National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Upper Columbia Basin Network
Vital Signs Monitoring Plan Appendixes

Natural Resource Report NPS/UCBN/NRR-2007/002







ON THE COVER

Seven of the 14 UCBN Vital Signs: Sagebrush-steppe, sage grouse, camas lily, aspen, invasive/exotic species, water quality, and bats.

NPS Photos.

Upper Columbia Basin Network
Vital Signs Monitoring Plan

Natural Resource Report NPS/UCBN/NRR—2007/002

Lisa K. Garrett
National Park Service, Upper Columbia Basin Network
University of Idaho, Department of Fish and Wildlife
Moscow, ID 83844-1136

Thomas J. Rodhouse
National Park Service, Upper Columbia Basin Network
Central Oregon Community College
2600 NW College Way - Ponderosa Building
Bend, OR 97701-5998

Gordon H. Dicus
National Park Service, Upper Columbia Basin Network
University of Idaho, Department of Fish and Wildlife
Moscow, ID 83844-1136

Christopher C. Caudill, Ph.D.
University of Idaho, Department of Fish and Wildlife
Moscow, ID 83844-1136

Mackenzie R. Shardlow
University of Idaho, Department of Fish and Wildlife
Moscow, ID 83844-1136

July 2007

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

Natural Resource Reports are the designated medium for disseminating high priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability. Examples of the diverse array of reports published in this series include vital signs monitoring plans; "how to" resource management papers; proceedings of resource management workshops or conferences; annual reports of resource programs or divisions of the Natural Resource Program Center; resource action plans; fact sheets; and regularly-published newsletters.

Printed copies of reports in these series may be produced in a limited quantity and they are only available as long as the supply lasts. This report is also available from the Upper Columbia Basin I&M Network website (http://www.nature.nps.gov/im/units/ucbn/) on the internet, or by sending a request to the address on the back cover.

Please cite this publication as:

Garrett, L. K., T. J. Rodhouse, G. H. Dicus, C. C. Caudill, and M. R. Shardlow. 2007. Upper Columbia Basin Network vital signs monitoring plan. Natural Resource Report NPS/UCBN/NRR—2007/002. National Park Service, Fort Collins, Colorado.

NPS D-025, July 2007

Appendixes
Contents

Page

Appendix A
Legislation and Policy

Appendix A.1. Summary of Federal Legislation and Policy Related to Inventory and Monitoring

Public Laws	Significance to Inventory and Monitoring
National Park Service Organic Act (16 USC 1 et seq. [1988], Aug. 25, 1916).	The 1916 National Park Service Organic Act is the core of park service authority and the definitive statement of the purposes of the parks and of the NPS mission. The act establishes the purpose of national parks: "…. To conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."
General Authorities Act of 1970 (16 USC 1a-1-1a-8 (1988), 84 Stat. 825, Pub. L. 91-383)	The General Authorities Act amends the Organic Act to unite individual parks into the 'National Park System'. The act states that areas of the National Park System, "though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage; that individually and collectively, these areas derive increased national dignity and recognition of their superb environmental quality through their inclusion jointly with each other in one national park system preserved and managed for the benefit and inspiration of all the people of the United States…"
National Parks Omnibus Management Act, 1998 (P.L. 105-391)	Requires Secretary of Interior to continually improve NPS' ability to provide state-of-the-art management, protection, and research on NPS resources. Section 5939 states that the purpose of legislation is to: (1) Enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; (2) Ensure appropriate documentation of resource conditions in the National Park System; (3) Encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value; and (4) Encourage the publication and dissemination of information derived from studies in the NPS.
National Historic Preservation Act (NHPA) of 1966, as amended (16 USC 470 et seq.)	The NHPA preserves the historical and cultural foundations of the Nation and irreplaceable examples important to our national heritage to maintain 'cultural, educational, aesthetic, inspirational, economic, and energy benefits.' NHPA established the National Register of Historic Places composed of places and objects 'significant in American history, architecture, archeology, engineering, and culture.' NHPA requires federal agencies to account for effects of actions on historic (state and federal) properties.

Public Laws	Significance to Inventory and Monitoring
National Environmental Policy Act (NEPA) of 1969 (42 USC 4321-4370)	The purposes of NEPA include encouraging 'harmony between [humans] and their environment and promote efforts which will prevent or eliminate damage to the environment… and stimulate the health and welfare of [humanity].' NEPA requires a systematic analysis of major federal actions that includes a consideration of all reasonable alternatives as well as an analysis of short-term and long-term, irretrievable, irreversible, and unavoidable impacts. Within NEPA the environment includes natural, historical, cultural, and human dimensions. Within the NPS emphasis is on minimizing negative impacts and preventing "impairment" of park resources as described and interpreted in the NPS Organic Act. The results of evaluations conducted under NEPA are presented to the public, federal agencies, and public officials in document format (e.g. EAs and EISs) for consideration prior to taking official action or making official decisions.
Clean Water Act (33 USC 1251-1376)	The Clean Water Act, passed in 1972 as amendments to the Federal Water Pollution Control Act, and significantly amended in 1977 and 1987, was designed to restore and maintain the integrity of the nation's water. It furthers the objectives of restoring and maintaining the chemical, physical and biological integrity of the nation's waters and of eliminating the discharge of pollutants into navigable waters by 1985. Establishes effluent limitation for new and existing industrial discharge into US waters. Provides an enforcement procedure for water pollution abatement. Requires conformance to permit required under S404 for actions that may result in discharge of dredged or fill material into a tributary to, wetland, or associated water source for a navigable river.
Clean Air Act (42 USC 7401-7671q, as amended in 1990)	Establishes a nationwide program for the prevention and control of air pollution and establishes National Ambient Air Quality Standards. Under the Prevention of Significant Deterioration provisions, the Act requires federal officials responsible for the management of Class I Areas (some national parks and wilderness areas) to protect the air quality related values of each area and to consult with permitting authorities regarding possible adverse impacts from new or modified emitting facilities. Establishes specific programs that provide special protection for air resources and air quality related values associated with NPS units. The EPA has been charged with implementing this act.
Federal Advisory Committee Act (FACA)	Creates a formal process for federal agencies to seek advice and assistance from citizens. Any council, panel, conference, task force or similar group used by federal officials to obtain consensus advice or recommendations on issues or policies fall under the purview of FACA.

Public Laws	Significance to Inventory and Monitoring
Endangered Species Act of 1973, as amended (ESA) (16 USC 1531-1544)	The purposes of the ESA include providing "a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved. According to the ESA 'all federal departments and agencies shall seek to conserve endangered species and threatened species ' and '[e]ach federal agency shall…insure that any action authorized, funded, or carried out by such agency…is not likely to jeopardize the continued existence of any endangered species or threatened species.' The effects of any agency action that may affect endangered, threatened, or proposed species must be evaluated in consultation with either the USFWS (non-marine species) or the National Marine Fisheries Service (all marine species) as appropriate.
Wilderness Act of 1964 (16 USC 1131 et seq.)	Establishes the National Wilderness Preservation System. Wilderness Areas designated by Congress are made of existing federal lands that have retained a wilderness character and meet the criteria found in the act. Federal officials are required to manage Wilderness Areas in a manner conducive to retention of their wilderness character and must consider the effect upon wilderness attributes from management activities on adjacent lands.
Government Performance and Results Act (GPRA)	Requires the NPS to set goals (strategic and annual performance plans) and report results (annual performance reports). The NPS Strategic Plan contains four GPRA goal categories: park resources, park visitors, external partnership programs, and organizational effectiveness all focused on measurable outcomes.
Other Related Public Laws and Executive Orders	Redwood National Park Act (16 USC 79a-79q (1988), 82 Stat. 931, Pub. L. 90-545; Environmental Quality Improvement Act of 1970 (42 U.S.C. 56 § 4371); Off-Road Vehicle Use (Executive Orders 11644 and 11989); Floodplain Management (Executive Order 11988); Protection of Wetlands (Executive Order 11990); and Executive Order 13112 on Invasive Species.
NPS Management Policies – 2001 (NPS Directives System)	This is the basic NPS servicewide policy document. The Directives System is designed to provide NPS management and staffs with clear and continuously updated information on NPS policy and required and/or recommended actions, as well as any other information that will help them manage parks and programs effectively.

Public Laws	Significance to Inventory and Monitoring
NPS Directors Orders	Directors Orders serve a vehicle to clarify or supplement *Management Policies* to meet the needs of NPS managers. Relevant Directors Orders: DO-2.1 Resource Management Planning DO-12 Environmental Impact Assessment DO-14 Resource Damage Assessment & Restoration DO-24 Museum Collections Management DO-41 Wilderness Preservation & Management DO-47 Sound Preservation & Noise Management DO-77 Natural Resource Protection
NPS Handbooks and Reference Manuals	These documents are issued by Associate Directors and provide NPS field employees with a compilation of legal references, operating policies, standards, procedures, general information, recommendations and examples to assist them in carrying out *Management Policies* and Director's Orders. Level 3 documents may not impose any new service-wide requirements, unless the Director has specifically authorized them to do so. Relevant Handbooks and Reference Manuals: NPS-75 Natural Resources Inventory & Monitoring NPS-77 Natural Resources Management Guidelines NPS Guide to Fed. Advisory Committee Act Website: Monitoring Natural Resources in our National Parks, http://www.nature.nps.gov/im/monitor

Appendix A.2. Designation of National Park System Units

The numerous designations within the National Park System sometime confuse visitors. The names are created in the Congressional legislation authorizing the sites or by the president, who proclaims "*national monuments*" under the Antiquities Act of 1906. Many names are descriptive -- lakeshores, seashores, battlefields --but others cannot be neatly categorized because of the diversity of resources within them. In 1970, Congress elaborated on the 1916 National Park Service Organic Act, saying all units of the system have equal legal standing in a national system.

National Monument
The Antiquities Act of 1906 authorized the President to declare by public proclamation landmarks, structures, and other objects of historic or scientific interest situated on lands owned or controlled by the government to be national monuments (Craters of the Moon NM and Preserve, Hagerman Fossil Beds NM, John Day Fossil Beds, Minidoka Internment NM).

National Preserve
National preserves are areas having characteristics associated with national parks, but in which Congress has permitted continued public hunting, trapping, oil/gas exploration and extraction. Many existing national preserves, without sport hunting, would qualify for national park designation (Craters of the Moon NM and Preserve).

National Historic Site
Usually, a national historic site contains a single historical feature that was directly associated with its subject. Derived from the Historic Sites Act of 1935, a number of historic sites were established by secretaries of the Interior, but most have been authorized by acts of Congress (Whitman Mission NHS).

National Historical Park
This designation generally applies to historic parks that extend beyond single properties or buildings (Nez Perce NHP).

National Battlefield
This general title includes national battlefield, national battlefield park, national battlefield site, and national military park. In 1958, an NPS committee recommended national battlefield as the single title for all such park lands (Big Hole NB).

National Recreation Area
Twelve National Recreation Areas (NRAs) in the system are centered on large reservoirs and emphasize water-based recreation. Five other NRAs are located near major population centers. Such urban parks combine scarce open spaces with the preservation

of significant historic resources and important natural areas in location that can provide outdoor recreation for large numbers of people (Lake Roosevelt NRA).

National Reserve
This unit of the National Park System is managed cooperatively by the NPS and the Idaho Department of Parks and Recreation (City of Rocks NR).

Appendix A.3. Resource Management and General Management Plan Summaries

Note: This information was assembled from various UCBN 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.

Big Hole National Battlefield
Source: NEPE/BIHO General Management Plan 1997

Big Hole National Battlefield	• Facilitate protection and offer interpretation of Nez Perce sites in Idaho, Oregon, Washington, Montana, and Wyoming that have exceptional value in commemorating the history of the United States. • Preserve and protect tangible resources that document the history of the Nez Perce peoples and the significant role of the Nez Perce in North American history. • Interpret the culture and history of the Nez Perce peoples and promote documentation to enhance that interpretation.	Purpose

City of Rocks National Reserve
Source: CIRO Resource Management Plan 1994

City of Rocks National Reserve	• To preserve, protect, and interpret the resources and significant values that contribute to City of Rocks' uniqueness and attractiveness. • To manage recreation to ensure preservation and protection of these resource values.	Purpose
	• Identify, inventory, evaluate, protect, and preserve the resources related to the California Trail. • Strive to preserve and restore natural resources. • Balance ecological relationships and processes with uses in the reserve. • Maintain natural conditions as much as possible. • Determine the location of and protect the important habitat used by rare species and species sensitive to human uses. • Protect air quality at the highest level possible under the Clean Air Act by working cooperatively with the state of Idaho to redesignate the area from Class II to Class I. • Conserve natural hydrologic processes, including subsurface hydrology and control the acceleration of erosion due to human activities to preserve natural, cultural, and scenic resources. • Protect or restore wetlands and riparian areas by managing their use wherever possible. • Complete a comprehensive inventory of natural resources in the reserve.	Management Objectives

Craters of the Moon National Monument and Preserve
Source: CRMO Strategic Plan 2000-2005 and 1988 Statement for Management

Craters of the Moon National Monument and Preserve	The purpose of Craters of the Moon National Monument is to preserve and protect the remarkable geologic features, wilderness solitude, and natural systems that have shaped, and continue to shape the landscape of the Great Rift region of the Snake River plain.	Purpose
	• To preserve to the greatest extent possible the basaltic volcanism features of the monument through effective interpretation and protection programs. • To perpetuate the natural ecosystems of the monument through active and effective resource management programs. • To preserve visibility and associated vistas and to prevent deterioration of the airshed and all air quality related values. • To promote a continuing program of scientific research and study to gather information that will allow for long-term wildlife management programs. • To work on a cooperative basis with other government agencies, primarily the Bureau of Land Management, in matters of mutual concern such as the effect of stock grazing in the vicinity of the monument. • To establish objective policy and guidelines (backcountry management plan) that will ensure a strong and definite commitment by park management to the preservation of the monument's wilderness.	Management Objectives

Hagerman Fossil Beds National Monument
Source: HAFO General Management Plan 1996

Hagerman Fossil Beds National Monument	• To preserve for the benefit and enjoyment of present and future generations the outstanding paleontological sites known as the Hagerman Valley fossil sites.	Purpose
	• Preserve and protect the paleontological resources of the Hagerman Valley fossil sites, including both specimens and their context. • Encourage and support scientific research and related activities associated with monument resources and the science of paleontology. • Preserve, protect, and interpret the natural and cultural resources associated with the monument. • Cooperatively manage hunting and fishing in the monument to ensure the continuance of this historic use as legislatively required, while protecting monument resources, values, public safety, research, and other authorized activities. • Cooperate with the operation, maintenance, repair, upgrade, and modification of existing electrical and irrigation facilities within the boundaries of the monument as legislatively required while minimizing any adverse impacts of these activities on monument resources, values, research, or visitors.	Management Goals

John Day Fossil Beds National Monument
Source: JODA Resource Management Plan 1999

John Day Fossil Beds National Monument	• Establishment of the monument is intended to preserve, protect, and interpret the extensive tertiary fossils found in the geologic formations of these areas.	Purpose
	• Encourage resource-compatible activities or scientific investigations of the monument, which results in obtaining and sharing knowledge of the paleontological, geologic, and ecological scientific study of the region. • In areas designated as "natural zones", maintain or restore indigenous flora, fauna, and natural communities to achieve species diversity and community structure equivalent to pre-European settlement conditions. • Identify, determine the significance of, and protect the monument's natural and cultural resources.	Management Goals

Lake Roosevelt National Recreation Area
Source: LARO Fire Management Plan 2000

Lake Roosevelt National Recreation Area	• Provide opportunities for diverse, safe, quality, outdoor recreation experiences for the public. • Preserve, conserve, and protect the integrity of natural, cultural, and scenic resources. • Provide opportunities to enhance public appreciation and understanding about the area's significant resources.	Purpose

Minidoka Internment National Monument
Source: MIIN Draft Management Plan 2004

Minidoka Internment National Monument	• The purpose of the Minidoka Internment National Monument is to provide opportunities for public education and interpretation of the incarceration and internment of Japanese Americans during WWII. The monument protects and manages resources related to the Minidoka Relocation Center.	Purpose
	• Protection and management of natural resources and the site. • Control of exotic plant species. • Fire management. • Hunting and the protection of sage grouse habitat.	Identified Management Issues

Nez Perce National Historic Park
Source: NEPE/BIHO General Management Plan 1997

Nez Perce National Historic Park	• Facilitate protection and offer interpretation of Nez Perce sites in Idaho, Oregon, Washington, Montana, and Wyoming that have exceptional value in commemorating the history of the United States. • Preserve and protect tangible resources that document the history of the Nez Perce peoples and the significant role of the Nez Perce in North American history. • Interpret the culture and history of the Nez Perce peoples and promote documentation to enhance that interpretation.	Purpose

Whitman Mission National Historic Site
Source: WHMI General Management Plan 2000

Whitman Mission National Historic Site	• To preserve and maintain the site of the Mission and school for Indians established by Marcus and Narcissa Whitman between 1836-1847 along the Walla Walla River at Waiilatpu, and to preserve and maintain the memorials to their lives.	Purpose
	• To preserve and protect the historic, cultural, and natural resources of Whitman Mission National Historic Site for present and future generations. • To preserve and enhance the natural resources of the NHS, including riparian and wetland areas, in accord with all applicable laws, NPS policies, and executive orders.	Mission Goals

Appendix A.4. Charter of the UCBN

CHARTER
of the
UPPER COLUMBIA BASIN INVENTORY & MONITORING NETWORK
BOARD OF DIRECTORS

Introduction

This charter describes the process used to plan, manage, and evaluate the monitoring program within the Upper Columbia Basin Network in accordance with the intent and purpose of the National Park Service (NPS) Natural Resource Challenge (NRC). The NRC strategy requires the development of an integrated monitoring program that includes short-term tactical monitoring as well as long-term monitoring. This program will provide scientifically sound information for managing park resources and informing the public and will allow managers to confront and mitigate threats to the parks and operate more effectively in regulatory, legal, and political arenas. The Board of Directors represents Superintendents from the nine parks within the Upper Columbia Basin Network and is charged with oversight of the Network's vital signs monitoring program.

The Upper Columbia Basin Network is comprised of nine units of the NPS across four states. Procedural and reporting requirements are coordinated at the Network level adhering to guidelines established by the WASO and Inventory and Monitoring (I&M) program.

UPPER COLUMBIA BASIN NETWORK	Big Hole National Battlefield City of Rocks National Reserve Craters of the Moon National Monument and Preserve Hagerman Fossil beds National Monument John Day Fossil Beds National Monument Lake Roosevelt National Recreation Area Minidoka Internment National Monument Nez Perce National Historical Park Whitman Mission National Historic Site

The Board of Directors will foster an atmosphere of professionalism and cooperation throughout the Network. The Board will provide guidance for the organizational and administrative functions of the Upper Columbia Basin Network Program. The Board is committed to operate in and foster an atmosphere of fairness, trust, and respect throughout the Network. It will pursue a holistic approach in implementing the Network I&M program using scientifically credible standards while addressing needs in all parks.

Board of Directors Membership

The membership of the Board of Directors includes three superintendents from the Upper Columbia Basin Network parks. Superintendents shall serve terms of 3 years. Each year the term of one superintendent shall expire. The term of each superintendent shall begin on January 1 of any given year and end on December 31. The terms of superintendents is shown in the table below.

Table A.1. Term of Superintendents.

Year	Park
2002	HAFO
2002,2003	LARO
2002,2003,2004	CRMO
2003,2004,2005	BIHO
2004,2005,2006	JODA
2005,2006,2007	WHMI
2006,2007,2008	NEPE
2007,2008,2009	CIRO
2008,2009,2010	HAFO
2009,2010,2011	LARO
2010,2011,2012	CRMO
2011,2012,2013	BIHO
2012,2013,2014	JODA
2013,2014,2015	WHMI
2014,2015,2016	NEPE
2016,2017,2018	CIRO

Additional members of the Board of Directors shall include a resource manager or in the case of a park that does not have a resource manager a representative may be designated by the superintendent of the park. All resource managers shall serve a term of 2 years. The term of resource managers is designated in the table below:

Table A.2. Term of Resource Managers.

Year	Park
2002,2003	NEPE/BIHO
2004,2005	HAFO
2006,2007	CRMO
2008,2009	JODA
2010,2011	WHMI
2012,2013	LARO
2014,2015	CIRO

Additional members of the Board of Directors shall include the Pacific West Region I&M Coordinator and the Network I&M Coordinator. The Network I&M Coordinator facilitates meetings and communication to members.

Responsibilities of the Board of Directors

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

- Promote accountability and effectiveness by reviewing organizational and administrative development of the Upper Columbia Basin Network I&M Program.
- Provide review of the design and implementation of vital signs monitoring to ensure that the program is relevant to natural resource management issues within the parks, as well as the comprehensive Servicewide I&M Program requirements.
- Recommend strategies for leveraging funds and personnel to best accomplish the monitoring objectives.
- Provide review of monitoring plans and network budgets and personnel selections.

Procedures

Board Meetings: Formal Board meetings will occur annually. Additionally, three members can jointly request meetings of the Board when determined necessary and appropriate. Formal meetings will require that a written agenda be distributed at least 2 weeks before the meeting. At the end of each meeting, members of the Board responsible for arranging the logistics and agenda for the next meeting will be designated. Telephone conference meetings and electronic mail messages will provide information to all members throughout the year.

Any member who cannot attend or otherwise participate in a meeting of the Board may assign an alternate. A Board member cannot serve as the alternate, or carry the proxy for an absent member.

All decisions will be made by consensus. Consensus is defined as an outcome that all Board members can live with if not ideal from any one viewpoint. If the Board cannot reach a consensus decision, the matter with all viewpoints represented, will be referred to the Associate Regional Director of Resources and Science. All recommendations will be documented with responsible individuals and deadlines identified, as appropriate. Meeting minutes will be distributed to all Board members, the Superintendents of all Network parks and Science Advisory Committee members.

Science Advisory Committee Membership

A Science Advisory committee comprised of natural resource managers and subject matter experts, both within and outside the NPS, will be formed to provide technical assistance and advice to the Board and Network parks. The committee will include the

Network I&M Coordinator, Resource Managers from each of the eight parks, and the Pacific West Region I&M Coordinator. In addition, scientists with knowledge of sampling procedures, monitoring techniques and statistical methods will serve as reviewers, evaluating conceptual designs, monitoring strategies and ecological relevance of monitoring proposals. The composition of the Science Advisory committee will be approved by the Board and the Network I&M Coordinator will chair its meetings and coordinate its efforts. Responsibilities of the Science Advisory committee include:

- Advising Network parks in the development of the Network Monitoring Plan and identification of monitoring objectives by:
  - Compiling and summarizing existing information about park resources and the findings and recommendations of any scoping workshops.
  - Development of a network monitoring strategy.
  - Selection of vital signs such as indicator species, communities, and processes.
  - Evaluating initial sampling designs, methods and protocols to assure they are scientifically credible.
- Reviewing annual data reports and interpretation as well as participating in the preparation of the Annual Work Plan and Annual Report.
- Developing materials for and facilitating the 5-Year Program Review.

The products and recommendations of the Science Advisory committee will be presented to the Board for discussion, modification, and final approval. The Board may form a standing Information and Education Committee comprised of interpretation, education, and public affairs staff at a later date.

When needed, the Board, the Science Advisory committee, or the Network I&M Coordinator may form groups of specialists to work on a particular task or a particular sub-program area.

Each year the Network I&M Coordinator, with the assistance of the Science Advisory committee, will prepare a budget to be approved by the Board of Directors for the travel, per diem, and any other costs associated with the conduct of meetings. These costs will be summarized in the Annual Work Plan.

Monitoring Plan: A monitoring plan that identifies the management and scientific issues facing each park, the vital signs to be monitored, where they will be monitored, and why they will be monitored shall be prepared by the Science Advisory committee and approved by the Board. In addition, the monitoring plan will specify the overall sampling design, staffing plan, and data management strategy.

Annual Work Plan: The Network I&M Coordinator will present a proposed Annual Work Plan to the Board for discussion, modification, and approval no later than January

31 of each year. The Annual Work Plan will identify specific projects, responsible individuals and deadlines, I&M program budget, anticipated accomplishments and products, to which park or office funds are assigned, and additional and potential funding sources (both NPS and others).

Annual Report: The Network I&M Coordinator will present an Annual Report to the Board for discussion, modification, and approval. The Annual Report will detail specific accomplishments and products, lessons learned, coordination with other projects supported by alternate funding sources, and a budget summary. A detailed accounting of the utilization of all I&M program funds assigned to each park and office will be appended to the Annual Report. This Annual Report will be widely distributed and posted at appropriate websites on the Internet. The Annual Report will be released no later than January 31 of each year.

Five Year Program Review: Beginning at the end of fiscal year 2009 and every 5 years thereafter, the Network will undertake a comprehensive program review to be conducted by national and regional NPS specialists as well as qualified independent specialists from other agencies and organizations. The purpose of this review will be to evaluate accomplishments and products, protocols used for gathering data, data management, fiscal management, and staffing. The program review shall provide the principal basis for any significant changes in program direction as well as reassignment of resources to any park or office.

Funding: The Upper Columbia Basin Network is scheduled to receive inventory funds in FY 2001, 2002 and 2003. The Upper Columbia Basin Network is scheduled to receive monitoring funds in FY 2004.

Coordination

To be most effective, the Board will need to maintain a close working relationship with the Resource Manager of each park in the Network, members of the Science Advisory committee, the Pacific West Region I&M Coordinator and the Network I&M Coordinator. Board meetings are open to all of the above. Board members are encouraged to participate in and/or keep informed with respect to the work of the Science Advisory committee. The Network I&M Coordinator will be expected to provide regular briefings (by memoranda, electronic mail or telephone conference) to the Board.

The Pacific West Region I&M Coordinator will provide professional supervision to the Network I&M Coordinator with direct input from the Science Advisory committee. The Science Advisory committee will participate in annual performance evaluations.

Meeting and Office Location

The office of the Network I&M Coordinator and Network Data Manager will be located in Moscow, ID.

Partnerships

The Network I&M program may evolve to include other land and resource managers (e.g. Federal, State, or Tribal) in the Upper Columbia Basin Network area. The Monitoring Plan will identify where it may be advantageous or desirable to expand Board membership to include non-NPS participants. In no case will this be done without unanimous approval of the Board as well as approval by the Associate Regional Director of Resources and Science.

Reporting

Minutes of Board and Science Advisory committee meetings will be circulated by the Network I&M Coordinator to all UCBN park superintendents, resource managers and the Pacific West Region I&M Coordinator. Copies of the Annual Work Plan, Annual Report and Monitoring Plan will be circulated to all UCBN park superintendents, resource managers and the Pacific West Region I&M Coordinator. The Network I&M Coordinator will be responsible for maintaining the administrative record.

Amendment

The Board may make amendments to this charter at any time. All Board members will be provided a 30-day advanced notice of any proposed amendments before they will take effect.

Appendix B
Ecological Context

Appendix B.1. Vertebrate Species of Greatest Conservation Need

In order to receive funding through the State Wildlife Grants, starting in 2001, each state was required to develop a Comprehensive Wildlife Conservation Strategy. The aim of this strategy was to provide a common framework that will enable conservation partners to jointly implement a long-term approach for the benefit of Species of Greatest Conservation Need (SGCN). The states used an objective rule-based process to evaluate all animals thought by experts to be a candidate for SGCN status. Factors that affected ranking status included information about population size, trend, viability, environmental specificity, threats, protection status, and amount of information available regarding the species. Species that are chosen are typically 1) low and declining and/or 2) indicative of the diversity and health of wildlife of the state. Thus a species described as widespread and abundant in the state may still be selected for the SGCN list.

Sources
Montana Natural Heritage Program, Idaho Conservation Data Center, Washington Natural Heritage Information System, Washington Department of Fish and Wildlife, Oregon Natural Heritage Program

Updated: December 2006

Note: Species of Greatest Conservation Need (SGCN) from the states' Conservation Wildlife Strategy and species federally listed as endangered (E), threatened (T), or candidate (C) were crosschecked against the UCBN NPSpecies database.

*Grayed boxes means the species is probably present in the park but not confirmed.

Common Name (Federal Status)	Scientific Name	States Listing Species as SGCN	BIHO	CIRO	CRMO	HAFO/ MIIN	JODA	LARO	NEPE	WHMI
Birds										
American Avocet	*Recurvirostra americana*	ID				S5B				
American White Pelican	*Pelecanus erythrorhynchos*	ID, OR, WA		S1B	S1B	S1B		S1B	S1B	S1B
Bald Eagle (T)	*Haliaeetus leucocephalus*	ID, MT, OR, WA	S3	S3B, S4N	S3B, S4N	S3B, S4N	S4B, S4N	S4	S3B, S4N	S4
Black Tern	*Chlidonias niger*	ID, MT	S3B		S1B	S1B				
Black-crowned Night-Heron	*Nycticorax nycticorax*	ID				S2B				
Brant	*Branta bernicla*	WA								S3N
Brewer's Sparrow	*Spizella breweri*	ID, OR		S3B	S3B	S3B				
Burrowing Owl	*Athene cunicularia*	ID, MT, OR, WA	S2B	S2B	S2B	S2B				
California Gull	*Larus californicus*	ID		S2B, S3N	S2B, S3N	S2B, S3N			S2B, S3N	
Caspian Tern	*Sterna caspia*	ID, OR			S2B	S2B				S3B
Cattle Egret	*Bubulcus ibis*	ID				S2B				
Common Loon	*Gavia immer*	ID, MT, WA	S2B			S1B, S2N		S2B, S4N		
Common Nighthawk	*Chordeiles minor*	OR					S5B			
Ferruginous Hawk	*Buteo regalis*	ID, OR, WA		S3B	S3B	S3B		S2B	S3B	S2B
Forster's Tern	*Sterna forsteri*	ID			S1B	S1B				
Franklin's Gull	*Larus pipixcan*	ID, OR			S2B	S2B			S2B	
Golden Eagle	*Aquila chrysaetos*	WA						S3		S3
Grasshopper Sparrow	*Ammodramus savannarum*	ID, OR			S2B	S2B			S2B	
Great Blue Heron	*Ardea herodias*	WA						S4S5B, S5N		S4
Greater Sage Grouse (C)	*Centrocercus urophasianus*	ID, MT, OR, WA		S2	S2	S2				
Greater Scaup	*Aythya marila*	WA						S3N		S3N

Common Name (Federal Status)	Scientific Name	States Listing Species as SGCN	BIHO	CIRO	CRMO	HAFO/ MIIN	JODA	LARO	NEPE	WHMI
Hooded Merganser	*Lophodytes cucullatus*	ID				S2B, S3N			S2B, S3N	
Juniper Titmouse	*Baeolophus ridgwayi*	ID,OR		S2	S2					
Lesser Goldfinch	*Carduelis psaltria*	ID			S2B					
Lesser Scaup	*Aythya affinis*	ID, WA			S3	S3		S3N, S4B		S3N, S4B
Lewis's Woodpecker	*Melanerpes lewis*	ID, OR, WA		S3B	S3B		S2S3B	S3B		S3B
Loggerhead Shrike	*Lanius ludovicianus*	OR					S3B, S2N	S3B		S3B
Long-billed Curlew	*Numenius americanus*	ID, MT	S2B	S2B	S2B	S2B			S2B	
Merlin	*Falco columbarius*	ID		S2B, S2N	S2B, S2N	S2B, S2N				
Mountain Quail	*Oreortyx pictus*	ID, OR, WA					S4			
Northern Goshawk	*Accipiter gentilis*	OR, WA					S3B	S3B, S3N		S3B, S3N
Northern Pintail	*Anas acuta*	ID, WA			S5B, S2N	S5B, S2N		S3B, S4N	S5B, S2N	S3B, S4N
Olive-sided Flycatcher	*Contopus cooperi*	MT, OR	S3B							
Peregrine Falcon (T)	*Falco peregrinus*	ID, OR, WA			S2B	S2B	S2B			S2B, S3N
Pileated Woodpecker	*Dryocopus pileatus*	OR, WA						S4		S4
Pinyon Jay	*Gymnrhinus cyanocephalus*	ID		S1	S1					
Prairie Falcon	*Falco mexicanus*	WA						S3B, S3N		S3B, S3N
Pygmy Nuthatch	*Sitta pygmaea*	ID, WA						S3B, S3N		
Red-necked Grebe	*Podiceps grisegena*	ID, OR			S2B					
Redhead	*Aythya americana*	WA						S3N, S5B		S3N, S5B
Sage Sparrow	*Amphispiza belli*	OR, WA						S3B		
Sage Thrasher	*Oreoscoptes montanus*	WA						S3B		
Sandhill Crane	*Grus canadensis*	ID, OR, WA		S3B	S3B		S3S4B	S1B, S3N	S3B	S1B, S3N
Short-eared Owl	*Asio flammeus*	ID, OR		S4	S4	S4			S4	
Snowy Egret	*Egretta thula*	ID, OR				S2B				
Swainson's Hawk	*Buteo swainsoni*	ID, OR		S3B	S3B	S3B			S3B	
Trumpeter Swan	*Cygnus columbianus*	ID, MT, WA	S2							

Common Name (Federal Status)	Scientific Name	States Listing Species as SGCN	BIHO	CIRO	CRMO	HAFO/ MIIN	JODA	LARO	NEPE	WHMI
Vaux's Swift	*Chaetura vauxi*	WA						S3S4B		S3S4B
Virginia's Warbler	*Vermivora virginiae*	ID		S1B						
Western Bluebird	*Sialia mexicana*	OR					S4B, S4N			
Western Grebe	*Aechmophorus occidentalis*	ID			S2B	S2B		S3B, S3N		
Western Meadowlark	*Sturnella neglecta*	OR					S4			
White-headed Woodpecker	*Picoides albolarvatus*	ID, OR WA						S2S3		
Wilson's Phalarope	*Phalaropus tricolor*	ID		S3B	S3B	S3B			S3B	
Yellow-breasted Chat	*Icteria virens*	OR					S4B			
Mammals										
American Badger	*Taxidea taxus*	WA						S4		S4
Bighorn Sheep	*Ovis canadensis*	ID			S1				S1	
California Myotis	*Myotis californicus*	ID, OR		S2	S2		S3		S2	
Cliff Chipmunk	*Tamias dorsalis*	ID		S1						
Fringed Myotis	*Myotis thysanodes*	ID, OR		S2	S2	S2	S2			
Gray Wolf (E)	*Canis lupus*	ID, MT, WA	S3		S3					
Great Basin Pocket Mouse	*Perognathus parvus*	MT	S2S3							
Hoary Bat	*Lasiurus cinereus*	OR					S3			
Long-legged Myotis	*Myotis volans*	OR					S3			
Merriam's Shrew	*Sorex merriami*	ID, WA		S2	S2			S3S4		
Pallid Bat	*Antrozous pallidus*	MT, OR					S2			
Pinyon Mouse	*Peromyscus truei*	ID		S1						
Silver-haired Bat	*Lasionycteris noctivagans*	OR					S3S4			
Spotted Bat	*Euderma maculatum*	ID, MT, OR	S2	S3			S2		S3	
Townsend's Big-eared Bat	*Plecotus townsendii*	ID, MT, OR, WA		S3	S3		S2	S3		

Common Name (Federal Status)	Scientific Name	States Listing Species as SGCN	BIHO	CIRO	CRMO	HAFO/ MIIN	JODA	LARO	NEPE	WHMI
White-tailed Jackrabbit	*Lepus townsendii*	OR, WA						S2S3		
Herpetofauna										
Northern Leopard Frog	*Rana pipiens*	ID, MT, OR, WA			S2	S2				
Ringneck Snake	*Diadophis punctatus*	ID							S2	
Tiger Salamander	*Ambystoma tigrinum*	WA						S3		
Western Rattlesnake	*Crotalus oreganus*	OR					S5			
Western Toad	*Bufo boreas*	MT, OR, WA	S2				S3	S3S4		
Fish										
Arctic Grayling	*Thymallus arcticus*	MT	S1							
Bull Trout (T)	*Salvelinus fontinalis*	ID, MT, WA						S3	S3	S3
Burbot	*Lota lota*	ID, MT	SNA							
Chinook Salmon	*Oncorhynchus tshawytscha*	ID, OR, WA					S2	S3S4		
Leopard Dace	*Rhinichthys falcatus*	ID, WA						S2S3		
Pygmy Whitefish	*Prosopium coulteri*	ID, WA						S1S2		
Rainbow trout, redband trout, steelhead	*Oncorhynchus mykiss*	ID, OR, MT, WA					S3	S5 SNR		S5 SNR
Slimy Sculpin	*Cottus cognatus*	WA						S3		
Steelhead, Middle Columbia ESU (T)	*Oncorhynchus mykiss*	OR					S2			S5 SNR??

