, degradation, and altered hydrology. This legacy of habitat alteration is clearly evident in most UCBN aquatic environments. Lake Roosevelt, the Snake River adjacent to HAFO, the Walla Walla River and Mill Creek at WHMI, the Clearwater River adjacent to NEPE, the North Fork Big Hole River at BIHO, and the John Day River at JODA have all experienced much of the significant habitat loss, degradation, and associated declines in native fish populations that have occurred throughout the Columbia Basin (National Research Council 1996, Quigley and Arbelbide 1997). Water quality impairment in the Columbia Basin is also widespread, primarily as a result of non-point source pollution (Quigley and Arbelbide 1997). Water temperature, turbidity and sedimentation, nutrients, and streamflow alteration have been identified as the most proximal causes of impairment (Quigley and Arbelbide 1997). However, specific cases of point-source discharge of pollutants are also numerous, and Lake Roosevelt itself has high levels of toxic industrial waste buried in sediments that originated upstream.

In 2003, a water quality questionnaire was sent to resource managers in UCBN parks to assess the threats to water quality in their parks. A summary of these threats is shown in Table 14. Information on water resources within the UCBN parks is limited. Funding to complete a thorough water quality monitoring component of the UCBN monitoring plan is forthcoming. HAFO has completed a water resources management plan (Farmer and Riedel 2003) and LARO has completed a water resources scoping report (Riedel 1997). All of the parks, except MIIN, have Level I baseline water quality data reports (“Horizon” reports) completed by NPS Water Resources Division (WRD). Currently, the majority of UCBN parks do not collect water quality monitoring data, although some parks have state DEQ monitoring sites located nearby. There are no designated Outstanding Natural Resource Waters (ONRW) or watersheds of exceptional quality identified in the UCBN.

Table 14. Summary of threats to water resources in the UCBN.

Park	State	Data	Threats to Water Resources
Big Hole National Battlefield (BIHO)	MT	Park data - none Outside sources from 1975	Mining, agriculture, and stormwater runoff
City of Rocks National Reserve (CIRO)	ID	Park – no data since 1985	Ranching and grazing activities; residential development; gas, oil and mining operations; recreational use
Craters of the Moon National Monument (CRMO	ID	1999-2003	Pesticide runoff and drift from agricultural lands, as well as weed management activities along state and county roads
Hagerman Fossil Beds National Monument (HAFO)	ID	2003	Irrigation and agricultural activities, altered subsurface hydrology, upstream agricultural and industrial effluent, altered flow regulation
John Day Fossil Beds National Monument (JODA)	OR	2003	Irrigation withdrawals and confined animal feeding upstream, untreated sewage effluent upstream
Lake Roosevelt National Recreation Area (LARO)	WA	2002-2003	Mining, permitted discharges from waste water treatment plants, residential development (septic tanks), and agriculture (grazing and farming), campsite sewage disposal, upstream industrial discharge, altered flow regulation
Minidoka Internment National Monument (MIIN)	ID	No Data	
Nez Perce National Historical Park (NEPE)	ID	1975-1994	Point and non-point discharge from upstream sources – Dworshak dam, agriculture, logging, grazing, recreation, highway runoff and urbanization
Whitman Mission National Historic Site (WHMI)	WA	2000-2003	Agricultural chemical use, over allocation of irrigation water, private airfield 3 miles upstream

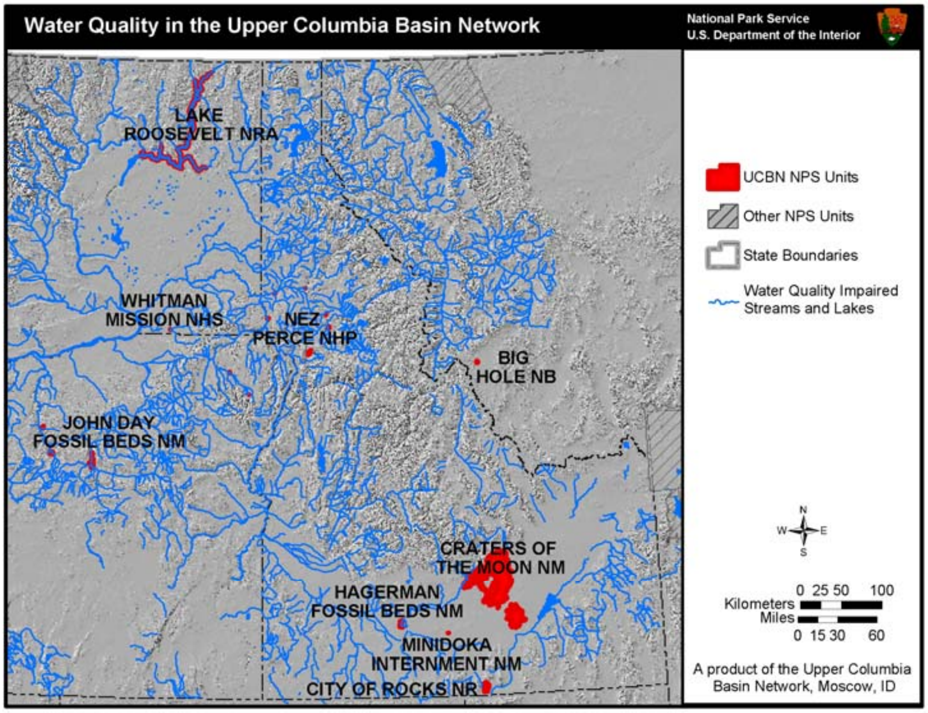
All UCBN waters assessed by state DEQ agencies are on 303(d) lists for impairment of at least one parameter. Table 15 lists the impairments for each UCBN park. Figure 12 shows the 303(d) listed waters for the entire UCBN region. In the case of the North Fork Big Hole River, Montana DEQ identifies agricultural crop related sources for impairment in its 2002 303(d) list (see http://maps2.nris.state.mt.us/wis/TMDLApp/TMDLReport2002). Information for HAFO from both Idaho DEQ and Farmer and Riedel (2003) indicate significant water quality stressors originating from extensive agricultural irrigation. The fossil-bearing bluffs in HAFO have experienced a series of large landslides beginning in 1979 resulting from perched aquifers formed from irrigation to the crop fields above the escarpment. Although pesticides and industrial chemicals are not listed on the 303(d) list for Lower Salmon Falls Reservoir, sturgeon tissue samples collected immediately below the reservoir have shown organochlorine and PCB levels exceeding maximum contaminant levels set by the EPA (Farmer and Riedel 2003). In the case of JODA, Oregon DEQ water quality index reports for the John Day Basin show fair to poor water quality both above and below the monument, one monitoring site near Dayville above the Sheep Rock Unit is showing improving water quality, and one at the confluence of the North

Fork John Day River downstream from Sheep Rock shows declining quality (see http://www.deq.state.or.us/lab/wqm/wqi/johnday/johnday3.htm). Average water quality index scores are poor for the mainstem John Day during summer due to low flow and increased concentrations of fecal coliform, elevated temperature, and reduced dissolved oxygen. In the case of Lake Roosevelt, serious concerns have been raised about the high levels of sediment contamination resulting from over 70 years of industrial discharge originating in Canada. The U.S. EPA is currently studying Lake Roosevelt for possible inclusion on the agencies "Superfund" list (see http://www.lrf.org/Env/Env-Sediment.html). In NEPE, the reach of the Clearwater adjacent to the Spalding Unit of NEPE and Lapwai Creek which flows through Spalding show impacts from upstream agriculture, highway runoff, and other land use practices. The reach of Jim Ford Creek through Weippe Prairie has not been assessed by Idaho DEQ but it has been severely degraded by historic channel straightening and intensive agricultural and grazing activities and water quality is almost certainly impaired there as well. Along Mill Creek and the Walla Walla River at WHMI, temperature, instream flow, and fish habitat are all impaired parameters. Impacts from agriculture throughout the Walla Walla Valley are of concern, and lower reaches of the Walla Walla River downstream of WHMI are on the Washington DEQ 303(d) list for chlordane, benzene, dieldrin, heptachlor, and total PCB's.

Table 15. The current 303(d) listings for waters in the UCBN.

Park	303(d) listed waters	Impairments	List Date
Big Hole National Battlefield (BIHO)	N. Fork Big Hole River	Flow Impairment, Dewatering	2002
City of Rocks National Reserve (CIRO)	No Data		
Craters of the Moon National Monument (CRMO	No Data		
Hagerman Fossil Beds National Monument (HAFO)	Lower Salmon Falls Reservoir (Snake R.)	Dissolved Oxygen (DO), Flow Alteration, Sediment	2000
John Day Fossil Beds National Monument (JODA)	John Day River, Pine Creek, Bridge Creek, Rock Creek	Temperature, Dissolved Oxygen (DO), Fecal Coliform	2002
Lake Roosevelt National Recreation Area (LARO)	Lake Roosevelt, Colville River, Spokane River, Colville River	Sediments, Fecal Coliform, Total PCB's, Mercury, Lead, Zinc, Cadmium, Copper, Dioxin, Arsenic, AROCLOR 1254, DDT, Dieldrin, Total Dissolved Gas	2002
Minidoka Internment National Monument (MIIN)	No Data		
Nez Perce National Historical Park (NEPE)	Lower Clearwater River, Lapwai Creek	Total Dissolved Gas, Nutrients, Bacteria, Dissolved O_2 (DO), Flow Alteration, Habitat Alteration, Sediment, Temperature	2002
Whitman Mission National Historic Site (WHMI)	Mill Creek, Walla Walla River	Temperature, Instream Flow, Fish Habitat	2002

Figure 12. Water quality impaired streams and lakes in the upper Columbia Basin. Data from the ICBEMP (Quigley and Arbelbide 1997).



VII. Summary of Past and Current Monitoring

A. Monitoring in UCBN Parks

The Resource Management Plan and the NPS Natural Resource Inventory and Monitoring Guidelines (NPS-75) guide current monitoring activities at the network parks. Monitoring of "Vital Signs" identified through Vital Signs Scoping Workshops should be complementary to existing monitoring programs already in place in parks in the network.

The lack of personnel to conduct monitoring in combination with the cultural resource focus of UCBN parks has limited the amount of natural resource monitoring currently occurring in network parks. The resource management staff at LARO collects observational data on wintering bald eagles for the USFWS. JODA and LARO have a fire effects monitoring plan that is coordinated and conducted by North Cascades National Park Complex. Groundwater dynamics monitoring is ongoing at HAFO, and WHMI is currently conducting a short-term soundscape monitoring project. Several parks participate in annual breeding bird surveys or Audubon Christmas bird counts but essentially none of the UCBN parks, except Craters of the Moon National Park and Preserve, conduct any formal natural resource monitoring.

We believe that it is important to acknowledge the existing monitoring program at CRMO as we build an integrated network monitoring program. Appendix O contains a current list of ongoing monitoring projects at CRMO. The existing monitoring program at CRMO is focused on air quality, wildlife, and vegetation. Several of the listed projects have a written protocol but none of the protocols have been peer-reviewed.

The lack of past monitoring activities in the network serves to reinforce the importance of the UCBN monitoring program to this group of parks. Natural resource information from which resource managers can base sound decisions upon is virtually non-existent.

B. Regional Monitoring

A wide variety of monitoring efforts have, and continue to, occur in the upper Columbia Basin. These efforts are aimed at numerous natural resources including wildlife, vegetation, air quality, water quality and weather conditions, and many of these efforts may provide opportunities for partnerships with the UCBN. The following list summarizes the primary monitoring activities by adjacent land managers and/or other organizations that have been identified thus far. In addition, numerous GIS and remote sensing data have been developed for UCBN parks and surrounding areas. These data, listed in Appendix P, will be invaluable for planning and conducting future monitoring.

<u>Air and Climate</u>

AirData, US Environmental Protection Agency

The EPA has been monitoring various aspects of air pollution since the 1970s. The AirData web site (epa.gov/air/data) provides access to several of these databases including the Air Quality System, National Emission Inventory, Hazardous Air Pollutants and Criteria Air Pollutants. Within the UCBN, 173 sites monitor the 6 criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, particulate matter and lead), in addition to other variables. Figure 7 shows the location of several EPA air quality monitoring networks in the UCBN region.

Department of Environmental Quality, Department of Ecology

Air quality programs are administered in all 4 states of the UCBN through the Department of Environmental Quality in Idaho, Oregon, and Montana and the Department of Ecology in Washington. The overall goals of these programs are to measure and evaluate levels of pollutants in the air and determine whether air quality is meeting federal and state air quality standards. Figure 7 shows the location of air quality stations in the UCBN.

SNOTEL, Natural Resources Conservation Service

Since 1980, the Natural Resources Conservation Service's SNOTEL data collection network has collected data necessary to produce water supply forecasts throughout the western US. The NRCS installs, operates, and maintains over 600 automated sites that collect a wide variety of snowpack and related climatic data including air temperature, precipitation, snow water content, snow depth, barometric pressure, relative humidity, wind speed and direction, solar radiation, soil moisture and soil temperature. No sites are located in UCBN parks but parks are situated within a network of regional sites and data generated from the network are applicable to UCBN parks.

Western Regional Climate Center, National Oceanic and Atmospheric Administration

The WRCC is one of 6 regional climate centers in the US and partners with the National Climatic Data Center and State Climate Offices to collect and provide current and historic climate data. Precipitation and temperature data in parts of the UCBN date back to at least 1880. Most UCBN parks have long-term climate data sets available through the WRCC collected from weather stations in nearby towns and airports.

Geology and Soils

Idaho National Engineering and Environmental Laboratory

In southeast Idaho, the INEEL supports a Seismic Monitoring Program including 27 seismic stations and 31 strong-motion accelerographs for the purpose of documenting earthquake activity on and around the eastern Snake River Plain. Initiated in 1971, the seismic network is used to acquire information on earthquake sources (such as locations, magnitudes, depths, fault dimensions, faulting style, and stress parameters), crustal structure, rock properties, and attenuation characteristics of the subsurface. The accelerograph network is used to determine the level of earthquake ground motions.

Pacific Northwest Seismograph Network

Funded by the USGS, the PNSN operates seismograph stations throughout Oregon and Washington. About 200 seismograph stations provide real-time data to locate earthquakes, estimate magnitude, and determine the strength of ground motion. Most sites are located in and around the Cascade Range, however, one station is located near Ft. Spokane at LARO and several are located north of the Clarno Unit of JODA near the Columbia Gorge.

Wildlife

Idaho National Engineering and Environmental Laboratory

The INEEL in southeast Idaho cover 890 sq. mi. of important habitat for many wildlife species. As part of their Environmental Surveillance, Education and Research Program, INEEL biologists conduct annual surveys for big game (elk, mule deer, antelope), sage grouse and predatory birds. In addition, breeding bird surveys are conducted in cooperation with the USGS.

North American Breeding Bird Survey

The BBS is a cooperative effort between the USGS's Patuxent Wildlife Research Center and the Canadian Wildlife Service's National Wildlife Research Centre. Following a standardized protocol, data are collected along over 3000 randomly established roadside routes to monitor the status and trends of North American bird populations. Routes are 24.5 mi long with observers stopping every 0.5 mi to record all birds seen and heard during a 3-minute point count. Over 100 routes are surveyed within the UCBN, approximately 20 of these occur on or near UCBN park units.

Christmas Bird Count, National Audubon Society

The CBC is an early-winter bird census conducted by the National Audubon Society. Volunteers count every bird seen or heard within a 15-mi diameter circle in 1 day. The primary objective of CBC is to monitor the status and distribution of bird populations across the Western Hemisphere. Most UCBN parks have CBC circles on or near parks, and CBC results have been incorporated into bird inventory results.

SAGEMAP, US Geological Survey

The SAGEMAP project, conducted by the Snake River Field Station of the USGS Forest and Rangeland Ecosystem Science Center, was initiated to identify and collect spatial data layers needed for research and management of sage grouse and shrubsteppe systems. More recently, SAGEMAP has become a repository for information related to the monitoring of greater sage-grouse.

Big Game Surveys, State agencies

Across the UCBN, state agencies (Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife and Montana Fish, Wildlife and Parks) conduct annual surveys to monitor the population status and trends of big game including elk, mule deer, whitetail deer, moose, bighorn sheep and mountain goat. Areas surveyed for each species vary annually, but often include areas on or near UCBN parks.

Partners in Flight

Begun in 1990, the goal of PIF is to focus resources on the improvement of monitoring and inventory, research, management, and education programs involving birds (primarily neotropical migrants) and their habitats. In conjunction with their cooperators, PIF has identified and developed a research and monitoring needs database. Recognized needs in the UCBN include monitoring population trends of landbirds in protected and restored pine forests and the population status and trends of colonial waterbirds.

USDA Forest Service Northern Region Landbird Monitoring Project

The goal of the NRLMP is to implement monitoring across the USFS Region 1 to provide a picture of landbird distributions, estimate overall population trends and allow an assessment of habitat relationships. Two UCBN parks (NEPE and BIHO) are within Region 1 and will benefit from information gathered with this project.

Northwest Bat Coop

This multi-agency cooperative includes the USFS Region 6, BLM, Plum Creek Timber Co., and the US Fish and Wildlife Service. Partners pool funds and identify and prioritize bat research and monitoring activities in the Pacific Northwest. Currently, the coop is supporting a long-term investigation of bat use of snags in mixed coniferous habitats of the eastern Cascades and central Idaho. Currently, the NPS is not a member of the coop but the UCBN may find that a partnership with this organization will benefit bat monitoring goals of the network.

Oregon/Washington Bat Grid Project

Led by USFS Region 6, this project is developing a region-wide bat monitoring program that may be employed within the UCBN in the future. Bat inventory data from JODA has already been shared with the project and, as the program expands into Washington in 2005, data from WHMI and LARO will also be shared.