Legend

S1 = Critically imperiled
S2 = Imperiled
S3 = Vulnerable to extirpation or extinction
S4 = Apparently secure
S5 = Demonstrably widespread, abundant, and secure

SX = Believed to be extinct
SNR = Unranked, status not yet assessed
B = Breeding status for a migratory species
N = Non-breeding status for a migratory species

Appendix B.2. Areas Currently Managed for the Long-term Maintenance of Biodiversity within 16 km (10 mi) of Upper Columbia Basin Parks

Little information is available on the flora, fauna, and habitat connectivity of these areas. Therefore it is difficult to determine the degree to which these areas contribute to maintaining the ecological integrity of park surroundings.

Park	Nearby conservation area[1]	Managing agency[2]	Distance (km)
Hagerman Fossil Beds NM	Thousand Springs Ranch and Preserve	TNC	<8
	Hagerman Wildlife Management Area	IDFG	<8
	Box Canyon/Blueheart Springs ACEC	BLM	<16
Minidoka Internment NM	Vineyard Creek ACEC	BLM	<16
City of Rocks NR	Jim Sage Canyon Research Natural Area	BLM	<16
Craters of the Moon NM and Preserve	Bear Track Williams Recreation Area	IDFG	<8
	Preacher Bridge Access Area	IDFG	<8
	Carey Lake Wildlife Management Area	IDFG	<8
	Minidoka National Wildlife Refuge	USFWS	<8
	Silver Creek Access Area	IDFG	<16
	Silver Creek Easements	TNC	<16
	China Cup Butte Research Natural Area	BLM	<16
	Sand Butte Wilderness Study Area	BLM	<8
	Shale Butte Wilderness Study Area	BLM	<8
	Idaho National Engineering and Environment Laboratory	DOE	<16
Nez Perce NHP (Idaho portion)	Lower Salmon River ACEC	BLM	<8
	Hells Canyon National Recreation Area	USFS	<16
	Lower Lolo Creek ACEC	BLM	<16
	Middle Fork Clearwater Wild River	USFS	<16
	Craig Mountain Wildlife Management Area	IDFG	<8
	Redbird Creek Research Natural Area	BLM	<8
	Captain John Creek Research Natural Area/ACEC	BLM	<8
	Craig Mountain ACEC	BLM	<8
	Garden Creek Preserve	TNC	<16
	Chief Joseph Wildlife Recreation Area	WDFW	<16
Nez Perce NHP (Oregon portion)	Eagle Cap Wilderness Area	USFS	<8
	Hells Canyon National Recreation Area	USFS	<8
Lake Roosevelt NRA	Northup Canyon State Park	WA STATE	<8
	Sherman Creek Wildlife Area	WA STATE	<8
John Day Fossil Beds NM	Spring Basin Wilderness Study Area	BLM	<8
	Pine Creek Conservation Area	CTWS	<8
	Bridge Creek Wilderness Area	USFS	<16
	Aldrich Mountain Wilderness Study Area	BLM	<16
	Murderer's Creek Wildlife Area	ODFW	<16
	Black Canyon Wilderness Area	USFS	<16

[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), USDA Forest Service (USFS), Washington Department of Fish and Wildlife (WDFW), Washington state (WA STATE), and Oregon Department of Fish and Wildlife (ODFW).

Appendix B.3. Soil Descriptions (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 m (1,214 to 9,843 ft). This area has a maritime-like climate, except in the east where a continental climate prevails. The average annual precipitation varies from about 40 to 250 cm (15.7 to 98.4 in). 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 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 (3.9 in) 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 m (984 to 12,139 ft). 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 50 cm (19.7 in) at the lowest elevations to over 75 cm (29.5 in) 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 and southeastern Oregon, and southern Idaho. Elevations range from approximately 60 to 2,400 m (197 to 7,874 ft). This area has a semi-arid, cool climate. Average annual precipitation varies from about 10 to 62.5 cm (3.9 to 24.6 in). 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.

Appendix B.4. Geoclimatic Characteristics Compiled by the ICBEMP for Ecological Reporting Units (Quigley and Arbelbide 1997)

ERU	Landforms	Bedrock and Surficial Material	Elevation Range (m)	Mean Annual Precipitation and Temperature	Major Potential Vegetation Groups
Columbia Plateau (NEPE, WHMI, JODA)	Plateaus, hills, and plains	Basalts and volcanic rocks; loess, glacial outwash, and flood deposits	61 to 1,220	18 to 45 cm 4 to 14°C	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 to 3,081	41 to 254 cm -1 to 14°C	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 to 2,501	20 to 40 cm 2 to 8°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 to 2,288	10 to 79 cm 4 to 13°C	Salt desert brush, sagebrush and juniper
Central Idaho Mountains (NEPE)	Dissected mountains, breaklands, canyons, basins, foothills, valleys, and some alpine glaciation	Granitics, gneiss, schist, shale, carbonate rocks, and volcanic rocks	427 to 3,861	25 to 203 cm 3 to 10°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 to 3,048	25 to 127 cm 3 to 14°C	Douglas-fir, grand fir, sagebrush, grasslands, and subalpine fir

Appendix B.5. Description of Geologic Sections of the Columbia Plateau (Quigley and Arbelbide 1997)

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 km^3 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 km (93 mi) 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&P, 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, 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 and over 80% of CRMO is lava.

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 61 m (200 ft) 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 168 m (550 ft) 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.

Walla Walla Plateau – 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.

Blue Mountains Section – 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.

Northern Rocky Mountains – 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 322 to 483 km (200 to 300 mi) 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 322 to 644 km (200 to 400 mi) inland from a subduction zone boundary, yet the Rockies are hundreds of kilometers 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.

Appendix B.6. Descriptions of Major Vegetation Types

Shrub-Steppe

Shrub-steppe habitat is found to some extent in all nine UCBN parks. The majority of shrubland habitat presented in Table 1.5 in Chapter 1 of the monitoring plan is shrub-steppe. Characteristic and dominant shrubs in the shrub-steppe vegetation type include several species of sagebrush, at least three subspecies of big sagebrush, antelope bitterbrush, and two 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 wild rye 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. However, in JODA and CIRO, juniper and pinyon-juniper woodlands have expanded into shrub-steppe areas as a result of historic over-grazing and fire suppression. For more information on shrub-steppe habitat descriptions, see the following link:
http://www.nwhi.org/index/habdescriptions#16.%20Shrub-steppe.

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 obscure phacelia at CRMO and palouse milkvetch in LARO.

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 (BLM 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 US, 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 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. 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 (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, 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 with pinyon pine at CIRO. 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 (BLM 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 and in mixed stands of pinyon-juniper woodlands 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). This species is vulnerable to exotic forest pathogens, particulary white pine blister rust, which was encountered in CRMO limber pine for the first time in 2006. 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 and northern slopes of older cinder cones 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 (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 BIHO, CRMO, HAFO, NEPE, and WHMI. 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 (USFS 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 1.5) 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 CIRO, CRMO, HAFO, and JODA. 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 HAFO, JODA, LARO, NEPE, and WHMI. 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, reed canary grass, occur in many wetlands in the UCBN. Reed canary grass is particularly abundant along the seasonally flooded portions of Lake Roosevelt, including the Kettle River arm of the lake, near the mill pond 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. Reed canary-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 1.5 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 (less than 32 ha). 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 reed canary-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 CIRO, JODA, NEPE, and portions of BIHO, CRMO, and LARO. Several UCBN parks are nearly surrounded by highly fragmented agricultural lands and exist as islands of much more stucturally complex vegetation. This is particularly evident at HAFO and WHMI, and fragmentation and connectivity issues will continue to be of concern throughout the UCBN in the future.

Appendix B.7. Descriptions of Associated Fauna

Vertebrates

Vertebrate communities associated with Upper Columbia Basin habitats are well represented in UCBN parks. The fauna present 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 network inventories, 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 B.1). However, there are many vertebrates listed as state and federal species of concern that occur, 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. One of the last strongholds of the arctic grayling south of Canada and Alaska is in the upper reaches of the Big Hole and North Fork Big Hole Rivers. The reach of the North Fork that passes through BIHO has not yet been evaluated for its importance to grayling.

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 B.1). 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, HAFO, NEPE, and WHMI where historic populations of spotted frogs and leopard frogs are now gone.

Table B.1. Species richness by taxon for network parks (updated from NPSpecies, December 2006).

Park	Amphibians	Birds	Mammals	Reptiles
BIHO	4	255	69	5
CIRO	2	168	64	23
CRMO	8	220	69	14
HAFO	8	200	35	17
JODA	6	185	60	19
LARO	7	241	71	15
MIIN	NA	NA	NA	NA
NEPE	7	161	46	9
WHMI	6	224	34	9

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 present in several network parks and 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 B.1), 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 (Idaho State University, Charles R. Peterson, herpetologist, pers. comm., 2002).

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 (USGS 2002). Loss of reptile diversity may also be associated with the cheatgrass-dominated ground cover in sagebrush-steppe ecosystems. (Alan St. John, herpetologist, pers. comm., 2002). Similar concerns 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 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 (Marcot 1996), significant information has become available in recent years. Work done by Keller et al. (1995, 1996, 1997) in CRMO and more recently by the UCBN through inventories and additional research (Rodhouse et al. 2005) has demonstrated that several parks, especially CIRO, CRMO, JODA, 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 (NPS, Michael Munts, CRMO Biological Technician, pers. comm., 2002). 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 1977) and 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 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. At CIRO, cliff nesting golden eagles and red-tailed hawks are potentially at risk from recreational rock-climbing disturbance.

While large carnivores do occur in several UCBN parks, they are not a focus of monitoring planning due to the wide-ranging nature of these species. None of the network parks have 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 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 and the foothills of the Pioneer Mountains at Craters of the Moon.

Invertebrates
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, may 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, 113 km (70 mi) 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 (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).

Appendix B.8. Water Quality Threats

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 (NRC 1996; Quigley and Arbelbide 1997; Levin et al. 2002). 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 (NRC 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). Again, 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 (Table B.1). Information on water resources within the Network is limited. HAFO has completed a water resources management plan (Farmer and Riedel 2003) and LARO has completed a water resources scoping report (Riedel 1997). All parks, except MIIN, have Level I baseline water quality data reports ("Horizon" reports) completed by NPS Water Resources Division (WRD). Currently, the majority do not collect water quality monitoring data, although some parks have state Division of Environmental Quality (DEQ) monitoring sites located nearby. There are no designated Outstanding Natural Resource Waters (ONRW) or watersheds of exceptional quality identified in the UCBN.

All UCBN waters assessed by state DEQ agencies are on 303(d) lists for impairment of at least one parameter (Table B.2). 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. Flow impairment is threatening the arctic grayling population in the Big Hole drainage. 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 polychlorinated biphenyl (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. 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.

Table B.2. Summary of threats to water resources in the UCBN.

Park	State	Data	Threats to Water Resources
BIHO	MT	Park data – none Outside sources from 1975	Mining, agriculture, and stormwater runoff
CIRO	ID	Park – no data since 1985	Ranching and grazing activities; residential development; gas, oil and mining operations; recreational use
CRMO	ID	1999-2003	Pesticide runoff and drift from agricultural lands, as well as weed management activities along state and county roads
HAFO	ID	2003	Irrigation and agricultural activities, altered subsurface hydrology, upstream agricultural and industrial effluent, altered flow regulation
JODA	OR	2003	Irrigation withdrawals and confined animal feeding upstream, untreated sewage effluent upstream
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
MIIN	ID	No Data	No water resources within the park boundaries
NEPE	ID	1975-1994	Point and non-point discharge from upstream sources – Dworshak dam, agriculture, logging, grazing, recreation, highway runoff and urbanization
WHMI	WA	2000-2003	Agricultural chemical use, over allocation of irrigation water, private airfield 4.8 km (3 mi) upstream

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. 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 B.3. Current 303(d) listings for waters in the UCBN.

Park	303(d) Listed Waters	Impairments	List Date
BIHO	N. Fork Big Hole River	Flow Impairment, Dewatering	2002
CIRO	Not assessed		
CRMO	Not assessed		
HAFO	Lower Salmon Falls Reservoir (Snake R.)	Dissolved Oxygen (DO), Flow Alteration, Sediment	2000
JODA	John Day River, Pine Creek, Bridge Creek, Rock Creek	Temperature, Dissolved Oxygen (DO), Fecal Coliform	2002
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
MIIN	Not assessed		
NEPE	Lower Clearwater River, Lapwai Creek	Total Dissolved Gas, Nutrients, Bacteria, Dissolved O_2 (DO), Flow Alteration, Habitat Alteration, Sediment, Temperature	2002
WHMI	Mill Creek, Walla Walla River	Temperature, Instream Flow, Fish Habitat	2002

Beyond the 303d listings, very few data are available to assess the status or trends of water quality within UCBN park boundaries. Few of the sampling sites compiled by the 1997 Baseline Water Quality Data Inventory and Analysis reports were within park boundaries (Table B.3). Similarly, few data or no data have been submitted to STORET since the 1997 reports (Table B.4).

Table B.4. Summary of sampling stations and sampling from the 1997 Baseline Water Quality Data Inventory and Analysis reports.

Park	Total Stations	Number in Park	% Stations in Park	% All Reported Observation that were in Park
BIHO	18	0	0.0	0.0
CIRO	12	3	25.0	21.9
CRMO	23	10	43.5	65.8
HAFO	66	4	6.1	0.3
JODA	42	4	9.5	2.3
NEPE	238	0	0.0	0.0
WHMI	20	9	45.0	35.3

During the vital sign prioritization process the UCBN identified the sampling of waterbodies within park units for macroinvertebrate community structure as the top water quality monitoring priority, followed by the characterization of channel morphology and in-stream habitat, and baseline sampling of water chemistry parameters as secondary priorities. The status of each body will be assessed using well developed indices of invertebrate community structure that indicate relative water quality compared to reference or unimpaired waterbodies within a region (Barbour et al. 1999). EPA and state guidelines will be used to determine if water chemistry parameters exceed threshold indicating impaired water quality.

A baseline survey of macroinvertebrates will provide a cost-effective baseline sampling of water quality designed to both identify park waterbodies with impaired water quality and provide baseline data on community structure and composition for an important aquatic resource Vital Sign. The latter will both inventory park faunal resources and provide baseline data for the monitoring of invasive species. Anticipated fiscal resources should allow annual sampling of a portion of UCBN parks, with each sampled on a 2 to 3-year rotation (see Appendix F.5).

Table B.5. Number of available water quality observations by category and sampling period for data reported in 1997. Baseline reports and downloaded from STORET, May, 2005. Data include all sites in 1997 Baseline report study areas.

Park	Sampling Period	Alkalinity	pH	Conductivity	Dissolved Oxygen	Temperature	Flow	Turbidity	Nitrate/ Nitrogen	Phosphate Phosphorus	Chlorophyll	Sulfates	Bacteria	Toxic Elements
BIHO	pre 1984	174	91	146	78	107	142	89	23	17	0	109	4	43
	1985-1996	0	0	13	0	12	13	0	0	0	0	0	0	0
	1997-2004	6	6	6	6	6	7	7	8	4	0	12	0	80
CIRO	pre 1984	23	14	14	0	11	4	0	1	1	0	7	0	0
	1985-1996	3	2	1	0	1	0	0	1	1	0	1	0	0
	1997-2004	0	0	0	0	0	0	0	0	0	0	0	0	0
CRMO	pre 1984	13	180	171	165	180	1	74	412	142	92	3	80	134
	1985-1996	0	169	160	165	169	0	74	411	137	92	0	80	104
	1997-2004	0	0	0	0	0	0	0	0	0	0	0	0	0
HAFO	pre 1984	666	749	724	386	678	562	753	1566	964	8	683	626	970
	1985-1996	102	127	174	128	162	141	312	560	309	0	120	108	28
	1997-2004	0	0	0	0	0	0	0	0	0	0	0	0	0
JODA	pre 1984	278	1271	1342	2330	5960	439	1159	1678	1076	273	425	804	290
	1985-1996	133	838	884	1705	5554	68	652	989	629	181	84	339	39
	1997-2004	0	16	14	15	16	0	32	16	0	0	14	47	0
NEPE	pre 1984	2287	3185	3087	2367	3557	3243	2754	6283	3705	89	3052	2299	6480
	1985-1996	361	813	1061	589	1168	774	466	2659	1497	71	455	517	856
	1997-2004	0	0	0	0	0	0	0	0	0	0	0	0	0
WHMI	pre 1984	563	352	352	384	404	314	352	902	735	0	547	553	326
	1985-1996	10	10	10	12	0	0	0	20	10	0	20	0	96
	1997-2004	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix B.9. Literature Cited for Appendix B

Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, DC.

Anderson, M., P. Bourgeron, M. T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D. H. Grossman, S. Landaal, and others. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: List of types. The Nature Conservancy, Arlington, VA.

Baker, W. L., and D. Ehle. 2001. Uncertainty in surface-fire history: the case of ponderosa pine forests in the western United States. Canadian Journal of Forest Research **31**:1205-1226.

Baker, W. L., and D. J. Shinneman. 2004. Fire and restoration of pinyon-juniper woodlands in the western United States: a review. Forest Ecology and Management **189**:1-21.

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second edition. EPA 841-B-99-002. US Environmental Protection Agency, Office of Water, Washington, DC.

Barrett, S. W., S. F. Arno, and J. P. Menakis. 1997. Fire episodes in the inland Northwest based on fire history data. General Technical Report INT-GTR-370. USDA Forest Service, Intermountain Research Station, Missoula, MT.

Bureau of Land Management (BLM). 2002. Management considerations for sagebrush (*Artemisia*) in the western United States: A selective summary of current information about the ecology and biology of woody North American sagebrush taxa. USDI Bureau of Land Management, Washington, DC.

Cummins, K. W., and R. W. Merritt. 2001. Application of invertebrate functional groups to wetland ecosystem function and biomonitoring. Pages 85-112 *in* R. B. Rader, D. P. Batzer, and S. A. Wissinger, editors. Bioassessment and management of North American freshwater wetlands. John Wiley and Sons, New York, NY.

D'Antonio, C. M. 2000. Fire, plant invasions, and global changes. Pages 65-93 *in* H. A. Mooney, and R. J. Hobbs, editors. Invasive species in a changing world. Island Press, Washington, DC.

Elmore, W., and J. B. Kauffman. 1994. Riparian and watershed systems: degradation and restoration. Pages 211-232 in Vavra, M, W.A. Laycock, and R.D. Piper, editors. Ecological implications of herbivory in the west. Society of Range Management, Denver, CO.

Farmer, N., and J. Riedel. 2003. Water resources management plan: Hagerman Fossil Beds National Monument, Idaho. National Park Service, Hagerman, ID.

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Department of Agriculture; US Department of the Interior [and others]. Portland, OR.

Geist, J. M., and P. H. Cochran. 1991. Influences of volcanic ash and pumice deposition on productivity of western interior forest soils. Pages 82-88 *in* Proceedings - Management and Productivity of Western-Montane Forest Soils. US Forest Service Gen. Tech. Rep. INT-280, Ogden, UT.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. Ecosystem perspective of riparian zones: Focus on links between land and water. Bioscience **41**:540-551.

Griffis-Kyle, K. L., and P. Beier. 2003. Small isolated aspen stands enrich bird communities in southwestern ponderosa pine forests. Biological Conservation **110**:375-385.

Hays, D. W., M. J. Tirhi, and D. W. Stinson. 1998. Washington state status report for the sage grouse. Washington Department of Fish and Wildlife, Wildlife Management Program, Olympia, WA.

Hessburg, P. F., and J. K. Agee. 2003. An environmental narrative of inland northwest Unites States forests, 1800-2000. Forest Ecology and Management **178**:23-59.

Hessburg, P. F., B. G. Smith, R. B. Salter, R. D. Ottman, and E. Alvarado. 2000. Recent changes (1930s-1990s) in spatial patterns of interior northwest forests, USA. Forest Ecology and Management **136**:53-83.

Hovingh, P. 2004. Intermountain freshwater mollusks, USA: geography, conservation, and fish management implications. Monographs of the Western North American Naturalist **2**: 109-135.

Janes, S. 1977. Raptors of the John Day Fossil Beds National Monument. Oregon State University, Corvallis, OR.

Kauffman, J. B., R. L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries **22**:12-24.

Keane, R. E., K. C. Ryan, T. T. Veblen, C. D. Allen, J. Logan, and B. Hawkes. 2002. Cascading effects of fire exclusion in the Rocky Mountain ecosystems: A literature review. General Technical Report RMRS-GTR- 91. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Keller, B. L. 1997. Analysis of the thermal characteristics of maternity caves and bat species present at Craters of the Monument National Monument, Butte County, Idaho. Unpublished. Western Environmental Research Associates, Pocatello, ID.

Keller, B. L., and R. T. Saathoff. 1995. A survey of day roosting by *Plecotus townsendii* in lava tube caves at Crater of the Moon National Monument, Butte County, Idaho. Unpublished. Idaho State University Museum of Natural History, Pocatello, ID.

Keller, B. L., and R.T. Saathoff. 1996. A netting survey of water and cave areas by bats at Craters of the Moon National Monument, Butte County, Idaho. Unpublished. Idaho Museum of Natural History, Idaho State University, Pocatello, ID.

Knopf, F. L., and F. B. Samson. 1994. Scale perspectives on avian diversity in western riparian ecosystems. Conservation Biology **8**:669-676.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, and C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin **100**:272-294.

Larrison, E. J. 1981. Mammals of Idaho. University of Idaho Press, Moscow, ID.

Larson, E. J., and W. J. Ripple. 2003. Aspen age structure in the northern Yellowstone ecosystem, USA. Forest Ecology and Management **179**:469-482.

Lawler, J. J., and T.C. Edwards. 2002. Composition of cavity-nesting bird communities in montane aspen woodland fragments: the role of landscape context and forest structure. Condor **140**:890-896.

Levin, P. S., S. Achord, B. E. Feist, and R. W. Zabel. 2002. Non-indigenous brook trout and the demise of Pacific salmon: a forgotten threat? Proceedings of the Royal Society of London Series B-Biological Sciences **269**:1663-1670.

Long, J. 2003. Diversity, complexity, and interactions: an overview of Rocky Mountain forest ecosystems. Tree Physiology **23**:1091-1099.

Mack, R. N., and C. M. D'Antonio. 1998. Impacts of biological invasions on disturbance regimes. Trends in Ecology and Evolution **13**:195-198.

Madison, E., K. Oelrich, T. Rodhouse, and L. Garrett. 2003a. Mammal inventories, City of Rocks National Reserve. University of Idaho, Moscow, ID.

Miller, R. F., and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management **52**:550-559.

Naiman, R. J., R. E. Bilby, and P. A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. Bioscience **50**:996-1011.

National Research Council (NRC). 1996. Upstream: salmon and society. Committee on protection and management of Pacific Northwest salmonids. National Academy Press, Washington, DC.

Niwa, C. G., R. E. Sandquist, R. Crawford, T. J. Frest, T. Griswold, P. Hammond, E. Ingham, S. James, E. J. Johannes, J. Johnson, and others. 2001. Invertebrates of the Columbia River basin assessment area. General Technical Report PNW-GTR-512. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

O'Connell, M. 2000. Threats to waterbirds and wetlands: implications for conservation, inventory, and research. Wildfowl **51**:1-15.

Paige, C., and S. A. Ritter. 1999. Birds in a sagebrush sea: Managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID.

Parsons, S., K. J. Lewis, and J. M. Psyllakis. 2003. Relationships between roosting habitat of bats and decay of aspen in the sub-boreal forests of British Columbia. Forest Ecology and Management **177**:559-570.

Peet, R. K. 2000. Forests and meadows of the Rocky Mountains. Pages 75-121 *in* M. G. Barbour, and W. D. Billings, editors. North American terrestrial vegetation, second edition. Cambridge University Press, Cambridge, UK.

Pierson, E. D. 1998. Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats. Pages 309-325 *in* T. H. Kunz and P. A. Racey, editors. Bat biology and conservation. Smithsonian Institution Press, Washington, DC.

Quigley, T. M., and S. J. Arbelbide, editors. 1997. An assessment of ecosystem components in the Interior Columbia Basin and portions of the Klamath and Great Basins, Volumes I-III. General Technical Report PNW-GTR-405. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Riedel, J. L. 1997. Water Resources Scoping Report: Lake Roosevelt National Recreatoin Area, Washington. Technical Report NPS/NRWRD/NRTR-97/107. Water Resources Division, Ft. Collins, CO.

Rodhouse, T. J., M. F. MacCaffrey, and R. G. Wright. 2005. Distribution, foraging behavior, and capture results of the spotted bat in Central Oregon. Western North American Naturalist **65**:215-222.

Rogers, P. 2002. Using forest health monitoring to assess aspen forest cover change in the southern Rockies ecoregion. Forest Ecology and Management **155**:223-236.

Rust, S. K., and C. L. Coulter. 2000. Composition, structure, and distribution of Utah juniper plant associations, Snake River Resource Area, Idaho. Conservation Data Center, Idaho Department of Fish and Game, Boise, ID.

Schuster, W. S. F., J. B. Mitton, D. K. Yamaguchi, and C. A. Woodhouse. 1995. A comparison of limber pine ages at lower and upper treeline sites east of the continental divide in Colorado. American Midland Naturalist **133**:101-111.

Sharp, B. 1985. Avifaunal changes in central Oregon since 1899. Western Birds **16**:63-70.

Soulé, P. T., P. A. Knapp, and H. D. Grissino-Mayer. 2004. Human agency, environmental drivers, and western juniper establishment during the late Holocene. Ecological Applications **14**:96-112.

USDA Forest Service (USFS). 1996. Status of the Interior Columbia Basin: Summary of scientific findings. General Technical Report PNW-GTR-385. USDA Forest Service, Pacific Northwest Research Station and USDI Bureau of Land Management. Portland, OR.

US Geological Survey (USGS). 2002. Loss of sagebrush ecosystems and declining bird populations in the Intermountain West: Priority research issues and information needs. FS-122-02. USDI Geological Survey, Boise, ID.

Verts, B. J., and L. N. Carraway. 1998. Land mammals of Oregon. University of California Press, Berkeley, CA.

Wagner, F. H., R. Angell, M. Hahn, T. Lawlor, R. Tausch, and D. Toweill. 2003. Natural ecosystems III: The Great Basin. Pages 207-240 *in* F. H. Wagner, editor. Rocky Mountain/Great Basin regional climate-change assessment. Report for the US global change research program. Utah State University, Logan, UT.

West, N. E., and J. A. Young. 2000. Intermountain valleys and lower mountain slopes. Pages 255-284 *in* M. G. Barbour, and W. D. Billings, editors. North American terrestrial vegetation. Cambridge University Press, Cambridge, UK.

Wisdom, M. J., R. S. Holthausen, B. C. Wales, C. D. Hargis, V. A. Saab, D. C. Lee, W. J. Hann, T. D. Rich, M. M. Rowland, W. J. Murphy, and M. R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the Interior Columbia Basin: Broadscale trends and management implications. Volume 1-Overview. General Technical Report PNW-GTR-485. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Appendix C
Conceptual Ecological Models

Appendix C.1. Cultural Landscapes

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 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 has explicitly incorporated cultural landscapes into its vital signs monitoring program. We believe this will help ensure the monitoring program is relevant to 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 highly "governed" or managed to reflect a particular historical period (Bertollo 1998). Defining cultural landscapes and identifying boundaries with 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 a 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.

Howett (2000) suggests application of the term "integrity" as a value for cultural landscape preservation is dependent upon 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).

Given that cultural landscapes are unique ecosystems, it is possible to identify important drivers, stressors, effects, and indicators of ecological integrity or, preferably, ecological condition. 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. Vital signs can be common to both cultural and natural ecosystems, and monitoring both can lead to a better understanding of interrelationships, in turn leading to more efficient and effective resource management. The following sections present a general cultural landscape ecosystem control model, a submodel for camas lily at NEPE and BIHO, and a narrative highlighting key model elements and relationships.

Cultural Landscape Ecosystem Control Model

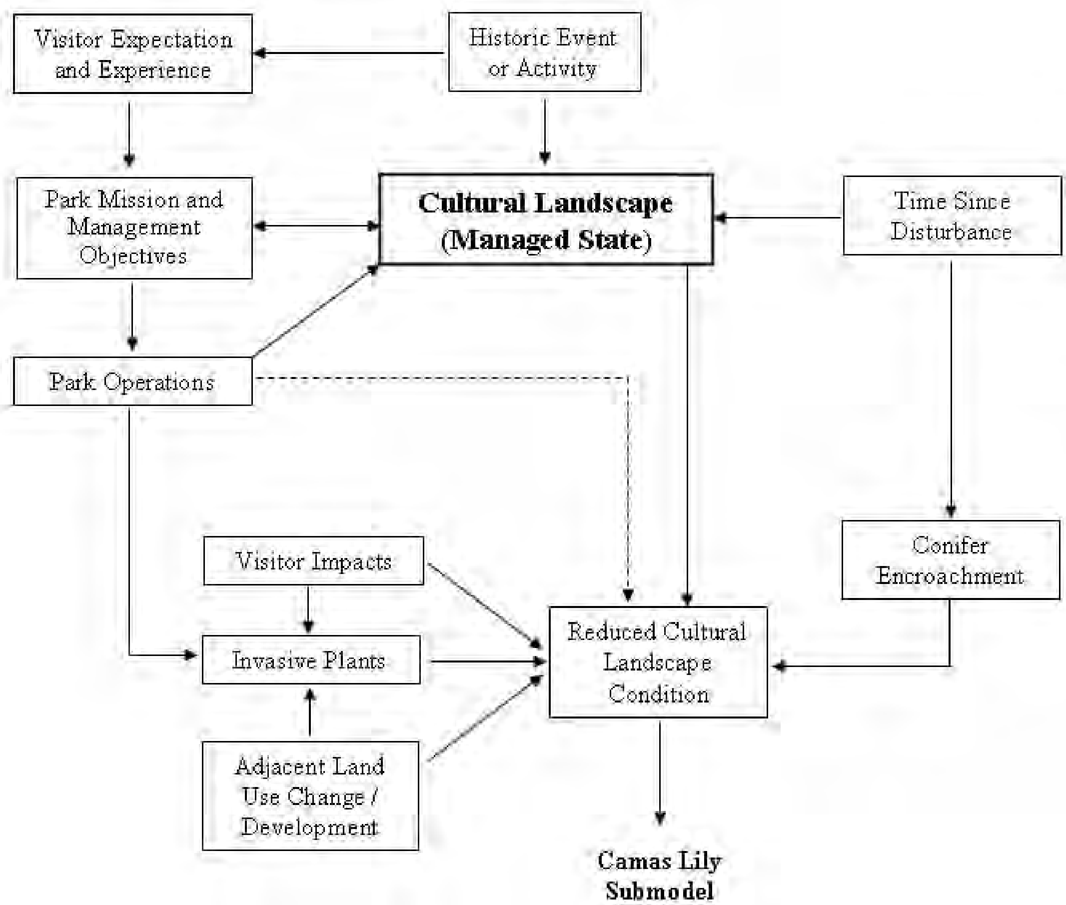


Figure C.1. Relationships among key drivers and stressors that exert fundamental controls on managed cultural landscapes. The dashed line represents a potential or hypothesized direct relationship between park operations and reduced condition.