Western States Bat Working Group

The WBWG is comprised of agencies, organizations and individuals interested in bat research, management, and conservation from 13 western states and the provinces of British Columbia and Alberta. The goals of the group are: to facilitate communication among interested parties and reduce risks of species decline or extinction; to provide a mechanism by which current information regarding bat ecology, distribution, and research techniques can be readily accessed; and to develop a forum in which conservation strategies can be discussed, technical assistance provided, and education programs encouraged. Individual state chapters for Oregon, Washington, and Idaho are all developing state management plans that include monitoring and these will likely intersect with UCBN monitoring in the future.

StreamNet

StreamNet is a cooperative venture between tribal, state, and federal fish and wildlife agencies to provide a web-based repository of data for Pacific Northwest fish, habitat, and related attributes. StreamNet has data for all UCBN parks except BIHO, which is outside of the Columbia Basin.

State Fish and Wildlife Agencies

State Fish and Wildlife (Game) agencies conduct annual surveys for fish and game animals in or near many UCBN parks. Annual fish surveys are conducted along the John Day River, Columbia River, Snake River, Clearwater River, and Big Hole River and these data will be important to the UCBN monitoring program.

Vegetation

Idaho National Engineering and Environmental Laboratory

The INEEL in southeast Idaho cover 890 sq. mi. of fairly untouched habitat. Vegetation surveys are conducted to evaluate the impact of current and past management activities, evaluate long-term vegetation trends and monitor the invasion and impacts of cheatgrass.

VegBank, Ecological Society of America

VegBank is a fairly recent endeavor to link actual vegetation plot records with vegetation types recognized in the US National Vegetation Classification System and types recognized by ITIS/USDA. The vegetation plot database developed and maintained by VegBank will provide valuable contextual and long-term monitoring information throughout the UCBN.

Forest Inventory and Analysis, US Forest Service

The objectives of FIA are to determine the extent and condition of forest resources across the US and analyze how these resources change over time. Both periodic and/or annual inventories are collected in all states, are maintained in the FIA national database and include information on plot and subplot characteristics, vegetation condition, and live and mortality tree measurements. Permanently established plots are distributed across the landscape with approximately one plot every 6,000 acres.

Forest Health Monitoring, US Forest Service

In addition to the forest stand information collected at FIA plots, a subset (1 plot every 96,000 acres) is measured to monitor forest health. Measurements include a full vegetation inventory, tree and crown condition, soil characteristics, lichen diversity, coarse woody debris and ozone damage. Approximately 10% of the plots in the western US are measured every year.

Water

Idaho Department of Water Resources

IDWR maintains a database of ground water levels throughout Idaho. Data are collected on 1388 observation wells across the state through a cooperative program with the USGS. The purposes of these data are to study changes in water levels, evaluate ground water availability for new water uses and identify areas with declining ground water levels that may need administrative action. IDWR also maintains information on nitrate levels at 1615 sites.

Oregon Water Resources Department

The mission of the OWRD is to ensure a sufficient supply of water to sustain Oregon’s growing economy, quality of life and natural heritage. The department monitors levels of ground and surface water to protect existing uses while maintaining adequate levels to support fish, wildlife and recreation.

Department of Environmental Quality, Department of Ecology

Water quality programs are administered in all 4 states of the UCBN through the Department of Environmental Quality in Idaho, Oregon, and Montana and the Department of Ecology in Washington. The overall goals of these programs are to measure and evaluate levels of pollutants in the water and determine whether water quality is meeting federal and state standards. While specific monitoring objectives and level of effort differ across the 4 states, aspects of river and stream flow, stream biology, and water quality are monitored. Several UCBN parks have DEQ monitoring sites located nearby. Water quality monitoring has been ongoing at Grand Coulee since 1949. Washington DEQ also regularly monitors water quality at Mill Creek adjacent to WHMI. Oregon DEQ sites are located above and below JODA on the John Day River.

Water Resources, US Geological Survey

In cooperation with state, county and other federal agencies, the USGS monitors surface and ground water levels as well as water quality across the US. Their National Water Information System Web Site maintains and distributes water data for approximately 1.5 million sites across the US from 1857 to present. Over 20,000 sites occur in Washington, Oregon, Idaho and Montana.

Chapter 2. Conceptual Models

I. Introduction

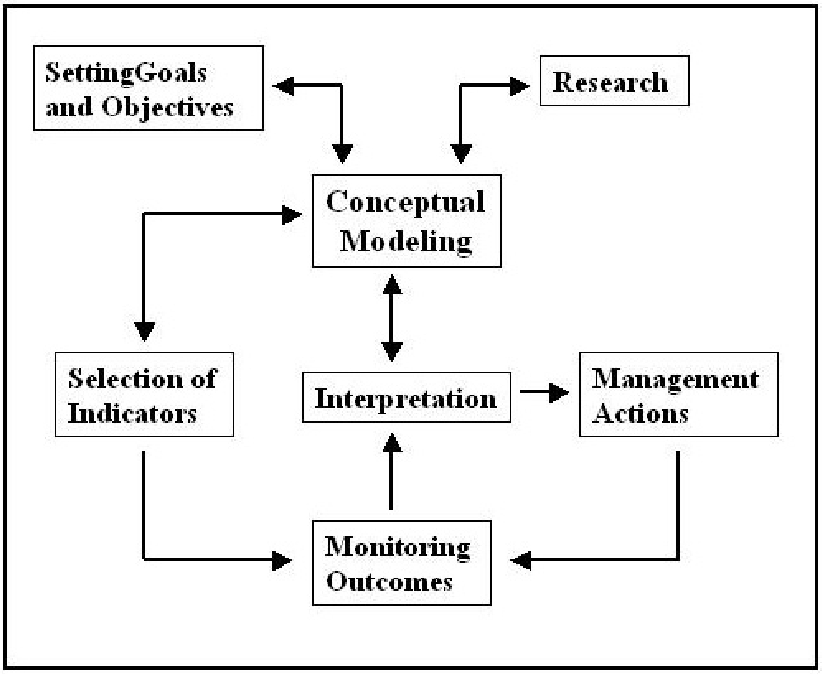
The inherent complexity of ecological systems presents a fundamental challenge to the development of a comprehensive and effective long-term ecological monitoring program. Long-term monitoring in the Upper Columbia Basin Network (UCBN) will help to predict, identify, and understand change in selected park resources that reflect ecological health and integrity. The monitoring program will also deliver information about ecological change into the hands of park managers and partner agencies in a timely and useful manner. In order to achieve this, it is necessary to reduce the complexity of the world in which we design the program into a manageable set of key components and processes.

Conceptual modeling has been widely used in monitoring programs to distill complex systems into key elements (Manley et al. 2000, Noon 2003). Conceptual modeling is not a goal in itself but is a tool to guide the thinking, communication, and organization that goes into identifying the key ecosystem attributes and monitoring questions (Maddox et al. 1999). Conceptual models developed in concert with scoping sessions and other ground-level program development activities often directly point to measurable indicators (Maddox et al. 1999).

As an exercise, conceptual modeling can be effective in identifying gaps in knowledge as well as highlighting well understood ecosystem attributes (Roman and Barrett 1999). It is important to emphasize that conceptual models, as vehicles for communication and organization, reflect an iterative process and frequently remain in a dynamic “work in progress” condition rather than in a static “finished” state (Roman and Barrett 1999). Figure 13 illustrates the central role that conceptual models can play in a monitoring program where models are refined and evolve as new information is gained through monitoring (Maddox et al. 1999).

The UCBN began using conceptual models early in the process of building a vital signs monitoring program. In its first vital signs scoping workshop, held in April 2002, participants identified key ecosystem drivers, stressors, and ecosystem effects. A stressor-based model was developed during the course of the workshop that reflected the central management concerns of the network parks. This early model can be seen in Appendix G of this report. This original model was refined during preparation for the second vital signs scoping workshop held in March 2004 and a new set of models were developed following the workshop that reflect the network’s progress in developing vital signs and monitoring questions. These most recent models are presented in this chapter.

Figure 13. Central role of conceptual modeling in a dynamic monitoring program (adapted from Maddox et al. 1999).



The UCBN remains focused on stressors and their effects on park ecosystems. Park resource managers have consistently expressed concern over the impacts of a suite of approximately 6-10 anthropogenic stressors on park resources and the current direction of the UCBN monitoring program is primarily aimed at addressing those concerns. We believe this emphasis on stressors and effects will lead to a monitoring program that is highly relevant to park management and will yield important information of more global significance as well. Dixon et al. (1997) and Olson et al. (1997) have suggested that a focus on stressors and effects leads to more rich and interpretable results. This is consistent with the “issues orientation” promoted by Maddox et al. (1999) in which the goals of management and threshold levels triggering management action are explicitly identified and incorporated into the monitoring program. Noon et al. (1999) have also promoted a stressor-oriented approach to monitoring and have recognized the importance of establishing appropriate benchmarks with which to compare measured variability or change. Benchmarks allow for “actionable” thresholds to be established which then tie monitoring directly to effective ecosystem management (Maddox et al. 1999, Noon et al. 1999). Of course determining meaningful benchmarks and properly defining the fuzzy boundary between “natural” and “unnatural” is difficult and often controversial, but conceptual modeling can greatly aid in these decisions.

The “historical range of variability” concept has been widely used as a theoretical and practical tool for establishing ecological benchmarks (Morgan et al. 1994, Cissel et al. 1999, Landres et al.

1999). This concept refers to the recognition that ecological systems are inherently "noisy" across both space and time (Osenberg et al. 1994, Landres et al. 1999). It also recognizes that this variability fluctuates within some range of parameters that are definable and, within appropriate scales, are relatively stable (Chapin et al. 1996, Landres et al. 1999). Swetnam et al. (1999) and others (Russell 1997, Cissel et al. 1999) demonstrate how historical ecology research is being utilized to define parameters of variability. The UCBN has incorporated existing knowledge of historical conditions in conceptual models presented in this chapter, and ultimately aims to ground its entire monitoring program on a historical foundation.

The utility of the historical variability concept is dependent on recognizing the importance of scale (Morgan et al. 1994). Temporal and spatial scale and the accompanying ecological organizational hierarchy act as lenses through which variability can become more or less focused. Patterns of variability may be apparent at one scale but not at another and meaningful detection of stressor-driven change is dependent upon measurement at appropriate scales (Noss 1990, Morgan et al. 1994). Likewise, drivers, stressors, and effects may be operating at different scales simultaneously within a nested hierarchy (O'Neill et al. 1986, Wu and David 2002). The NPS Inventory and Monitoring Program, following suggestions by O'Neill et al. (1986), Noss (1990) and others, has identified integration of spatial, temporal, and ecological hierarchies as a key ingredient to network monitoring efforts (NPS Inventory and Monitoring website http://science.nature.nps.gov/im/monitor/vsmTG.htm#Integration). Integration involves the inclusion of hierarchical levels above and below the level of interest into conceptual models and monitoring designs. The current set of conceptual models reflects our initial steps toward an integrated suite of vital signs and we expect this integration to become more explicit as we progress through the vital signs selection process.

As part of our effort to develop an integrated monitoring program, the UCBN has developed a set of nested conceptual models that focus on stressors and effects. Model sets have been developed for five key focal systems: cultural landscapes, sagebrush-steppe ecosystems, forest and woodland ecosystems, riparian and wetland ecosystems, and aquatic resources. An accompanying narrative provides a review of relevant literature and an explanation of model properties. The UCBN conceptual modeling process will evolve and change through each step of the 3-phase program development.

Currently, the models and accompanying narratives reflect the Phase I focus of identifying a range of monitoring objectives and potential vital signs. The primary goal of these models is to illustrate the current state of knowledge about key network focal systems and to facilitate communication within the UCBN science advisory committee as it works towards vital signs prioritization. Table 16 lists the models developed for the Phase I report.

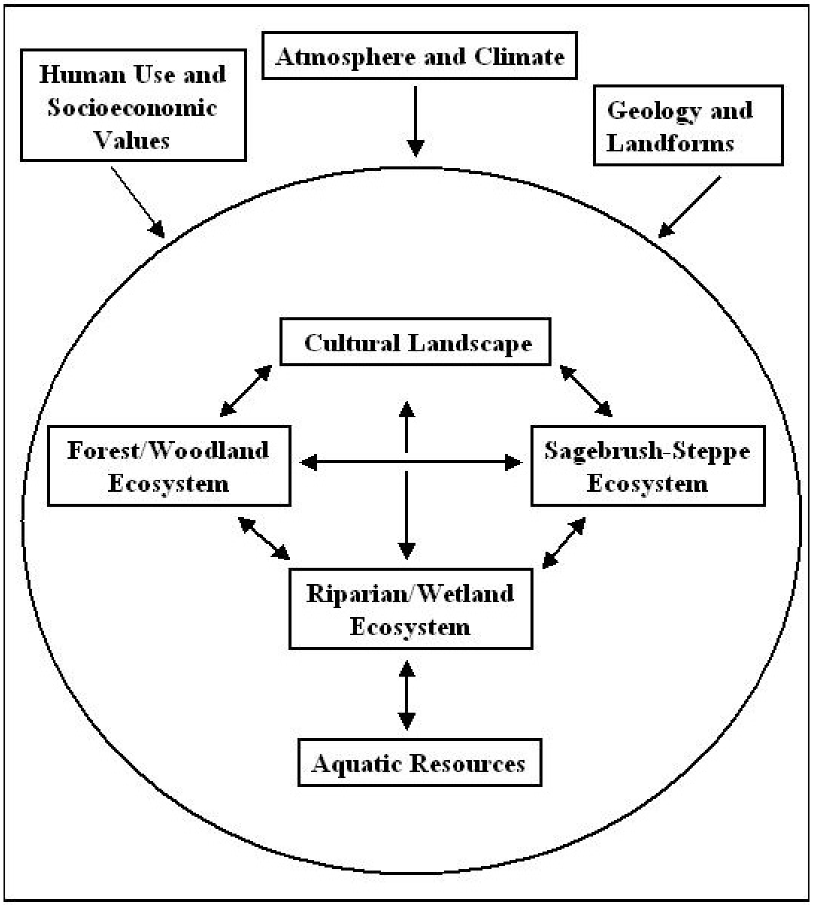
Table 16. Conceptual models developed for the UCBN vital-signs monitoring program.

Cultural Landscape	Cultural Landscape Vital Signs Model	Figure 15, pg. 80
Sagebrush Steppe Ecosystem	Sagebrush-steppe Ecosystem Control Model	Figure 17, pg. 88
Sagebrush Steppe Ecosystem	Sagebrush-steppe Altered Fire Regime Model	Figure 18, pg. 89
Sagebrush Steppe Ecosystem	Sagebrush-steppe Invasive Plant Model	Figure 19, pg. 90
Sagebrush Steppe Ecosystem	Sagebrush-steppe Agricultural Development Model	Figure 20, pg. 91
Forest and Woodland Ecosystem	Forest and Woodland Ecosystem Control Model	Figure 23, pg. 103
Forest and Woodland Ecosystem	Climate/Fire-Regime Interaction Model	Figure 24, pg. 104
Forest and Woodland Ecosystem	Ponderosa Pine Altered Fire-Regime Model	Figure 25, pg. 105
Forest and Woodland Ecosystem	Pinyon-Juniper Altered Fire-Regime Model	Figure 26, pg. 106
Forest and Woodland Ecosystem	Aspen Altered Fire-Regime Model	Figure 107, pg. 107
Riparian and Wetland Ecosystem	Under Development – January 2005	Figure X., pg. X
Aquatic Resources	Under Development – January 2005	Figure X., pg. X

II. Focal Systems of the Upper Columbia Basin Network

The UCBN science advisory committee has identified five focal systems upon which the monitoring program will be based: cultural landscapes, sagebrush-steppe ecosystems, forest and woodland ecosystems, riparian and wetland ecosystems, and aquatic resources. These systems are primarily defined by land cover and vegetation type and encompass the suite of significant ecological resources of concern and from which measurable information-rich indicators will be developed. Figure 14 illustrates the interrelationships between these five systems and the three global drivers that exert the strongest influence on the distribution of these systems across the UCBN region. The decision to proceed with five focal systems was made following the second vital signs scoping workshop held in March 2004. At that time it was clear that the majority of the monitoring questions and potential vital signs could be categorized in this way. Not all questions and vital sign candidates were placed within the focal systems context and some of these may not be reflected in current models. However, these focal system model sets capture the majority of significant ecosystem components, processes, and stressor-effect relationships recognized in the UCBN parks today.

Figure 14. Relationship between the three global drivers and the five focal systems of the UCBN.



Atmosphere and climate, geology and landforms, and human use and socioeconomic values are the most significant global drivers in the UCBN. This is not identical but certainly consistent with a number of other networks that have included some kind of overarching "explanation of the world" model into their Phase I reports, including the modified Jenny-Chapin models presented by the Northern Colorado and Southern Colorado Plateau Networks as well as the "holistic model" presented by the Southwest Alaska Network (Evenden et al. 2002, Bennett et al. 2003, Thomas et al. 2003). The Interior Columbia Basin Ecosystem Management Project has also presented an “ecosystems model” that presents a similar set of global drivers (USDA Forest Service 1996).

Atmosphere and climate and geology and landforms require little introduction. These two driver categories provide strong constraints on where focal systems occur in the UCBN and how long they may persist. Elevation and topographic moisture gradients are clear examples of this, largely explaining the distribution of sagebrush-steppe, woodland, and pine/fir forest across the region (Whittaker 1967, Peet 2000). Riparian and wetland zones are also constrained in distribution, form, and function largely by topography and climate, and the same may be said of aquatic resources. Note that Figure 14 models aquatic resources connected to upland systems through riparian or wetland zones (Gregory et al. 1991). While we recognize that the benthic environment, water quality, and other aspects of aquatic resources in the UCBN are subject to upland influences other than those buffered by riparian/wetland zones, we feel that it is necessary to highlight the integral link between aquatic resources and riparian and wetland zones (Gregory et al. 1991). Cultural landscapes are also largely constrained by atmosphere, climate, geology, and landforms. While these are largely systems governed by human manipulation, this is done within the constraints of large-scale global abiotic forces (Farina 2000).

The fundamental role of humans in shaping and controlling ecosystems is represented in Figure 14 as a global driver and as a cultural landscape focal system. Understanding and modeling both historic and contemporary human impacts is going to be a very important ingredient in the UCBN monitoring program. The UCBN acknowledges that humans have been a profound source of ecosystem change in the Columbia Basin (USDA Forest Service 1996, Marquet and Bradshaw 2003). We also acknowledge that the long-term ecological trajectories of UCBN ecosystems and landscapes are heavily influenced by historic land use and disturbance regimes (Foster 2002). In contrast to the Southwest Alaska Network, for example, where large, relatively pristine ecosystems still occur, the UCBN contains parks heavily influenced by historic and current human activities where only fragments of functioning “natural” ecosystems remain (USDA Forest Service 1996, Bennett et al. 2003). In addition, many UCBN parks were established to preserve some type of historic cultural landscape or feature. As a result, the UCBN has explicitly incorporated the human “scene” into its conceptual models not only as a key driver but also as a focal system that has its own unique ecosystem attributes and processes and requires a unique approach to vital signs monitoring. Without this explicit consideration, entire UCBN parks, such as Whitman Mission National Historic Site, would be greatly under-represented in the conceptual models developed for other focal systems. Although humans constitute a major influence even in pristine systems, the unique historic and legislative context of the UCBN requires this be addressed in the monitoring plan in a very fundamental way.

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III. Cultural Landscapes

A. Introduction

The historic and ethnographic landscapes of the UCBN pose a conceptual challenge for the natural resource monitoring program. Areas such as the Cant Ranch in JODA and the Ft. Spokane parade grounds at LARO are not readily incorporated into other focal system conceptual models such as forest and woodland or riparian and wetland, even though these landscapes may be surrounded by forest or contain riparian features. These landscapes represent only a small percentage of the total land area in the network, but tend to be disproportionately important to park management because of their significance to park enabling legislation and visitation. In several parks, cultural landscapes represent the entire park, making it even more imperative to address them in the conceptual modeling process. The UCBN seeks to explicitly incorporate cultural landscapes into its vital signs monitoring program. We believe this will help ensure that the monitoring program is relevant to UCBN park management. It also will further our goal for integration, allowing for coordination of monitoring and management activities between cultural landscapes and adjacent "natural" landscapes.

As a concept, the "cultural landscape" provides a useful ecological and logistical framework to organize vital signs and monitoring questions around. Viewed within an ecological context, cultural landscapes may often exhibit unique patterns and processes, especially in landscapes that are highly "governed" or managed to reflect a particular historical period (Bertollo 1998). Defining cultural landscapes and identifying boundaries between them and other landscapes, however, can be problematic (La Pierre 1997). On one hand, this can imply a split between humans and nature (Melnick 2000, Taylor 2002). Conversely, it can be so broadly defined as to include virtually all landscapes. For example, Taylor (2002) suggests that cultural landscapes can include any "landscape bearing the impact of human activity". This approach reflects the growing interest in ecology to incorporate an historical perspective and to recognize the importance of human influences on ecosystem development (Naveh 1982, Foster 2000). There is an equally growing interest among cultural scientists to incorporate an ecological perspective into the study of human-dominated landscapes (La Pierre 1997, Taylor 2002). We are in favor of this synthetic approach and are actively promoting the inclusion of human history into our conceptual models and monitoring strategies for other focal ecosystems. Likewise, we are attempting here to explicitly treat cultural landscapes as unique ecosystems integral to an effective and comprehensive monitoring program. Nonetheless, it is necessary for the purposes of conceptual modeling and general program logistics to assign some kind of boundary, even a somewhat artificial one, between cultural landscapes and other ecosystem types in the UCBN.

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The NPS has been one of the leaders in the United States in defining and incorporating cultural landscapes into resource management, although the concept and utility of cultural landscapes in ecology has been much more widely exploited in Europe (La Pierre 1997, Taylor 2002). Birnbaum (1994), writing for the NPS, defines cultural landscapes as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values". Again, interpreted broadly, this definition could be applied to most, perhaps all landscapes in the network. However, existing NPS definitions of cultural landscape types help narrow this down somewhat and clarify what the cultural landscapes are for the UCBN monitoring program. The NPS recognizes four types of cultural landscapes: historic designed landscapes, historic vernacular landscapes, historic sites, and ethnographic landscapes (Birnbaum 1994). The definitions of each type are included in Table 17.

Table 17. NPS definitions for the four types of cultural landscapes

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Historic Designed Landscape	A landscape that was consciously designed or laid out by a landscape architect, master gardener, architect, or horticulturist according to design principles, or an amateur gardener working in a recognized style or tradition. The landscape may be associated with a significant person(s), trend, or event in landscape architecture; or illustrate an important development in the theory and practice of landscape architecture. Aesthetic values play a significant role in designed landscapes. Examples include parks, campuses, and estates.
Historic Vernacular Landscape	A landscape that evolved through use by the people whose activities or occupancy shaped that landscape. Through social or cultural attitudes of an individual, family or a community, the landscape reflects the physical, biological, and cultural character of those everyday lives. Function plays a significant role in vernacular landscapes. They can be a single property such as a farm or a collection of properties such as a district of historic farms along a river valley. Examples include rural villages, industrial complexes, and agricultural landscapes.
Historic Site	A landscape significant for its association with a historic event, activity, or person. Examples include battlefields and president's house properties.
Ethnographic Landscape	A landscape containing a variety of natural and cultural resources that associated people define as heritage resources. Examples are contemporary settlements, religious sacred sites, and massive geological structures. Small plant communities, animals, subsistence and ceremonial grounds are often components.

The UCBN has no historic designated landscapes, but historic vernacular landscapes, historic sites, and ethnographic landscapes are all represented in the network. A number of these landscapes have been inventoried and evaluated (Beckham and Lentz 2000, National Park Service 2003b) and a region-wide effort is ongoing to complete more of these inventories (Gilbert 1991). A number of other landscapes in the UCBN, especially those that meet the definition of the ethnographic landscape type, remain outside formal designation but nonetheless are important and significant for the monitoring program.

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A UCBN example of historic vernacular landscapes includes the Cant Ranch and surrounding hay fields in JODA. Historic sites include the Big Hole Battlefield at BIHO and the Whitman Mission at WHMI. Ethnographic landscapes include the Ft. Spokane parade grounds at LARO and the sacred geologic features known as “Heart of the Monster” and “Liver of the Monster” at NEPE. A number of other geologic features in the UCBN may also be considered ethnographic landscapes, although they are not designated as such. For the purposes of conceptual modeling, it is helpful to include features such as the Smithsonian Horse Quarry at HAFO and the numerous lava tube caves and other lava features at CRMO into the cultural landscape definition. These are defining park features that are integral to enabling legislation and park missions. These also are features that are highly regarded by contemporary society as representation of our natural and even our evolutionary heritage. These geologic features frequently experience heavy visitation and in some cases may have also been important to earlier cultures. A good example of this can be found at the Palisades cliff complex in the Clarno Unit of JODA, today a centerpiece of the monument for its striking natural beauty and fossil record. The presence of numerous archaeological sites in and around the area suggests it was important for pre-historic cultures as well (Gannon 1978, Endzweig 1992). Table 18 is an informal list of the various landscapes or features considered, for purposes of the UCBN monitoring program, to be cultural landscapes. It is important to note that many of these landscapes or features are not formally recognized by the NPS as cultural landscapes but they meet definitions listed in Table 17 sufficiently to warrant inclusion in the conceptual modeling process. More importantly, these landscapes and features represent important aspects of UCBN ecological integrity that should be considered for long-term monitoring and are more easily modeled under the framework of cultural landscape than within some other framework.

Howett (2000) suggests that the application of the term “integrity” as a value for cultural landscape preservation is dependent upon the recognition that such landscapes are dynamic and evolving, both in a biophysical sense and within the world of human values. What is considered desirable or historically relevant at one point in time may change as social values change. This notion can be extended to include “ecological integrity” (see glossary), which is also dependent both on an understanding that ecosystems are dynamic and that what is considered “appropriate” is a value-laden judgment. There is no reason, then, that cultural landscapes, even those intensively managed to reflect historical conditions, cannot be treated as dynamic ecosystems exhibiting the capability for self-renewal (Bertollo 1998, Foster 2002). The historical period to which a cultural landscape is managed is analogous to the idea of “future desired condition” frequently employed in ecological restoration (Cissel et al. 1999), albeit with a much tighter range of acceptable variation (La Pierre 1997).

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Table 18. Landscapes and features representing the range of cultural landscapes within the UCBN (This list is not comprehensive and not all listed features are formally designated NPS cultural landscapes).

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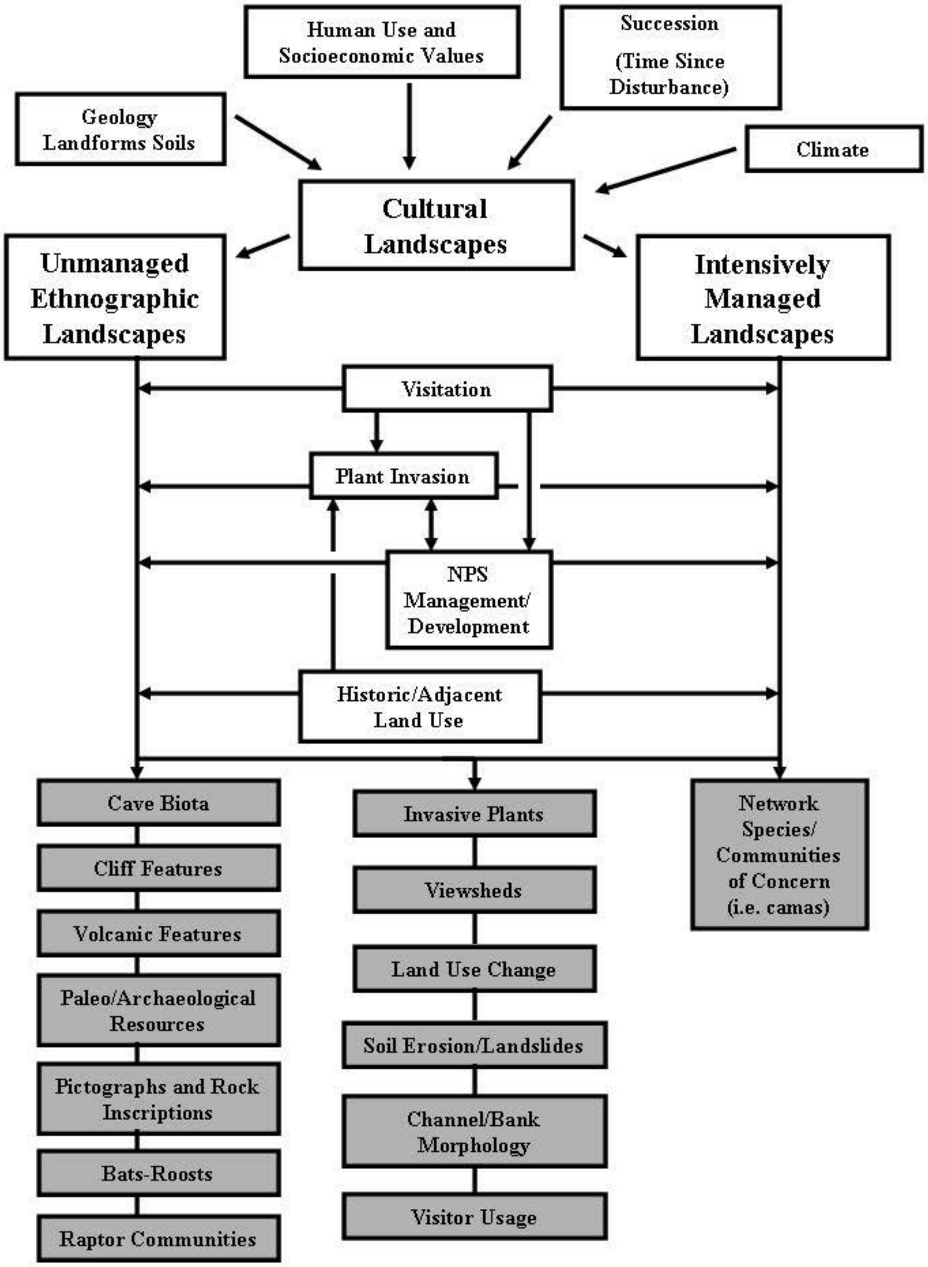
Cultural Landscape or Feature	UCBN Park	Cultural Landscape Type
Ft. Spokane (incl. parade grounds)	LARO	Historic Site
Mission Point	LARO	Ethnographic Landscape
Whitman Mission (entire NHS)	WHMI	Historic Site
Cant Ranch (incl. farm fields)	JODA	Historic Vernacular Landscape
Goose Rock	JODA	Ethnographic Landscape
Picture Gorge (rock canyon only)	JODA	Ethnographic Landscape
Palisades	JODA	Ethnographic Landscape
Painted Hills (bare slopes)	JODA	Ethnographic Landscape
Blue Basin Fossil Beds	JODA	Ethnographic Landscape
Foree Fossil Beds	JODA	Ethnographic Landscape
Big Hole Battlefield	BIHO	Historic Site
Heart of the Monster	NEPE	Ethnographic Landscape
White Bird Battlefield	NEPE	Historic Site
Spalding (entire site)	NEPE	Historic Vernacular Landscape
Weippe Prairie	NEPE	Ethnographic Landscape
Buffalo Eddy	NEPE	Ethnographic Landscape
Bear Paw Battlefield	NEPE	Historic Site
Great Rift Lava Tubes and Lava Features	CRMO	Ethnographic Landscape
Minidoka Internment Site	MIIN	Historic Site
Smithsonian Horse Quarry	HAFO	Ethnographic Landscape
California Trail	CIRO	Ethnographic Landscape
Twin Sisters	CIRO	Ethnographic Landscape

Given that cultural landscapes are unique ecosystems, it is possible to identify important drivers, stressors, effects, and indicators of ecological integrity or health. It is also possible to identify and monitor the influence of cultural landscapes on adjacent "natural" landscapes and vice-versa. This underscores the importance of considering cultural landscapes for an integrated monitoring program in the UCBN. Many of the vital signs are common to both cultural and natural ecosystems, and monitoring both can lead to a better understanding of their inter-relationships, in turn leading to more efficient and effective resource management.

The following sections present a conceptual model for cultural landscapes and a narrative highlighting the key drivers, stressors, and effects for UCBN cultural landscapes.

B. Cultural Landscape Conceptual Model

Figure 15. Relationships between the key drivers, stressors, and vital signs for cultural landscapes in the UCBN. Vital signs are highlighted in gray.



C. Cultural Landscape Drivers

As was presented in Figure 15, the fundamental global drivers affecting UCBN focal ecosystems are human use and socioeconomic values, climate, and geology and landforms. Figure 15 introduces an additional driver, succession or "time since disturbance", and this figure illustrates these drivers as the primary constraints on where cultural landscapes occur in the UCBN, what form they take, and how long they persist. Each of these driver categories varies in the degree of influence on cultural landscapes depending on the landscape type. In particular, cultural landscape types in the UCBN occur along a gradient of management intensity, with unmanaged geologic formations ocurring at the low end and intensively managed memorial landscapes, such as the lawns of WHMI, occurring at the high end. Human use and values play a much greater role in highly governed landscapes, such as Whitman Mission, and geology and landforms play a greater role in the largely unmanaged geologic formations such as the Great Rift lava tubes at CRMO. There are also profoundly influential interactions between these drivers. For example, the interaction between topography, soils, and climate led to the development of a wet meadow and a productive site for camas lily along the North Fork Big Hole River. During their flight from U.S. cavalry in August of 1877, the Nez Perce stopped there to rest and dig camas bulbs. The ensuing battle is now memorialized at BIHO, and today the vegetation is managed to discourage encroachment of pine and other woody species into the old meadow so that the landscape better resembles the conditions of 1877.

From this example, time since disturbance, or succession, emerges as an additional driver. Fire disturbance was an integral component in many landscapes throughout the UCBN until the settlement era (Agee 1993, USDA Forest Service 1996). In the example from BIHO, fires, at times likely set by native people to maintain camas, periodically moved through the site. The elimination of fire from this and other cultural landscapes in the UCBN has led to a successional shift in vegetation away from historic conditions. Today, park resource managers see this as a major concern for certain cultural landscapes, including Big Hole National Battlefield, Ft. Spokane parade grounds, and the California Trail at CIRO. In this context, succession may also be seen as a stressor to managed cultural landscapes, although it is such a fundamental ecological process independent of anthropogenic control that we prefer to emphasize it as an ecosystem driver. Park management activities attempting to control and direct succession are a much more likely cause of stress to the cultural landscape and adjacent ecosystems.

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D. Cultural Landscape Stressors

Like all terrestrial environments in the UCBN, invasive plants emerge as the most significant stressor for park cultural landscapes. This is even the case for many geological formations such as the Heart of the Monster. There is sufficient soil on the basalt exposure that weedy invasive plants are changing the appearance of the feature considerably (National Park Service 2003a). Figure 15 illustrates how weedy plant invasions are exacerbated by visitation, land use activities, and NPS management activities. Invasive species degrade ecological integrity in cultural landscapes through their association with reduced native and desirable cultivated species, increased bare ground, surface runoff, and soil erosion. The intensive management and visitation at many cultural landscapes in the UCBN facilitates weedy plant invasions, and it is likely that

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some cultural landscapes are source localities for the spread of invasive species into adjacent ecosystems.