Camas Lily Submodel

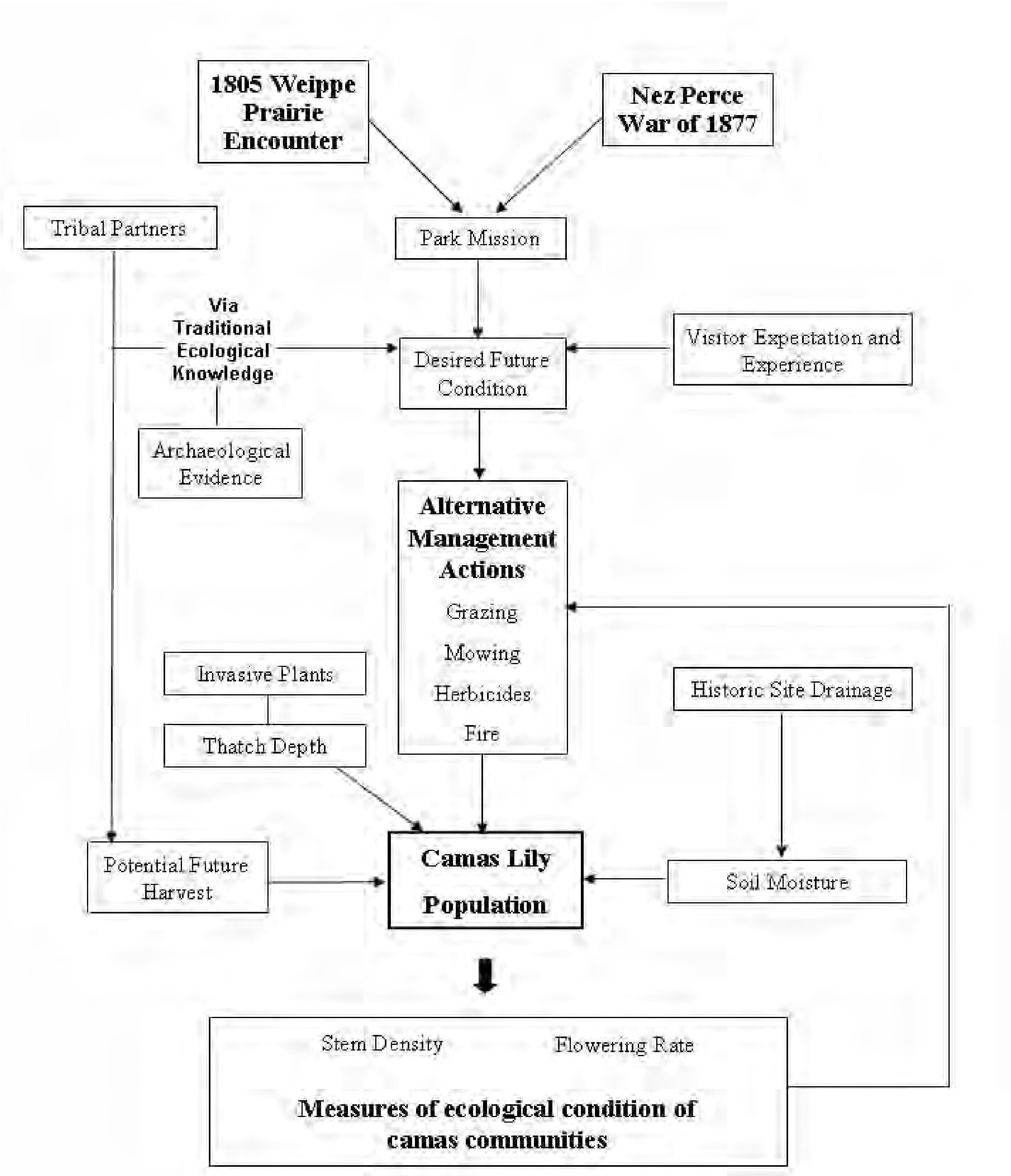


Figure C.2. Key drivers, stressors, and measures of camas lily population condition in NEPE and BIHO.

Cultural Landscape Models Narrative

Figures C.1 and C.2 illustrate the importance of both historical and contemporary human socioeconomic values in determining where and why cultural landscapes exist. By definition, cultural landscapes are dependent upon some type of historical use or activity, driven by human social or economic values. Likewise, their recognition and persistence are dependent upon contemporary values. In the UCBN, most cultural landscapes are managed to resemble the conditions as they existed at some point in the past. Typical of landscapes throughout the intermountain west, these were disturbance-driven systems and post-disturbance succession presents one of the most significant management issues facing UCBN cultural landscapes (Agee 1993; USFS 1996). In BIHO, portions of the historic battlefield, an open steppe and wet meadow complex during the Nez Perce War of 1877, has been colonized by lodgepole pine from upslope forest, prompting a management response by the park in recent years. Forest structure has been identified as a vital sign for the BIHO cultural landscape. Similar phenomena are ongoing in the Ft. Spokane area of LARO and the California Trail at CIRO. Most UCBN cultural landscapes have been managed to remain within some narrow range of seral condition, either because of ongoing cultural use, such as hay cropping and grazing at Weippe Prairie, or because of park mission and management objectives related to maintenance of a particular historic condition.

Invasive plants are a significant issue in most UCBN cultural landscapes. Figure C.1 illustrates how weedy plant invasions are exacerbated by visitation, historic and contemporary land use activities, and NPS management activities. Invasive species degrade ecological condition in cultural landscapes through their competition with native and desirable cultivated species, increased bare ground, surface runoff, soil erosion, and degraded viewshed. The intensive management and visitation at many cultural landscapes facilitates weedy plant invasions, and some cultural landscapes are likely source localities for the spread of invasive species into adjacent ecosystems. Noteworthy examples include the dominance of non-native species at White Bird Battlefield in NEPE, and the ongoing efforts at native vegetation restoration in WHMI (NPS 2003). In JODA, historic hay fields are maintained as part of the Cant Ranch historic vernacular landscape and contribute to weed infestation in adjacent sagebrush-steppe and riparian areas.

Figure C.2 illustrates the important relationships between historic and contemporary influences on desired future conditions and site management, the fundamental driver of soil moisture, and the significant influences of historic site drainage and invasive plants, as ecological stressors. In the UCBN, camas populations are significant at BIHO and at the Weippe Prairie in NEPE, and have been selected as a focal resource vital sign in the UCBN monitoring program. Camas bulbs are an important traditional food for the Nez Perce people and it was during the camas harvest at Weippe Prairie when the Lewis and Clark Corps of Discovery first encountered the Nez Perce in 1805. A significant population of camas remains on the site despite over a century of farming and ranching. Visitor experience is an important factor in determining desired future conditions and management strategies. According to the journal of Meriwether Lewis on 12 June 1806, "…the quawmash in now in blume and from the colour of its bloom at a short distance it resembles lakes of fine clear water, so complete is this deseption than on first sight I could have swarn it was water" (Moulton 1983). Although the park archaeologist serving both NEPE and BIHO believes the camas populations at both sites are well below historic levels, central management focus at this time is on maintenance of current populations, rather than on enhancing camas production, and detection of significant decline the primary objective for monitoring. Input from Nez Perce tribal members and from available archaeological literature (e.g. Thoms 1989), as a source of tradition ecological knowledge (TEK), can contribute to park desired future condition statements. For example, bulb size is density-dependent and Weippe Prairie camas bulbs are currently considered too small to justify harvesting by some Nez Perce (NPS, Jason Lyon, NEPE Resource Manager, pers. comm., 2005).

Current threats to the camas prairie resource include invasive plants and an extensively altered stream channel and site hydrology. Altered site hydrology has fundamentally impacted the camas populations at NEPE and BIHO. Drainage ditches and channel straightening at Weippe Prairie have caused entire sections of the site to dry out much earlier in the spring, and pilot data from 2005 and 2006 indicates that these areas support few camas plants. An interesting historical anecdote is that the Nez Perce were harvesting camas in September, 1805, when the Lewis and Clark Expedition arrived at Weippe Prairie. This suggests that the site was much wetter at that time, and today it would be impossible to harvest at Weippe after mid-July (Thoms 1989; NPS, Jason Lyon, NEPE Resource Manager, pers. comm., 2005). At BIHO, the subsurface drainage from the slope above the camas-supporting floodplain has been interrupted by two irrigation canals that run through the park. The impacts of these on the floodplain are not well understood at this time. NEPE is working with the Natural Resources Conservation Service (NRCS) and local ranchers to allow limited grazing for weed control. The impacts of cattle on camas have not been evaluated in the site. The possibility of allowing limited ceremonial harvest of camas at Weippe Prairie by Nez Perce tribal members has also been raised. At BIHO, the camas community has been less impacted by historic activities and site hydrology has been altered but to a lesser extent. However, non-native plant invasion is an important concern. In both sites, graminoid thatch depth may be a significant factor limiting camas germination and survival. Pre-historic use of fire was common in camas prairies where intensification of the crop was focused, and removal of thatch would certainly have been an outcome of this. Reintroduction of fire is one promising management tool for park consideration.

Appendix C.2. Sagebrush-Steppe Ecosystems

The sagebrush-steppe region has undergone radical and extensive changes during the last 150 years (USFS 1996; West and Young 2000; BLM 2002; Reid et al. 2002). Prior to European colonization, sagebrush-steppe covered approximately 44 million hectares (109 million acres) 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 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 the ecological condition of 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, especially given their ability to accommodate multiple successional pathways and steady states (Tausch et al. 1993; Stringham et al. 2001). Figure C.3 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 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.

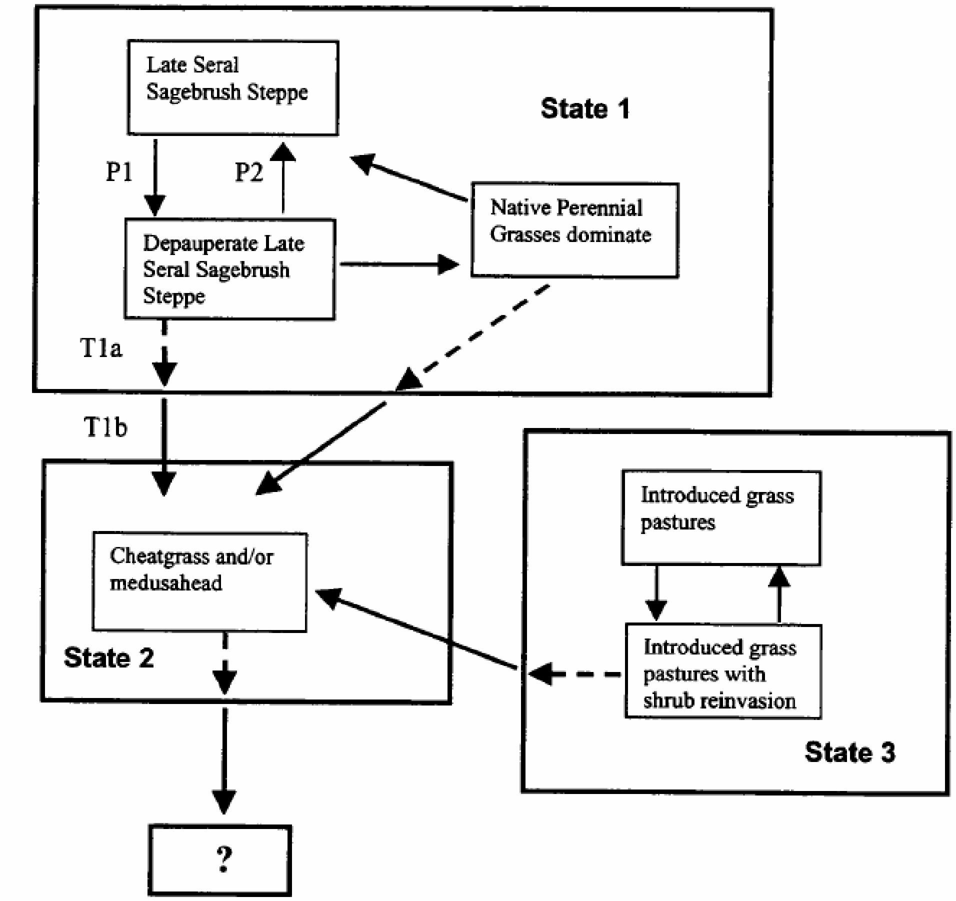


Figure C.3. Sagebrush-steppe state and transition model proposed by Stringham et al. (2001).

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 phenomenon, 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 a set of nested conceptual models and accompanying narrative developed for UCBN sagebrush-steppe ecosystems highlighting key community dynamics and measures of sagebrush community condition.

Sagebrush-Steppe Ecosystem Control Model

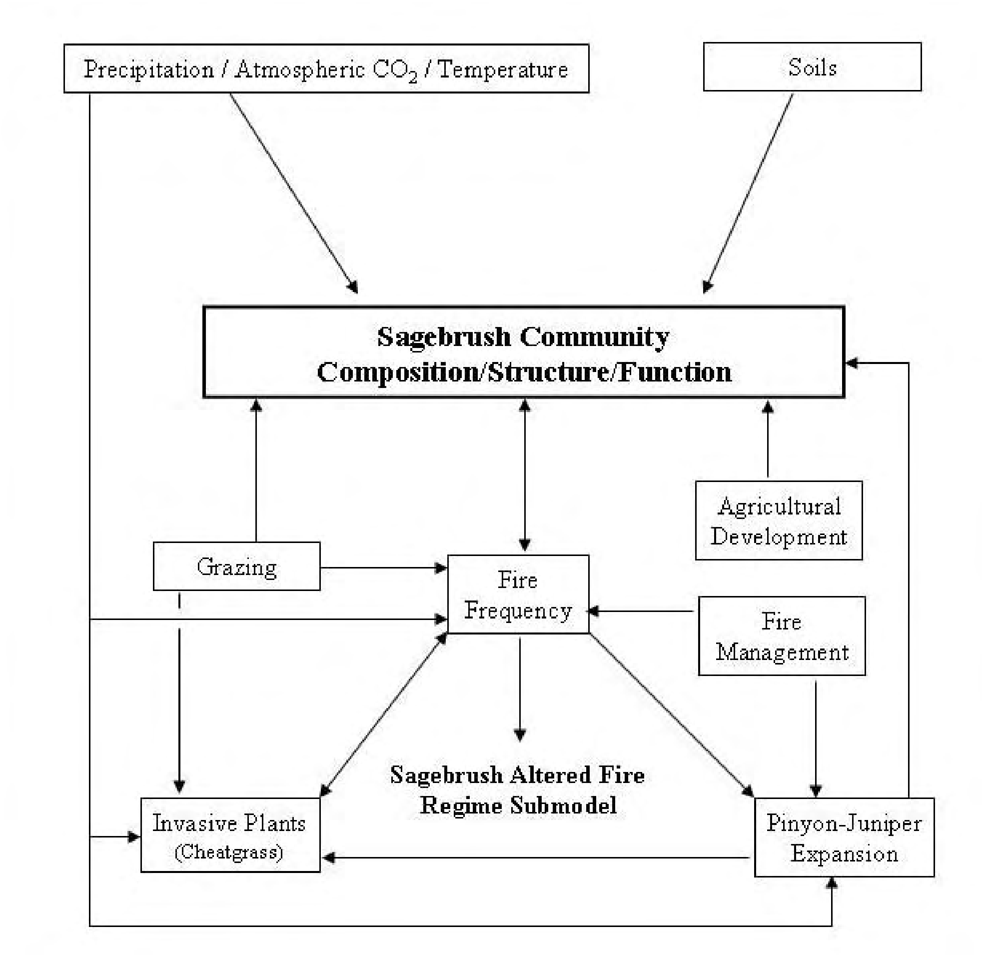


Figure C.4. Primary natural and anthropogenic controls on the composition, structure, and function of sagebrush-steppe in the UCBN.

Sagebrush-Steppe Altered Fire Regime Submodel

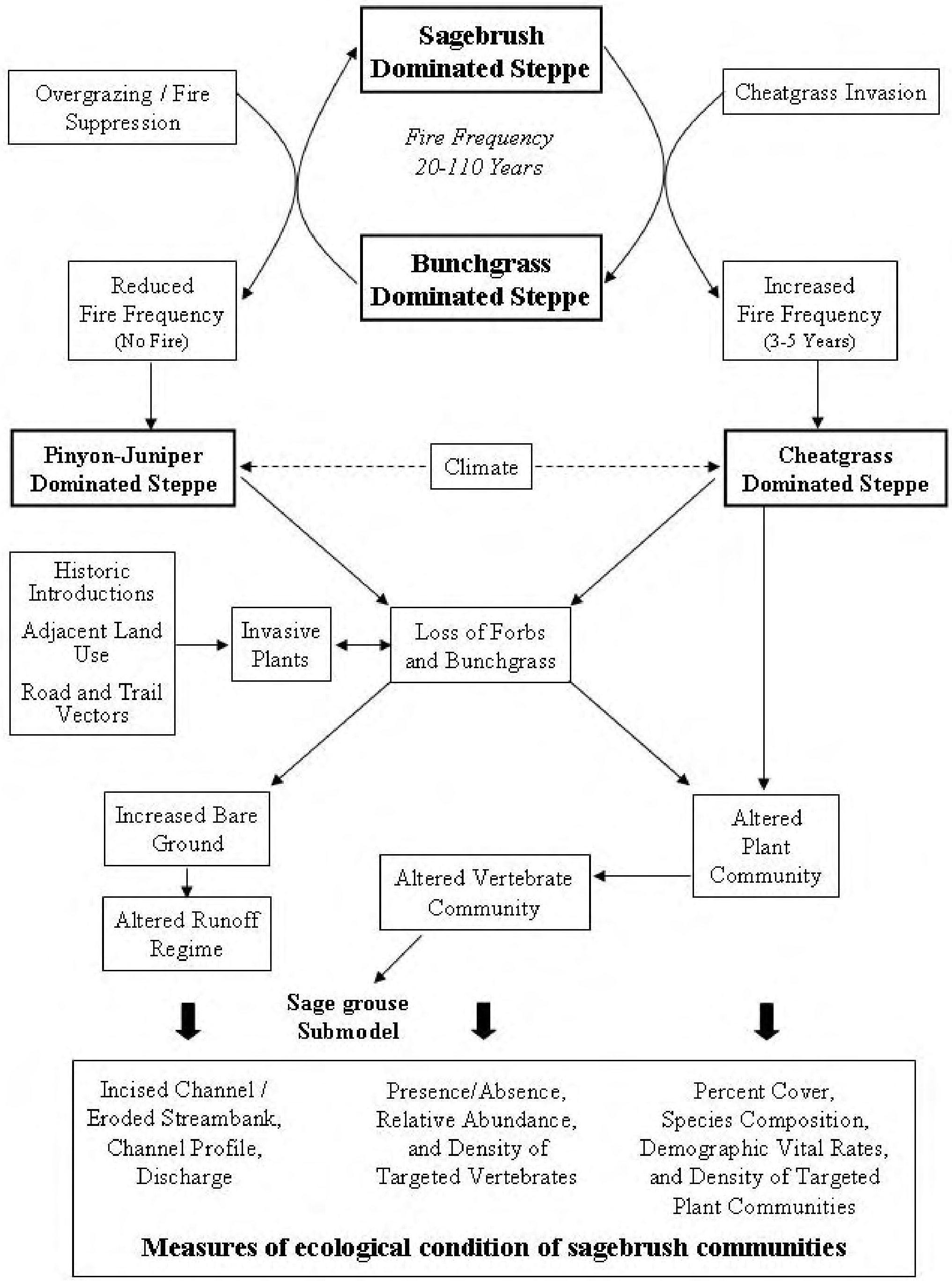


Figure C.5. Fire-driven community dynamics in sagebrush-steppe. The dashed lines represent hypothesized relationships.

Sage Grouse Population Dynamics Submodel

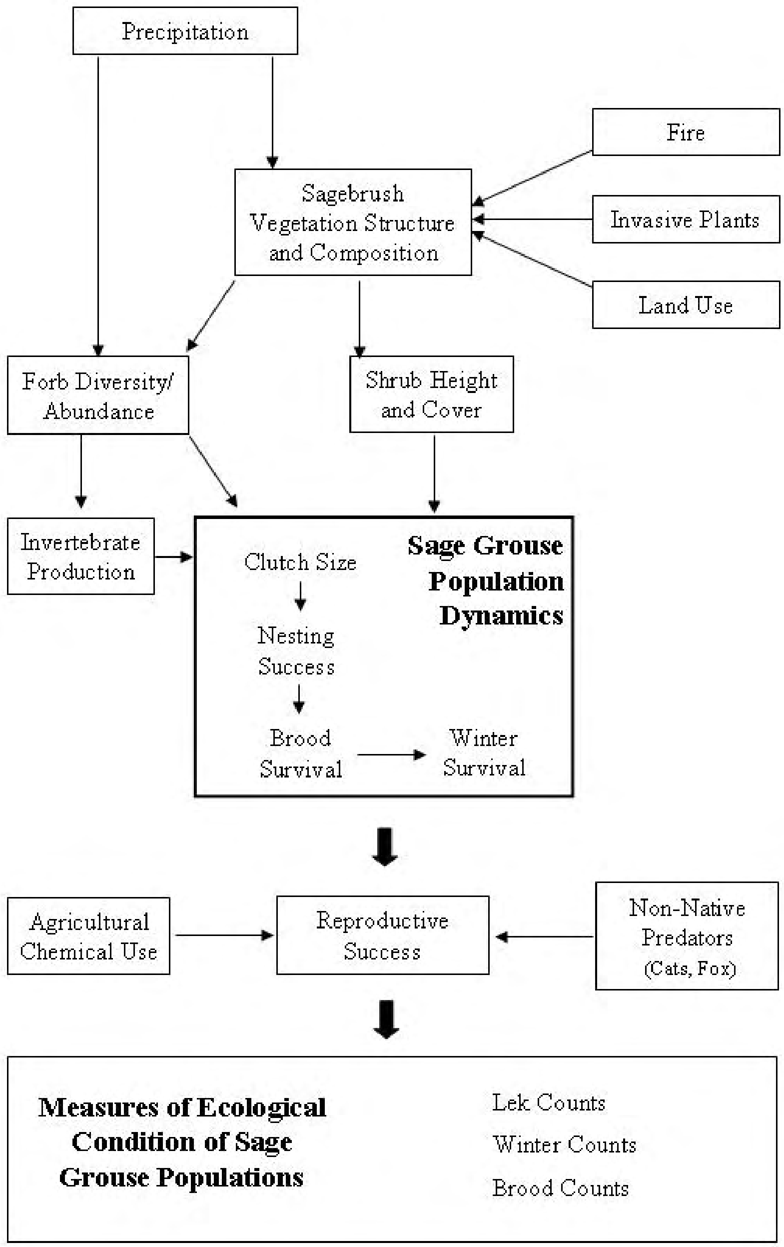


Figure C.6. Fundamental drivers of and stressors on sage grouse population dynamics.

Sagebrush-Steppe Models Narrative

As indicated in Figure C.4, weather, climate, soils, and fire are the most fundamental drivers of sagebrush-steppe ecosystems (Reid et al. 2002). Precipitation is the most important aspect of weather and 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, indicated by dashed line in Figure C.5). 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 18 to 40 cm (7.1 to 15.7 in) for basin big sagebrush and 26 to 60 cm (10.2 to 23.6 in) for mountain big sagebrush (BLM 2002).

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 (BLM 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. 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 C.1 shows the major sagebrush species and big sagebrush subspecies of the UCBN and the primary soil-moisture and fire regime characteristics of those alliances.

Fire frequency is a critical driver in sagebrush-steppe ecosystems, but this is largely constrained by precipitation, soil, and sagebrush alliance type (Reid et al. 2002). Figure C.5 illustrates the interrelationships among fire frequency, climate, and sagebrush community or alliance type. Table C.1 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. Inter-annual 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 context of the cheatgrass-driven altered fire regime of sagebrush-steppe illustrated in Figure C.5. Dry alliances, particularly 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. Reestablishment of sagebrush following fire in Wyoming big sage alliance types can be particularly slow during drought conditions (BLM 2002). Although not yet quantified, low elevation steppe habitats of CRMO, HAFO, and JODA are clearly more impacted by cheatgrass than the higher elevation steppe of CIRO and the northern portion of CRMO.

Table C.1. Soil-moisture and fire regime characteristics associated with sagebrush species and big sagebrush subspecies "alliances" in the UCBN (from BLM 2002 and Reid et al. 2002).

Species	Common Name	Elevation (m)	Soil
A. arbuscula	low sagebrush	900 to 3500	rocky, shallow
A. tripartita	threetip sagebrush	900 to 3000	moderate to deep, loamy to sandy
A. tridentata wyomingensis	Wyoming big sagebrush	1500 to 2000	deep, coarse to fine
A. t. tridentata	basin big sagebrush	250 to 3000	deep, coarse to fine
A. t. vaseyana	mountain big sagebrush	1400 to 3000	deep, coarse to fine

Species	Fire Tolerance	Fire Return Interval (years)	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

Considerable unanimity exists within the scientific community as well as the UCBN management community regarding the significance of non-native invasive plants in sagebrush-steppe ecosystems (USFS 1996; BLM 2002; Reid et al. 2002). Cheatgrass, medusahead, thistles, and knapweeds, to name a few, are actively spreading throughout the Network and having profound impacts on park ecosystems (Yensen 1981; USFS 1996). UCBN park managers have consistently ranked this as their top resource concern and monitoring of sagebrush-steppe communities will be closely tied to management objectives and activities related to invasive species. The spread of exotics are linked with other stressors of concern, including historic overgrazing, adjacent agriculture, expanding woodlands, and prescribed fire. Recent predictions of climate change scenarios have provided evidence that elevated temperature and atmospheric CO_2 concentrations may further facilitate the spread of certain exotic species, including cheatgrass (Smith et al. 2000; Wagner et al. 2003) (Figure C.5).

Mismanaged grazing ranks near the top of significant sources of ecological change in sagebrush-steppe, although it has had less impact in the UCBN than other public lands of the region (USFS 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 CRMO, HAFO, JODA, and NEPE. Heavy historic grazing has contributed to a reduction in fire frequency, leading to structural changes in sagebrush-steppe (see Figure C.5; Belsky 1996; Keane et al. 2002; Soulé et al. 2004). The expansion of pinyon pine, western juniper, and rocky mountain juniper woodlands into sagebrush-steppe has been linked to grazing-induced altered fire regime, although the sources and impacts of this invasion on ecological condition are not entirely clear (Belsky 1996; Miller and Rose 1999; Gedney et al. 1999; West and Young 2000). 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.

Altered fire regimes, historic overgrazing, and invasive plant species have led to widespread qualitative degradation of sagebrush-steppe vegetation that, in concert with quantitative loss of steppe through agricultural conversion, have led to second-order changes in surface water dynamics and loss of sagebrush-obligate vertebrates (Figure C.5; Dobkin 1995; Noss et al. 1995; USFS 1996; National Research Council 1996; Quigley and Arbelbide 1997; Kauffman et al. 1997; Wisdom et al. 2000). Network priority vital signs include sagebrush-steppe vegetation, sage grouse, and surface water dynamics and channel/bank morphology.

Altered fire regimes and plant invasions have led to a cascade of biophysical effects from increased bare ground to reduced capacity for infiltration, increased surface runoff, reduced water storage capacity, lowered water table, and, ultimately, degraded stream channel morphology (Figure C.5; BLM 2002; Bunting et al. 2002; Keane et al. 2002). 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 zones along waterbodies 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 (National Research Council 1996; Quigley and Arbelbide 1997). In the UCBN, most sagebrush-steppe waterbodies are in some stage of recovery from historic stressors.

The sage grouse is particularly representative of tight coupling between steppe obligate vertebrates and vegetation composition and structure (Figure C.6; Connelly et al. 2000).

Reproductive success of sage grouse depends on sagebrush shrub height and cover, diversity of spring forbs, and abundant invertebrates (Connelly et al. 2000). Historic and contemporary land use, including grazing, fire, and plant invasion all impact vegetation composition and structure in profound ways as previously discussed. Sage grouse frequently use agricultural lands during late spring and summer as adjacent steppe dries out, and in turn become susceptible to agricultural chemicals (Connelly et al. 1988; Blus et al. 1989). Feral cats and red fox have also been implicated in increased sage grouse mortality in some parts of their range (Flinders 1999; Connelly et al. 2000). Sage grouse were historically present at JODA and southern LARO, but is absent from these parks today (Sharp 1985; Hays et al. 1998). The species has likely been extirpated from HAFO. Sage grouse are present in CRMO and CIRO and coordinated monitoring with IDFG and BLM is anticipated in those parks.

Appendix C.3. Forest and Woodland Ecosystems

As is the case throughout the intermountain west, forests and woodlands of the UCBN are disturbance driven ecosystems (Peet 2000). Fire is the most widespread and significant disturbance agent, but insect pest outbreaks are becoming increasingly important and are also highlighted in the following conceptual models (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),

Much of the current uncertainty surrounding disturbance in 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 characteristics of forests and woodlands (Long 2003). Each of these factors are influential in UCBN parks and the most influential, elevation and topography, occur along gradients that fundamentally control where forests occur and the types of disturbances (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, quite complex. Figure C.7 illustrates the relationship between elevation and topographic moisture gradients. Of particular note in the figure is the diagonal orientation of vegetation types, which tend to occur at increasing elevation as sites become drier.

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. Insect pest outbreaks are also linked to fire and topographic moisture gradients in complex ways.

With the exception of limber pine communities, both the presence and absence of fire is a central focus for 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 density of pine stands at LARO and 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).

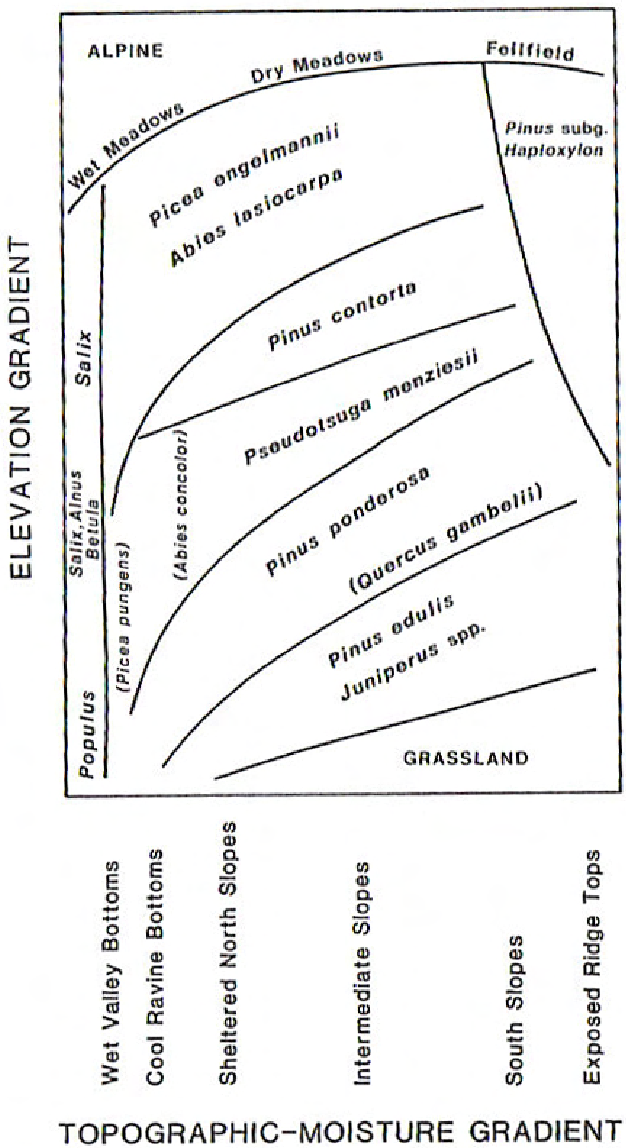


Figure C.7. The generalized relationship between elevation and topographic moisture gradients and their influence on the distribution of forest and woodland vegetation (Peet 2000).

Our understanding of fire suppression in UCBN forests and woodlands is framed by the generalized fire regimes developed for Pacific Northwest forests (Martin and Sapsis 1991; Agee 1993). Figure C.8 shows the relationship among fire frequency, topographic moisture, and forest vegetation that guides 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 (Everett et al. 2000; Ohlsen 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 (Rust and Coulter 2000; Rogers 2002). In the UCBN, limber pine stands are restricted to sparsely vegetated rocky environments that rarely experienced fire.