The impacts of visitors are another significant stressor affecting all types of cultural resources in the UCBN. Visitors are typically concentrated in and around cultural landscapes and are of much greater management concern there than in upland sagebrush-steppe or forest ecosystems in the UCBN. Impacts include disturbance of nesting raptors by rock climbers at CIRO, damage of unique lava tube features at CRMO, and soil erosion caused by off-trail hikers along the base of the Palisades at JODA. Visitor impacts may also include vandalism of pictographs and rock inscriptions, as has occurred at one site in JODA recently.

UCBN resource managers frequently cite NPS management and site development activities as another significant stressor in cultural landscapes. Often these activities are conducted in response to another stressor, such as invasive plants or visitors, or in response to plant succession. Unintended or anticipated but unavoidable conflicts or ecological damage often occur. For example, the maintenance of irrigated hay fields in the Cant Ranch historic vernacular landscape at JODA facilitates weed invasion, which works against efforts to control weeds in adjacent sagebrush-steppe. The access road and trail to the siege area at BIHO are built on a dike that has altered the channel morphology and hydrology of the North Fork Big Hole River. This situation has not yet been assessed but concerns have been raised over the potential of erosion from altered channel movement to expose burial sites in the battlefield.

Land use practices, including historic and current practices adjacent to UCBN cultural landscapes, exert strong and intractable negative influences on the integrity of these landscapes. As with other UCBN ecosystems, the current health of the cultural landscape is dependent upon the legacy of the past. White Bird Battlefield at NEPE was heavily grazed for many decades and today invasive plants and degraded soil conditions compromise the site. The Smithsonian Horse Quarry and other fossil beds at HAFO are continually threatened by mass slope failures caused by many years of heavy irrigation on the plateau above. Contemporary and future land use changes are of great concern for the integrity of the historic setting at Whitman Mission, which is located in an area facing development pressure as the city of Walla Walla grows. The historic setting around Ft. Spokane at LARO is facing similar pressures from future land use changes and the intensive boating recreation on Lake Roosevelt itself constitutes an important impact on the viewshed for that cultural landscape.

E. Cultural Landscape Stressor-Effects

The stressor-effects relationships in cultural landscapes include several that are exhibited in other ecosystems in the UCBN and a number that are park specific and limited in extent. The degree to which these are incorporated into the UCBN monitoring program will depend on the decisions of the science advisory committee during prioritization. Figure 15 presents potential vital-signs that represent key stressor-effects relationships in UCBN cultural landscapes. The objectives identified with these vital signs are presented in Appendix M. In Figure 15, vital signs are divided into those associated with unique park-specific unmanaged ethnographic landscapes, primarily geologic formations, those associated with intensively managed cultural landscapes, and those that are common to both.

The four primary stressors discussed in the previous section are closely related and even exert positive feedback loops upon one another. For example, visitors trigger a management and development response by NPS, which leads to soil disturbance, which then facilitates weed invasion, and so on. UCBN resource managers consistently express concern over a number of direct and indirect effects resulting from weed invasion. These include degradation of the visual quality of the landscape or feature, loss of native or desirable cultivated species, increased bare ground, and accelerated soil erosion. There are also important impacts on riparian and aquatic ecosystems within cultural landscapes, including loss of desired riparian vegetation and reduced water quality. These riparian and aquatic issues are discussed in more detail in the riparian and wetland ecosystems and aquatic resources conceptual model sections.

Visitors, NPS management and development, and historic and adjacent agriculture facilitate weed invasions in cultural landscapes. Visitors contribute to soil compaction and increased bare ground, two conditions favorable to weed establishment. Visitors also act as vectors for weed seed dispersal. Trails and roads used by visitors are vectors for the spread of weeds. NPS management activities, including those accommodating visitation such as trail maintenance and facilities construction, also can contribute to the spread of invasive species. It is important to recognize that even management activities intended to benefit cultural resources may have unintended or unavoidable consequences that negatively impact the integrity of these landscapes. Finally, historic and adjacent land use practices, especially agricultural practices, act as a continuous source of invasive species. A number of plant invasions were established in and adjacent to UCBN cultural landscapes many decades ago (Yensen 1981). Current agricultural practices, including the maintenance of unvegetated field edges and access roads, facilitate new invasions.

A suite of feature-specific effects is occurring or is potentially occurring in the culturally significant geologic features of the UCBN. Many of these features receive heavy and concentrated impacts from visitors and several examples of direct and indirect impacts are represented in the vital signs of Figure 15. At CIRO, efforts are ongoing to manage the impacts of recreational rock climbing on cliff-nesting raptors. Management activities include seasonal closures on certain climbing routes. Impacts of climbing on other vertebrates, such as bats, are also likely occurring to some extent. The presence of spotted bats and several other cliff-roosting bat species of concern in CIRO make this a relevant issue. Similar but less intense impacts may be occurring at other frequently visited cliff sites in the UCBN. Recent research by the UCBN in JODA found that pallid bat maternity colonies were concentrated in large cliffs such as the Palisades in the Clarno Unit, a feature that experiences daily trail use along the cliff base. Cliff dwelling colonies of pallid bats in one Arizona site experiencing increased recreational use have shown potentially steep declines over a 20 year period (O'Shea and Vaughan 1999). Visitation to the Palisades is increasing and expected to continue to increase (John Lainge, JODA Ranger, personal communication). At CRMO, concern has emerged over the potential impacts of visitation and other stressors on the unique biotic and abiotic features of lava tubes and other unique lava features. The blind cave leiodid beetle is a cave-obligate species of concern that occurs in the lava tubes of the monument. Cave tours have also been shown to impact bats, and several clusters of lava tubes at CRMO are regularly used by pup-rearing Townsend's big-eared bats (Mann et al. 2002). Fossil beds at JODA and HAFO are also

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features of concern that may fall within the scope of the UCBN monitoring program. At HAFO, the Smithsonian Horse Quarry and other fossil beds are threatened by landslides resulting from adjacent irrigation practices. Visitation, including illegal prospecting, and increased weathering also pose potential threats to fossil beds.

Viewshed integrity is fundamental to cultural landscapes, especially those formally designated and those where visitor interpretation is an important park activity. The historic setting is an important element of many UCBN cultural landscapes. Land use change, invasive species, heavy impacts from visitation, and NPS management and development activities all have the potential to negatively affect UCBN viewsheds. Succession also has negative impacts on culturally significant landscapes that are dependent upon a particular stage of succession. The camas meadows of BIHO and NEPE are the primary examples of this, however other examples exist at LARO and JODA.

F. Cultural Landscapes Vital Signs

The following list of potential vital signs have been identified for cultural landscapes in the UCBN: invasive plants, network species/communities of concern (cultural plant communities, i.e. camas), viewsheds, visitor usage, soil erosion, landslides, land use change, cave biota, raptor communities, bats (roosts), cliff features, pictographs and rock inscriptions, volcanic features, paleontological resources, archaeological resources, and channel/bank morphology. These vital signs are organized in Figure 15 according to cultural landscape management intensity. The associated objectives for each of these vital signs are presented in Appendix M. In many cases, these vital signs are common to all UCBN focal systems and monitoring will likely occur across systems. Some vital signs, especially those related to specific geologic features, are unique to the cultural landscape and will require park-specific monitoring efforts.

IV. Sagebrush-Steppe Ecosystem

A. Introduction

The term sagebrush-steppe generally refers to a number of plant assemblages dominated by one or more of the big sagebrush shrub species in association with perennial bunchgrasses and forbs (West and Young 2000, Bureau of Land Management 2002, Reid et al. 2002). The sagebrush-steppe ecosystem is often distinguished from sagebrush ecosystems of the Great Basin, in which the density of big sagebrush is much greater and perennial bunchgrass forms a relatively minor component of the system (Kuchler 1970, West and Young 2000). The climate of the sagebrush-steppe is generally cooler and more mesic than the Great Basin sagebrush zone (Bureau of Land Management 2002). Sagebrush-steppe is widespread throughout the Columbia Plateau, Snake River Plain, and northern Great Basin, and overlaps with a significant portion of the UCBN (West and Young 2000).

The sagebrush-steppe ecosystem is the most widely distributed ecosystem type within the UCBN. Sagebrush-steppe comprises over 50% of land cover in CIRO, JODA, and HAFO. At CRMO, where bare lava rock comprises 81% of the total land cover, sagebrush-steppe represents over 90% of the existing vegetation cover (see Table 9). In the remaining parks of the UCBN, sagebrush-steppe is present and significant at LARO, is present as a transitional form in BIHO and occurs as minor relicts in NEPE, MIIN, and WHMI.

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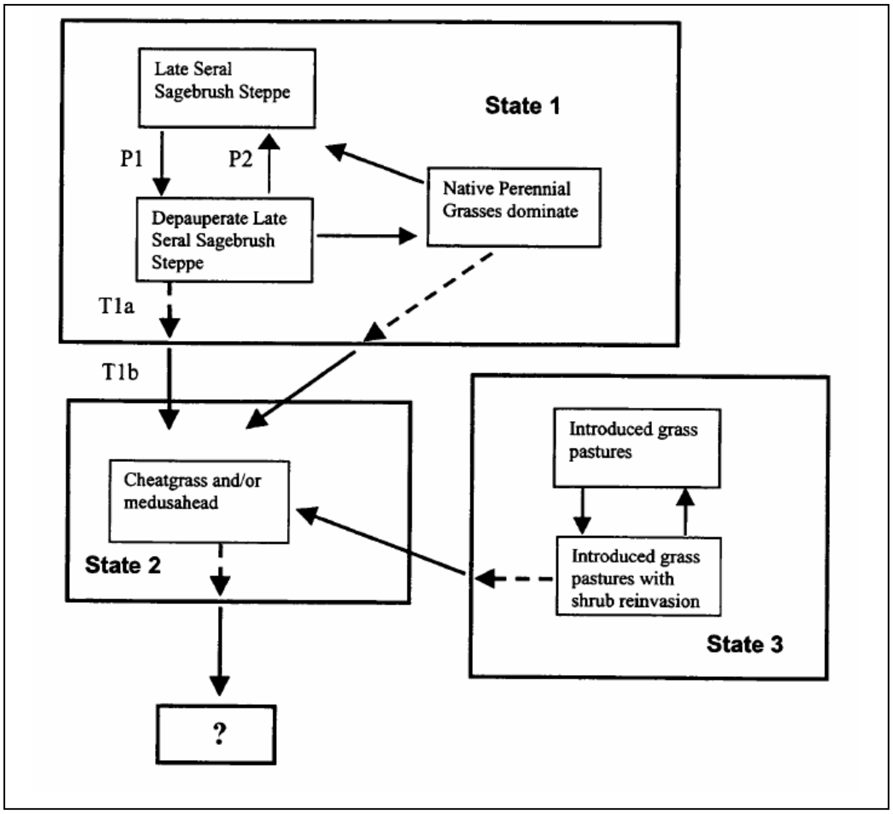
The sagebrush-steppe region has undergone radical and extensive changes during the last 150 years (USDA Forest Service 1996, West and Young 2000, Bureau of Land Management 2002, Reid et al. 2002). Prior to European colonization, sagebrush-steppe covered approximately 44 million hectares of the intermountain west (West and Young 2000). Significant portions of the region have since been converted to agriculture and heavily grazed rangeland (West and Young 2000, Bunting et al. 2002). Much of the remaining sagebrush-steppe has been degraded through altered fire regimes and invasion of introduced plants (Reid et al. 2002). These changes have had significant impacts on ecological integrity of the sagebrush-steppe, including a decline in native flora and fauna, decreased soil stability, and reduced hydrologic function (Mack and D’Antonio 1998, Wisdom et al. 2000, Keane et al. 2002).

One of the most significant changes in this ecosystem has been the arrival of cheatgrass and the subsequent shift in fire frequencies (Mack 1981, Yensen 1981, D’Antonio and Vitousek 1992). This has emerged as one of the paramount examples of state transitions, in which the sagebrush-steppe state crosses a “threshold” into a new state dominated by cheatgrass (Stringham et al. 2001). The resulting increase in fire frequency prevents reestablishment of sagebrush and a return to the former state. State transition models have been widely used to represent this kind of ecological phenomena and they have been especially helpful in their ability to accommodate multiple successional pathways and steady states (Tausch et al. 1993, Stringham et al. 2001). Figure 16 shows the state transition model proposed by Stringham et al. (2001) for sagebrush-steppe. In this figure, multiple pathways are shown, represented by arrows inside state boxes, as well as multiple transitions between states. Although fire as an agent of transition is not explicitly represented in this model, it is applicable to many of the sagebrush-steppe environments in UCBN parks. States 1 and 2, conditions in which native steppe vegetation and cheatgrass dominate, are the most prevalent. However, old fields of crested wheatgrass pastures with varying degrees of shrub reinvasion and transition to annual grass dominance do occur at HAFO and JODA.

Figure 16. Sagebrush-steppe state and transition model proposed by Stringham et al. (2001).



The sagebrush-steppe ecosystems of the UCBN have been affected by this altered fire regime to varying degrees and, because it is such a synoptic phenomena, it has emerged as a central focus of our conceptual models. There are, however, a number of other important issues to consider, including the legacy of grazing, agricultural conversion, and the expansion of pinyon-juniper woodland into park steppe landscapes. The following sections present the set of nested conceptual models developed for UCBN sagebrush-steppe vital signs identification and highlight key model elements including system drivers, stressors, ecosystem effects, and potential vital signs. Figure 17 illustrates the fundamental drivers and stressors that control the composition, structure, and function of sagebrush-steppe systems in the UCBN. It is designed to highlight the most important ecosystem attributes of current sagebrush-steppe communities in UCBN parks. Figure 18 illustrates the two altered fire-regime pathways that sagebrush-steppe ecosystems have taken in the upper Columbia Basin. One route is that of an accelerated frequency, resulting from the introduction of cheatgrass, the other is that of reduced frequency resulting from historic grazing, removal of fine fuels, and an increase in woody plant density beyond the range of historical variability. Figure 19 illustrates the related phenomena of plant invasions. A number of anthropogenic and natural factors contribute to invasions in UCBN steppe. Finally, Figure 20 illustrates the pathways from the three primary agricultural development types, vegetable farming, hay crop production, and cattle grazing, to stressor-effects vital signs for UCBN steppe. This model is designed to address the impacts originating from outside park boundaries as well as those from permitted grazing inside park boundaries.

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B. Sagebrush-Steppe Conceptual Models

Figure 17. Sagebrush-steppe ecosystem control model.

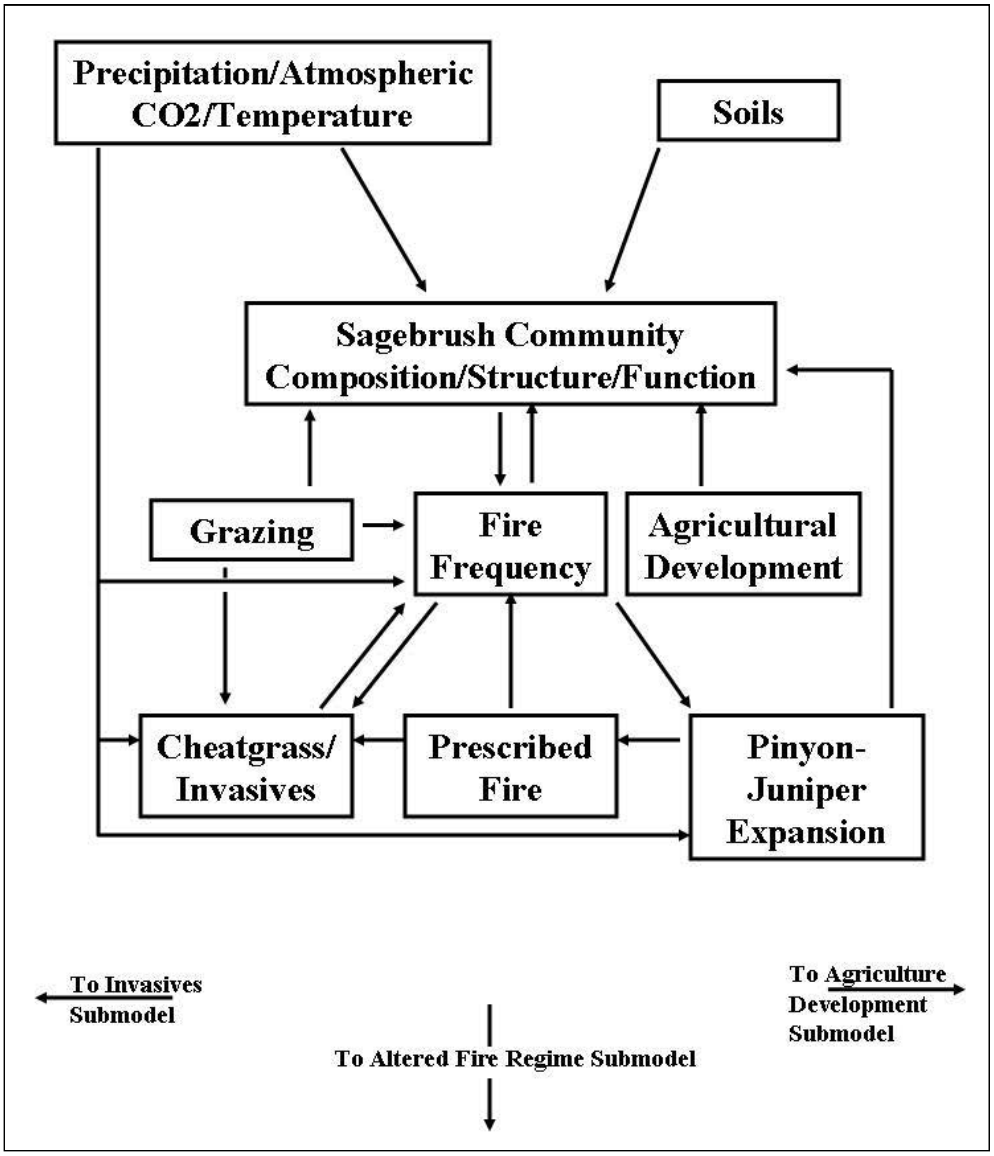


Figure 18. Sagebrush-steppe altered fire regime model. Vital signs are highlighted in gray.