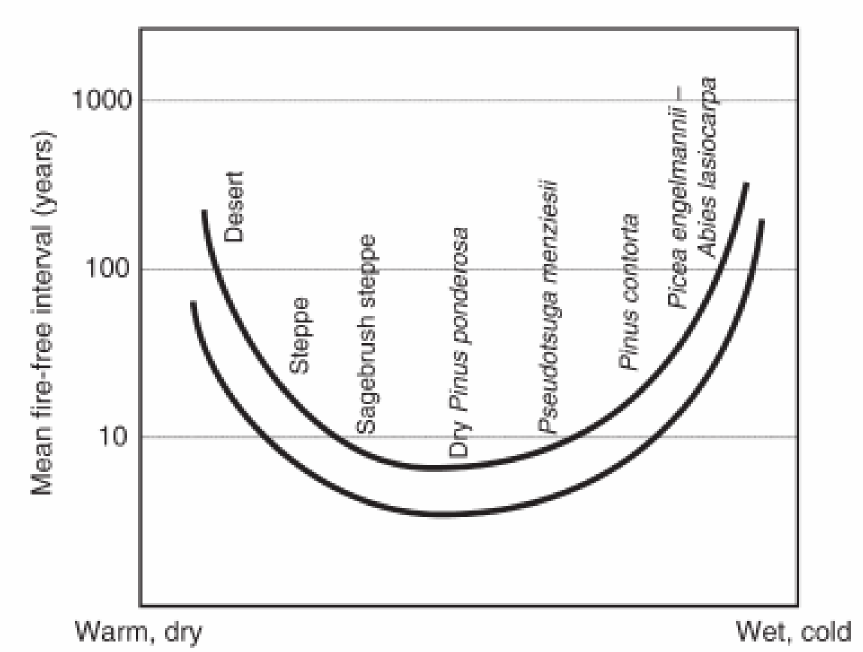


Figure C.8. Fire frequency, elevation/topographic moisture gradients, and forest vegetation in the intermountain west (Long 2003).

While the generalized relationships illustrated in Figure C.8 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 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 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 implications for NPS policy and management. Today there is great interest in using an understanding of historic disturbance regimes to design ecosystem management (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). The prospect of future climate change adds additional complexity, and is likely to significantly alter forest disturbance regimes (Logan and Powell 2001).

The following sections present conceptual models and a brief narrative highlighting key relationships in forest and woodland community dynamics in the UCBN. The models focus on altered distrubance 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.

Forest and Woodland Ecosystem Control Model

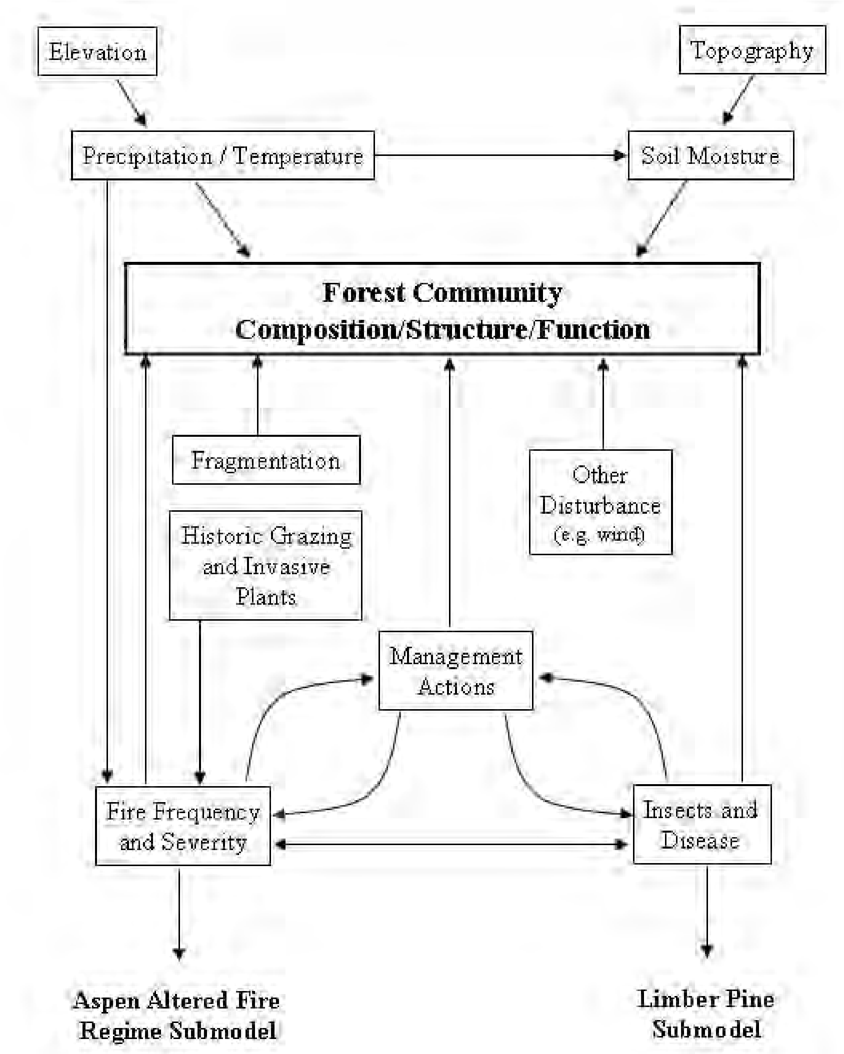


Figure C.9. Primary drivers of forest community composition, structure, and function.

Aspen Community Dynamics Submodel

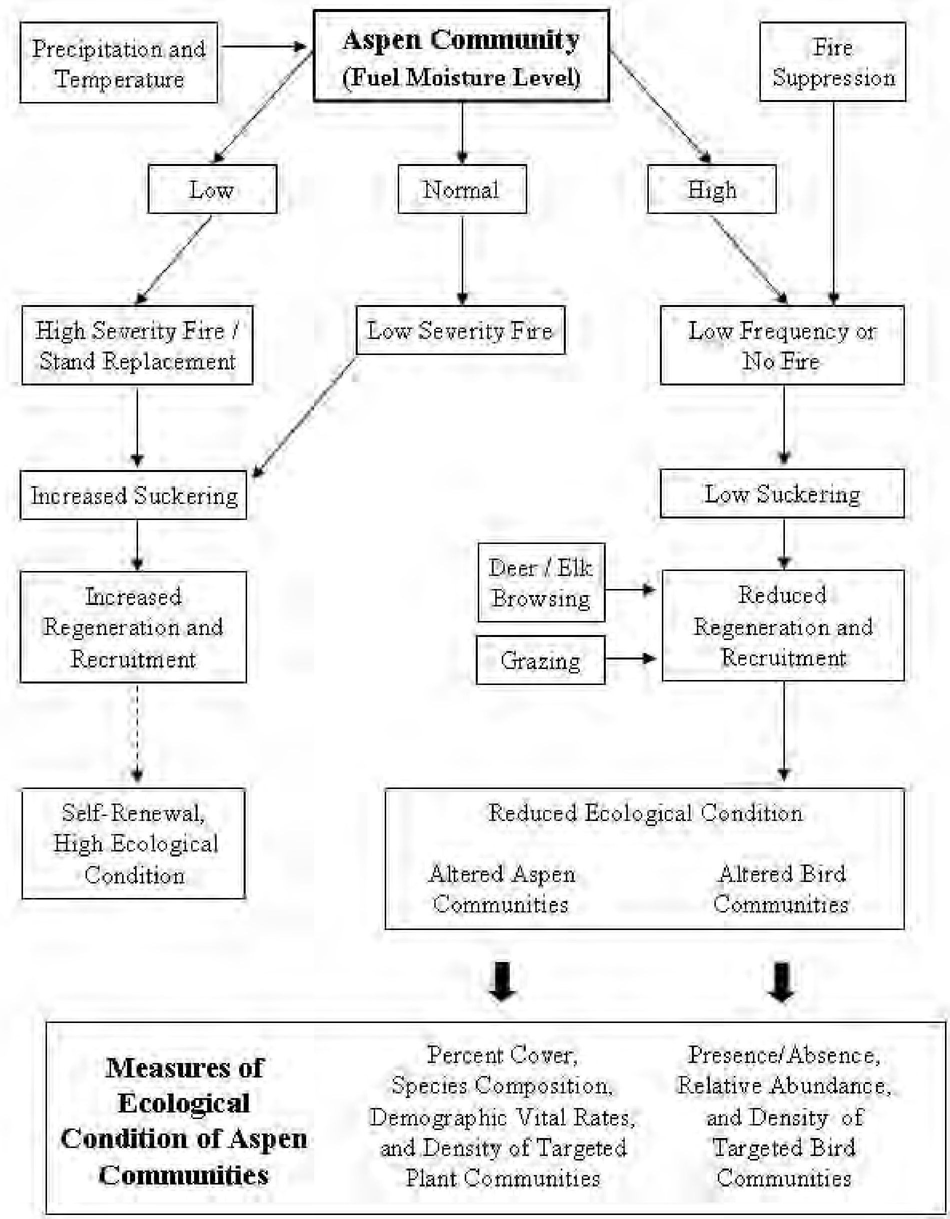


Figure C.10. Fire-driven aspen community dynamics. The dashed line represents a hypothesized or potential relationship.

Limber Pine Community Dynamics Submodel

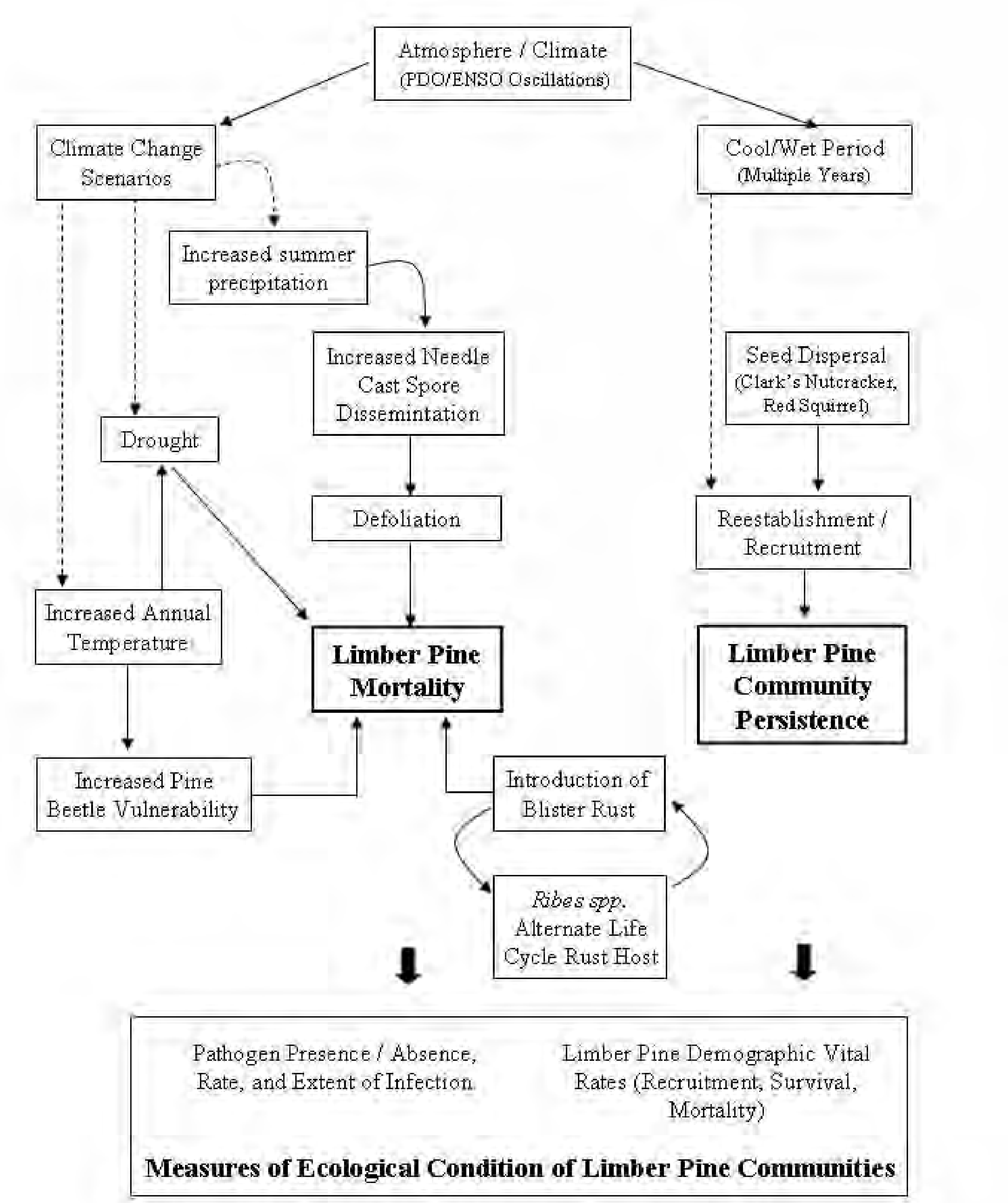


Figure C.11. Insect and climate dependent limber pine community dynamics. Dashed lines indicated a hypothesized relationship.

Forest and Woodland Models Narrative

The distribution of forests and woodlands of the UCBN are largely governed by the topographic moisture gradient, as are their composition, structure, and function (Peet 2000). This gradient, in turn, has historically driven fire, insect pest outbreaks, and other disturbances. Anthropogenic stressors, including climate change and the introduction of exotic pathogens, have significantly altered forest ecosystem processes. Hessburg et al. (2000) 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 forest stands across the basin exhibited an overall condition of vulnerability to insect outbreak and catastrophic, stand replacing fires. These relationships are illustrated in Figure C.9 and drive the community dynamics in Figures C.10 and C.11.

Ponderosa pine forests are primarily found in LARO and represent the majority of 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. Dendrochronology and fire scar studies from northeastern Washington indicate ponderosa pine forests exhibited “classic” high frequency, low severity fire regimes and 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 reported that in the Okanagan National Forest, northwest of LARO, ponderosa pine forests were almost twice as dense as historic conditions and western larch, a unique and important component to the forests of northeastern Washington, had declined significantly during the last 100 years. Forest management practices in LARO are currently focused on reducing stand density for fuel reduction. Potential stressor-induced effects stemming from this management include soil compaction and erosion, loss of snags and downed wood, and increased invasive weeds. A number of priority vital signs and monitoring objectives have been identified addressing the ponderosa pine ecosystem at LARO, focusing on effects of altered forest structure and function and management response, including fire and fuel dynamics, invasive plants, forest structure, and insect pests.

The pinyon-juniper woodlands of CIRO, CRMO, and JODA are also disturbance-driven but pose difficult conceptual and management challenges for the Network because of uncertain science surrounding the disturbance ecology of these communities (Soulé et al. 2004; Belsky 1996). Pinyon-juniper woodlands are a unique and important vegetation type that contributes to biological diversity but is also expanding into sagebrush-steppe, a phenomenon considered to be adversely affecting the ecological condition of steppe ecosystems (Gedney et al. 1999; Miller and Rose 1999). Fundamental differences exist in the structure and function of pinyon-juniper in each of the three UCBN parks. The western juniper woodlands at JODA have exhibited a dramatic shift in distribution during the 20th century, expanding out of fire-protected draws and rims onto deeper soiled areas (Gedney et al. 1999; Miller and Rose 1999). Management at JODA has been very concerned with this expansion and has actively pursued 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 is 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; BLM 2002).

At CIRO, pinyon pine and 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, including pinyon mouse, cliff chipmunk, and ringtail are also at the northern limits of their distribution. 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 pinyon *Ips* beetle infection identified in approximately 30% of CIRO's pinyon pine stands in 2004. Monitoring of this beetle outbreak in CIRO is an anticipated future project, as is monitoring of the pinyon-juniper woodland associated vertebrates that reach their northern range limits in JODA and CIRO. Monitoring of juniper woodland dynamics in JODA will be addressed within the sagebrush-steppe vegetation monitoring effort.

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 (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 are 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 C.10 illustrates the relationship among reduced fire, browsing, and grazing on declining rates of regeneration in aspen stands. Like many systems in the UCBN, the actual relationships have not been investigated for aspen stands, but preliminary investigations are underway for CIRO and CRMO and long-term monitoring of aspen vegetation and associated vertebrate communities has been recognized as a priority network activity.

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 (Figure C.11; Schuster et al. 1995). Limber pine stands in CRMO represent a unique and important component of biodiversity. 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 five-needle pines in general, and specifically in whitebark and limber pine populations in Montana and Colorado (Jackson and Lockman 2003). Blister rust was first identified in CRMO limber pine stands in 2006. Global warming has been identified as a potential cause of increased outbreaks in the future (Logan and Powell 2001). Monitoring is planned for limber pine in CRMO.

Appendix C.4. Riparian Ecosystems

Riparian zones are transition areas between terrestrial and aquatic ecosystems and can be difficult to delineate because of high complexity and heterogeneity in form and function (Gregory et al. 1991; Naiman and Decamps 1997). They are often defined by the presence of hydrophilic vegetation and soils strongly dependent on adjacent surface or groundwater (i.e., Cowardin et al. 1979). Gregory et al. (1991) provide a more integrated conceptual framework for considering riparian zones as a union of complex geomorphic and biotic components and processes (Figure C.12). Functionally, riparian zones interact with adjacent terrestrial and aquatic systems in three dimensions; longitudinally along borders of aquatic areas, laterally away from aquatic areas into adjacent uplands, and vertically through the canopy of riparian vegetation (Gregory et al. 1991). In the arid west, riparian systems typically occur in narrow bands and gradients between aquatic, riparian, and upland systems can be quite steep.

Riparian areas are highly productive compared to upland areas (e.g. Kauffman et al. 2004), contain unique floral and faunal communities, act as seasonal migration corridors or refuges (Shirley 2004), and consequently increase regional biodiversity (Wright et al. 2002). While riparian areas may only represent a small proportion of total land area, they have disproportionate influences on biological communities and ecosystem processes. For example, wetland and riparian areas comprise less than 2% of three western states (Wyoming, Nevada, and Montana), but more than 80% of the wildlife in those states use these habitats during some portion of their life cycles (McKinstry et al. 2004). Additionally, riparian ecosystems provide essential ecosystem services, including nutrient cycling, water purification, stream bank stability, and attenuation of floods (Kauffman et al. 1997; Wissmar 2004; Sweeney et al. 2004).

Significant alteration and degradation of interior Columbia Basin riparian ecosystems have occurred over the last 150 years (USFS 1996; Kauffman et al. 1997). Historic land use practices, including ranching and farming, have had long-term impacts on riparian hydrologic, geomorphic, and biotic structure and function. Figure C.13 illustrates the inextricable linkages between biota, geomorphology (including soils), and hydrology upon which riparian ecological condition depends. Anthropogenic stressors have led to interruptions between these links and triggered cascading ecosystem effects in terrestrial and aquatic systems as well as within riparian zones. The following conceptual models focus on the ecosystem dynamics that influence riparian vegetation structure and function. A submodel for bat communities has been included here because of their strong dependence on riparian and aquatic habitats. Both riparian vegetation and the bat community have been identified as important vital signs for the UCBN monitoring program.

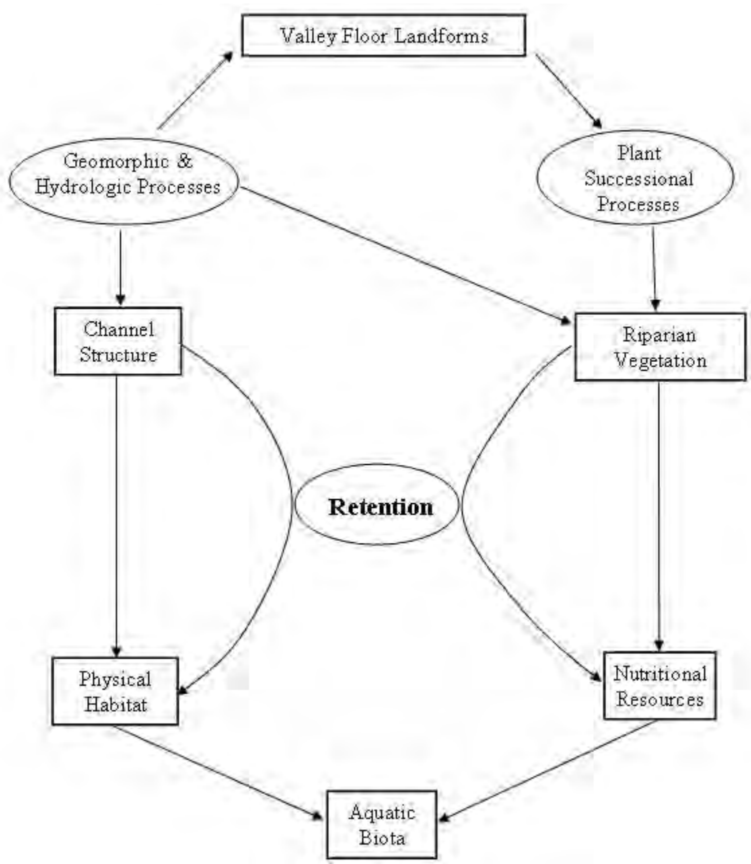


Figure C.12. Representation of relationships between geomorphic, biotic, and aquatic ecological components (rectangles) and processes (circles) in riparian ecosystems (from Gregory et al. 1991).

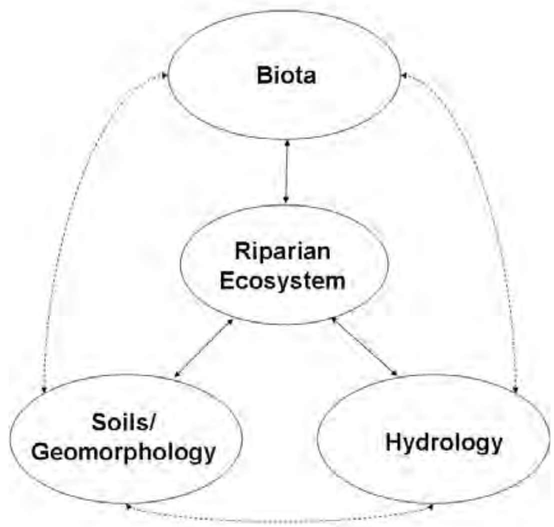


Figure C.13. The structure and function of riparian ecosystems are driven by biotic, hydrologic, and geomorphic components and processes (from Kauffman et al. 1997).

Riparian Ecosystem Control Model

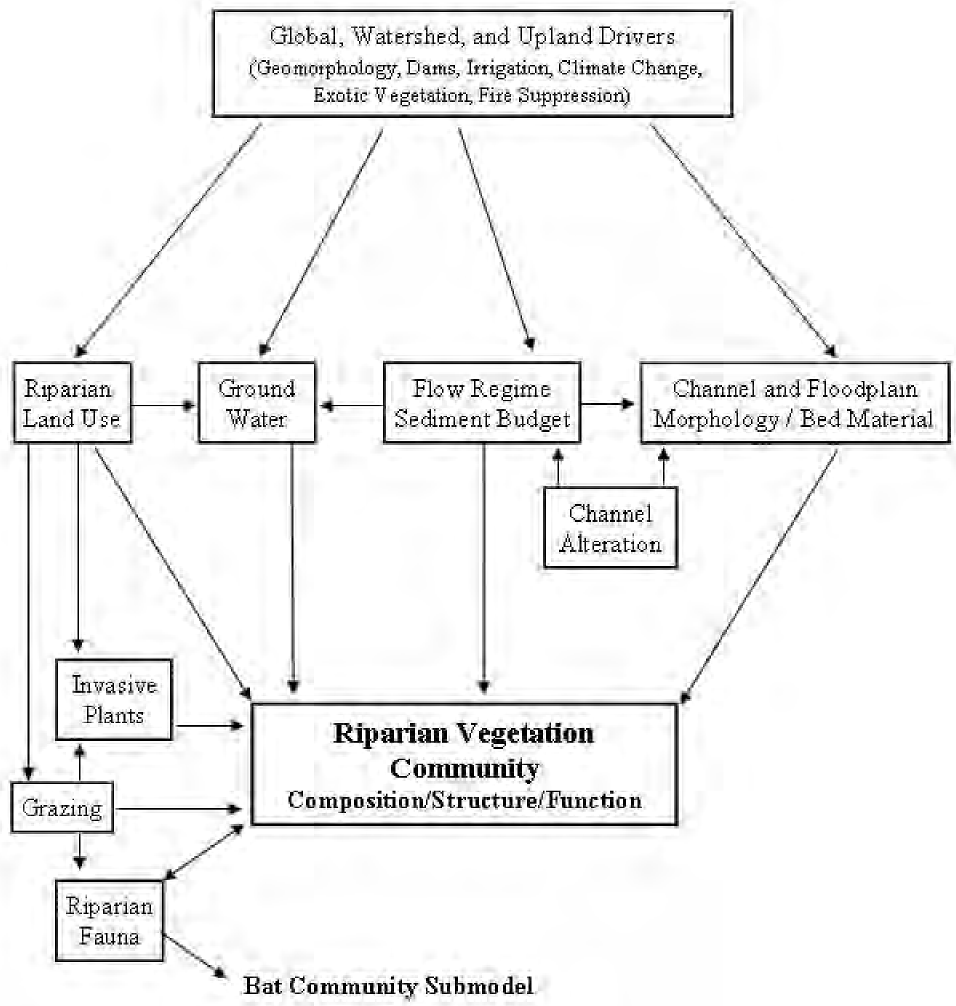


Figure C.14. Hydrologic, geomorphic, and biotic drivers and stressors of riparian vegetation communities in the UCBN.

Bat Community Dynamics Submodel

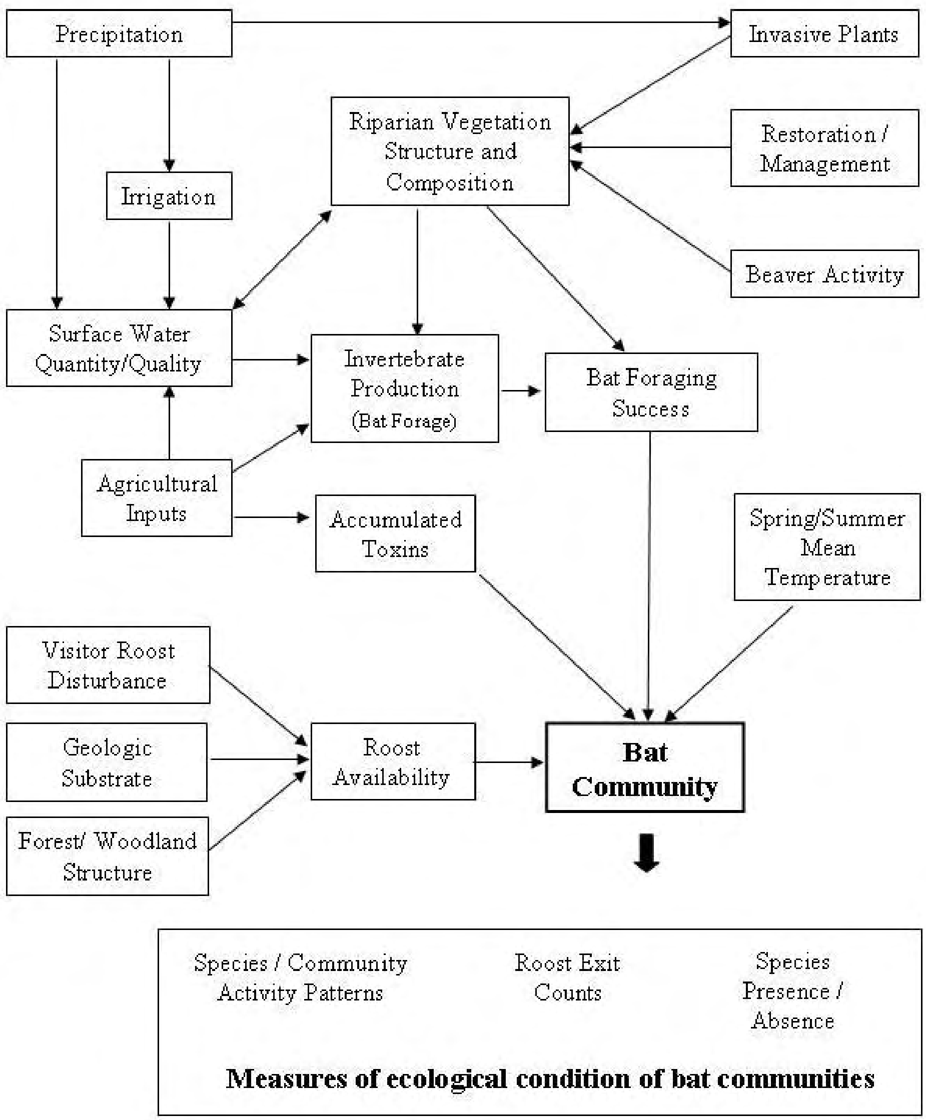


Figure C.15. Relationship among riparian vegetation, invertebrates, and bats. Roost dynamics are represented here, underscoring the important lateral connection between riparian and aquatic and upland systems.

Riparian Ecosystem Models Narrative

Riparian ecosystem processes are strongly linked to global and watershed drivers that also affect river processes because both are dependent on prevailing hydrologic and sediment regimes (Figure C.14; Naiman and Decamps 1997; Wissmar 2004). A central driver in both riparian and lotic systems is the flow regime (Poff et al. 1997), a description of the timing, magnitude, and variability of streamflow. In the UCBN, changes in channel morphology and most erosion occur during spring run-off. Notably, spring run-off follows a highly predictable seasonal pattern, but differs markedly among years in timing and magnitude, and it is this variation in magnitude that is a primary influence in determining the disturbance regime in both habitats. In semi-arid regions such as the UCBN, the flow regime tends to be less predictable and results in streams with "flashy" flow patterns. Collectively, the flow regime and upland drivers have strong effects on riparian sediment dynamics by determining sediment input rates and erosive potential.

Fluvial geomorphology also has strong effects on riparian communities. In high gradient reaches, constrained channels limit the width of the riparian zone and higher erosion results in lower soil organic matter, whereas lower gradient reaches are typically less constrained, have higher channel sinuousity, lower stream power and erosion, and finer soils with higher soil organic content (Naiman and Bilby 1998). Flow regime and channel morphology directly affect soil conditions, local disturbance regime and riparian vegetation. Flow regime and sediment budget interact with watershed drivers to determine ground water levels, and these have strong effects on riparian vegetation. Riparian vegetation, in turn, influences ground water conditions through evapo-transpiration (Naiman and Bilby 1998). Riparian vegetation has strong effects on channel form because vegetated riparian areas resist erosion and provide structural and nutrient inputs from woody debris and other dead material, or necromass (Kauffman et al. 1997; Gregory et al. 2003). Riparian vegetation is also controlled by soil characteristics, disturbance (flood) regime, directly by native and non-native grazers (beavers, elk, and livestock; Naiman et al. 1988; Baker et al. 2005), and indirectly by their predators (Beschta 2005).

Because of the importance of water to human societies and scarcity of water in the west, riparian and wetland areas have been drastically altered by current and historical human activities (McKinstry et al. 2004; Wissmar 2004). Over the past 200 years a large number of human activities have impacted riparian areas of the UCBN including mining, livestock grazing, fire suppression, timber harvest, agricultural practices (including irrigation), recreation, dams, construction of flood control and transportation infrastructure, urbanization and suburbanization, and the transport of exotic flora and fauna (reviewed in Dwire and Kaufmann 2003; Wissmar 2004). The greatest change in the Columbia Basin has occurred since the economic development associated with World War II (USFS 1996). During this period, there have been large scale changes in upland land-use and regulation of the region's water resources. There are currently more than 400 dams in the Basin. Riparian habitats in UCBN parks are no exception to the regional pattern, and alterations include channelization and confinement (WHMI, BIHO, HAFO), alteration of hydrologic regime through damming (Snake & Columbia Rivers: NEPE, HAFO, LARO; stock ponds, JODA), irrigation (HAFO, WHMI), and diversion (WHMI), presence of introduced species (bullfrogs, most UCBN units), and grazing (Weippe Prairie NEPE, CIRO, LARO).

These changes in global and watershed drivers have strong effects on riparian biota, primarily thorough alteration of physical habitat and flow regimes. Dams and irrigation alter channel and floodplains directly by changing surface and ground water levels, and indirectly by altering flow and sediment regimes (Montgomery and Buffington 1998). In particular, flow regulation prevents large flow events (floods) that have the greatest effect on floodplain form and sediment composition (Benda et al. 1998), and plant succession (Naiman and Bilby 1998). Local irrigation and conversion to agriculture or pasture in floodplain areas often includes portions of the riparian zone. Global and watershed drivers, especially urbanization, may directly affect channel and floodplain morphology through channelization and flood control projects.

Both Figures C.14 and C.15 illustrate the influence of invasive plants on riparian vegetation. In the UCBN, riparian zones are heavily infested with non-native vegetation. In many riparian areas, the vegetation consists entirely of non-native species. Site productivity contributes to this, but the intensity of historic damaging land use practices in riparian areas, including grazing and irrigation developments, is a primary factor. Wholesale shifts in riparian vegetation composition and structure have occurred, with native plant communities replaced by monocultures of reed canary grass, knapweeds, and other exotic species. Native riparian cottonwood galleries have been eliminated and replaced with non-native herbaceous vegetation, resulting in significant structural changes as well as in species composition.

The effects of these changes in vegetation structure and composition on riparian-dependent vertebrates has been well articulated for birds, but not as well for other taxa, including bats (e.g. Knopf and Samson 1994; Dobkin et al. 1998). For example, riparian structure and composition have been linked to population viability of the southwestern willow flycatcher and avian richness has been positively correlated with structural conditions in riparian zones (Dobkin et al. 1998; Sogge and Marshall 2000). Bats are also strongly associated with riparian and aquatic environments, which they use nightly for drinking and foraging, and may be effective indicators of riparian vegetation condition (Figure C.15; Fenton 2003). For example, bats respond to structural conditions and seek out optimal foraging areas (Mackey and Barclay 1989; Brigham et al. 1992). Likewise, insectivorous North American bats include both invertebrate prey generalists and specialists, and respond to availability of prey by shifting foraging in space and in diet composition (Whitaker et al. 1981; Brigham et al. 1992; Whitaker 2004). Figure C.15 illustrates how vegetation structure and composition influences both prey availability and foraging success. Bats exhibit high fidelity to roosting and foraging areas but will quickly alter use patterns in response to changes in resource conditions (Fenton 2003; Rodhouse and Wright 2004; Veilleux and Veilleux 2004). Hickey et al. (2002) also demonstrated that bats are vulnerable to accumulations of agricultural chemicals. In the UCBN, as many as 14 species of bats can occur together, representing up to seven state and federal species of concern, including the rare spotted bat (Rodhouse et al. 2005). Several diets and foraging strategies are represented, including beetle and moth specialists (Coleoptera and Lepidoptera, respectively), as well as generalists that respond to hatches of aquatic flies (Trichoptera and Diptera) (Whitaker et al. 1981; Verts and Carraway 1998). This sensitivity to insect abundance and foraging habitat structure, as well as their mobility and longevity, warrants inclusion of bats as indicators of riparian ecological condition in the UCBN (Fenton 1993).

Although not directly related to riparian ecosystems, roost availability (represented in Figure C.15) is also a significant issue for at least some species of bats found in the UCBN. Species such as the pallid bat and Townsend's big-eared bat select roosts in geologic features that are limited in availability across the landscape in the Network (Lewis 1995; Keller 1997; Rodhouse and Wright 2004). These same species are also vulnerable to human disturbance at roosts (O'Shea and Vaughan 1999). Foliage and tree-roosting bats, including the hoary bat and silver-haired bat, may also be roost limited because of the historic reductions in cottonwood galleries and aspen groves, and landscape-level reductions in snags in ponderosa pine forests (Pierson 1998).

Appendix C.5. Aquatic Ecosystems

Aquatic ecosystems are typically subdivided into lotic (running water) and lentic (lake and pond) habitats although impoundments on some of the larger river systems have also created lentic conditions. Though small in terms of surface area, they have a disproportionate impact on biological communities, ecosystem processes, and regional biodiversity. Riparian habitats are the ecotone, or border, between upland and aquatic habitats. Wetlands are areas with saturated soil or shallow (less than 1 m) surface water, and frequently with extensive areas of floating or emergent vegetation. Despite these intuitive definitions, the classification of aquatic habitats is often problematic because of the diversity of habitat types within ecosystems, temporal variation within habitats (e.g., water level), and the often indistinct transition between habitat types (e.g., riparian vs. upland forest; when does a pond become a lake?). This is particularly true of riparian and wetland areas (McKinstry et al. 2004).

The ecology of freshwater is strongly affected by drivers and stressors at multiple scales, and these drivers are hierarchical or nested (Poff et al. 1997; Allan 2004; Figure C.16). The largest scale drivers are global or regional drivers acting on entire watersheds such as precipitation, climate regime (e.g., Pacific Decadal Oscillation (PDO), El Niño Southern Oscillation (ENSO); Beebee and Manga 2004), underlying geology and topography, and large scale disturbances including volcanic (e.g. Quinn et al. 1991) and large-scale fires (Rieman et al. 2003). Global and landscape stressors include human-induced climate change, non-local pollution sources (e.g. atmospheric nitrogen deposition), alterations to hydrologic regimes through damming and irrigation withdrawals, and broad scale cultural policies affecting water quality and fisheries policy (NRC 1996; Rahel 1997; Poff et al. 2003; Postel and Richter 2003).

Within individual drainage basins, upland land cover/land use and cultural landscapes strongly affect aquatic ecosystems and communities by influencing hydrology, physical habitat, and nutrient, sediment, and toxicant inputs (Thompson and Lee 2000; Kershner et al. 2004; Allan 2004). Many effects of upland habitats are mediated (and 'buffered') by riparian areas and wetlands because these areas strongly affect the magnitude and timing of upland inputs to surface water habitats (Naiman and Bilby 1998; McKinstry et al. 2004). For instance, riparian condition strongly affects aquatic physical habitat characteristics including light availability, temperature, channel form, sediment regimes, and substrate composition (Naiman and Bilby 1998; McKinstry et al. 2004).

The local distribution and abundance of aquatic organisms within each habitat type are determined primarily by spatial heterogeneity in physical and chemical properties among microhabitats (current speed, temperature, nutrients, dissolved oxygen) (Allan 1995; Dodson 2005), while global and watershed drivers indirectly affect local communities by determining the characteristics of physical habitats and influencing regional species pools. In turn, biota can alter the physical and chemical environment through metabolic activities (nutrient uptake, excretion, respiration), redd-building behaviors by salmonids that alter sediment composition and transport (Gottesfeld 2004), and the "ecosystem engineering" activities of beaver damming (Jones et al. 1997), or even stream macroinvertebrates (Zanatell and Peckarsky 1996). Introduced species and manipulation of fish populations represent stressors acting at the local scale. Predator-prey and competitive interactions with introduced species, including warm water fishes, bullfrogs and non-native salmonids, have strong local effects on communities (Levin et al. 2002; Kolar and Lodge 2002; Adams et al. 2003). For instance, survival of Chinook salmon juveniles in wilderness streams without introduced brook trout was near twice that of salmon in invaded streams (Levin et al. 2002).

Interestingly, most aquatic systems are characterized by "open populations" where immigration and emigration have strong effects on local population dynamics (Schlosser 1995; Peckarsky et al. 2000; Bilton et al. 2001; Fausch et al. 2002; Caudill 2003), and consequently, the condition of upland and riparian migration corridors can have strong effects on local population dynamics of aquatic species with terrestrial life history stages (e.g., aquatic insects, amphibians). Consequently a major challenge to effectively managing and conserving aquatic populations is that local management efforts may be swamped by regional scale population and ecosystem processes. The following models and narrative emphasize the "open" and three-dimensional nature (discussed for riparian ecosystems above) of aquatic ecosystems. Influences from upland and riparian inputs and watershed-scale drivers are emphasized.

Aquatic Ecosystem Control Model

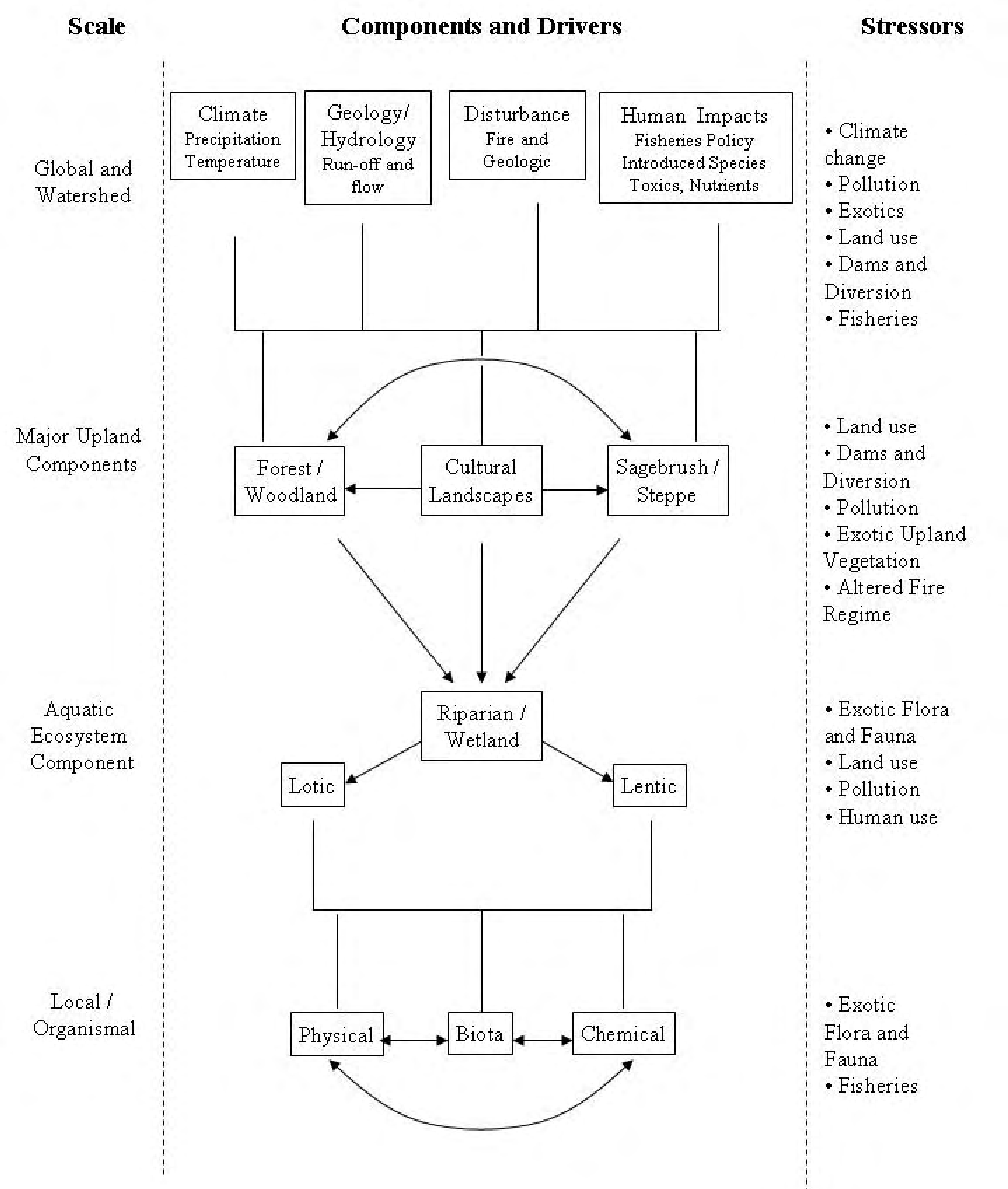


Figure C.16. Fundamental components and processes of aquatic ecosystems at multiple nested scales.

Lotic Ecosystem Submodel

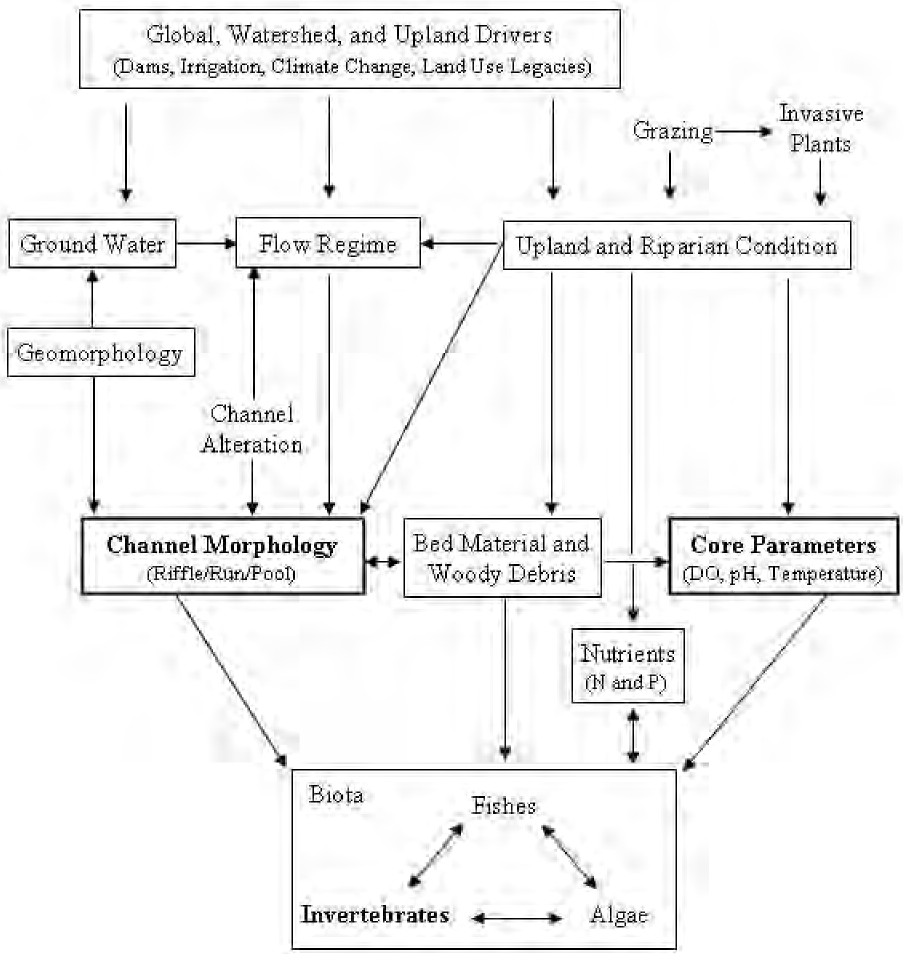


Figure C.17. Hydrologic, biotic, and geomorphic components and processes of UCBN lotic systems.

Lentic Ecosystem Submodel

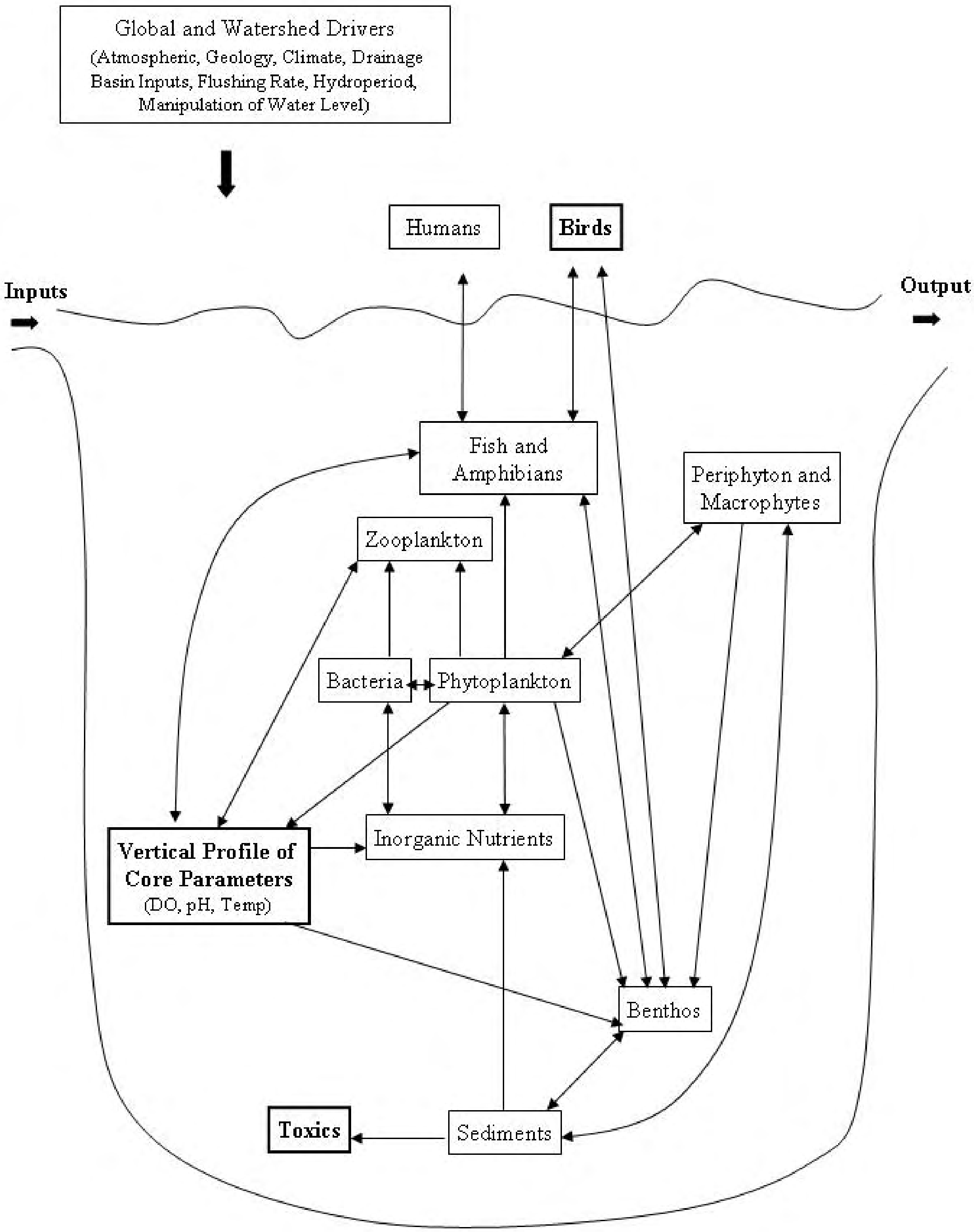


Figure C.18. Hydrologic, biotic, and geomorphic components and processes of UCBN lentic systems.

Osprey Population Stressors Submodel

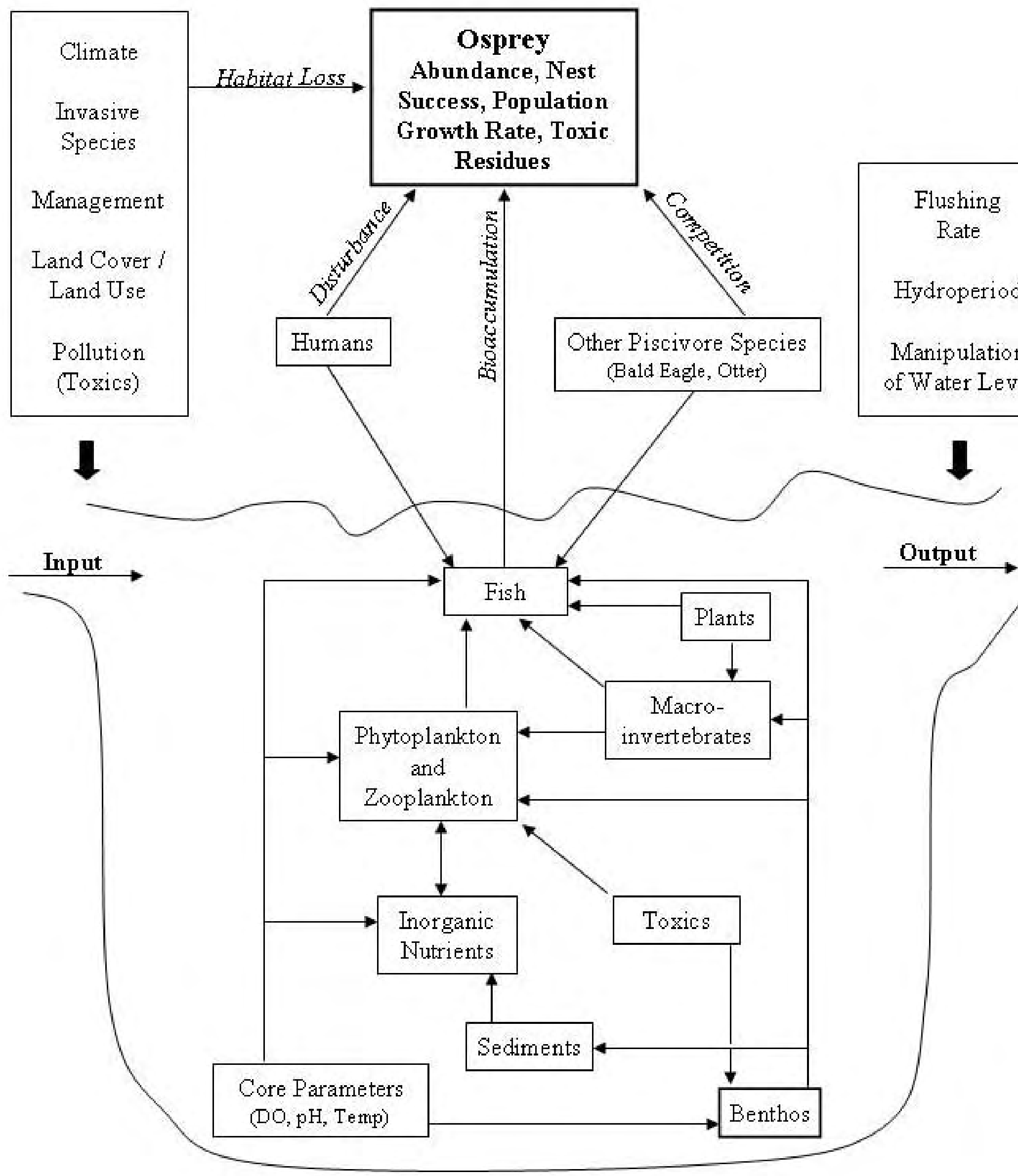


Figure C.19. External and internal sources of osprey population stress in Lake Roosevelt National Recreation Area (lentic system).

Aquatic Ecosystem Models Narrative

Lotic Ecosystems: Streams and Rivers
Figures C.16 through C.19 emphasize global and watershed processes and geomorphology, which are frequently modified by riparian and groundwater processes, and have strong effects on unmodified streams and rivers by determining local stream gradient, sediment and nutrient inputs, water chemistry, thermal regime, and ground water budgets (Allan 1995, 2004; Naiman and Bilby 1998; Matheussen et al. 2000). The flow regime, in conjunction with these larger scale drivers, determines the structure and distribution of meso- and microhabitats within the stream channel. The relative distribution of channel units (typically riffles, runs, and pools) is strongly affected by geomorphology, flow regime, upland and riparian condition, bed material and wood. In steep streams with constrained channels, riffles and runs may dominate, while in similar streams with wider floodplains, classic riffle-run-pool sequences may develop (Allan 1995). The distribution of wood interacts with channel units because wood can accumulate in pool habitats, and because large wood has strong effects on local channel morphology, frequently creating dams, undercuts, and pools (Gregory et al. 2003). Upland land cover (e.g., forest vs. shrub-steppe) and flood frequency and magnitude regulate the build-up and distribution of wood in stream channels. Gradient, local geology, flood frequency and magnitude, and soil affect the particle size distributions in channels by determining the erosive power of a stream. These drivers also act on substrate characteristics through their effects on upland and riparian condition, with larger cobbles and gravels common in mountainous high gradient streams and sands and silts dominating in lower gradient streams.

Locally, the abundance and distribution of stream biota are controlled by these meso- and microscale habitats, biotic interactions, and by small scale heterogeneity in water chemistry. For example, many stream invertebrates are restricted to riffles and fish assemblages in slow water and rapid water channel units often differ. Water chemistry can have both local and regional effects on biota. In particular, pH, temperature, nutrient concentrations, and dissolved oxygen have strong effects on stream biota. Regionally, climate and geology affect broad-scale patterns of stream thermal regime, pH, and nutrient status, which collectively have strong influence on the regional species pool and patterns of community structure (Allan 2004). Nutrient concentrations are determined by complex interactions between inputs and transformations within the stream, primarily by algae and microbes, and may limit primary productivity in some systems. The local distribution of organisms may be affected by smaller scale heterogeneity in water chemistry patterns as well. For instance, stream reaches with cool water were important refuges for summer Chinook salmon on the John Day River (Torgersen et al 1999). Finally, biotic interactions including both negative (competition, predator-prey, parasitism; Allan 1995) and positive interactions (facilitation and mutualisms; Hay et al. 2004).

Not surprisingly, stream communities are affected by stressors at multiple scales, and again many of these are shared by riparian habitats. Generally, stressors work through three general pathways: stressors affecting physical habitat characteristics, landscape alterations that include changes to stream nutrient status, and alteration of biotic interactions by the introduction of non-native species, including game fishes. Changing climate affects lotic habitats directly by altering precipitation patterns and thermal regimes, and indirectly through the alteration of upland and riparian communities. The regulation of rivers by damming clearly has strong effects on the communities of inundated reaches, but also strong effects on downstream communities through the alteration of sediment budgets, flow, thermal, and disturbance regimes; irrigation withdrawal produces similar effects (Poff et al. 1997; Postel and Richter 2003). Attenuation of peak flows can impact stream biota because important life history events are cued by annual high flow events in many species (Lytle and Poff 2004).

Land use legacies alter thermal and flow regimes primarily by altering vegetative land cover from the historical condition (Matheussen et al. 2000). For example, differences in mean stream temperature among sub-basins of the John Day River were attributed to differences in land use (Torgersen et al. 1999). In general, alterations in land cover affect stream biota, and the magnitude of the impact depends both on the type, extent, and spatial arrangement of altered land use classes (Allan 2004). In addition to contemporary land use patterns, historical land-use legacies, including grazing, logging, and agriculture can have long lasting effects that affect hydrology and biotic communities (Harding et al. 1998; Matheussen et al. 2000).

Exotic species have strong impacts on aquatic ecosystems, and important intentionally or accidentally introduced species in the Columbia Basin include largemouth and smallmouth bass, walleye, American shad, brook trout, and brown trout. These species affect food web dynamics (Baldwin et al. 2003; Naughton et al. 2005) and interact with native fishes (Levin et al. 2002). Other important invaders include the New Zealand mudsnail (Hall et al. 2003; Richards et al. 2004) and non-native macrophytes. Alteration of the flow regime, particularly the attenuation of peak flows, may facilitate the invasion of non-native species in flood-dominated regions with flood adapted native fauna.

Beaver and anadramous fish are two keystones that have strong current and historical effects on freshwater ecosystems in the Columbia River Basin. Beaver have strong direct effects on vegetation through tree cutting and browsing activities (Naiman et al. 1988) and larger effects through dam building activities (Naiman et al. 1988; Pollock et al. 1995, 2003). Beavers are the quintessential ecosystem engineer (Jones et al. 1997) because pond construction drastically alters riparian and stream physical habitat and biota. Historically, beavers and beaver ponds were the dominant feature of permanent streams throughout North America, and the majority of headwater streams were likely dammed (Pollock et al. 2003; Laliberte and Ripple 2003). Reported pond densities from relatively undisturbed populations range from 9.6 to as high as 73.7 dams/km along

Rocky Mountain streams with slopes of 1 to 12.5% (reviewed in Pollock et al. 2003). In the well-drained intermountain west, beaver ponds probably were, and currently may be, the most common wetland type numerically and by total area. Moreover, available literature suggests these ponds have strong and generally positive effects on habitat and biota. Damming increases hydraulic recharge of aquifers, in some cases shifting ephemeral streams into perennial streams supporting salmonid populations (Pollock et al. 2003). The depositional environment alters sediment dynamics, widens floodplains and riparian areas, and increases nutrient retention and processing (Naiman et al. 1986, 1994; reviews in Naiman et al. 1988; Pollock et al. 1995, 2003). Increased productivity per stream length and increased habitat heterogeneity increase regional plant (Wright et al. 2002) and bird (Medin and Clary 1990; Brown et al. 1996) diversity in riparian areas. More recently, the indirect effects of marine-derived nutrients transported by salmon on stream, lake, riparian, and even upland, communities has been recognized (Helfield and Naiman 2001; Koyama et al. 2005; Wilkinson et al. 2005; Quinn 2005).

Lentic Systems: Lakes and Ponds

Standing water habitats encompass a wide range of sizes and types, from small temporary wetlands to ponds to large lakes. Like other aquatic habitats, they are affected by drivers and stressors at multiple scales (Figures C.18 and C.19). Global drivers include climate, basin morphometry, precipitation rates, and nutrient inputs determined by both water- and air-shed inputs. Local drivers include point sources of nutrients, local bathymetry, local water chemistry, and local bottom type. Major stressors include alteration of nutrient status and water chemistry through cultural eutrophication, increased sedimentation, and acid rain, alteration of shorelines and littoral zones through development, inputs of toxics, fishing and boating impacts, and the introduction of non-native species. Reservoirs, by definition, result from a stressor (dam) applied to a stream or river, and differ from ponds and lakes in important respects.

The character of a particular lake is strongly influenced by its hydroperiod (i.e., whether it dries), morphometry, water source, and nutrient status. Typically, permanent ponds and lakes with sufficient depth have well developed fish communities. Temporary ponds and shallow ponds that periodically dry or “winter-kill” have vertebrate communities dominated by amphibians and distinct invertebrate communities (Wellborn et al. 1996). Overall size and depth influence both the relative ecosystem importance of benthic (bottom associated) versus pelagic processes and whether the water column stratifies or not. The magnitude and relative contribution of different water sources (precipitation, riverine or groundwater) affect water level fluctuations, flushing rate, and nutrient inputs. Finally, one of the strongest controls on biological communities in lentic habitats is nutrient status—whether the body is oligotrophic, mesotrophic, or eutrophic—because phosphorus and nitrogen frequently limit primary production (Barber et al. 1999; Dodson 2005).

The largest lentic ecosystem in the UCBN is Lake Roosevelt, a meso- to oligotrophic reservoir on the Columbia River behind Grand Coulee Dam that spans approximately 210 river km (Barber et al. 1999) and displays lotic conditions in the upper portion. Lentic habitats at all other units are substantially smaller and comprised primarily of oxbow lakes or small artificial ponds. Oxbow lakes are present in BIHO and NEPE, formed by the Big Hole and Snake Rivers, respectively. JODA has two stock ponds in the Clarno Unit, Schwartz Pond is an old mill pond in NEPE, and WHMI also has a restored millpond. CRMO has perhaps the greatest diversity in lentic habitat types, with many small vernal pools and ponds associated with lava tubes, and part of the unit borders the approximately 6 ha (15 acres) Lava Lake. Small temporary habitats, such as those at CRMO, remain largely uninvestigated but probably have similar ecologies to the temporary ponds known as Tinajas formed in sandstone depressions in southeastern Utah (Anderson et al. 1999).

Under natural conditions, several global and watershed drivers have strong influence on lentic habitat structure and ecosystem process. Water chemistry is strongly affected by the geology and land cover within the drainage basin, and by precipitation and atmospheric inputs. Drainage basin geology and climate also affect morphometry by determining depth, size, shoreline development (shoreline length/area), flushing rate and seasonal and annual water levels. In particular, depth has a strong influence on stratification. Riverine and groundwater inputs of nutrients eventually equilibrate with outputs under natural conditions. Inputs of sediment eventually fill lake basins over geologic time scales.
There are predictable seasonal changes in water chemistry in temperate lakes. Most lentic habitats exhibit some degree of vertical stratification in summer, with limited mixing of water between the warm, nutrient poor, and oxygenated surface waters and cooler, relatively nutrient rich and oxygen depleted water below the thermocline. In shallower waterbodies, wind mixing frequently prevents strong or persistent stratification. In fall and spring, stratification breaks down as temperatures cool, and the water column mixes completely as it ‘turns-over”. After ice-out and spring turn-over, many lakes experience a spring bloom of phytoplankton throughout the photic zone of the lake associated with increasing light availability and the availability of nutrients released from the sediments and profundal zone during turnover (Kalff 2002; Dodson 2005).

The spring bloom in the pelagic zone by phytoplankton depletes nutrient concentrations in the upper water column after the thermocline forms, and much of this primary production settles out to the lake sediments. Depending on the degree of stratification, lake temperatures, and amount of organic deposition, oxygen concentrations below the thermocline may depleted to hypoxic (low) or anoxic (no dissolved oxygen) levels by respiring bacteria. Hypoxia and anoxia are rare in oligotrophic or deep lakes. Secondary production of zooplankton peaks in association with the spring bloom, and larval, juvenile, and adult fishes may consume a large proportion of this secondary production and may have strong effects on plankton community composition and structure. During summer, nutrients may cycle rapidly among microbes, phytoplankton, and zooplankton.

Reservoirs differ in at least three important respects from natural lakes. First, reservoirs typically have much greater shoreline development (shoreline/area) because they typically occupy drowned river valleys. Second, though the large amount of shoreline suggests a greater importance of littoral zone processes, this potential is rarely realized because of high frequency and large amplitude fluctuations in water level caused by dam operations. These fluctuations prevent the establishment of well developed littoral communities (Black et al. 2003). Third, large riverine inputs and high flushing rates of many reservoirs alter plankton community dynamics by exporting plankton downstream, and river inputs often create large gradients in nutrient and suspended sediments from reservoir input to dam (output). For example, Barber et al. (1999) classified upper Lake Roosevelt as mesotrophic, but the lower reservoir as oligotrophic, based on primary productivity estimates.

Stressors to lake ecosystems occur at both global/watershed and local scales. Atmospheric deposition of sulfuric and nitric acids (acid rain) and other toxins are important stressors in some regions. This is particularly significant at LARO. One of the most important stressors to lakes is the input of anthropogenic phosphorus and nitrogen, which frequently limit primary productivity. Such cultural eutrophication occurs through point and non-point sources, including atmospheric deposition, septic input, run-off from agricultural application of synthetic fertilizers, and treated and untreated septic and sewer inputs. Cultural eutrophication leads to changes in lake food webs, fisheries, and can exacerbate hypoxia/anoxia events below the summer thermocline. Sediment loading to lakes may increase with changes in drainage basin land use, and suspended sediments can have strong effects on littoral and pelagic communities, primarily through changes in the light environment (Kalff 2002; Dodson 2005).