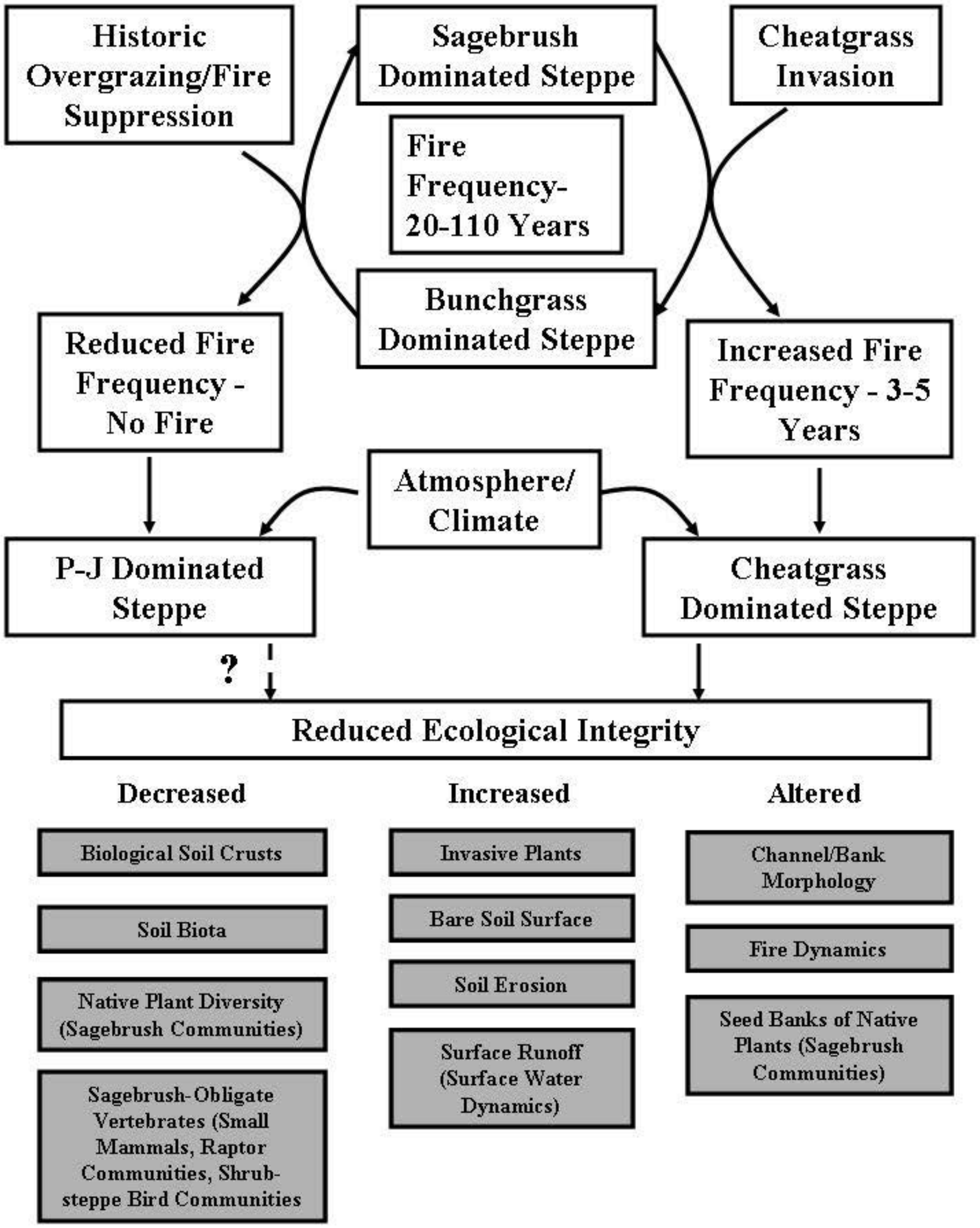


Figure 19. Sagebrush-steppe ecosystem invasive plant model. Vital signs are highlighted in gray.

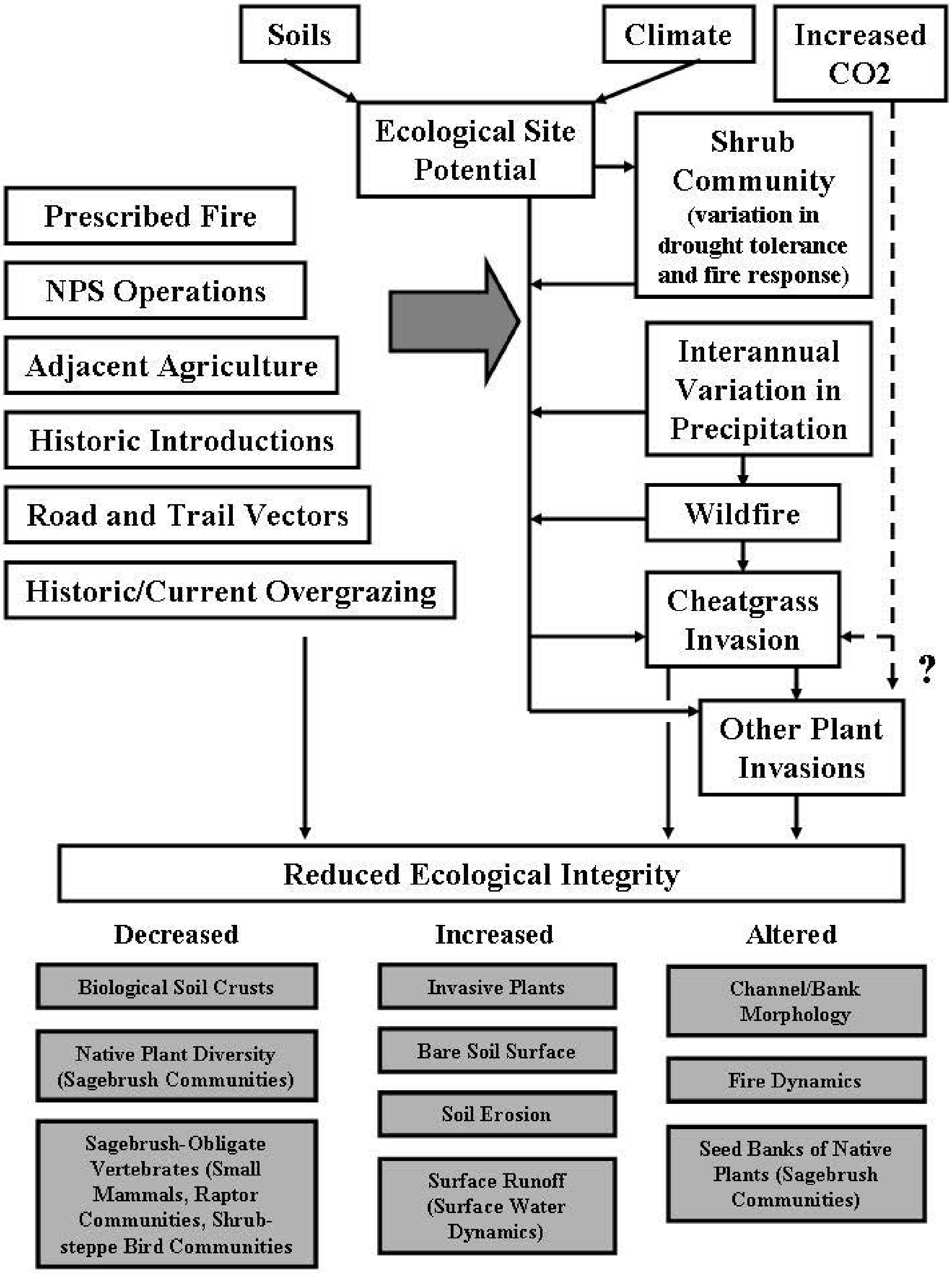
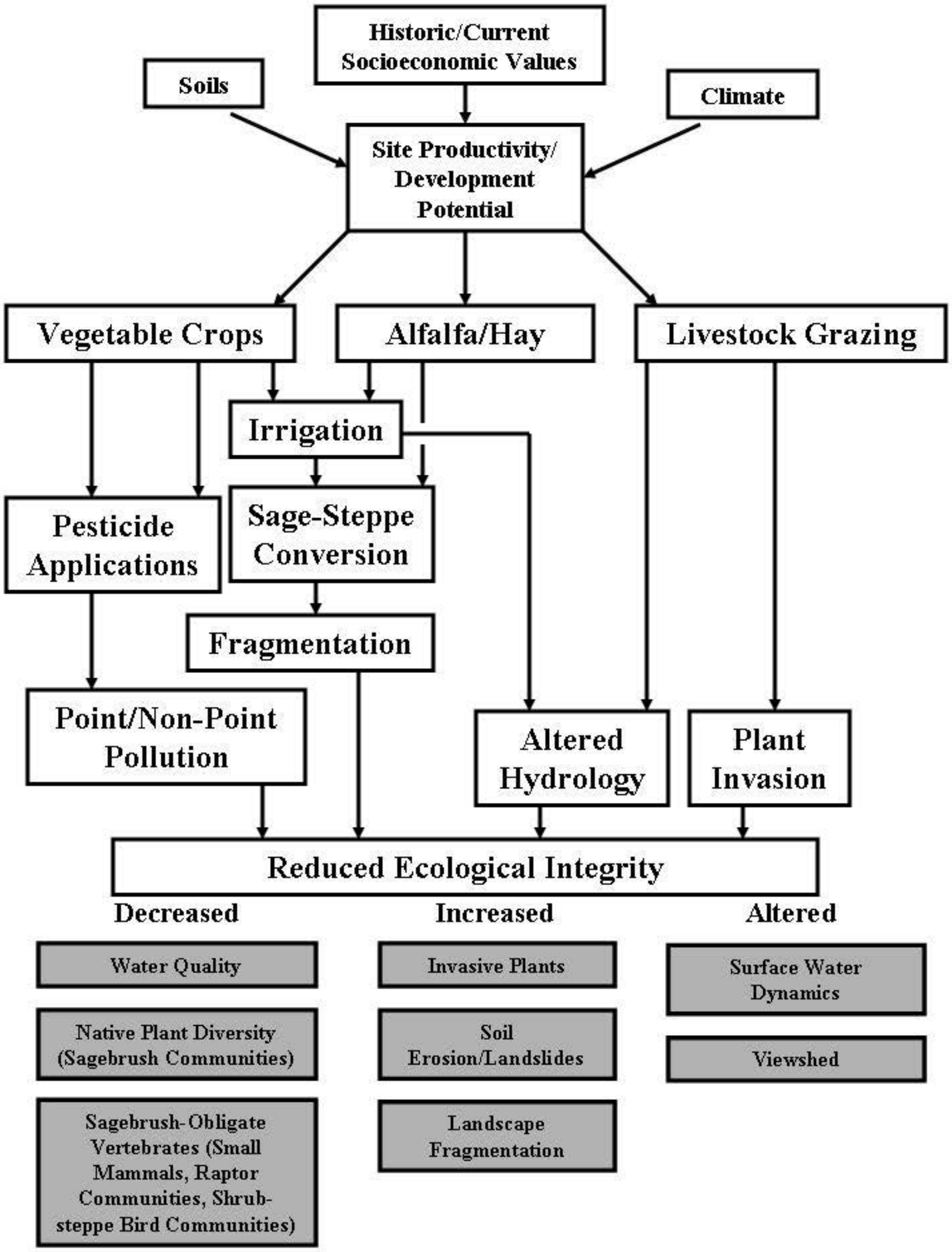


Figure 20. Sagebrush-steppe ecosystem agricultural development model. Vital signs are highlighted in gray. This model primarily addresses agricultural land use occurring outside UCBN park boundaries, although permitted grazing occurs within 3 UCBN parks.



C. Sagebrush-Steppe Ecosystem Drivers

As is indicated in Figures 17-20, there are two fundamental drivers of sagebrush-steppe ecosystems: climate and soils (Reid et al. 2002). Precipitation is the most important aspect of climate influencing sagebrush-steppe, but temperature is extremely influential in evapotranspiration and atmospheric CO_2 is emerging as a potential contributor to increasing invasive species and pinyon-juniper expansion (Smith et al. 2000). This is indicated in Figure 19 by the dashed line and question mark. The precipitation gradient, itself influenced by elevation and regional climate patterns, determines the distribution of sagebrush-steppe within the UCBN. Sagebrush-steppe is bounded by salt desert shrub vegetation at the lower range of precipitation and in poorly drained alkaline playas and is bounded by coniferous woodland and forest at the upper end of precipitation (West and Young 2000). Sagebrush-steppe typically occurs in valley bottoms and lower mountain slopes where annual precipitation ranges from 18cm-40cm for basin big sagebrush and 26cm-60cm for mountain big sagebrush (Bureau of Land Management 2002).

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Precipitation coupled with soil texture, soil depth, site drainage, and soil moisture dictate the distribution of sagebrush species and subspecies, which have been grouped into vegetation "alliances" (Reid et al. 2002). These sagebrush alliances exhibit important differences in ecosystem dynamics, including resistance and resiliency to disturbances (Bureau of Land Management 2002, Reid et al. 2002). Sagebrush-steppe occurs within a relatively broad range of soil types and depths but subspecific affinities are exhibited within this range. Both the sagebrush subspecies as well as the presence and density of other shrubs, such as rabbitbrush and horsebrush, are important factors in steppe ecosystem development and response to drought, fire, and other disturbances. Table 19 shows the major sagebrush species and big sagebrush subspecies of the UCBN and the primary soil-moisture and fire regime characteristics of those alliances.

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Fire frequency is a third critical driver in sagebrush-steppe ecosystems of the UCBN, but this is largely constrained by precipitation, soil, and sagebrush alliance type (Reid et al. 2002). Figure 17 illustrates the interrelationships between fire frequency, climate, and sagebrush community or alliance type. Table 19 describes the connection between alliance type, soil moisture, and fire regime. Fire return intervals are longest on dry sites and shortest on mesic sites. The grass and forb component of sagebrush-steppe acts as fine fuels when dry, and mesic mountain big sagebrush sites generally produce more fine fuels than drier alliances, in turn driving more frequent fires. Interannual variation in precipitation also influences fire frequency within alliance types, with wet years producing more fine fuels and more fire.

Given the extent to which current fire return intervals are outside the historical range of variability, fire has also become a significant stressor on sagebrush-steppe ecosystems (D'Antonio and Vitousek 1992, D'Antonio 2000, Keane et al. 2002). This is particularly evident when placed within the context of the cheatgrass-driven altered fire regime of sagebrush-steppe illustrated in Figure 18. Dry alliances, particularly that of Wyoming big sagebrush, tend to be most susceptible to cheatgrass invasion and altered fire regimes. Recovery from fire also tends to be slower in dry alliances, and drought conditions can further inhibit recovery. Reestablisment of sagebrush following fire in Wyoming big sage alliance types can be particularly slow during drought conditions (Bureau of Land Management 2002). The shrub community element in figure 19 illustrates the importance that alliance type has in determining site susceptibility and response to disturbance and weed invasion. Although not yet quantified, low elevation steppe habitats of JODA, HAFO, and CRMO are clearly more impacted by cheatgrass than the higher elevation steppe of CIRO and the northern portion of CRMO.

Table 19. Soil-moisture and fire regime characteristics associated with sagebrush (Genus *Artemisia*) species and big sagebrush (*Artemisia tridentata*) subspecies “alliances” in the UCBN (from Bureau of Land Management 2002 and Reid et al. 2002).

Species	Common Name	Elevation (m)	Soil
A. arbuscula	low sagebrush	900-3500	rocky, shallow
A. tripartita	threetip sagebrush	900-3000	moderate to deep, loamy to sandy
A. tridentata wyomingensis	Wyoming big sagebrush	1500-2000	deep, coarse to fine
A. t. tridentata	basin big sagebrush	250-3000	deep, coarse to fine
A. t. vaseyana	mountain big sagebrush	1400-3000	deep, coarse to fine
Species	Fire Tolerance	Fire Return Interval	Moisture Regime
A. arbuscula	intolerant	long, 50+	dry
A. tripartita	resprouter	medium, 20-50	semi-dry
A. t. wyomingensis	intolerant	long, 50+	dry
A. t. tridentata	intolerant	medium to long, 20-100	semi-dry
A. t. vaseyana	intolerant	short, 10-25	semi-dry to mesic

D. Sagebrush-Steppe Ecosystem Stressors

There is considerable unanimity within the scientific community as well as within the UCBN management community regarding sagebrush-steppe stressors (e.g. USDA Forest Service 1996, Bureau of Land Management 2002, Reid et al. 2002). Foremost among them is the introduction of undesirable invasive plants. Cheatgrass, medusahead, thistles, and knapweeds, to name a few, are actively spreading throughout the network and are having profound impacts on park ecosystems (Yensen 1981, USDA Forest Service 1996). UCBN park managers have consistently ranked this as their top resource concern. The spread of exotics are linked with other stressors of concern, including grazing, adjacent agriculture, expanding woodlands, and prescribed fire. Recent predictions of climate change scenarios have provided evidence that elevated atmospheric CO_2 concentrations may further facilitate the spread of certain exotic species, including cheatgrass (Smith et al. 2000, Wagner et al. 2003).