Inputs of toxins to lakes, through atmospheric deposition (e.g., mercury) or upstream point and non-point sources enter food webs directly or after chemical transformation in the sediments. Unfortunately, toxins can accumulate at higher trophic levels through biomagnification, leading to poor reproductive success in birds, as in the well known case of DDT, or accumulate to levels that create a health risk when consumed by humans. Lake Roosevelt is currently being considered for addition to the EPA National Priorities List, better known as the "Superfund" list. Lake Roosevelt sediments contain elevated levels of heavy metals ((cadmium, copper, lead, mercury, zinc) USGS 2003) and other toxics (e.g., PCBs, dioxins, furans), primarily originating from an upstream smelter in Canada and pulp mills. The Spokane River also contributes heavy metal inputs derived from historical upstream mining sources (Grosbois et al. 2001). PCBs and mercury in fish have been at unsafe levels for human consumption in the past, thereby affecting the recreational quality of fisheries. However, there is some evidence that levels of some toxins such as mercury are declining since decreases in toxin loadings to the river starting in the early 1990s (Munn 2000).

Given the extent of contamination in Lake Roosevelt, avian piscivores such as the osprey are particularly at risk of bioaccumulation. As a top predator, osprey are one of the most vulnerable members of the aquatic ecosystem with regard to contamination effects. Studies have shown that many contaminants-of-concern biomagnify from fish to osprey eggs, sometimes by factors of 10-200 times (Henny et al. 2003).

Many characteristics of osprey make them ideal biological indicators. Not only are they top predators and specialists, but greater than 99% of the fish eaten are captured near the nest site. They often build large, visible nests that are regularly spaced along lake shores making them ideal candidates for assessing changes in spatial patterns. Osprey are long-lived, mate for life, and typically return to the same nest each year (US Geological Survey 2003). One of the largest birds in North America, osprey populations were historically reported as numerous and widespread. Through the mid-1970's, populations drastically declined as a result of pesticide use. Most populations have since recovered and, to some extent, adapted to human-dominated landscapes, nesting on power poles, cellular towers, and channel markers when suitable natural nest sites are scarce (Ewins 1997; US Geological Survey 2003). Osprey are currently found throughout the Columbia River system and several recent osprey-contaminant studies in the region have detailed the spatial extent and level of contamination (Elliott et al. 1998, 2000, 2001; Henny et al. 2003, 2004).

In addition to bioaccumulation, Figure C.19 shows the relationships among other external and internal sources of stress to osprey populations in the upper Columbia Basin. Competition for food with other piscivore species (e.g., bald eagles, otter) and nest predation from raccoons and great-horned owls can influence osprey population dynamics (Ewins 1997). While osprey are fairly adapted to anthropogenic disturbances (Henny and Kaiser 1996; US Geological Survey 2003), changes in land cover/land use, climate, and/or invasive species that result in loss of nesting habitat may impact osprey populations at LARO. These factors, in addition to manipulation of water levels, hydroperiod, and flushing rate, influence the integrity of the lake itself (see Figure C.18) and can impact bird communities indirectly through various fish species.

Perhaps the greatest transformation to the communities of western lentic habitats has resulted from the introduction of exotic species. Reservoirs frequently contain fisheries composed primarily of non-native fishes. The illegal or intentional introduction of non-native game and forage fishes has been widespread (Rahel 2002). Consequently, few UCBN lakes and ponds have natural vertebrate communities. Important introduced fish species in the region include walleye, centarchid sunfishes, brook, brown, and rainbow trout, carp, tench, large- and smallmouth bass, yellow perch, and black crappie. As part of mitigation offset for anadromous salmonid returns blocked by hydropower dams (Scholz et al. 1985), large numbers of kokanee (land-locked sockeye salmon) and rainbow trout continue to be released annually to Lake Roosevelt. These fisheries have failed to meet management goals in terms of production, perhaps due to predation (including walleye; Baldwin et al. 2003), downstream entrainment in Grand Coulee Dam, and hatchery practices (McLellan et al. 2004). Despite this altered fish community, Lake Roosevelt appears to harbor a stable or growing population of burbot, a native species thought to be in decline regionally (Bonar et al. 2000).

In ponds and wetlands, the establishment of exotic bullfrogs, in addition to sunfishes and bass, has been implicated in the decline of native amphibians (Adams 2000). Adams et al. (2003) provided experimental evidence that sunfish facilitate bullfrogs in Oregon ponds by depressing native odonates that are otherwise strong predators on bullfrog tadpoles. Introduced aquatic plants also have substantial impacts. At least 16 exotic aquatic plants have been recorded in the state of Washington (http://www.ecy.wa.gov/programs/wq/plants/weeds/exotic.html). Eurasian milfoil occurs in Snake River reservoirs, where it dominates SAV communities. Two other species have been recorded in eastern Washington, the lilypad yellow floating heart and the wetland plant purple loosestrife.

Appendix C.6. Landscape Dynamics

Resiliency of biodiversity in a protected area is intimately tied to the ecological integrity of the surrounding matrix. Attributes of surrounding landscapes contribute to 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). Land cover composition, configuration, and connectivity help shape the complex of species occurring in an area, movements of individual organisms, and energy and material flows (Dunning et al. 1992; Taylor et al. 1993). Substantial changes in these land cover attributes occur in response to natural and anthropogenic processes. Natural disturbance regimes largely are driven by climatic factors (e.g., Agee 1993; Peet 2000; Reid et al. 2002; Long 2003) and expected changes in climatic conditions may elevate the frequency and/or severity of natural disturbances such as wildfire and insect and disease outbreaks. Discerning between natural and anthropogenic forces of change is also critical for effective mitigation action. Management actions seldom can influence natural processes, but can be effective in mitigating human-induced changes. Anthropogenic disturbance along park boundaries is of special concern as increases in cross-border contrasts can lead to undesirable changes. For instance, habitat fragmentation has been associated with a variety of negative consequences to both wildlife and vegetative communities and also provides the opportunity for invasion of exotic or undesirable species (Wilcove et al. 1986; Yahner and Scott 1988).

Over 10 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 (NPS 1993). In fact, concerns over external influences 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; NPCA 1979; NPS 1980; Buechner et al. 1992). The majority of parks are dependent on adjacent lands simply because their boundaries fail to encompass habitats and processes (e.g., migratory species, fire regimes) necessary to maintain complete species communities (Myers 1972; Western 1982; Curry-Lindahl 1972; Garratt 1984). Therefore, threats from outside park boundaries can, and are, significantly modifying biodiversity within the parks (NPCA 1979; Garratt 1984; Sinclair 1998).

Monitoring long-term changes in land cover and land use may establish a broader context for each park, and can help natural resource managers determine patterns which may threaten future ecological integrity within parks. Selecting an adequate scale at which to evaluate the effects of land cover change and fragmentation is difficult without first identifying what is being managed (e.g. what species or processes; Beatley 2000) and the scales of disturbance to which those species/processes respond.

Land Cover/Land Use Control Model

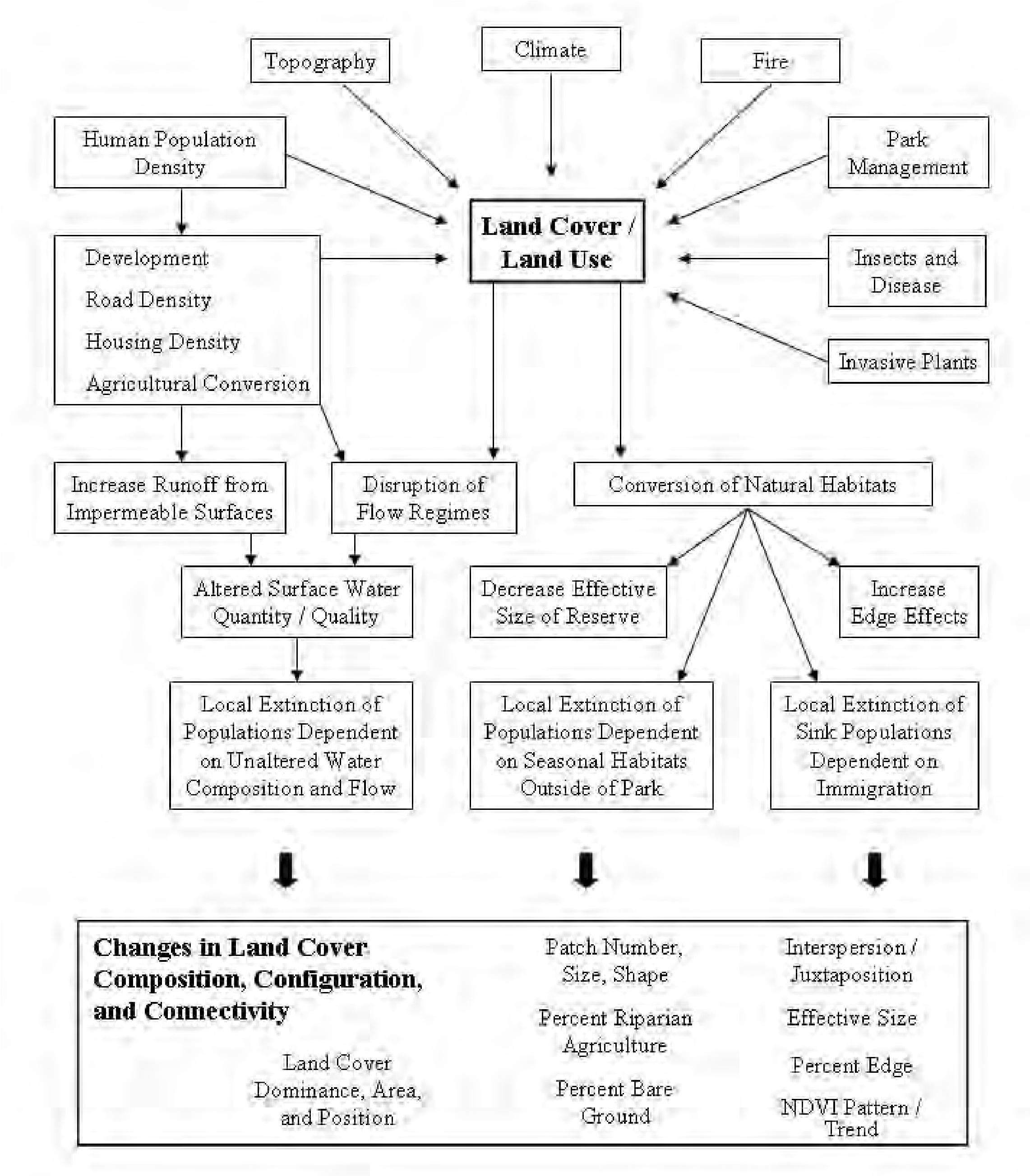


Figure C.20. Components, effects, and measures of change in land cover and land use in the UCBN.

Land Cover Model Narrative

As shown in Figure C.20, a multitude of factors contribute to changes in land cover and land use in UCBN parks and surrounding lands. The presence/absence of different vegetation communities is driven by topography, climate, and natural disturbances such as fire (Agee 1993; Peet 2000; Reid et al. 2002; Long 2003; see also Figure C.7). Human population growth and related developments (e.g., housing, roads, and agriculture) are probably the greatest and most widespread impacts on natural habitats (Sisk et al. 1994; Vitousek et al. 1997). These factors lead to altered surface water quantity and quality through the disruption of flow regimes and increased runoff from impervious surfaces (McKinstry et al. 2004; Wissmar 2004). This can then lead to local extinction of populations dependent on unaltered water regimes. Humans also indirectly affect native land cover through the introduction of invasive species, insects, and our irrepressible need to manage everything from fire to vegetation, wildlife, and the actions of other humans.

Landscapes are not static entities and change is inevitable. While not all changes in land cover are harmful (e.g., succession unassisted by human management such as fire suppression), the expanding human population in the US makes this one of the most significant impacts on native fauna and flora (Wilcove et al. 2000; Shaffer and Stein 2000). The conversion of natural habitats through changes in land cover and/or land use result in numerous stresses that can impact fauna in the area including not only a decrease in total area of habitat available but also increased edge effects and increased separation distance between patches of habitat. This fragmentation of habitat is associated with a variety of negative consequences to both wildlife and vegetative communities and also provides the opportunity for invasion of exotic or undesirable species (Wilcove et al. 1986; Yahner and Scott 1988). Combined, these factors may result in a decrease in the effective size of the reserve. 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). For species dependent on season habitats outside of the park, or populations dependent on immigration, this may result in local extinctions. For example, studies in the Greater Yellowstone Ecosystem have shown that some species cannot persist in the 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).

Changes in the land cover and/or land use however, may or may not equate to habitat loss for a particular species of interest depending on the extent and severity of change as well as the degree of specialism in the species. While the “suitability” of any particular landscape for a species is a continuum from suitable to non-suitable, threshold amounts of habitat loss do occur at which a slight decrease of habitat may result in significant changes in species occurrences and/or abundance leading to population extinction (Fahrig 2001). These thresholds are not common across species and may range from less than 1% to greater than 99% (With and King 1999; Fahrig 2001). Identification of these thresholds through long-term monitoring will be critical in understanding the degree of ecological integrity of UCBN parks and impacts of regional land cover/land use change.

Appendix C.7. Literature Cited for Appendix C

Adams, M. J. 2000. Pond permanence and the effects of exotic vertebrates on anurans. Ecological Applications **10**:559-568.

Adams, M. J., C. A. Pearl, and R. B. Bury. 2003. Indirect facilitation of an anuran invasion by non-native fishes. Ecology Letters **6**:343-351.

Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, DC.

Allan, J. D. 1995. Stream ecology: structure and function of running waters. London, Chapman and Hall.

Allan, J. D. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. Annual Review of Ecology and Systematics **35**:257-84.

Anderson, C. R., B. L. Peckarsky, and S. A. Wissinger. 1999. Tinajas of southeastern Utah: invertebrate reproductive strategies and the habitat templet. Pages 791-810 *in* Invertebrates in freshwater wetlands of North America: ecology and management. D. P. Batzer, R. B. Rader, and S. A. Wissinger., editors. John Wiley and Sons, New York, NY.

Baker, B. W., H. C. Ducharme, D. C. S. Mitchell, T. R. Stanley, and H. R. Peinetti. 2005. Interaction of beaver and elk herbivory reduces standing crop of willow. Ecological Applications **15**:110-118.

Baker, W. L., and D. Ehle. 2001. Uncertainty in surface-fire history: the case of ponderosa pine forests in the western United States. Canadian Journal of Forest Research **31**:1205-1226.

Baker, W. L., and D. J. Shinneman. 2004. Fire and restoration of pinyon-juniper woodlands in the western United States: a review. Forest Ecology and Management **189**:1-21.

Baldwin, C. M., J. G. McLellan, M. C. Polacek, and K. Underwood. 2003. Walleye predation on hatchery releases of kokanees and rainbow trout in Lake Roosevelt, Washington. North American Journal of Fisheries Management **23**:660-676.

Barber, M. E., S. T. J. Juul, R. E. Wierenga, and W. H. Funk. 1999. Determining primary productivity of Lake Roosevelt with C-14. Journal of Environmental Engineering-Asce **125**:747-754.

Beatley, T. 2000. Preserving biodiversity: challenges for planners. Journal of the American Planning Association **66**:5-21.

Beebee, R. A., and M. Manga. 2004. Variation in the relationship between snowmelt runoff in Oregon and ENSO and PDO. Journal of the American Water Resources Association **40**:1011-1024.

Belsky, A. J. 1996. Viewpoint: Western juniper expansion: Is it a threat to arid northwest ecosystems? Journal of Range Management **49**:53-59.

Benda, L. E., D. J. Mailler, T. Dunne, G. H. Reeves, and J. K. Agee. 1998. Dynamic landscape systems. Pages 261-288 *in* R. J. Naiman and R. E. Bilby, editors. River ecology and management lessons from the Pacific coastal ecoregion. Springer-Verlag, New York, NY.

Bertollo, P. 1998. Assessing ecosystem health in governed landscapes: A framework for developing core indicators. Ecosystem Health **4**:33-51.

Beschta, R. L. 2005. Reduced cottonwood recruitment following extirpation of wolves in Yellowstone's northern range. Ecology **86**:391-403.

Bilton, D. T., J. R. Freeland, and B. Okamura. 2001. Dispersal in freshwater invertebrates. Annual Review of Ecology and Systematics **32**:159-181.

Black, A. R., G. W. Barlow, and A. T. Scholz. 2003. Carbon and nitrogen stable isotope assessment of the Lake Roosevelt aquatic food web. Northwest Science **77**:1-11.

Blus, L. J., C. S. Staley, C. J. Henny, G. W. Pendleton, T. H. Craig, E. H. Craig, and D. K. Halford. 1989. Effects of organophosphorus insecticides on sage grouse in southeastern Idaho. Journal of Wildlife Management **53**:1139–1146.

Bonar, S. A., L. G. Brown, P. E. Mongillo, and K. Williams. 2000. Biology, distribution and management of burbot (Lota lota) in Washington state. Northwest Science **74**:87-96.

Brigham, R. M., H. D. Aldridge, and R. L. Mackey. 1992. Variation in habitat use and prey selection by Yuma bats, *Myotis yumanensis*. Journal of Mammalogy **73**:640-645.

Brown, D. J., W. A. Hubert, and S. J. Anderson. 1996. Beaver ponds create wetland habitat for birds in mountains of southeastern Wyoming. Wetlands **16**:127-133.

Buechner, M., C. Schonewald-Cox, R. Sauvajot, and B. A. Wilcox. 1992. Cross-boundary issues for national parks: What works "on the ground." Environmental Management **16**:799-809.

Bunting, S. C., J. L. Kingery, M. A. Hemstrom, M. A. Schroeder, R. A. Gravenmier, and W. J. Hann. 2002. Altered rangeland ecosystems in the Interior Columbia Basin. General Technical Report PNW-GTR-553. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Bureau of Land Management (BLM). 2002. Management considerations for sagebrush (*Artemisia*) in the western United States: A selective summary of current information about the ecology and biology of woody North American sagebrush taxa. USDI Bureau of Land Management, Washington, DC.

Caudill, C. C. 2003. Measuring dispersal in a metapopulation using stable isotope enrichment: high rates of sex-biased dispersal between patches in a mayfly metapopulation. Oikos **101**:624-630.

Cissel, J. H., F. J. Swanson, and P. J. Weisberg. 1999. Landscape management using historical fire regimes: Blue River, Oregon. Ecological Applications **9**:1217-1231.

Connelly, J. W., H. W. Browers, and R. J. Gates. 1988. Seasonal movements of sage grouse in southeastern Idaho. Journal of Wildlife Management **52**:116–122.

Connelly, J. W., M. A. Sanders, A. R. Sands, and C. E. Brown. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin **28**:967-985.

Cowardin, L. M., V. Carter, F. C. Golet, and E. D. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Publication FWS/OBS-79/31. US Department of Interior Fish and Wildlife Service, Office of Biological Services, Washington, DC.

Curry-Lindahl, K. 1972. Ecological research and management. Pages 197-213 *in* R. Osten, editor. World national parks: progress and opportunities. World Conservation Union, Brussels.

D'Antonio, C. M. 2000. Fire, plant invasions, and global changes. Pages 65-93 *in* H. A. Mooney, and R. J. Hobbs, editors. Invasive species in a changing world. Island Press, Washington, DC.

D'Antonio, C. M., and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecological Systems **23**:63-87.

Dobkin, D. S. 1995. Management and conservation of sage grouse, denominative species for the ecological health of shrubsteppe ecosystems. USDI Bureau of Land Management, Portland, OR.

Dobkin, D. S., A.C. Rich, and W. H. Pyle. 1998. Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin. Conservation Biology **12**:209-221.

Dodson, S. I. 2005. Introduction to Limnology. Boston, McGraw Hill.

Dunning, J. B., B. J. Danielson, and H. R. Pulliam. 1992. Ecological processes that affect populations in complex landscapes. Oikos **65**:169-175.

Dwire, K. A., and J. B. Kauffman. 2003. Fire and riparian ecosystems in landscapes of the western USA. Forest Ecology and Management **178**:61-74.

Elliott, J. E., L. K. Wilson, C. J. Henny, S. F. Trudeau, F. A. Leighton, S. W. Kennedy, and K. M. Cheng. 2001. Assessment of biological effects of chlorinated hydrocarbons in osprey chicks. Environmental Toxicology and Contaminants. **20**:866-879.

Elliott, J. E., M. M. Machmer, C. J. Henny, L. K. Wilson, and R .J. Norstrom. 1998. Contaminants in osprey from the Pacific Northwest: I. Trends and patterns in polychlorinated dibenzo-p-dioxins and dibenzofurans in eggs and plasma. Archives of Environmental Contamination and Toxicology **35**:620-631.

Elliott, J. E., M. M. Machmer, L. K. Wilson, and C. J. Henny. 2000. Contaminants in ospreys from the Pacific Northwest: II. Organochlorine pesticides, polychlorinated biphenyls and mercury, 1991-1997. Archives of Environmental Contamination and Toxicology **38**:93-106.

Everett, R. L., R. Schellhaas, D. Keenum, D. Spurbeck, and P. Ohlson. 2000. Fire history in the ponderosa pine/Douglas fir forests on the east slope of the Washington Cascades. Forest Ecology and Management **129**:207-225.

Ewins, P. J. 1997. Osprey (*Pandion haliaetus*) populations in forested areas of North America: changes, their causes and management recommendations. Journal of Raptor Research **31**:138-150.

Fahrig, L. 2001. How much habitat is enough? Biological Conservation **100**:65-74.

Fausch, K. D., C. E. Torgersen, C. V. Baxter, and H. W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. Bioscience **52**:483-498.

Fenton, M. B. 2003. Science and the conservation of bats: where to next? Wildlife Society Bulletin **31**:6-15.

Flinders, J. T. 1999. Restoration of sage grouse in Strawberry Valley, Utah, 1998–99 report. Utah Reclamation Mitigation and Conservation Commission, Progress Report. BrighamYoung University, Provo, UT.

Foster, D. R. 2000. From bobolinks to bears: interjecting geographical history into ecological studies, environmental interpretation, and conservation planning. Journal of Biogeography **27**:27-30.

Foster, D. R. 2002. Conservation issues and approaches for dynamic cultural landscapes. Journal of Biogeography **29**:1533-1535.

Franklin, J. F., T. A. Spies, R. Van Pelt, A. B. Carey, D. A. Thornburgh, D. R. Berg, D. B. Lindenmayer, M. E. Harmon, W. S. Keeton, D. C. Shaw, K. Bible, and J. Chen. 2002. Disturbance and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management **155**:399-423.

Garratt, K. 1984. The relationship between adjacent lands and protected areas: Issues of concern for the protected area manager. Pages 65-71 *in* J. A. McNeely, and K. R. Miller, editors. National parks, conservation and development: the role of protected areas in sustaining society. Proceedings of the World Congress on National Parks, Bali, Indonesia, October 11-22, 1982. Smithsonian Institute Press, Washington, DC.

Gedney, D. R., D. L. Azuma, C. L. Bolsinger, and N. McKay. 1999. Western juniper in eastern Oregon. General Technical Report PNW-GTR-464.USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Gottesfeld, A. S., M. A. Hassan, J. F. Tunnicliffe, and R. W. Poirier. 2004. Sediment dispersion in salmon spawning streams: the influence of floods and salmon redd construction. Journal of the American Water Resources Association **40**:1071-1086.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. Ecosystem perspective of riparian zones: Focus on links between land and water. Bioscience **41**:540-551.

Gregory, S., K. Boyer, and A. Gurnell, editors. 2003. The Ecology and Management of Wood in World Rivers. American Fisheries Society Symposium 37. American Fisheries Society. Bethesda, MD.

Griffis-Kyle, K.L., and P. Beier. 2003. Small isolated aspen stands enrich bird communities in southwestern ponderosa pine forests. Biological Conservation **110**:375-385.

Grosbois, C. A., A. J. Horowitz, J. J. Smith, and K. A. Elrick. 2001. The effect of mining and related activities on the sediment-trace element geochemistry of Lake Coeur d'Alene, Idaho, USA. Part III. Downstream effects: the Spokane River Basin. Hydrological Processes **15**:855-875.

Hall, R., J. L. Tank, and M. F. Dybdahl. 2003. Exotic snails dominate nitrogen and carbon cycling in a highly productive stream. Frontiers in Ecology and the Environment **1**:407-411.

Hansen, A. J., and J. J. Rotella. 2002. Biophysical factors, land use, and species viability in and around nature reserves. Conservation Biology **16**:1112-1122.

Hansen, A. J., R. P. Neilson, V. H. Dale, C. H. Flather, L. R. Iverson, D. J. Currie, S. Shafer, R. Cook, and P. J. Bartlein. 2001. Global change in forests: Responses of species, communities, and biomes. BioScience **51**:765-779.

Harding, J., E. F. Benfield, P. V. Bolstad, G. S. Helfman, and E. B. D. Jones III. 1998. Stream biodiversity: the ghost of land use past. Proceedings of the National Academy of Sciences **95**:14843-14847.

Hay, M. E., J. D. Parker, D. E. Burkepile, C. C. Caudill, A. E. Wilson, Z. P. Hallinan, and A. D. Chequer. 2004. Mutualisms and aquatic community structure: The enemy of my enemy is my friend. Annual Review of Ecology Evolution and Systematics **35**:175-197.

Hays, D. W., M. J. Tirhi, and D. W. Stinson. 1998. Washington state status report for the sage grouse. Washington Department of Fish and Wildlife, Wildlife Management Program, Olympia, WA.

Helfield, J. M., and R. J. Naiman. 2001. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity. Ecology **82**:2403-2409.

Henny, C. J., and J. L. Kaiser. 1996. Osprey population increase along the Willamette River, Oregon, and the role of utility structures, 1976-1993. Pages 97-108 *In* Raptors in human landscapes. Academic Press, London.

Henny, C. J., J. L. Kaiser, R. A. Grove, V. R. Bentley, and J. E. Elliott. 2003. Biomagnification factors (fish to osprey eggs from the Willamette River, Oregon, USA) for PCDDs, PCDFs, PCBs and OC pesticides. Environmental Monitoring Assessment **84**:275-315.

Henny, C. J., R. A. Grove, J. L. Kaiser, and V. R. Bentley. 2004. An evaluation of osprey eggs to determine spatial residue patterns and effects of contaminants along the lower Columbia river, USA. Pages 369-388 *In* R. D. Chancellor, and B. U. Meyburg, editors. Raptors Worldwide, WWGBP/MME, Budapest, Hungary.

Hessburg, P. F., and J. K. Agee. 2003. An environmental narrative of inland northwest Unites States forests, 1800-2000. Forest Ecology and Management **178**:23-59.

Hessburg, P. F., B. G. Smith, R. B. Salter, R. D. Ottman, and E. Alvarado. 2000. Recent changes (1930s-1990s) in spatial patterns of interior northwest forests, USA. Forest Ecology and Management **136**:53-83.

Hickey, M. B., M. B. Fenton, K. C. MacDonald, and C. Soulliere. 2002. Metal contaminants in the fur of bats from Ontario and Quebec. Bulletin of Environmental Contamination and Toxicology **66**:699-706.

Howett, C. 2000. Integrity as a value in cultural landscape preservation. Pages 186-207 *in* Alanen, A. R. and R. Z. Melnick, editors. Preserving cultural landscapes in America. Johns Hopkins University Press, Baltimore, MD.

Jackson, M., and B. Lockman. 2003. Update on limber pine decline and mortality on the Lewis and Clark National Forest, Montana. Forest Health Protection Report 03-4. USDA Forest Service, Northern Region, Missoula, MT.

Johnson, Jr., C. G. 1994. Forest health in the Blue Mountains: an ecologist's perspective on ecosystem processes and biological diversity. General Technical Report PNW-GTR-339. USDA Forest Service, Pacific Northwest Research Station. Portland, OR.

Jones, C., J. H. Lawton, and M. Shachak. 1997. Positive and negative effects of organisms as physical ecosystem engineers. Ecology **78**:1946-1957.

Kalff, J. 2002. Limnology: Inland Water Ecosystems, Prentice Hall, Upper Saddle River, NJ.

Kauffman, J. B., A. S. Thorpe, and E. N. J. Brookshire. 2004. Livestock exclusion and belowground ecosystem responses in riparian meadows of Eastern Oregon. Ecological Applications **14**:1671-1679.

Kauffman, J. B., R. L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries **22**:12-24.

Keane, R. E., K. C. Ryan, T. T. Veblen, C. D. Allen, J. Logan, and B. Hawkes. 2002. Cascading effects of fire exclusion in the Rocky Mountain ecosystems: A literature review. General Technical Report RMRS-GTR- 91. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Keller, B. L. 1997. Analysis of the thermal characteristics of maternity caves and bat species present at Craters of the Monument National Monument, Butte County, Idaho. Unpublished. Western Environmental Research Associates, Pocatello, ID.

Kershner, J. L., B. B. Roper, N. Bouwes, R. Henderson, and E. Archer. 2004. An analysis of stream habitat conditions in reference and managed watersheds on some federal lands within the Columbia River basin. North American Journal of Fisheries Management **24**:1363-1375.

Knopf, F. L., and F.B. Samson. 1994. Scale perspectives on avian diversity in western riparian ecosystems. Conservation Biology **8**:669-676.

Kolar, C. S., and D. M. Lodge. 2002. Ecological predictions and risk assessment for alien fishes in North America. Science **298**:1233-1236.

Koyama, A., K. Kavanagh, and A. Robinson. 2005. Marine nitrogen in central Idaho riparian forests: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences. **62**:518-526.

La Pierre, Y. 1997. The taming of the view. National Parks **71**:30-35.

Laliberte, A. S., and W. J. Ripple. 2003. Wildlife encounters by Lewis and Clark: A spatial analysis of interactions between Native Americans and wildlife. Bioscience **53**:994-1003.

Larson, E. J., and W. J. Ripple. 2003. Aspen age structure in the northern Yellowstone ecosystem, USA. Forest Ecology and Management **179**:469-482.

Lawler, J. J., and T.C. Edwards. 2002. Composition of cavity-nesting bird communities in montane aspen woodland fragments: the role of landscape context and forest structure. Condor **140**:890-896.

Levin, P. S., S. Achord, B. E. Feist, and R. W. Zabel. 2002. Non-indigenous brook trout and the demise of Pacific salmon: a forgotten threat? Proceedings of the Royal Society of London Series B-Biological Sciences **269**:1663-1670.

Lewis, S. E. 1995. Roost fidelity of bats: a review. Journal of Mammalogy **76**:481-496.

Logan, J. A., and J. A. Powell. 2001. Ghost forests, global warming, and the mountain pine beetle. American Entomologist **47**:160-172.

Long, J. 2003. Diversity, complexity, and interactions: an overview of Rocky Mountain forest ecosystems. Tree Physiology **23**:1091-1099.

Lytle, D. A., and N. L. Poff. 2004. Adaptation to natural flow regimes. Trends in Ecology & Evolution **19**:94-100.

Mack, R. N. 1981. Invasion of *Bromus tectorum* L. into western North America: An ecological chronicle. Agroecosystems **7**:145-165.

Mack, R. N., and C. M. D'Antonio. 1998. Impacts of biological invasions on disturbance regimes. Trends in Ecology and Evolution **13**:195-198.

Mackey, R. L., and R. M. R. Barclay. 1989. The influence of physical clutter and noise on the activity of bats over water. Canadian Journal of Zoology **67**:1167-1170.

Martin, R. E., and D. B. Sapsis. 1991. Fires as agents of biodiversity: pyrodiversity promotes biodiversity. Pages 150-157 *in* J. LeBlance, editor. Biodiversity of Northwestern California. Proc. Symp. Santa Rosa, CA.

Matheussen, B., R. L. Kirshbaum, I. A. Goodman, G. M. O'Donnell, and D. P. Lettenmaier. 2000. Effects of land cover change on streamflow in the interior Columbia Basin. Hydrological Processes **14**:867-885.

McKinstry, M. C., W. A. Hubert, and S. H. Anderson, editors. 2004. Wetland and Riparian of the Intermountain West: Ecology and Management. University of Texas Press, Austin, TX.

McLellan, H. J., J. G. McLellan, and A. T. Scholz. 2004. Evaluation of release strategies for hatchery kokanee in Lake Roosevelt, Washington. Northwest Science **78**:158-167.

Medin, D. E., and W. P. Clary. 1990. Bird and small mammal populations in a grazed and ungrazed riparian habitat in Idaho. Research Paper INT-RP-425. USDA Forest Service.

Meffe, G. K., and C. R. Carroll. 1997. Conservation reserves in heterogeneous landscapes. Pages 305-346 *In* G. K. Meffe, and C. R. Carroll, editors. Principles of conservation biology. 2nd Edition. Sinauer Associates, Sunderland, MA.

Melnick, R. Z. 2000. Considering nature and culture in historic landscape preservation. Pages 22-43 *in* Preserving cultural landscapes in America. A. R. Alanen, and R. Z. Melnick, editors. Johns Hopkins University Press, Baltimore, MD.

Meyer, G. A., and J. L. Pierce. 2003. Climate controls on fire induced sediment pulses in Yellowstone National Park and central Idaho: a long-term perspective. Forest Ecology and Management **178**:89-104.

Miller, R. F., and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management **52**:550-559.