As is illustrated in figure 17, exotic species are affecting the ecological integrity of sagebrush-steppe ecosystems in a qualitative manner, altering structure and reducing function (Noss et al. 1995). Agricultural development impacts sagebrush-steppe in a more direct, quantitative manner via wholesale conversion of sagebrush-steppe to cultivated lands (see figure 20; Noss et al. 1995, USDA Forest Service 1996). Much of the deep soiled expanses of sagebrush-steppe have been converted to agriculture in the Columbia Basin (USDA Forest Service 1996). Within the UCBN, this has been particularly influential at WHMI, HAFO, MIIN, LARO, NEPE, and JODA, and to a lesser degree at CIRO. CRMO, by virtue of its young lava flows, has largely been unaffected by agriculture, although the southern portion of the preserve has some adjacent agriculture. Alfalfa and hay production are the primary agricultural activities adjacent to steppe portions of UCBN parks today, although the area around HAFO and WHMI is extensively planted in vegetable crops.

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The primary effect of agricultural conversion on steppe in the UCBN is fragmentation and habitat loss, which has emerged as a particularly important concern for sagebrush-obligate birds (Dobkin 1995, Saab and Rich 1997, Paige and Ritter 1999). In addition to land conversion, adjacent and historic agricultural developments have also contributed in various ways to the qualitative degradation of sagebrush-steppe through irrigation and by facilitating the spread of exotic plants. In JODA, for example, old hay fields along Bridge Creek have converted to dense stands of basin big sagebrush, greasewood, and Russian knapweed. These fields are lined with old irrigation ditches that have altered the floodplain hydrology and further complicated recovery of native vegetation.

Mismanaged grazing ranks near the top of significant sources of ecological change in sagebrush-steppe, although it has had less of an impact in the UCBN than is generally the case elsewhere in the public lands of the region (USDA Forest Service 1996, Bunting et al. 2002). Currently, only LARO, NEPE, and CIRO permit allotted grazing inside park boundaries, but historic grazing effects are still influential in JODA, HAFO, NEPE and CRMO. Heavy historic grazing has contributed to a reduction in fire frequency, leading to structural changes in sagebrush-steppe (see figure 17; Belsky 1996, Keane et al. 2002, Soulé et al. 2004). The expansion of pinyon pine, western juniper, and Utah juniper woodlands into sagebrush-steppe has been linked to grazing-induced altered fire regime, although the impacts of this invasion on ecological integrity are not entirely clear (Belsky 1996, Miller and Rose 1999, Gedney et al. 1999, West and Young 2000). Figure 18 illustrates this dynamic and the uncertain impacts on ecological integrity. Climate change has also been identified as a source of pinyon–juniper expansion in the region (Soulé et al. 2004). In the UCBN, the issue of conifer expansion into steppe is limited to JODA and CIRO, and is of particular relevance at JODA. Perhaps of greater relevance to the UCBN as a whole are the historic and contemporary impacts of grazing on biological soil crusts, soil stability, and hydrologic function (Belnap 1993, St. Clair et al. 1993, Fleischner 1994, Belnap 2003). Although these impacts have not been quantified in the UCBN, grazing in the upper Columbia Basin began early in the settlement era, was intense, with large herds, and was very widespread (Yensen 1981, Elmore and Kauffman 1994, Todd and Elmore 1997, Quigley and Arbelbide 1997). Substantial degradation of sagebrush-steppe ecosystems have undoubtedly occurred in most UCBN park lands as a result of historic grazing.

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The use of prescribed fire to control woody species, increase native perennial grasses, or to accomplish other management purposes has complex ramifications and has become rather controversial (Bureau of Land Management 2002, D'Antonio 2000). Fire often enhances cheatgrass and other annual exotics at the expense of native vegetation (D'Antonio 2000). Likewise, biological crusts can be destroyed by fire (St. Clair et al. 1993). Currently, prescribed fire is only being used in steppe ecosystems in JODA, although BIHO has also employed prescribed fire in steppe as well. Wildfires periodically occur in network steppe ecosystems, with the most recent activity occurring in JODA, NEPE, and CIRO.

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E. Sagebrush-Steppe Ecosystem Stressor-Effects

Big sagebrush subspecies alliances each exhibit distinct ecosystem dynamics, creating challenges in generalizing the description of sagebrush-steppe response to stressors (Reid et al. 2002). In the UCBN, basin big sagebrush, Wyoming big sagebrush, and mountain big sagebrush are the dominant subspecies, and two “dwarf” or “low” sagebrush species, threetip and low sagebrush, also occur in several UCBN parks. All are largely intolerant to fire except threetip sagebrush, which only occurs in the northern portion of CRMO. This species differs from the big sagebrush group in its ability to resprout after fire (Reid et al. 2002). Both threetip and low sagebrush likely only influence ecosystem dynamics in the UCBN at a relatively fine, site-level spatial scale because of localized distribution and co-dominance with basin big sagebrush (Bunting et al. 2002). The three subspecies of big sagebrush exhibit response to grazing and fire disturbance along a gradient characterized by soil moisture. Wyoming big sage occurs in the driest sites, is believed to have experienced the longest fire return intervals, and is most vulnerable to the cheatgrass-altered fire regime described in Figures 16 and 18 (Bureau of Land Management 2002). Mountain big sage occurs in the most mesic sites, historically experienced short fire return intervals, and today appears to be the least degraded by invasive annual grasses. The soil moisture and disturbance response of basin big sage lies somewhere in between.

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Big sagebrush dominated systems in the UCBN exhibit complex interactions between grazing, precipitation, exotic annual grasses (namely cheatgrass), and fire (Reid et al. 2002). Grazing has led to a reduction of fine fuels, a decrease in fire frequency, and an increase in exotics and certain “increaser” native plant species such as gray rabbitbrush (see Figure 18; Fleischner 1994). Historic grazing has created a fundamental change, or “state transition”, in vegetation structure and function in UCBN sagebrush-steppe (USDA Forest Service 1996). The impacts of current grazing in CIRO and LARO have not been well evaluated but are likely continuing to negatively impact ecosystem structure and function. Reduction in fire frequency is associated with invasion by woody species, namely juniper and pinyon pine in some areas of the network, particularly at JODA (Miller and Rose 1999, Gedney et al. 1999, Soulé et al. 2004). Reduction in fire frequency is also associated with increasing densities of sagebrush. These changes are accompanied by a reduction in native perennial grass cover. A significant ecosystem state transition occurs when fires burn these altered sagebrush systems (Stringham et al. 2001). This typically involves a loss of woody vegetation and a shift to a cheatgrass dominated system (D’Antonio and Vitousek 1992). Often cheatgrass dominated systems are self-renewing because fires become so frequent that native vegetation cannot become reestablished (D’Antonio and Vitousek 1992).

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It is important to underscore the profound role of precipitation in this cascade of stressor-effects relationships. Higher elevation regions of the network, such as those found at CIRO and the northern portion of CRMO, are dominated by mountain big sage, a sagebrush alliance type associated with more frequent fires than drier low elevation basin big sage and Wyoming big sagebrush ecosystems and tends to be more resistant and resilient to stressors than low elevation, low moisture sites (Bunting et al. 2002, Reid et al. 2002). Inter-annual variability in precipitation also influences burn cycles through fine fuel production and seed production of big sagebrush, further reducing the ability of fire impacted sites to recover (Bureau of Land Management 2002). Reduced seed production during drought seems most acutely exhibited in Wyoming big sagebrush (Bureau of Land Management 2002).

Finally, second-order shifts in ecosystem structure and function occur as a result of quantitative and qualitative reductions in integrity of sagebrush-steppe vegetation structure and function. Most notably, sagebrush obligate birds and other vertebrates have experienced significant reductions in habitat quantity and quality as a result of habitat loss, fragmentation, and degradation due to grazing and altered fire regimes in the Columbia Basin (Dobkin 1995, Saab and Rich 1997, Paige and Ritter 1999, Wisdom et al. 2000). Sage grouse were historically present at JODA and in the southern portion of LARO, but the species is absent from these parks today (Sharp 1985, Hays et al. 1998). Sage grouse, Brewer's sparrow, vesper sparrow, sage sparrow, and sage thrasher have all been documented in sage steppe portions of UCBN parks and may emerge as important indicators of sage steppe ecosystem health for the UCBN monitoring program. Other less well-documented effects are likely occurring within invertebrate populations (Niwa et al. 2001). A virtual "laundry list" of other fundamental biophysical effects include loss of biological soil crusts, increased bare ground, loss of soil stability, reduced capacity for infiltration, increased surface runoff, reduced water storage capacity, lowered water table, and degraded stream channel morphology (Bureau of Land Management 2002, Bunting et al. 2002, Keane et al. 2002, Belnap 2003). Degradation of riparian ecosystem integrity has been particularly acute in sagebrush-steppe ecosystems (National Research Council 1996, Quigley and Arbelbide 1997, Kauffman et al. 1997). Because the sagebrush-steppe is a semi-arid environment, the narrow riparian zone along waterbodies in UCBN steppe environments were quickly overgrazed during historic times (Todd and Elmore 1997). Loss of riparian vegetation, as well as changes in surface water dynamics across adjacent uplands, caused rapid and dramatic downcutting or "incising" of stream channels during the early 20th century throughout the upper Columbia Basin (Todd and Elmore 1997, Kauffman et al. 1997). Dramatic changes in water quality and streambed substrates resulted, and in turn resulted in widespread loss of fish-rearing habitat throughout the Basin (National Research Council 1996, Quigley and Arbelbide 1997). In the UCBN, most sagebrush-steppe waterbodies are in some stage of recovery from historic stressors.

F. Vital Signs

The following list of potential vital signs has been identified for sagebrush-steppe ecosystems in the UCBN: biological Soil Crusts, Soil Biota, Invasive Plants, Sagebrush Communities (vegetation), Shrub-steppe Bird Communities, Raptor Communities, Small Mammals, Bare Soil Surface, Soil Erosion, Fire Dynamics, Surface Water Dynamics, Water Quality, and Channel/Bank Morphology. These vital signs are organized in Figures 18-20 according to whether indicators are predicted to increase, decrease, or become altered in some other way in response to stressors. This list of vital signs emerged out of the March 2004 vital signs scoping workshop and were refined as a result of an intensive literature review and a web-based survey of UCBN constituents. The complete list of vital signs and associated monitoring objectives are found located in Appendix M. These vital signs are largely consistent with indicators developed

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through similar efforts, including those in the interagency text, *Interpreting Indicators of Rangeland Health* (Pellant et al. 2000). It is our hope that, rather than “reinventing the wheel”, the UCBN will develop a suite of vital signs that are consistent and perhaps even identical to those in use by other agencies and organizations, therefore increasing the opportunity for collaboration in the monitoring program.

V. Forest and Woodland Ecosystem

A. Introduction

Forest and woodland ecosystems are the second most widespread ecosystem type in the UCBN, accounting for over 20% of the landscape in BIHO and JODA, and over 50% of the terrestrial land cover in LARO. Forest and woodland ecosystems are also significant at CIRO, NEPE, and CRMO. Small woody riparian areas are present at HAFO and WHMI and no woodland is present at MIIN. Forest and woodland types that occur in the UCBN include mixed fir and pine forest, ponderosa pine forest, limber pine woodland, pinyon-juniper woodland, aspen groves, and riparian cottonwood galleries. Much like the cultural landscapes of the network, forest and woodland ecosystems tend to be disproportionately important to the ecology of the UCBN. Forest and woodland ecosystems contribute significantly to the biological diversity of the network. This is particularly well illustrated at CRMO, where the small stands of aspen, fir, and limber pine on the extreme north end of the monument contain a large number of vertebrates that are found nowhere else in the monument. Forests and woodlands of the network also play key roles in ecological processes that are important to current park management, including conifer encroachment into cultural landscapes, juniper expansion into sagebrush steppe, fuel accumulation, and fire.

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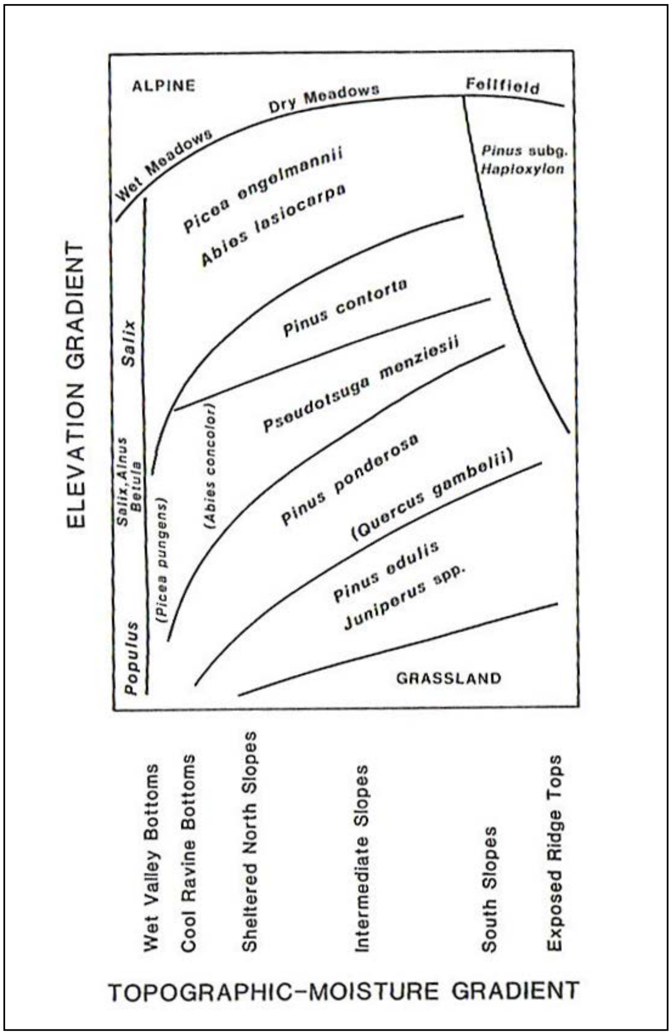
As is the case throughout the intermountain west, the forests and woodlands of the UCBN are disturbance driven ecosystems (Peet 2000). Fire is the most widespread and significant disturbance agent in the region, but insects, windthrow, floods, and various human activities are also important (Hessburg and Agee 2003, Long 2003). The ecology of distubance in our forests and woodlands is extremely complex and the developing science around this topic is in a state of flux and uncertainty (Simberloff 1999, Baker and Ehle 2001, Long 2003, Baker and Shinneman 2004). While this uncertainty creates an exciting and dynamic research environment, it poses a difficult challenge to UCBN managers. This situation underscores the need for long term monitoring (see Simberloff 1999) in the network, and it is hoped that the UCBN monitoring program will be able to generate information on the disturbance ecology of network forests that will be useful to managers.

Much of the current uncertainty surrounding disturbance in the forest systems of the intermountain west stems from the complexity of edaphic conditions and environmental gradients found there (Peet 2000, Long 2003). Across the region, latitude, elevation, topographic position, and parent material all strongly influence the distribution and the characteristics of forests and woodlands (Long 2003). Each of these factors are influential in the UCBN and the most influential, elevation and topography, occur along gradients that are the fundamental controls on where forests occur and on the types of disturbances that occur there (Peet 2000). Elevation itself influences precipitation, temperature, and other environmental variables crucial to plant distribution. In general, an increase in elevation leads to an increase in precipitation, solar radiation, and wind, and a decrease in temperature (Peet 2000). Topography, via slope and aspect, strongly influences soil moisture and temperature – a phenomenon frequently referred to as the “topographic moisture gradient” (Whittaker 1967, Peet 2000, Long 2003). The influence of these drivers on forest disturbances is profound and, given the elevational and topographic variability in the intermountain region, quite complex. Figure 21 illustrates the relationship between elevation and topographic moisture gradients. Of particular note in the figure is the diagonal orientation of the vegetation types, which tend to occur at increasing elevation as sites become drier.

Figure 21. The generalized relationship between elevation and topographic moisture gradients and their influence on the distribution of forest and woodland vegetation (from Peet 2000).

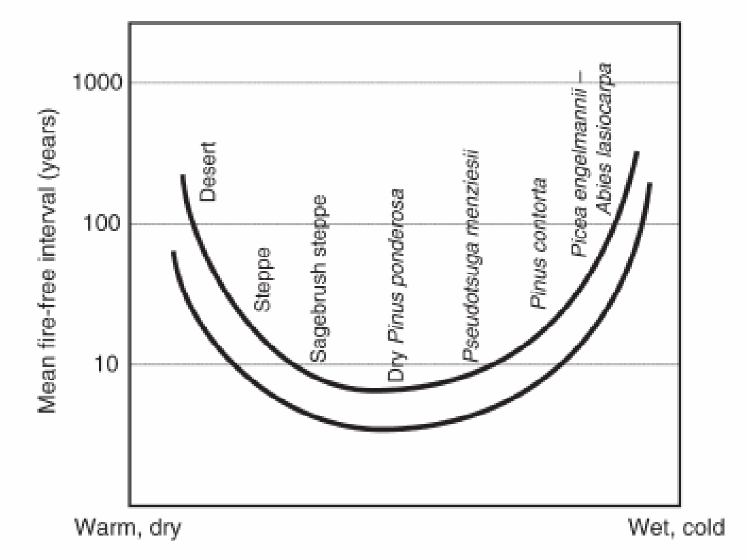


Elevation and topographic moisture gradients interact with synoptic climate patterns to strongly influence the frequency and severity of disturbances (Long 2003, Meyer and Pierce 2003). With fire disturbance in particular, these influences constrain vegetation type, fuel accumulation, soil moisture, and other site characteristics that determine fire regimes. Figures 23-27 highlight the importance of elevation, topography, climate, and disturbance regimes (i.e. frequency and severity) as key drivers in the forest and woodland ecosystems of the UCBN. These figures are designed to show linkages between these gradients, stressors, and vital signs.

As with the sagebrush-steppe ecosystems in the UCBN, both the presence and absence of fire is a central focus for the UCBN forests and woodlands conceptual models. These ecosystems developed under the influence of fire and are today all at some stage of succession resulting from fire (Peet 2000). Many of the management issues in the network, such as the density of pine stands at LARO and of juniper woodlands at JODA, are closely connected to historic patterns of fire frequency and intensity. In particular, fire absence has been identified as a major factor in the decline of forest health in the region (Tiedemann et al. 2000). Fire suppression and overgrazing have been attributed to an increase in stand density and fuel accumulations, making forests more susceptible to large, catastrophic fire and insect outbreaks (Johnson 1994, Tiedemann et al. 2000). Fire suppression is also attributed to declining rates of aspen regeneration and expansion of pinyon-juniper woodland into adjacent sagebrush-steppe (Miller and Rose 1999, Gedney et al. 1999, West and Young 2000, Rogers 2002).

Our understanding of fire suppression in UCBN forests and woodlands is framed by the generalized fire regimes that have been developed for Pacific Northwest forests (e.g. Martin and Sapsis 1991, Agee 1993). Figure 22 shows the relationship between fire frequency, topographic moisture, and forest vegetation that guides the research and management discourse on fire ecology in the region. In general, low elevation mesic sites dominated by ponderosa pine are believed to have experienced frequent low severity fires, while higher sites with increasing moisture as well as drier sites with slower rates of fine fuel accumulation typically experienced less frequent higher severity fires (Agee 1993, Peet 2000). In this context, severity refers to damage to crown structure, with the highest severity fires resulting in stand replacement (Long 2003). Accordingly, fire suppression has been most important in high frequency ponderosa pine systems in which several fire cycles have been skipped during the post-settlement era beginning in the late 19th century (Long 2003). A number of dendrochronology and fire-scar studies have demonstrated this altered fire regime in ponderosa pine forests of eastern Washington (e.g. Everett et al. 2000, Ohlson and Schellhaas unpublished). Increased stand density, increased presence of shade tolerant firs, insect pathogen infestation, and increased fire severity are some of the resulting changes in ecosystem structure and function (Peet 2000). Similar studies have shown fire suppression to be a factor in pinyon-juniper and aspen ecosystems, resulting in altered stand structure and function (e.g. Rust and Coulter 2000, Rogers 2002).

Figure 22. Fire frequency, elevation/topographic moisture gradients, and forest vegetation in the intermountain west (from Long 2003).



While the generalized reltaionships illustrated in Figure 22 remain the dominant paradigm for fire ecology in the west today, a number of investigators have questioned the universality of this paradigm and recent data have introduced an element of uncertainty into the discussion. For example, Baker and Ehle (2001) and Baker and Shinneman (2004) urge caution in the interpretation of fire-scar studies in ponderosa pine and juniper systems and suggest that fire frequencies in these systems may have been much longer than currently believed. Whitlock et al. (2003), Meyer and Pierce (2003), and Soulé et al. (2004) show that periods of increased and decreased fire activity in northwest forests and woodlands correspond to global warming and cooling trends and that anthropogenic suppression, while an important factor, may be less so than previously believed. Grappling with these issues of uncertainty will be important in the UCBN because of their implications for NPS policy and management. Today there is great interest in using an understanding of historic disturbance regimes to design ecosystem management (e.g. Wallin et al. 1996, Cissel et al. 1999, Franklin et al. 2002), however the historic picture is still emerging, many questions remain unanswered, and conservative management approaches and accompanying monitoring are recommended (Simberloff 1999, Tiedemann et al. 2000).

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The following sections present conceptual models and brief narratives highlighting specific aspects of UCBN forest and woodland ecosystems, including stressors and potential vital signs. The models focus on altered fire regimes and are constructed with the explicit recognition that contemporary UCBN forest and woodlands developed upon a complex legacy of historic disturbance and a mosaic of biophysical characteristics that are not fully understood. We expect that these models will change as more site specific information is gathered from UCBN systems and as generalized regional information becomes more available. Figure 23 illustrates the importance of the topographic-moisture gradient on forest community development, and highlights the role of

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Fire, insects, and management response in shaping current and future forest ecosystems. Historic grazing and suppression are highlighted for their role in removing fine fuels and reducing fire frequency during the 20th century. Figure 24 presents a generalized description of the influence of alternating wet and dry climatic cycles on forest fire regimes in the Pacific Northwest. This model is designed to be particularly useful as a reference for the UCBN Science Advisory Committee during additional conceptual framework development for forest community monitoring within the context of past and future climate change. Figures 25-27 highlight pathways between altered fire regimes and vital signs in ponderosa pine, pinyon-juniper, and aspen ecosystems.

B. Forest and Woodland Conceptual Models

Figure 23. The forest and woodland ecosystem control model.

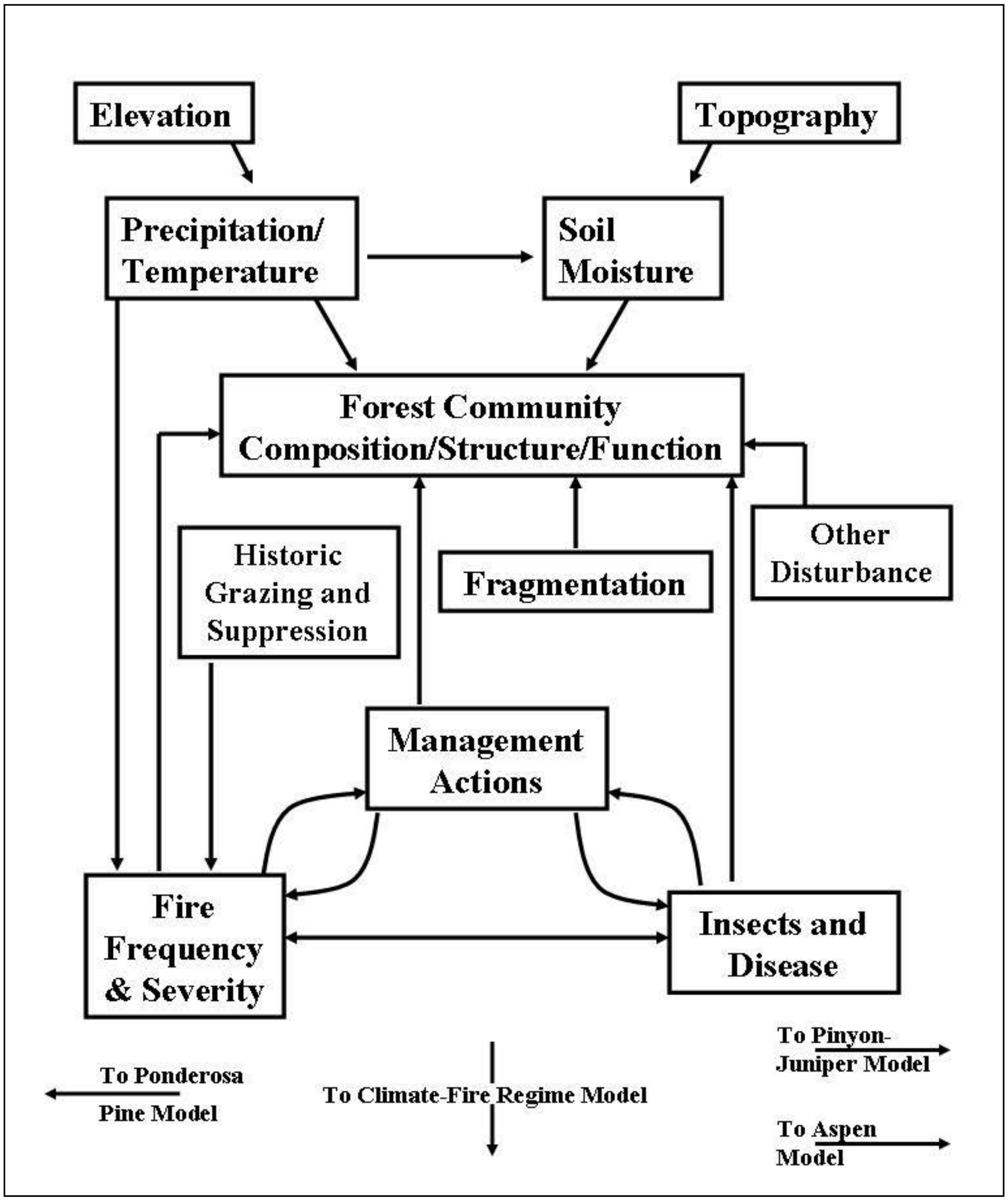


Figure 24. The climate/fire-regime interaction conceptual model. This model presents generalized relationships between climatic fluctuations and changing fire regimes.

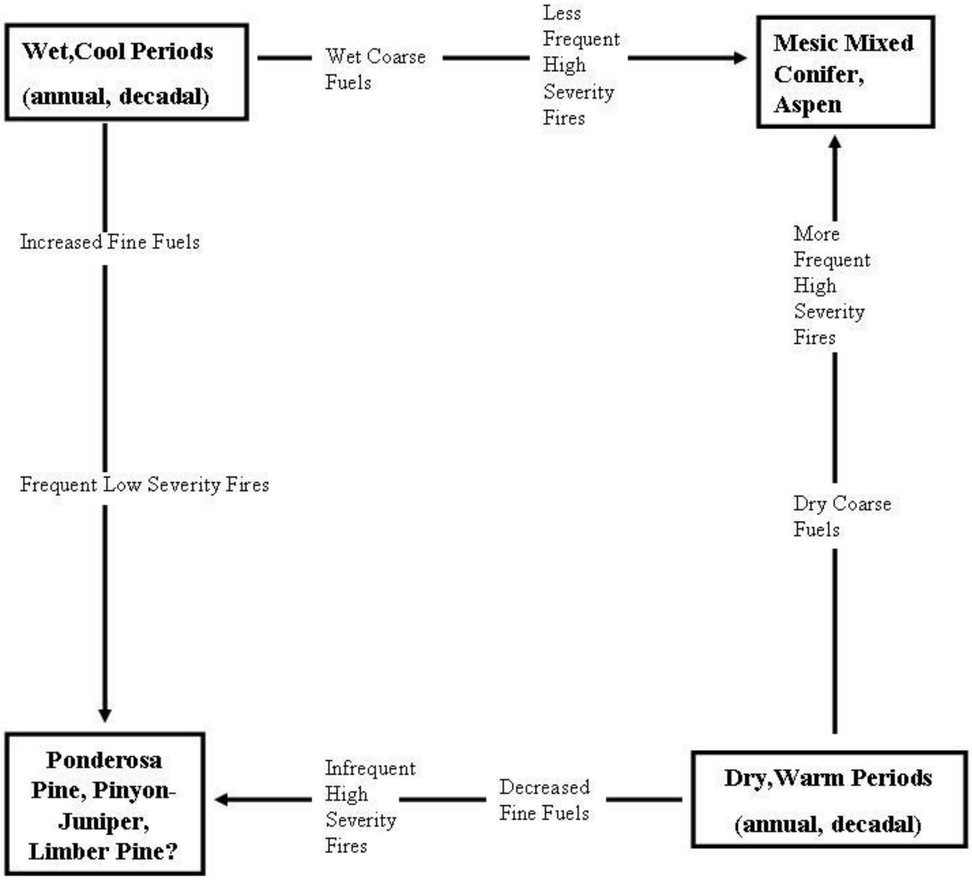


Figure 25. The ponderosa pine altered fire-regime conceptual model. Vital signs are highlighted in gray.

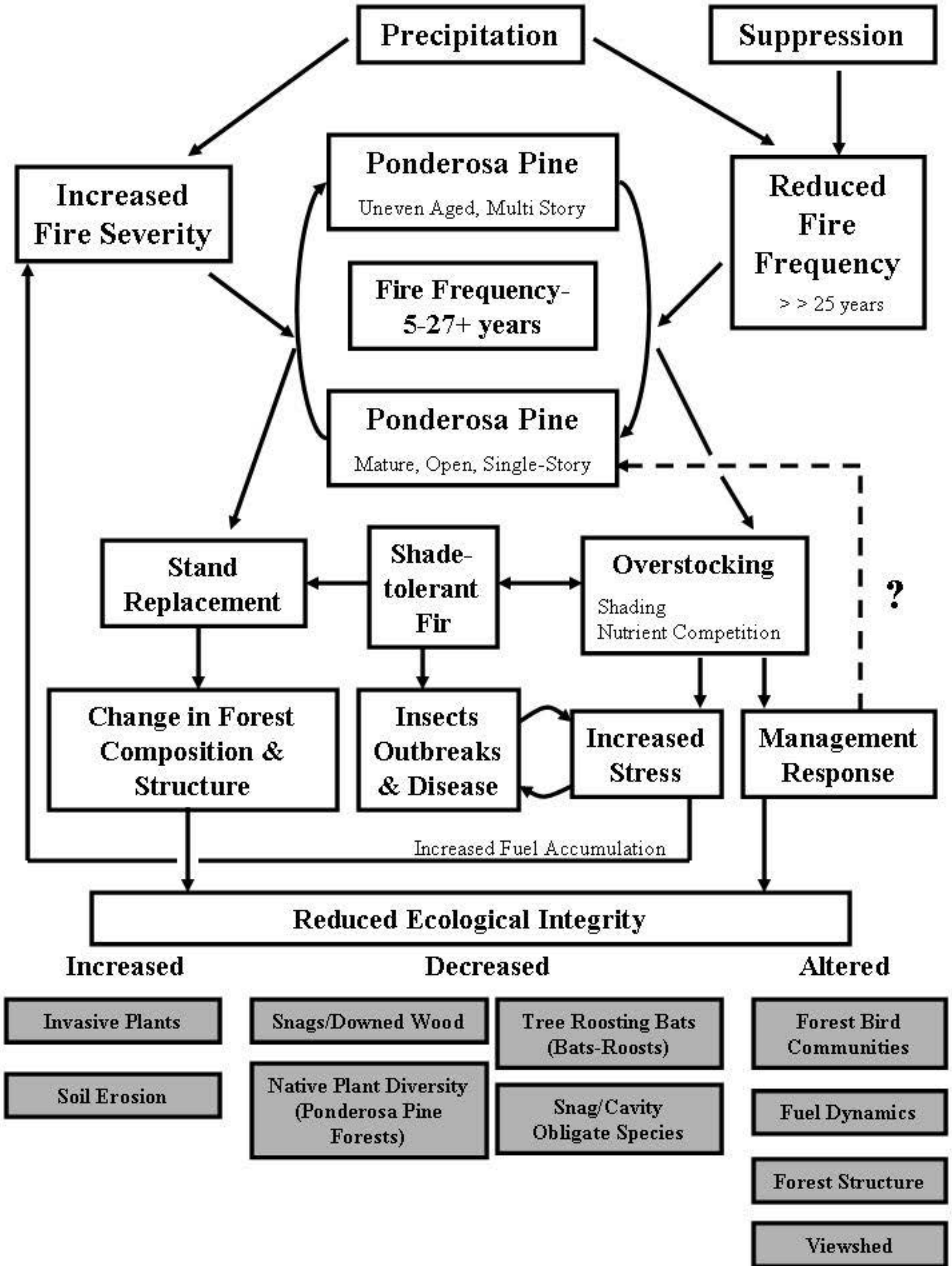


Figure 26. The pinyon-juniper altered fire-regime conceptual model. Vital signs are highlighted in gray.