Montgomery, D. R., and J. M. Buffington. 1998. Channel processes, classification, and response Potential. Pages 13-42 *in* River Ecology and Management. R. J. Naiman and R. E. Bilby, editors. Springer-Verlag Inc., New York, NY.

Moulton G. E., editor. 1983. The journals of the Lewis and Clark expedition. Volume 8, June 10 - September 26, 1806. University of Nebraska Press, Lincoln.

Munn, M. D. 2000. Contaminant trends in sport fish from Lake Roosevelt and upper Columbia River, Washington, 1994 - 1998: Report 00-4024. US Geological Survey Water-Resources Investigations.

Myers, N. 1972. National parks in savannah Africa. Science **178**:1255-1263.

Naiman, R., and H. Decamps. 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics **28**:621-658.

Naiman, R. J., C. A. Johnston, and J. C. Kelley. 1988. Alteration of North American streams by beaver. Bioscience **38**:753-762.

Naiman, R. J., G. Pinay, C. A. Johnston, and J. Pastor. 1994. Beaver influences on the long-term biogeochemical characteristics of boreal forest drainage networks. Ecology **75**:905-921.

Naiman, R. J., and R. E. Bilby, editors. 1998. River Ecology and Management: Lessons from the Pacific Coastal Region. Springer, New York, NY.

Naiman, R., and H. Decamps. 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics **28**:621-658.

Naiman, R., J. M. Melillo, and J. E. Hobbie. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology **67**:1254-1269.

National Park Service (NPS). 1980. State of the Parks -1980: A report to the congress. USDI National Park Service, Washington, DC.

National Park Service (NPS). 1993. Science and the National Parks II: Adapting to Change. USDI National Park Service, Washington, DC.

National Park Service (NPS). 2003. Outline for vital signs monitoring plans. Internal guidance document. USDI National Park Service, Inventory and Monitoring Program, Ft. Collins, CO.

National Parks and Conservation Association (NPCA). 1979. NPCA adjacent lands survey: No park is an island. National Parks and Conservation Magazine **53**:4-9.

National Research Council (NRC). 1996. Upstream: salmon and society. Committee on protection and management of Pacific Northwest salmonids. National Academy Press, Washington, DC.

Naughton, G. P., C. C. Caudill, M. L. Keefer, T. C. Bjornn, and L. C. Struehrenberg. 2005. Late season mortality during migration of radio-tagged adult sockeye salmon (*Onchorhynchus nerka*) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences **62**:30-47.

Naveh, Z. 1982. Landscape ecology as an emerging branch of human ecosystem science. Pages 189-237 *in* A. MacFayden, and E. D. Ford, editors. Advances in Ecological Research. Academic Press, New York, NY.

Noss, R., E. T. LaRoe, III, and J. M. Scott. 1995. Endangered ecosystems of the United States: A preliminary assessment of loss and degradation. Biological Report 28. National Biological Service, Washington, DC.

O'Shea, T. J., and T. A. Vaughan. 1999. Population changes in bats from central Arizona: 1972 and 1997. Southwestern Naturalist **44**:495-500.

Ohlsen, P., and R. Schellhaas. Unpublished report. Historical and current stand structure in Douglas-fir and ponderosa pine forests. USDA Forest Service, Wenatchee, Forestry Sciences Lab, Wenatchee, WA.

Parsons, S., K. J. Lewis, and J. M. Psyllakis. 2003. Relationships between roosting habitat of bats and decay of aspen in the sub-boreal forests of British Columbia. Forest Ecology and Management **177**:559-570.

Peckarsky, B. L., B. W. Taylor, and C. C. Caudill. 2000. Hydrologic and behavioral constraints on oviposition of stream insects: implications for adult dispersal. Oecologia **125**:186-200.

Peet, R. K. 2000. Forests and meadows of the Rocky Mountains. Pages 75-121 *in* M. G. Barbour, and W. D. Billings, editors. North American terrestrial vegetation, second edition. Cambridge University Press, Cambridge, UK.

Pierson, E. D. 1998. Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats. Pages 309-325 *in* T. H. Kunz and P. A. Racey, editors. Bat biology and conservation. Smithsonian Institution Press, Washington, DC.

Poff, N. L., J. D. Allan, M. A. Palmer, D. D. Hart, B. D. Richter, A. H. Arthington, K. H. Rogers, J. L. Meyers, and J. A. Stanford. 2003. River flows and water wars: emerging science for environmental decision making. Frontiers in Ecology and the Environment **1**:298-306.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime: A paradigm for river conservation and restoration. Bioscience **47**:769-784.

Pollock, M. M., M. Heim, and D. Werner. 2003. Hydrologic and geomorphic effects of beaver dams and their influence on fishes. American Fisheries Society Symposium **37**:213-233.

Pollock, M., R. J. Naiman, H. E. Erikson, C. A. Johnston, J. Pastor, and G. Pinay. 1995. Beavers as engineers: influences on biotic and abiotic characteristics of drainage basins. Pages 117-126 *in* Linking species and ecosystems. C. Jones and J.H. Lawton, editors. Chapman and Hall, New York, NY.

Postel, S., and B. Richter. 2003. Rivers for life: Managing water for people and nature. Washington, Island Press, Washington, DC.

Quigley, T. M., and S. J. Arbelbide, editors. 1997. An assessment of ecosystem components in the Interior Columbia Basin and portions of the Klamath and Great Basins, Volumes I-III. General Technical Report PNW-GTR-405. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Quinn, T. P. 2005. The behavior and ecology of pacific salmon and trout. American Fisheries Society. University of Washington Press, Seattle, WA.

Quinn, T. P., R. S. Nemeth, and D. O. McIsaac. 1991. Homing and straying patterns of fall chinook salmon in the Lower Columbia River. Transactions of the American Fisheries Society **120**:150-156.

Rahel, F. J. 1997. From Johnny Appleseed to Dr. Frankenstein: Changing values and the legacy of fisheries management. Fisheries **22**:8-9.

Rahel, F. J. 2002. Homogenization of freshwater faunas. Annual Review of Ecology and Systematics **33**:291-315.

Reid, M., P. Comer, H. Barrett, S. Caicco, R. Crawford, C. Jean, G. Jones, J. Kagan, M. Karl, G. Kittel, and others. 2002. International classification of ecological communities: Terrestrial vegetation in the United States. Sagebrush vegetation of the western United States. Final Report for the USGS Forest and Rangeland Ecosystem Science Center, Boise, Idaho. NatureServe, Arlington, VA.

Richards, D. C., P. O'Connell and D. C. Shinn. 2004. Simple control method to limit the spread of the New Zealand mudsnail (*Potamopyrgus antipodarum*): North American Journal of Fisheries Management **24**:114-117.

Rieman, B. E., C. H. Luce, R. E. Gresswell, and M. K. Young. 2003. Introduction to the effects of wildland fire on aquatic ecosystems in the Western USA [Special Issue]. Forest Ecology and Management **178**:1-3.

Rodhouse, T. J., and R. G. Wright. 2004. 2003 study of bat roosts: John Day Fossil Beds National Monument. Report for cooperative agreement no. CA9088A00008. University of Idaho, Moscow, ID.

Rodhouse, T. J., M. F. McCaffrey, and R. G. Wright. 2005. Distribution, foraging behavior, and capture results of the spotted bat (*Euderma maculatum*) in central Oregon. Western.North American Naturalist **65**:215-222.

Rogers, P. 2002. Using forest health monitoring to assess aspen forest cover change in the southern Rockies ecoregion. Forest Ecology and Management **155**:223-236.

Rust, S. K., and C. L. Coulter. 2000. Composition, structure, and distribution of Utah juniper plant associations, Snake River Resource Area, Idaho. Conservation Data Center, Idaho Department of Fish and Game, Boise, ID.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology **5**:18-32.

Schlosser, I. J. 1995. Dispersal, boundary processes, and trophic-level interactions in streams adjacent to beaver ponds. Ecology **76**:908-925.

Scholz, A. T., K. O'Laughlin, D. Geist, D. Peone, J. Uehara, L. Fields, T. Kleist, I. Zozaya, T. Peone and K. Teesatuskie. 1985. Compilation of information on salmon and steelhead total run size, catch and hydropower related losses in the Upper Columbia River Basin, above Grand Coulee Dam. Tech. Report No. 2. Upper Columbia United Tribes Fisheries. Coeur d'Alene, ID and Cheney, WA.

Schonewald-Cox, C. M. 1988. Boundaries in the protection of nature reserves: Translating multidisciplinary knowledge into practical conservation. BioScience **38**:480-486.

Schuster, W. S. F., J. B. Mitton, D. K. Yamaguchi, and C. A. Woodhouse. 1995. A comparison of limber pine (*Pinus flexilis*) ages at lower and upper treeline sites east of the continental divide in Colorado. American Midland Naturalist **133**:101-111.

Shaffer, M. L., and B. A. Stein. 2000. Safeguarding our precious heritage. Pages 301-322 *in* B.A. Stein, L. S. Kutner, and J. S. Adams, editors. Precious heritage: The status of biodiversity in the United States. Oxford University Press, New York, NY.

Shands, W. E. 1979. Federal resource lands and their neighbors. Conservation Foundation, Washington, DC.

Sharp, B. 1985. Avifaunal changes in central Oregon since 1899. Western Birds **16**:63-70.

Shirley, S. 2004. The influence of habitat diversity and structure on bird use of riparian buffer strips in coastal forests of British Columbia, Canada. Canadian Journal of Forest Research **34**:1499-1510.

Simberloff, D. 1999. The role of science in the preservation of biodiversity. Forest Ecology and Management **115**:101-111.

Sinclair, A. R. E. 1998. Natural regulation of ecosystems in protected areas as ecological baselines. Wildlife Society Bulletin **26**:399-409.

Sisk, T. D., A. E. Launer, K. R. Switky, and P. R. Ehrlich. 1994. Identifying extinction threats. BioScience **44**:592-604.

Smith, S. D., T. E. Huxman, S. F. Zitzer, T. N. Charlet, D. C. Housman, J. S. Coleman, L. K. Fenstermaker, J. R. Seemann, and R. S. Nowak. 2000. Elevated CO_2 increases productivity and invasive species success in an arid ecosystem. Nature **408**:79-82.

Sogge, M. K., and R. M. Marshall. 2000. Chapter 9: A survey of current breeding habitats *in* D. M. Finch, editor. Status, ecology, and conservation of the willow flycatcher. USDA Forest Service, Albuquerque, NM.

Soulé, P. T., P. A. Knapp, and H. D. Grissino-Mayer. 2004. Human agency, environmental drivers, and western juniper establishment during the late Holocene. Ecological Applications **14**:96-112.

Stringham, T. K., W. C. Krueger, and P. L. Shaver. 2001. States, transitions, and thresholds: Further refinement for rangeland applications. Agricultural Experiment Station, Oregon State University, Corvallis, OR. Online (http://www.ftw.nrcs.usda.gov/glti/pubs.html).

Sweeney, B. W., T. L. Bott, J. K. Jackson, L. A. Kaplan, J. D. Newbold, L. J. Standley, W. C. Hession, and R. J. Horwitz. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. Proceedings of the National Academy of Sciences of the United States of America **101**:14132-14137.

Tausch, R. J., P. E. Wigand, and J. W. Burkhardt. 1993. Viewpoint: Plant community thresholds, multiple steady states, and multiple successional pathways: Legacy of the Quaternary? Journal of Range Management **46**:439-447.

Taylor, P. D. 2002. Fragmentation and cultural landscapes: Tightening the relationship between human beings and the environment. Landscape and Urban Planning **58**:93-99.

Taylor, P. D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity is a vital element of landscape structure. Oikos **73**:43-48.

Teidemann, A. R., J. O. Klemmedson, and E. L. Bull. 2000. Solution of forest health problems with prescribed fire: are forest productivity and wildlife at risk? Forest Ecology and Management **127**:1-18.

Thompson, W. L., and D. C. Lee. 2000. Modeling relationships between landscape-level attributes and snorkel counts of chinook salmon and steelhead parr in Idaho. Canadian Journal of Fisheries and Aquatic Sciences **57**:1834-1842.

Thoms, A. 1989. The northern roots of hunter-gatherer intensification: camas and the Pacific Northwest. PhD dissertation. Dept. of Anthropology, Washington State University, Pullman, Washington. 521 pp.

Todd, M., and W. Elmore. 1997. Historical changes in western riparian ecosystems. Transactions of the 62nd North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington, DC. **1997**:1-17.

Torgersen, C. E., D. M. Price, H. W. Li, and B. A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of chinook salmon in northeastern Oregon. Ecological Applications **9**:301-319.

US Geological Survey (USGS). 2003. Ospreys in Oregon and the Pacific Northwest. USGS FS-153-02, US Department of Interior, Washington, DC.

USDA Forest Service (USFS). 1996. Status of the Interior Columbia Basin: Summary of scientific findings. General Technical Report PNW-GTR-385. USDA Forest Service, Pacific Northwest Research Station and USDI Bureau of Land Management. Portland, OR.

Veilleux, J. P., and S. L. Veilleux. 2004. Intra-annual and inter-annual fidelity to summer roost areas by female eastern pipistrelles, *Pipistrellus subflavus*. American Midland Naturalist **152**:196-200.

Verts, B. J., and L. N. Carraway. 1998. Land mammals of Oregon. University of California Press, Berkeley, CA.

Vitousek, P. M., H. A. Mooney, J. Lubchenco, and J. M. Melillo. 1997. Human domination of Earth's ecosystems. Science **277**:494-499.

Wagner, F. H., R. Angell, M. Hahn, T. Lawlor, R. Tausch, and D. Toweill. 2003. Natural ecosystems III: The Great Basin. Pages 207-240 *in* F. H. Wagner, editor. Rocky Mountain/Great Basin regional climate-change assessment. Report for the US global change research program. Utah State University, Logan, UT.

Wallin, D. O., F. J. Swanson, B. Marks, J. H. Cissel, and J. Kertis. 1996. Comparison of managed and pre-settlement landscape dynamics in forests of the Pacific Northwest, USA. Forest Ecology and Management **85**:291-309.

Wellborn, G. A., D. K. Skelly, and E. E. Werner. 1996. Mechanisms creating community structure across a freshwater habitat gradient. Annual Review of Ecology and Systematics **27**:337-363.

West, N. E., and J. A. Young. 2000. Intermountain valleys and lower mountain slopes. Pages 255-284 *in* M. G. Barbour, and W. D. Billings, editors. North American terrestrial vegetation. Cambridge University Press, Cambridge, UK.

Western, D. 1982. Amboseli National Park: Enlisting landowners to conserve migratory wildlife. Ambio **11**:302-308.

Whitaker, J. O. 2004. Prey selection in a temperate zone insectivorous bat community Journal of Mamalogy **85**:460-469.

Whitaker, J. O., C. Maser, and S. P. Cross. 1981. Food habits of eastern Oregon bats, based on stomach and scat analysis. Northwest Science **55**:281-292.

Whitlock, C., S. L. Shafer, and J. Marlon. 2003. The role of climate and vegetation change in shaping past and future fire regimes in the northwestern US and the implications for ecosystem management. Forest Ecology and Management **178**:5-21.

Whittaker, R. H. 1967. Gradient analysis of vegetation. Biological Reviews of the Cambridge Philosophical Society **42**:207-264.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pages 237-256 *in* M. Soulé, editor. Conservation biology: The science of scarcity and diversity. Sinauer Associates, Sunderland, MA.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 2000. Leading threats to biodiversity: What's imperiling US species? Pages 239-254 *in* B. A. Stein, L. S. Kutner, and J. S. Adams, editors. Precious heritage: The status of biodiversity in the United States. Oxford University Press, New York, NY.

Wilkinson, C. E., M. D. Hocking, and T. E. Reimchen. 2005. Uptake of salmon-derived nitrogen by mosses and liverworts in coastal British Columbia. Oikos **108**:85-98.

Wisdom, M. J., R. S. Holthausen, B. C. Wales, C. D. Hargis, V. A. Saab, D. C. Lee, W. J. Hann, T. D. Rich, M. M. Rowland, W. J. Murphy, and M. R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the Interior Columbia Basin: Broadscale trends and management implications. Volume 1-Overview. General Technical Report PNW-GTR-485. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Wissmar, R. C. 2004. Riparian corridors of Eastern Oregon and Washington: Functions and sustainability along lowland-arid to mountain gradients. Aquatic Sciences **66**:373-387.

With, K. A., and A. W. King. 1999. Extinction thresholds for species in fractal landscapes. Conservation Biology **13**:314-326.

Wright, G. M., J. S. Dixon, and B. H. Thompson. 1933. Fauna of the national parks: A preliminary survey of faunal relations in national parks. Fauna series No. 1. US Government Printing Office, Washington, DC. Online (http://www.cr.nps.gov/history/online_books/fauna1/fauna.htm).

Wright, J. P., C. G. Jones, and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia **132**:96-101.

Yahner, R. H., and D. P. Scott. 1988. Effects of forest fragmentation on depredation of artificial avian nests. Journal of Wildlife Management **52**:158-161.

Yensen, D. L. 1981. The 1900 invasion of alien plants into southern Idaho. Great Basin Naturalist **41**:176-182.

Zanetell, B. A., and B. L. Peckarsky. 1996. Stoneflies as ecological engineers: Hungry predators reduce fine sediments in stream beds. Freshwater Biology **36**:569-577.

Appendix D
Workshop Handouts and Results

Appendix D.1. Resource Managers Responses to Significant Management Issues Questionnaire (2002 Vital Signs Monitoring Workshop)

Park Summaries
Network park site representatives defined their park's ecological concerns in written responses and workshop presentations. Park site representatives addressed site conditions and concerns in the context of the following:

- What are the 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 uniqueness, or because they serve as indicators of regional trends?
- What are the greatest current or prospective internal threats to significant park resources?
- What are the greatest external threats?

Big Hole National Battlefield (BIHO) Dan Foster
Cultural landscapes are the most significant resources to be protected at BIHO, with invasion of exotic species and changes to local hydrology as both internal and external threats. Over the years, fire has been kept out of the landscape, creating a change in ecology. Additionally, four nearby irrigation canals have leaked, encouraging non-native willow growth. Grazing patterns near park borders have impacted native grasses, as well. BIHO identifies restoration of forest ecology by thinning and prescribed burn, and prescribed fire in willow/riparian and sage/grasslands as ecosystem restoration projects for which long-term monitoring is needed.

Nez Perce National Historical Park (NEPE) Dan Foster
With 38 dispersed cultural landscape locations, the park's sites are all listed on the National Register of Historic Places and are thus in need of protection, especially from encroaching development to satisfy visitor demand. Proposed visitor centers such as those at Bear Paw and Heart of the Monster will impact ecosystems. Currently NEPE's Spalding site needs restoration of ponderosa pine/grass areas, while the White Bird village site requires building removal. All locations suffer some amount of impact from exotic species.

City of Rocks National Reserve (CIRO) Wallace Keck
CIRO's significant resources include the California Trail, Indian Grove and riparian communities, with the area boasting Idaho's largest pinyon pine and a large pinyon pine forest. The park's high elevation supports several distinct plant communities (sagebrush, pinyon-juniper, etc.), and granite monoliths provide shelter for raptors, pack rats, cliff swallows and swifts. The area is a rock-climbing mecca, but current threats from rock

climbers are being mitigated. Grazing in riparian areas, dust dispersal from gravel roads and erosion and sedimentation are additional areas of concern within the park, and juniper theft is an external threat that has become a recent problem.

Craters of the Moon National Monument (CRMO) John Apel
With its borders recently expanded to more than 12 times the original size, CRMO's significant resources include numerous volcanic features, kipukas, a Class I airshed, lava tubes, populations of sage grouse, Townsend's big-eared bats and pygmy rabbits, natural quiet and night skies. The spread of invasive weeds, destruction of geologic features by collectors, and illegal off-road vehicle use pose some of the biggest problems to the park itself. External threats include the spread of invasive weeds, regional haze impacts on visibility, development impacts on night sky, and white pine blister rust impacts on limber pine. Restoration of sagebrush steppe habitat downgraded by wildland fire and invasion of cheatgrass is a major focus.

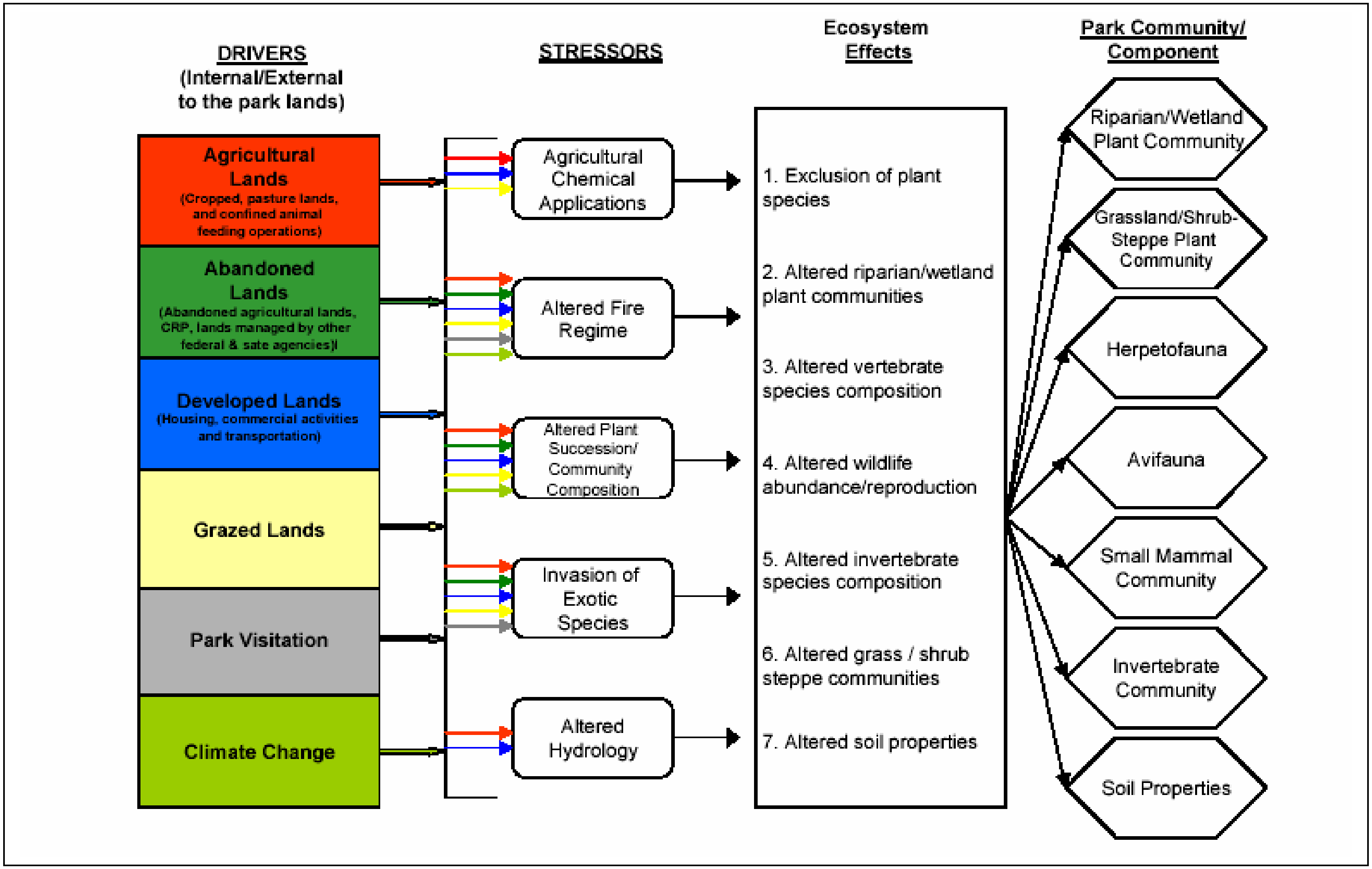
Hagerman Fossil Beds National Monument (HAFO) Mike Wissenbach
Fossils and the associated stratigraphy are HAFO's most significant resources, while landslides, altered hydrological regimes (high water tables, fluctuating reservoir levels, perched aquifers, irrigation) and wind/water erosion pose the biggest threats to slope stability and fossil resources. Restoration and monitoring work would likely focus on revegetation of landslide areas to stabilize slopes, and control of exotic species. This section of the Snake River does not currently meet water quality standards; some of the impacts affect submerged lands that are within monument boundaries.

John Day Fossil Beds National Monument (JODA) Ken Hyde
JODA lists three areas of focus: riparian area vegetation changes; changes in plant communities due to noxious weed invasions and reintroduction of fire; population dynamics of amphibians, reptiles and small rodents. The amphibian population as well as steelhead salmon, bald eagle and Columbia spotted frog, are of concern, and noxious weeds such as cheatgrass and medusa head are impacting sagebrush, mountain mahogany and rodent populations. The reintroduction of fire may or may not benefit native plant and animal communities, and newly planted old farm fields should be monitored for noxious weeds, future flood events and benefits to native wildlife populations.

Lake Roosevelt National Recreation Area (LARO) Scott Hebner
LARO's focus concentrates on plant communities, water and fish, with raptors and water birds also of special significance. The mixed ownership and water fluctuations fragment resource management, and industrial pollution, residential development and noxious weeds pose major threats to the landscape. Restoration projects which require monitoring programs include polluted sediment impacts and shrub-steppe and forest restoration. Because the lake is manmade, it is not a natural aquatic environment.

Whitman Mission National Historic Site (WHMI) Roger Trick
WHMI has a cultural resource focus, but native vegetation and surface water quality and quantity are the park's major resource interests for new monitoring programs. As with other network sites, exotic species and noxious weeds are a major concern, as is the quality of irrigation water coming into the park. There is some ongoing vegetation restoration work, which will require monitoring, and water quality monitoring also needs to be undertaken.

Appendix D.2. Conceptual Model Developed from Vital Signs Monitoring Workshop 2002



Appendix D.3. Potential Upper Columbia Basin Network Partners

- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Burke Museum of Natural History and Culture
- Confederated Tribes of Colville Reservation
- Confederated Tribes of Warm Springs Reservation
- Cooperative Ecosystem Studies Units
- County Governments
- Idaho Conservation Data Center
- Idaho Department of Fish and Game
- Idaho Geologic Survey
- Idaho Museum of Natural History
- Idaho State Climate Services
- Idaho State University
- Land Trusts
- Montana Natural Heritage Program
- National Gap Analysis Program
- National Resources Conservation Service
- Nez Perce Tribe
- Oregon Department of Fish and Wildlife
- Oregon Museum of Science and Industry
- Oregon Natural Heritage Program
- Oregon State University
- Palouse Clearwater Environmental Institute
- Private Landowners
- Sawtooth Science Institute
- School Districts
- Spokane Tribe of Indians
- The Nature Conservancy
- US Fish and Wildlife Service
- US Forest Service
- US Geological Survey
- University of Idaho
- University of Washington
- Washington Dept. of Fish and Wildlife
- Washington State University

Appendix D.4. Invasive Plant Species of Concern

Note: This list was assembled from “top 10” lists provided by each Network park, Exotic Plant Management Team (EPMT) reports, and 2003 University of Idaho weed team reports.

Common Name	Scientific Name	BIHO	CIRO	CRMO	HAFO	JODA	LARO	MIIN	NEPE	WHMI	*Total*
Canada Thistle	*Cirsium arvense*	x	x	x	x		x	x	x	x	8
Spotted Knapweed	*Centaurea maculosa*	x	x	x		x	x		x		6
Toadflax	*Linaria spp.*	x	x	x		x	x		x		6
Cheatgrass	*Bromus tectorum*	x		x	x	x		x		x	6
Scotch Thistle	*Onopordum acanthium*		x	x				x	x	x	5
Yellow Starthistle	*Centaurea solstitialis*					x	x	x	x	x	5
Diffuse Knapweed	*Centaurea diffusa*	x		x	x	x	x				5
Russian Knapweed	*Acroptilon repens*	x		x		x	x	x			5
Field Bindweed	*Convolvus arvensis*	x	x		x			x	x		5
Rush Skeletonweed	*Chondrilla juncea*			x	x		x	x			4
Houndstongue	*Cynoglossum officinale*		x			x	x		x		4
Bull Thistle	*Cirsium vulgare*	x	x		x			x			4
Common Mullein	*Verbascum thapsus*				x		x	x			3
Poison Hemlock	*Conium maculatum*		x						x	x	3
Leafy Spurge	*Euphorbia esula*	x		x			x				3
Common Tansy	*Descuriania pinnata*	x		x					x		3
Musk Thistle	*Carduus nutans*		x					x			2
Prickly Sowthistle	*Sonchus asper*				x			x			2
Common Teasel	*Dipsacus fullonum*				x				x		2
Black Henbane	*Hyoscyanus niger*	x	x								2
Bedstraw	*Galium aparine*									x	1
Burdock	*Arctium minus*							x			1
Chicory	*Chicorium intybus*		x								1
Dyer's Woad	*Isatis tinctoria*		x								1
Kochia	*Kochia scoparia*									x	1

Common Name	Scientific Name	BIHO	CIRO	CRMO	HAFO	JODA	LARO	MIIN	NEPE	WHMI	*Total*
Longspine Sandbur	*Cenchrus longispinus*						x				1
Medusahead	*Elymus caput-medusae*					x					1
Perennial Pepperweed	*Lepidium perfoliatum*					x					1
Prickly Lettuce	*Lactuca serriola*									x	1
Puncturevine	*Tribulus terrestris*						x				1
Purple Loosestrife	*Lythrum salicaria*				x						1
Reed Canary Grass	*Phalaris arundinaceae*									x	1
Russian Thistle	*Salsola kali*						x				1
Saltcedar	*Tamarix ramosissima*				x						1
Spikeweed	*Hemizonia pungens*									x	1
Whitetop	*Cardaria draba*					x					1

Appendix D.5. Prioritized Stressors Affecting Park Natural Resources

Stressor: any physical, chemical, or biological entity or process that can induce an adverse response. For purposes of monitoring, stressors are considered to be anthropogenic factors that are outside the range of disturbances naturally experienced by the ecosystem.

Priority Scale: High = 3, Medium = 2, Low = 1, None = 0; Priority reflects degree to which stressor is impacting park resources NOT a prioritization of future monitoring activities.

Stressors	BIHO	CIRO	CRMO	HAFO	JODA	LARO	MIIN	NEPE	WHMI	Total
Exotic plants	3	3	3	3	3	3	3	3	3	27
Agriculture on adjacent lands (water diversion, chemical use, livestock etc.)	3	1	2	3	2	2	3	2	3	21
Fire management practices (NPS and adjacent lands)	2	2	2	2	3	3	1	2	2	19
Other NPS management (weed control, agriculture, restoration, reintroductions, etc.)	3	2	1	1	2	2	3	2	3	19
Other historic human impacts (sagebrush removal, irrigation etc.)	2	1	1	3	2	1	3	2	3	18
NPS development (facilities, trails, campgrounds, roads, etc.)	3	3	1	1	1	2	1	3	1	16
Historic livestock grazing	2	3	2	2	2	1	2	2	0	16
Visitation/recreation (boating, hiking, climbing, ORV, etc.)	1	3	2	1	1	3	1	1	1	14
Historic fire suppression	2	2	2	1	2	2	1	2	0	14
Landscape fragmentation	2	1	1	1	1	1	2	2	3	14
Exotic animals (incl. livestock trespass)	1	1	1	1	2	2	1	1	3	13

Stressors	BIHO	CIRO	CRMO	HAFO	JODA	LARO	MIIN	NEPE	WHMI	Total
Extreme disturbance events (flood, fire, drought, landslides, etc.)	1	1	1	3	1	1	1	1	1	11
Wildlife impacts (browsing, other damage)	1	1	1	1	2	1	1	1	1	10
Global warming/climate change	1	1	2	1	1	1	1	1	1	10
Hunting (NPS and adjacent lands)	1	1	1	1	1	2	1	1	0	9
Urban development (housing, roads etc.)	1	0	1	0	0	2	1	1	3	9
Exotic disease organisms	1	2	2	0	0	0	1	1	1	8
Forest Management Practices (NPS and adjacent lands)	2	0	1	0	0	3	0	2	0	8
Dams or reservoir operations	0	0	0	3	0	3	0	0	0	6
Permitted livestock grazing	0	3	0	0	0	3	0	0	0	6
Utilities/industry	0	0	1	1	0	3	0	1	0	6
Collection/poaching	0	1	1	1	2	1	0	0	0	6
Air traffic	0	1	2	0	0	1	0	0	0	4

Appendix D.6. Vital Signs and Associated Monitoring Objectives from Phase 1.