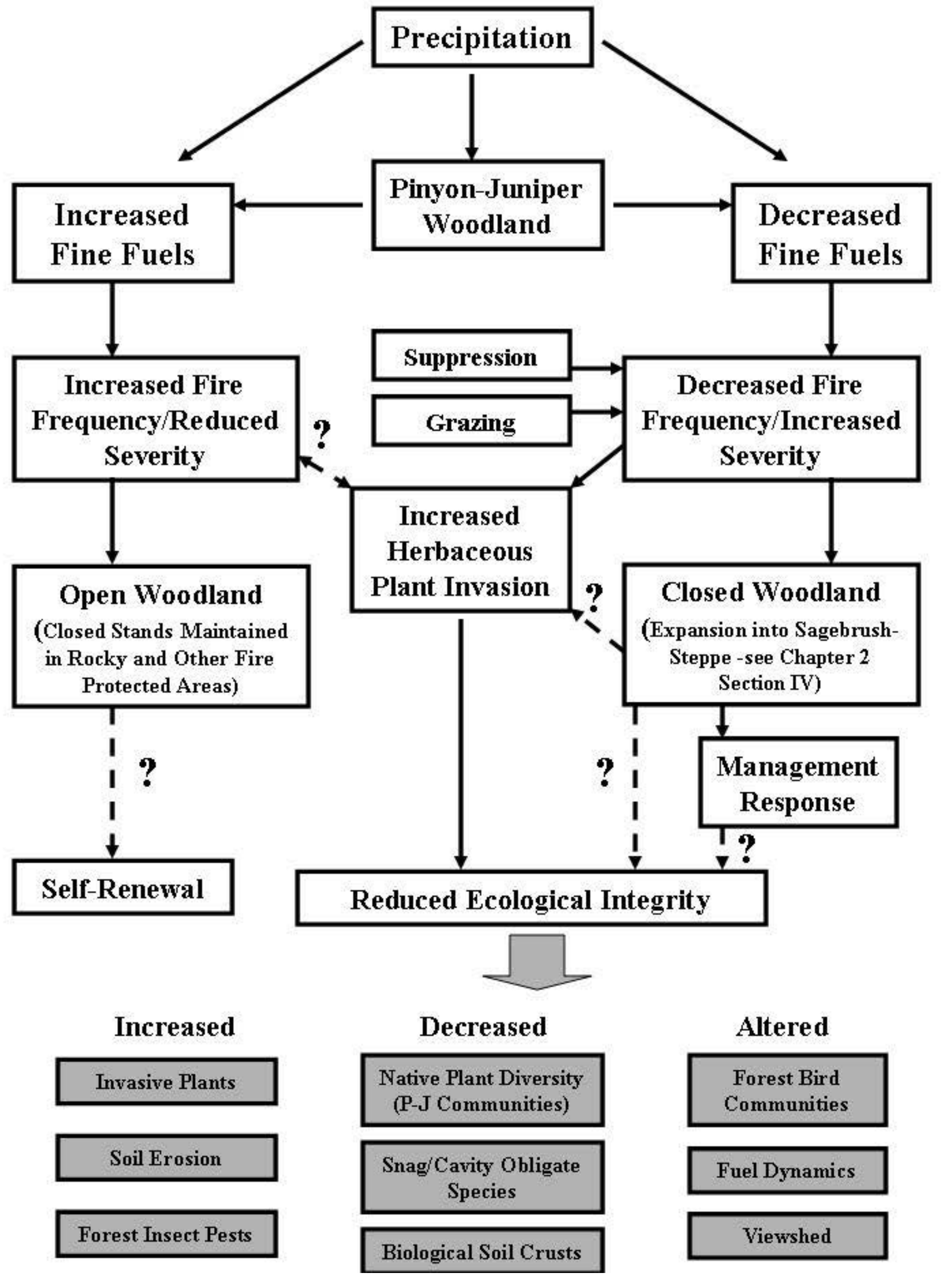
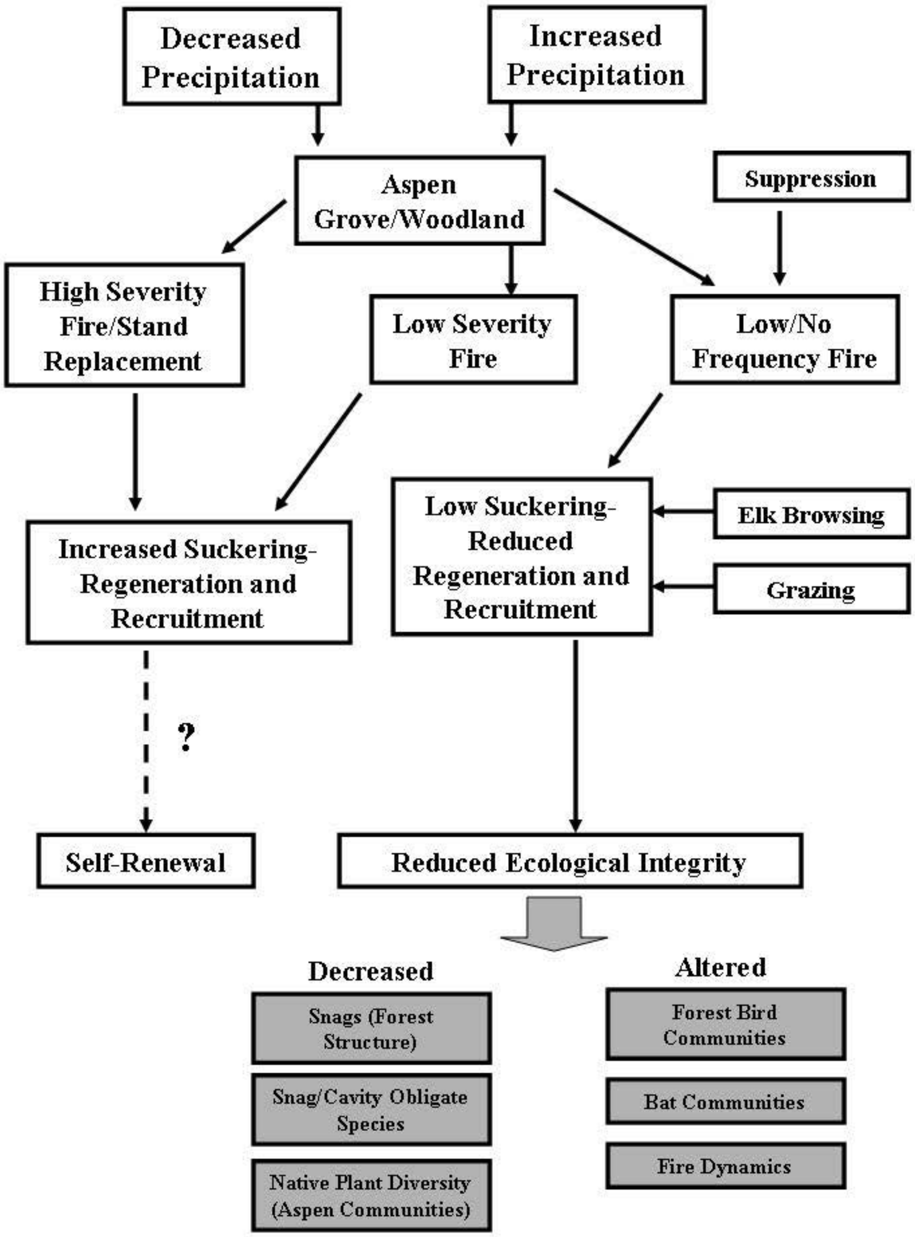


Figure 27. The aspen woodland altered fire-regime conceptual model. Vital signs are highlighted in gray.



C. Ponderosa Pine

Ponderosa pine forests are primarily found in LARO and represent the majority of the vegetation in the northern half of the recreation area. The area was heavily logged in the past and today very few stands exist that exhibit old-growth structural characteristics. Today, LARO management is focused on reducing fuel loads through mechanical thinning and prescribed fire. Dendrochronology and fire scar studies from northeastern Washington indicate that ponderosa pine forests in the region exhibited “classic” high frequency, low severity fire regimes and that these forests consisted of large, mature trees with an understory of perennial grasses and forbs (Everett et al. 2000, Ohlson and Schellhaas unpublished). Much of this habitat has been converted through logging to young even-aged stands of “black bark” pine. Fire suppression has also dramatically altered the structure of these forests. Ohlson and Schellhaas report that in the Okanagan National Forest, northwest of LARO, ponderosa pine forests were almost twice as dense as historic conditions and that the western larch, a unique and important component to the forests of northeastern Washington, has declined significantly during the last 100 years. This report is consistent with Hessburg et al. (2000) that reported significant declines in the interior Columbia Basin during the 20th century of old-growth structural characteristics, increases in shade-tolerant firs, as well as increasing fragmentation of remaining forests. They also reported that forest stands across the basin exhibited an overall condition of vulnerability to insect outbreak and catastrophic, stand replacing fires. Forest management practices in LARO are currently focused on reducing these threats.

The ponderosa pine conceptual model, Figure 25, illustrates the altered fire regime condition that is widespread in LARO forests and show the linkages between altered fire regime and various management responses, primarily those of thinning and prescribed fire. These two activities constitute the most significant anthropogenic stressors of the ponderosa pine ecosystem in LARO today. Long-term monitoring will be important to track ecosystem response to forest management practices, as well as response to stand-replacing fires, should they occur. Potential stressor-induced effects stemming from LARO forest management include soil compaction and erosion, loss of snags and downed wood, and increased invasive weeds. A number of potential vital signs and monitoring objectives have been identified by the UCBN science advisory committee for the ponderosa pine ecosystem at LARO that focus on the effects resulting from altered forest structure and function and management response (see Figure 25 and Appendix M). These include: invasive plants, soil erosion, forest bird communities, snag/cavity obligate species, ponderosa pine communities (native plants diversity), bat roosts and communities, forest structure, surface water dynamics, fire control, fuel dynamics and landscape fragmentation and connectivity. Ponderosa pine is also an ozone-sensitive plant species and the question of ozone damage may evolve into an area of interest for the UCBN monitoring program (Porter 2003).

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D. Pinyon-Juniper Woodland

Pinyon-juniper woodland occurs in CIRO, JODA, and CRMO. This ecosystem type presents difficult conceptual and management challenges for the UCBN because of the uncertain science surrounding its disturbance ecology (e.g. Soulé et al. 1994, Belsky 1996). Also, pinyon-juniper woodland is a unique and important vegetation type that contributes to the biological diversity of

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the network but is also expanding into sagebrush-steppe, a phenomenon considered to be adversely affecting the ecological integrity of steppe ecosystems (Gedney et al. 1999, Miller and Rose 1999).

Fundamental differences exist in the composition and function of pinyon-juiper in each of the 3 UCBN parks. At JODA, western juniper woodlands occur. These woodland communities have exhibited a dramatic shift in distribution during the 20th century, having expanded out of fire-protected draws and rims onto deeper soiled areas (Gedney et al. 1999, Miller and Rose 1999). Management at JODA is very concerned with this expansion and is actively pursuing control options through prescribed fire and selective cutting. However, the western juniper woodlands of eastern Oregon provide unique habitat value for frugivorous birds as well as unique mammals such as the pinyon mouse, and the historical benchmark of pre-expansion conditions are not adequately defined (Miller and Rose 1999, Baker and Shinneman 2004, Soulé et al. 2004). More importantly, the control of juniper, especially through use of prescribed fire, is problematic because it often leads to dramatic increases in noxious weeds (D'Antonio 2000, Bureau of Land Management 2002).

At CIRO, pinyon pine, rocky mountain and Utah junipers co-occur and represent a very unique habitat type for Idaho (Rust and Coulter 2000). Utah juniper reaches its most northerly distribution there and several Great Basin vertebrates, inclding the pinyon mouse, cliff chipmunk, and ringtail also are at the northern limits of their distribution there. While there may be some evidence for woodland expansion down into sagebrush flats at CIRO, it is much less of a concern than at JODA. At CRMO too, juniper expansion is of little or no ecological or management concern, as the type, dominated by rocky mountain juniper, occurs as scattered trees across the broken lava flows, and represents a relatively minor component of the overall landscape. Rust and Coulter (2000) suggest that some pinyon-juniper woodlands in southern Idaho may still be within historical ranges of variability for fire intervals, and this is probably the case at CIRO and CRMO. A much more pressing concern for the pinyon-juniper woodlands of southern Idaho parks in the UCBN is the new and emerging threat of *Ips confusus* bark beetle infection that was identified in approximately 30% of CIRO's pinyon pine stands in 2004. Further investigations are planned for 2005, and this will be monitored in the future.

Because of the differences in composition and function as well as with management concerns in pinyon-juniper at each of the parks, it is challenging to develop an entirely satisfactory generalized conceptual model. Figure 26 most adequately reflects the situation at JODA, and, perhaps because there are less understood direct stressors and effects, is less informative for CIRO and CRMO. It is not clear whether fire and stand density are related to the *Ips* outbreak at CIRO. Figure 26 illustrates the relationship between precipitation and fine fuel production, between grazing and fire suppression and reduced fire frequency, and between altered fire regime (especially increased intensity) and increased plant invasion. While the juniper woodlands of JODA clearly express these relationships, they are not as clear in the woodlands of CIRO and CRMO (Miller and Rose 1999, Rust and Coulter 2000). Nonetheless, a number of potential vital signs and monitoring objectives have been proposed and would apply across all 3 parks and include: invasive plants, pinyon-juniper communities (vegetation), forest bird communities, small mammals, soil erosion, altered hydrology, and altered stream morphology. For JODA, there is also interest in monitoring the effects of prescribed fire and mechanical thinning on the juniper woodlands there. In both CIRO and JODA, pinyon-juniper woodlands host several peripheral vertebrate species that are of interest to monitor in order to track expanding and/or contracting distributions, including the pinyon mouse, ringtail, and northern mockingbird.

E. Limber Pine

Limber pine occurs on Graham Peak in CIRO but is most significant at CRMO, where it occurs in many, isolated small stands in the northern portion of CRMO. This species is considered a relict by some investigators but this is not entirely clear (Schuster et al. 1995). Limber pine forms rather monotypic stands along the rocky exposed soils on north facing slopes of cinder cones and other volcanic features in CRMO. The patchy distribution of limber pine reflects its physiological requirements and its dependence on Clark's nutcrackers, red squirrels, and other vertebrates for seed dispersal (Schuster et al. 1995). Limber pine stands in CRMO represent a unique and important component of biodiversity in the network. The primary threats to limber pine include those from insect and disease pathogens and climate change (Long 2003). Limber pine ecosystems in CRMO are probably not adversely affected by fire suppression, harvest, or other management-type stressors. White-pine blister rust and needle-cast are the two pathogenic threats that have caused considerable mortality among populations of 5-needle pines in general, and specifically in limber pine populations in Montana and Colorado (Jackson and Lockman 2003). To date, outbreaks have not occurred in CRMO limber pine stands, but may do so in the future. Global warming has been identified as a potential cause of increased outbreaks in the future (Logan and Powell 2001).

F. Douglas-fir, Mixed Fir, and Lodgepole Pine

The mesic mixed fir and pine forests of BIHO, CIRO, CRMO, and LARO occur only in small portions of the network but do provide unique habitat value, especially in CRMO, where the isolated pocket of Douglas-fir along the northern boundary supports nesting golden eagles and provides other important ecological services. At LARO, Douglas fir occurs in wetter portions of the forested regions of the northern half of the monument. Nowhere is it widespread in LARO and conceptually it is adequately included in the discussion on ponderosa pine above. At BIHO, lodgepole pine forest is contiguous with the much larger forest community of the adjacent Beaverhead Mountains. Succession of these trees into the battlefield meadow complex is of concern to the park (see Chapter 2 section III). Fire suppression and altered fire regimes have probably affected encroachment, although the meadow was likely maintained with prescribed fire for camas harvesting by the Nez Perce. However, the forests themselves have been less affected by fire suppression since this more mesic ecosystem experiences relatively infrequent, high severity fires (Agee 1993, Peet 2000).

G. Aspen

Aspen groves occur in isolated stands in CIRO, CRMO, BIHO, and LARO. These woodlands provide important habitat values and support cavity nesting birds and other vertebrates that would not remain in the parks in the absence of aspen (e.g. Lawler and Edwards 2002, Griffis-Kyle and Beier 2003, Parsons et al. 2003). Aspen is a particularly important resource for cavity nesting birds and bats because of the structural characteristics that form in mature stands (Parsons et al. 2003). Marked declines in aspen have been noted throughout the intermountain west and been the subject of much debate (Peet 2000). Fire suppression has been identified as the most widespread proximal factor, but elk browsing and domestic cattle grazing has also been recognized (Rogers 2002, Larsen and Ripple 2003). Figure 27 illustrates the relationship between reduced fire, browsing, and grazing on declining rates of regeneration in aspen stands. Like many of the systems in the UCBN, the actual relationships have not been investigated for aspen stands in the UCBN, but investigations are planned for 2005 in CIRO and CRMO. What is clear for the UCBN is the importanc of aspen to biodiversity and the suite of vital signs proposed for aspen woodlands reflect this focus (see figure 27). Aspen has also been identified as a bioindicator for ozone injury and this may be included in the UCBN monitoring program (Porter 2003).

H. Riparian Woodland

Riparian woodlands in the network consist primarily of cottonwood galleries that are characterized by scattered large, structurally diverse cottonwoods that sometimes co-occur with dense stands of willows. These cottonwood stands are present and significant at WHMI, supporting rookeries of black-crowned night herons and great blue herons, along with numerous species of insectivorous passerines. They are also present at BIHO, NEPE, CRMO, and HAFO. At JODA, a unique wooded riparian habitat occurs along Rock Creek that consists of mountain alder. Throughout the region, these riparian woodlands have declined due to grazing, altered hydrology and stream morphology, and other anthropogenic causes (USDA Forest Service 1996). These ecosystems are typically not subject to fire disturbance but have evolved within the context of floods and exhibit dispersal mechanisms and other characteristics well adapted to this type of disturbance (Knopf et al. 1988, Naiman et al. 2000). Typical of riparian areas in semi-arid biomes, the riparian woodlands of the network provide extremely valuable habitat for many species of vertebrates and invertebrates (Knopf et al. 1988, Knopf and Samson 1994). They also provide important ecological services, including flood control and bank stability (Knopf et al. 1988). A number of vital signs have been proposed that apply to riparian woodlands including snag/cavity obligate species, bats (roosts and communities), wetland/riparian bird communities, wetland/riparian communities, invasive plants, and water quality.

VI. Riparian and Wetland Ecosystem

Under Development – Tentative completion date January 2005

VII. Aquatic Resources

Under Development – Tentative completion date January 2005

Chapter 3. Prioritization and Selection of Vital Signs
Chapter 4. Sampling Design
Chapter 5. Sampling Protocols
Chapter 6. Data Management
Chapter 7. Data Analysis and Reporting
Chapter 8. Administration/Implementation of the Monitoring Program
Chapter 9. Schedule
Chapter 10. Budget

Chapter 11. Literature Cited

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Glossary of Terms Used by the NPS Inventory and Monitoring Program

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

Ecological integrity is a concept that expresses the degree to which the physical, chemical, and biological components (including composition, structure, and process) of an ecosystem and their relationships are present, functioning, and capable of self-renewal. Ecological integrity implies the presence of appropriate species, populations and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes.

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

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

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

Focal resources are park resources that, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring regardless of current threats or whether they would be monitored as an indication of ecosystem integrity. Focal resources might include ecological processes such as deposition rates of nitrates and sulfates in certain parks, or they may be a species that is harvested, endemic, alien, or has protected status.

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

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

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

Vital Signs, as used by the National Park Service, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).