Level 1	Level 2	UCBN Vital Sign	Monitoring Objective	Monitoring Category
Air and climate	Air quality	Air chemistry - Ozone	Determine status and track trends in ozone injury occurring in sensitive plant species across the UCBN.	Stressor effects
		Air chemistry-Emissions	Determine status and track trends in atmospheric pollutant emissions present in UCBN parks from adjacent agriculture, urbanization, and industry.	Stressor effects
		Air chemistry-Mercury	Track trends in mercury deposition at LARO.	Stressor effects
		Visibility	Track trends in UCBN viewsheds.	Stressor effects
	Weather	Climate change	Monitor key measurable climate change parameters to determine rate and extent of climate change in the UCBN.	Baseline
Geology and soils	Geomorph-ology	Landslides	Track trends in landslides at HAFO.	Stressor effects
		Channel/bank morphology	Track changes in morphology of stream bank and other riparian features in the UCBN.	Baseline
		Paleontological resources	Monitor trends of in-situ paleontological resources in the UCBN.	Baseline
		Archaeological resources	Determine the status and trends of visitor damage to in-situ archaeological resources.	Stressor effects
		Cave features	Determine the type, rate, and extent of damage or impacts from visitors on UCBN geologic features.	Stressor effects
		Volcanic features	Determine the type, rate, and extent of damage or impacts from visitors on UCBN geologic features.	Stressor effects
		Cliffs and other geologic features	Determine the type, rate, and extent of damage or impacts from visitors on UCBN geologic features.	Stressor effects
		Pictographs and rock inscriptions	Determine the status and track changes in pictographs and rock inscriptions in JODA and CIRO.	Baseline
	Soil quality	Soil erosion	Track trends in soil erosion	Baseline
		Soil biota	Determine the status and track changes in soil biota of UCBN riparian areas.	Baseline
		Bare soil surface	Track trends in the amount and spatial pattern of bare soil surface.	Baseline
		Soil chemistry	Determine the status and trends of mercury contamination in sediments and soils of Lake Roosevelt.	Baseline

Level 1	Level 2	UCBN Vital Sign	Monitoring Objective	Monitoring Category
		Soil compaction	Determine status and measure changes in soil compaction before and after park management and in areas of heavy visitor use.	Stressor effects
		Biological soil crusts	Determine the status and trends of biological soil crust communities in sagebrush-steppe areas of the UCBN.	Baseline
		Biological soil crusts	Determine the status and trends of biological soil crust communities in sagebrush-steppe areas of the UCBN before and after prescribed and wildfire events.	Stressor effects
Water	Hydrology	Surface water dynamics	Determine the status and trend of surface water quantity in the UCBN, including flow in streams, springs, and seeps.	Baseline
	Water quality	Water quality- Core parameters	Track changes in core water quality parameters in the UCBN.	Stressor effects
		Water quality- Nutrients	Track changes of nutrient levels in UCBN waterbodies.	Stressor effects
		Water .quality- Toxics	Track changes in toxic pollutant levels in water and sediment of Lake Roosevelt.	Stressor effects
		Water quality- Macroinvertebrates	Determine the status and track changes in the species and functional group composition of dragonflies and damselflies in the UCBN.	Baseline
		Water quality- Macroinvertebrates	Determine the status and track changes in the species and functional group composition and abundance of aquatic macroinvertebrates in the UCBN.	Baseline
Biological Integrity	Invasive species	Invasive plants	Monitor the status and trend of invasive plants along roads, trails, and other park facilities.	Stressor Effects
		Invasive plants	Document changes in established populations of invasive species, including response to treatment.	Baseline
		Invasive plants	Use monitoring data for early detection & predictive modeling of incipient invasive species.	Baseline
		Exotic vertebrates	Determine the status and track changes in populations of invasive exotic vertebrates in the UCBN.	Baseline
	Infestations and disease	Forest insect pests	Monitor P-J woodlands in CIRO and other UCBN juniper systems for *Ips* infection.	Stressor effects
		Forest rust disease	Monitor limber pine stands in CRMO for early detection and increase of white pine blister rust infection.	Baseline
	Focal species or community	Cave biota	Determine the status and trend of cave-obligate organisms in CRMO.	Baseline
		Forest structure	Track spatial and temporal patterns in the distribution, recruitment, and persistence of snags and downed wood in UCBN forest and woodlands ecosystems.	Baseline

Level 1	Level 2	UCBN Vital Sign	Monitoring Objective	Monitoring Category
Biological Integrity	Focal Species or Community	Ponderosa pine forests	Determine trends in ponderosa pine forest composition and structure in the UCBN.	Baseline
		Ponderosa pine forests	Track changes in composition, structure, and landscape pattern of ponderosa pine vegetation.	Baseline
		Pinyon-juniper communities	Track expansion of P-J woodland into sagebrush-steppe ecosystems of the UCBN.	Baseline
		Pinyon-juniper communities	Determine trends in pinyon-juniper vegetation composition and structure in the UCBN.	Baseline
		Pinyon-juniper communities	Track changes in composition, structure, and landscape pattern of pinyon-juniper vegetation.	Baseline
		Aspen communities	Determine trends in aspen vegetation composition and structure in the UCBN.	Baseline
		Aspen communities	Determine the reproductive status and trends of aspen in the UCBN.	Baseline
		Aspen communities	Track changes in composition, structure, and landscape pattern of aspen vegetation.	Baseline
		Wetland/riparian communities	Determine trends in wetland and riparian vegetation composition and structure in the UCBN.	Baseline
		Wetland/riparian communities	Track changes in composition, structure, and landscape pattern of wetland and riparian vegetation.	Baseline
		Sagebrush communities	Determine trends in sagebrush-steppe vegetation composition and structure in the UCBN.	Baseline
		Butterfly/moth Communities	Identify important lepidoptera-plant relationships in the UCBN and track lepidoptera populations over time.	Baseline
		Invertebrate communities	Determine the status and trend of selected invertebrate focal species and communities.	Baseline
		Freshwater mussel communities	Determine the status and trend of freshwater mussels in the Snake River adjacent to HAFO and along the John Day River at JODA.	Baseline
		Cold-water fish	Determine the status and trend of cold-water fish species of concern, including steelhead.	Baseline
		Frogs	Use monitoring data to determine the impact of spring drawdown of Lake Roosevelt on Pacific tree frog and long-toed salamander reproduction.	Stressor effects
		Reptiles	Determine the status and track changes in the populations of relict and small populations of reptile species of concern.	Baseline
		Reptiles	Track changes in snake hibernacula.	Baseline

Level 1	Level 2	UCBN Vital Sign	Monitoring Objective	Monitoring Category
		Forest bird communities	Track forest obligate bird community composition, species abundance, and reproductive success.	Baseline
		Shrub-steppe bird communities	Track sagebrush-steppe obligate bird community composition, species abundance, and reproductive success.	Baseline
		Wetland/riparian bird communities	Track wetland/riparian obligate bird community composition, species abundance, and reproductive success.	Baseline
		Raptor communities	Determine the status and trend of raptors that breed and winter in the UCBN.	Baseline
		Small mammals	Determine the status and trend of habitat-specific small mammals, such as the water shrew, sagebrush vole, and Merriam's shrew in the UCBN?	Baseline
		Bats-roosts	Identify and monitor roosts of pallid bat, Townsend's big-eared bat, and other colonial roosting bat species of concern in the UCBN.	Baseline
		Bats-communities	Track spatio-temporal patterns of bat species presence and activity along important riparian foraging areas in the UCBN.	Baseline
		Network species/community of special concern	Track changes in the areal extent and density of camas lily in relation to land use practices in NEPE and BIHO.	Stressor effects
	At-risk biota	State and federal species of concern	Determine trends in populations of threatened, endangered, and at-risk species within the parks.	Baseline
		Federal T&E species	Determine trends in populations of threatened, endangered, and at-risk species within the parks.	Baseline
		Peripheral/relict species	Monitor the distribution of peripheral vertebrate species, such as pika, pinyon mice, cliff chipmunk, ringtail, western whiptail, and northern mockingbird to track range expansion and contraction	Baseline
		Snag/cavity obligate species	Determine the status and trend of snag and downed wood-dependent forest invertebrates and vertebrates in UCBN forest and woodland habitats.	Baseline
Human Use	Point Source Human Effects	Fire control	Conduct pre and post prescribed fire monitoring of plant and animal communities in the UCBN.	Effectiveness
		Invasive plant control	Conduct pre and post control monitoring of plant communities in weed treatment areas in the UCBN.	Effectiveness
		Bioaccumulation of toxins	Conduct monitoring of toxicity levels in selected species of waterfowl, fish, and other species at risk of bioaccumulations in Lake Roosevelt.	Stressor effects

Level 1	Level 2	UCBN Vital Sign	Monitoring Objective	Monitoring Category
	Non-point Source Human Effects	Hunting	Conduct monitoring of at-risk natural resources during hunting season, conduct interviews of hunters, etc…to determine the extent and trend of impacts from within-park hunting and poaching.	Stressor effects
	Consumptive Use	Grazing	Use monitoring data to determine the impacts of permitted livestock grazing in vulnerable ecosystems of CIRO, NEPE, and LARO.	Stressor effects
		Visitor usage	Track changes in visitation and in spatio-temporal patterns of park use by visitors.	Baseline
	Visitor and Recreation Use	Dark night sky	Track trends in UCBN viewsheds.	Stressor effects
Ecosystem Pattern and Processes	Fire	Fire dynamics	Track spatial and temporal changes and variability in wildfire events across the UCBN.	Baseline
		Fire dynamics	Conduct pre and post fire monitoring of plant communities, including sagebrush-steppe and forested ecosystems of the UCBN.	Effectiveness
		Fire dynamics	Conduct pre and post fire monitoring of vulnerable plant and animal communities and species.	Effectiveness
		Fuel dynamics	Monitor pre and post thinning snag and downed wood resources in LARO.	Effectiveness
	Land use and cover	Land use change	Document changes in development, land conversion, and succession outside UCBN park boundaries.	Baseline
		Landscape fragmentation and connectivity	Determine trends in a suite of landscape metrics including patch shape, size, and connectivity	Baseline
		Viewshed	Track trends in UCBN viewsheds.	Stressor effects
	Soundscape	Soundscapes	Track changes in soundscapes in vulnerable UCBN parks, including WHMI, LARO, and NEPE.	Stressor effects

Appendix D.7. Screen Captures from the Microsoft ACCESS Database Used to Help Prioritize Vital Signs

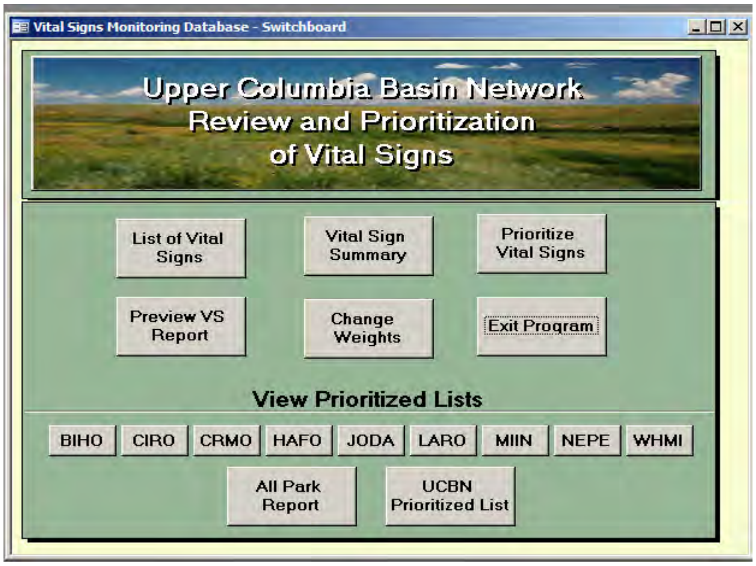


Figure D.1. Vital signs database switchboard with links to the list of vital signs in the national framework, descriptions of the vital signs, reports, weights, and prioritizing screen.

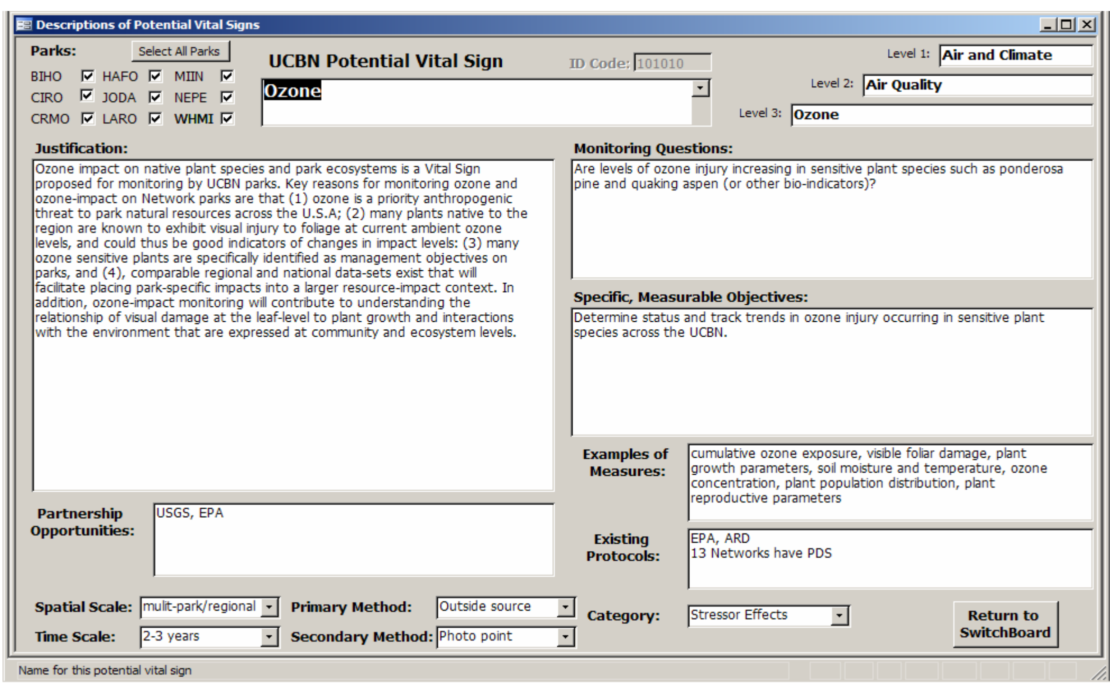


Figure D.2. Descriptions of potential vital signs including justification, questions, objectives, measures, existing protocol, and potential partnerships.

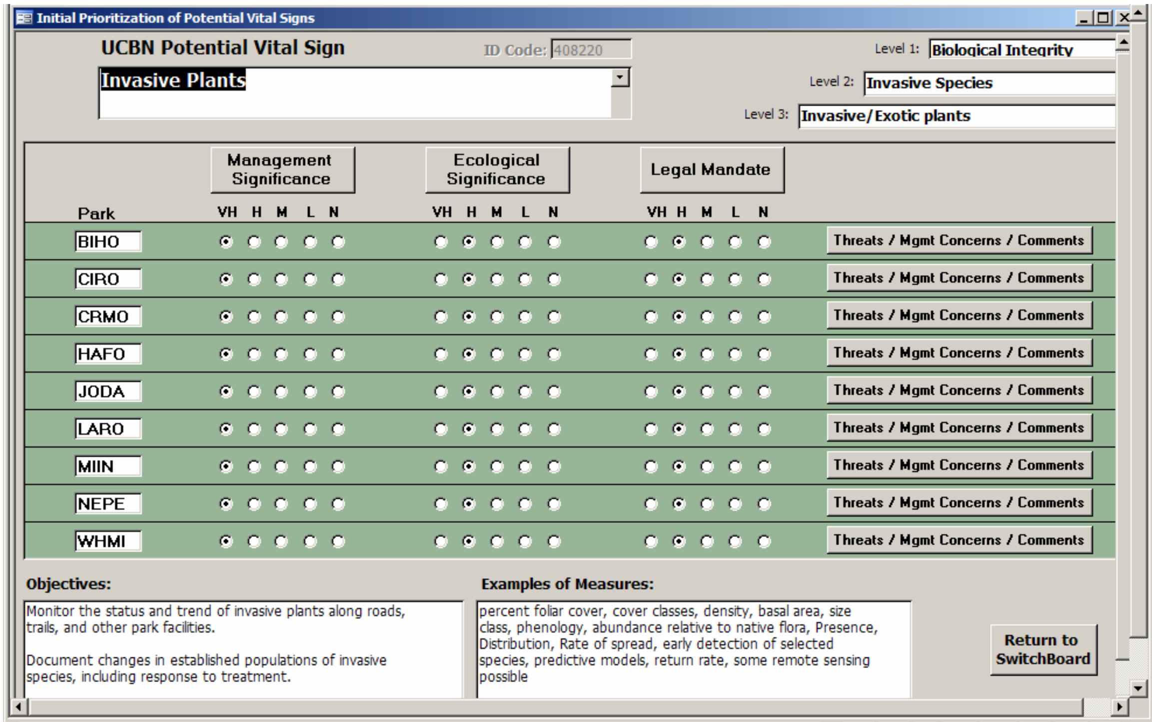


Figure D.3. Input screen used to prioritize each vital sign for management significance, ecological significance, and legal mandate.

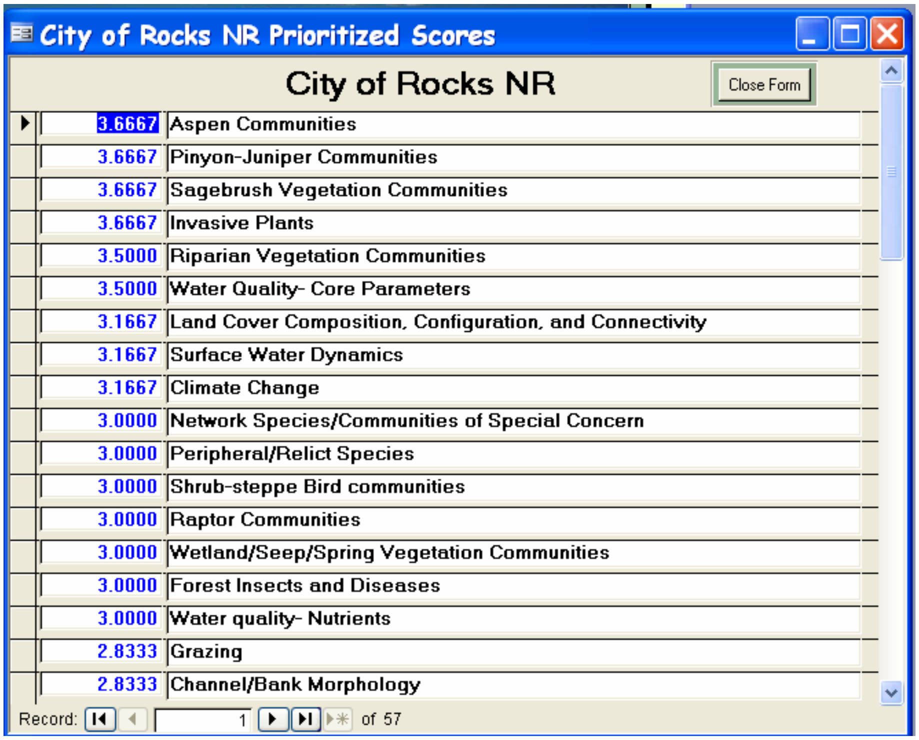


Figure D.4. Example report of the prioritized scores created for each park.

Appendix D.8. Criteria for ranking vital signs

Management Significance 40%

- For this potential vital sign, how many of the following statements do you STRONGLY AGREE with?
- There is an obvious, direct application of the data to a key management decision , or for evaluating the effectiveness of the program.
- The vital sign will produce results that are clearly understood and accepted by park managers , other policy makers, research scientists, and the general public.
- Monitoring results are likely to produce early warning of resource impairment, and will save park resources and money if a problem is discovered early.
- In cases where data will be used primarily to influence external decisions, the decisions will likely affect key resources in the park, and there is a great potential for the park to influence the external decisions.
- Data are of high interest to the public.
- For species-level monitoring, involves species that are harvested, endemic, invasive, or at-risk biota.
- There is an obvious, direct application of the data to performance (GRPA) goals.
- Contributes to increased understanding that ultimately leads to better management.

VERY HIGH: Strongly aggress with all 7 of the statements above.
HIGH: Strongly agree with 6 of the statements above.
MODERATE: Strongly agree with 5 of the statements above.
LOW: Strongly agree with 3 or 4 of the statements above.
NONE: Strongly agree with 2 or fewer of the statements above.

Ecological Significance 40%

- There is a strong, defensible linkage between the vital sign and the ecological function or critical resource it is intended to represent.
- The resource being represented by the vital sign has high ecological importance based on a conceptual model of the system or is well-supported by the ecological literature.
- The vital sign characterizes the state of unmeasured structural and compositional resources and system processes.
- The vital sign provides early warning of undesirable changes to important resources. It can signify an impending change in the ecological system.
- The vital sign reflects the functional status of one or more key ecosystem processes or the status of ecosystem properties that are clearly related to ecosystem processes. [Note: replace the word ecosystem with landscape or population, as appropriate.]
- The vital sign reflects the capacity of key ecosystem processes to resist or recover from change induced by exposure to natural disturbances and/or anthropogenic stressors. [Note: replace the word ecosystem with landscape or population, as appropriate.]

VERY HIGH: Strongly agrees with all 6 of the statements above.
HIGH: Strongly agree with 5 of the statements above.
MODERATE: Strongly agree with 3 or 4 of the statements above.
LOW: Strongly agree with at least 1 of the statements above.
NONE: This is an important attribute to monitor, but I do not agree with any of the statements above.

Legal Mandate 20%

- VERY HIGH: The park is required to monitor this resource by some specific, binding, legal mandate (e.g., Endangered Species Act for an endangered species, Clean Air Act for Class 1 airsheds), or park enabling legislation that mentions a specific resource to be monitored.
- HIGH: The resource/vital sign is specifically covered by an Executive Order (e.g., invasive plants, wetlands) or a specific Memorandum of Understanding signed by the NPS (e.g., bird monitoring), as well as the Organic Act, other general legislative or Congressional mandates, and NPS Management Policies.
- MODERATE: There is a GPRA goal specifically mentioned for the resource/vital sign being monitored, or the need to monitor the resource is generally indicated by some type of federal or state law as well as the Organic Act and other general legislative mandates and NPS Management Policies, but there is no specific legal mandate for this particular resource.
- LOW: The resource/vital sign is listed as a sensitive resource or resource of special concern by credible state, regional, or local conservation agencies or organizations, but it is not specially identified in any legally-binding federal or state legislation. The resource/vital sign is also covered by the Organic Act and other general legislative or Congressional mandates such as the Omnibus Park Management Act and GPRA, and by NPS Management Policies.
- NONE: There is no legal mandate for this particular resource.

Appendix D.9. Top 10 Prioritized Vitals Signs for Individual Parks

Note: MIIN is not included - vital signs will be decided for this park after restoration of the cultural landscape complete.

Big Hole National Battlefield	
	Water quality- core parameters
	Channel/bank morphology
	Invasive plants
	Surface water dynamics
	Land cover composition, configuration, and connectivity
	Forest structure
	Sagebrush vegetation communities
	Riparian vegetation communities
	Viewshed
	Network species/communities of special concern
City of Rocks National Reserve	
	Aspen communities
	Pinyon-juniper communities
	Sagebrush vegetation communities
	Invasive plants
	Riparian vegetation communities
	Water quality- core parameters
	Land cover composition, configuration, and connectivity
	Surface water dynamics
	Climate change
	Network species/communities of special concern
Craters of the Moon National Monument and Preserve	
	Sagebrush vegetation communities
	Invasive plants
	Network species/communities of special concern
	Land cover composition, configuration, and connectivity
	Bats
	Shrub-steppe bird communities
	Forest insects and diseases
	Water quality- core parameters
	Surface water dynamics
	Climate change
Hagerman Fossil Beds National Monument	
	Invasive plants
	Landslides
	Sagebrush vegetation communities
	Land cover composition, configuration, and connectivity
	State and federal species of concern
	Riparian vegetation communities
	Soil erosion
	Biological soil crusts
	Wetland/riparian bird communities
	Shrub-steppe bird communities

Park / Vital sign
John Day Fossil Beds National Monument
Sagebrush vegetation communities
Invasive plants
Paleontological resources
Riparian vegetation communities
Water quality- core parameters
Bats
Land cover composition, configuration, and connectivity
Fire dynamics - prescribed fire
Visitor usage
State and federal species of concern
Lake Roosevelt National Recreation Area
Water quality-toxics
Invasive plants
Riparian vegetation communities
Land cover composition, configuration, and connectivity
State and federal species of concern
Ponderosa pine forests
Viewshed
Grazing
Snag/cavity obligate species
Raptor communities
Nez Perce National Historical Park
Invasive plants
Federal T&E species
Water quality- core parameters
Land cover composition, configuration, and connectivity
Network species/communities of special concern
State and federal species of concern
Riparian vegetation communities
Surface water dynamics
Wetland/riparian bird communities
Channel/bank morphology
Whitman Mission National Historic Site
Invasive plants
Fire dynamics - prescribed fire
Water quality- core parameters
Land cover composition, configuration, and connectivity
Riparian vegetation communities
Channel/bank morphology
Water quality- nutrients
Surface water dynamics
Wetland/riparian bird communities
Amphibians

Appendix E
Sources for Monitoring Data

Appendix E.1. Existing Monitoring Programs at Craters of the Moon National Monument and Preserve

Program	# of Sites	Frequency	Month(s) of Year	Comments
Air resources				
National Acid Deposition Program	1	1/week	1-12	1980-present http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=ID03&net=NADP
Ozone	1	Continuous	1-12	NPS 1992-present (currently DOE funded)
Visibility, fine Particulates	1	Samplers run every third day; filter change 1/week	1-12	Interagency Monitoring of Protected Visual Environments (IMPROVE); http://vista.cira.colostate.edu/improve/ Module A 1992-2000, Modules A-D 2000-present
Visibility camera (35mm color slides)	1	3/day	NA	NPS 1985-2001, Discontinued
Gross Alpha & Beta radiation, gamma spectrometry (Iodine-131)	1	Weekly	1-12	DOE/INL Environmental Surveillance Program http://www.stoller-eser.com/Surveillance.htm
Gamma spectrometry (Cesium 137)	1	Quarterly	1-12	DOE/INL Environmental Surveillance Program http://www.stoller-eser.com/Surveillance.htm
Tritium (atmospheric moisture)	1			State of Idaho/INL Oversight Program http://www.oversight.state.id.us/monitoring/air/index.htm
Gross Alpha & Beta radiation	1	Weekly	1-12	State of Idaho/INL Oversight Program http://www.oversight.state.id.us/monitoring/air/index.htm
Wildlife				
Mule deer (spring)	Loop Road	As observed	4-5	NPS 1991-present
Mule deer (fall)	"North End" Route	8/year	Mid-Aug. to Mid- Sept.	NPS 1989-present
Breeding bird surveys	10	Each route 1/year	5-6	NPS 1997-present
Weather/climate				
Climate Reference Network	1	Continuous	1-12	NOAA- Temperature, solar radiation RH, Wind Speed, precipitation (2003-present) http://www.ncdc.noaa.gov/oa/climate/uscrn/

Program	# of Sites	Frequency	Month(s) of Year	Comments
Cooperative Network	1	Daily	1-12	NWS- temperature maximum/minimum, precipitation (1958-present) http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?idcrat
Ozone MET (VC)	1	Continuous	1-12	Temperature, wind speed/direction, solar radiation, RH (1992-present)
Broken top	1	Continuous	1-12	DOE/NOAA – Temperature, wind speed/direction, RH, dew point (1997-present) http://www.met.utah.edu/cgi-bin/roman/meso_base.cgi?stn=COMID
Geology				
Geologic features photo points	18	3-5 years	5-8	NPS 1996-Present
Vegetation				
Vegetation transect	8	Every 4 years	6-7	NPS 1990-Present. Stratified by vegetation type (sagebrush, limber pine, aspen/riparian, cinder, Douglas fir
Landscape photo points	Annual	6-7	6-7	NPS 1997-present (Note: historical photos date as early as 1920's)
Water resources				
Water quality	8			NPS, four stream sites & four water holes; Core parameters, nutrients, metals

Appendix E.2. Available Geographic Information System (GIS) and Remotely Sensed (RS) Data

A tremendous amount of GIS and RS data have been developed and gathered for lands encompassed by the UCBN. Over 170 different data layers were compiled or created in support of the Interior Columbia Basin Ecosystem Management Project, whose boundary includes more than 90% of the Network. Gap Analysis Projects have been completed in each of the four states, generating 300+ vertebrate species models and supporting data per state. In addition, over a dozen well-known groups specializing in GIS and RS research and data delivery reside in the region. These information sources include the Wildlife Spatial Analysis Lab (Univ. of Montana), USFS Fire Sciences Lab (Univ. of Montana), Montana Natural Resource Information System, Landscape Dynamics Lab (Univ. of Idaho), Remote Sensing and GIS Research Lab (Univ. of Idaho), Inside Idaho (Univ. of Idaho), Idaho Department of Water Resources, GIS Training and Research Center (Idaho State Univ.), Oregon Geospatial Data Clearinghouse, Oregon/Washington Bureau of Land Management, Washington Department of Ecology, Washington Department of Transportation, USFS Pacific Northwest Research Station, USGS Snake River Field Station, StreamNet, and SageMap.

The majority of data available in the region are mid to broad-scale (1:100,000 – 1:500,000), providing excellent opportunities to develop long-term monitoring schemes within the "big picture" context. Many fine scale (1:24,000) data layers are also available and, given the expertise in the region, additional park and management specific data could easily be generated. The following table identifies GIS and RS data currently available.

Theme	Data	Scale	BIHO	CIRO	CRMO	HAFO	MIIN	NEPE	JODA	LARO	WHMI
Air/climate	Air quality point source emissions	1:100	■	■	■	■	■	■	■	■	■
	Superfund sites	1:100			■						
	Air quality estimates (20 variables)	1:10	■	■	■	■		■	■	■	■
	Weather (eight variables)	1:100	■	■	■	■	■	■	■	■	■
Hydrology	Rivers	1:100	■	■	■	■	■	■	■	■	■
	Lakes	1:100	■	■	■	■	■	■	■	■	■
	Gaging stations	1:100	■	■	■	■		■	■		■
	Impoundments	1:100	■	■	■	■	■	■	■	■	■
	Water quality stations	1:100	■	■	■	■		■	■		■

Theme	Data	Scale	BIHO	CIRO	CRMO	HAFO	MIIN	NEPE	JODA	LARO	WHMI
Hydrology	Springs	1:100		■	■			■		■	
	Waterholes	1:100			■						
	Wetlands	1:100	■					■			
	Basin and subbasin boundaries	1:100	■	■	■	■	■	■	■	■	■
	Pollutant sources	1:100		■	■	■	■	■	■	■	■
	Water quality impaired lakes and streams	1:100		■	■	■	■	■	■	■	■
	Water stress index	1:100	■	■	■	■	■	■	■	■	■
Topography/geology	Contours	Varies	■					■		■	
	Digital elevation model	30m	■	■	■	■	■	■	■	■	■
	Digital elevation model	10m		■	■	■	■	Part		■	■
	Land slides	1:24				■				■	
	Paleontological sites	1:24				■			■		
	Geology	Varies		■	■	■	■	■	■		
	Soil survey	1:24			Part	■		■	■		
	Caves	1:24			Part						
	Nutrient availability index	1:100	■	■	■	■	■	■	■	■	■
	Bedrock mineral content	1:100	■	■	■	■	■	■	■	■	■
	Major lithology	1:100	■	■	■	■	■	■	■	■	■
	Low-temperature geothermal sites	1:100	■	■	■	■	■	■	■	■	■
	Mines (mineral industry locator system)	1:100	■	■	■	■	■	■	■	■	■
Vegetation	Land cover	1:100		■	■	■	■	■	■	■	■
	Land cover	1:24			Part	Part		■			
	Weed locations	1:24		Part	Part				■	■	■
	Weed treatments	1:24								Part	■
	Kipukas	1:24			■						
	Rare plant locations	1:100			Part						
	Vegetation transects	1:24			Part						
	Forest health vegetation vulnerability	1:100		■	■	■	■	■	■	■	■

Theme	Data	Scale	BIHO	CIRO	CRMO	HAFO	MIIN	NEPE	JODA	LARO	WHMI
Vegetation	Rangeland health vegetation vulnerability	1:100									
	Distribution big sagebrush (double CO2)	1:100									
	Distribution Ponderosa Pine (double CO2)	1:100									
	Historic (1936) vegetation	1:100									
	Net primary productivity	1:100									
Wildlife	Sage grouse leks	1:100									
	Sensitive species locations	1:100									
	Breeding bird survey routes	1:100									
	Relative aquatic integrity	1:100									
	Fish species ranges, current and historic	1:100									
	Wildlife habitat relationship models	1:100									
Political	State boundaries	1:100									
	County boundaries	1:100									
	Cities	1:100									
	Park boundaries	1:100									
	Ownership	1:100									
	Parcel tracts	1:24						Part			
	Other protected areas	1:100									
	Wilderness study areas	1:100									
	Campgrounds/parking areas	1:100									
	Highway mile markers	1:100									
	Road density	1:100									
	Roads	1:100									
	4WD roads	1:100									
	Trails	1:100									
	Utility corridors	1:100									
	Railroads	1:100									

Theme	Data	Scale	BIHO	CIRO	CRMO	HAFO	MIIN	NEPE	JODA	LARO	WHMI
Cultural	Archeological sites	1:24			Part			■			
	Historic photo series locations	1:24	■		■						
	Structures	1:24	■		■			Part			
	Historic trails	1:24		■	■						
	Cultural resource sites	1:24						Part			
	Scenic integrity	1:100		■	■	■	■	■	■	Part	■
	Human population information	1:100	■	■	■	■	■	■	■	■	■
	Tribal reservations and ceded lands	1:100		■	■	■	■	■	■	■	■
Disturbance	Fire ignition locations	1:100	■	■	■	■	■	■	■	■	■
	Fire boundaries/history	1:100		■	■	■	■				
	Fire treatment areas	1:24							■	■	
	Current (1990) fire regime	1:100		■	■	■	■	■	■	■	■
	Historic (1900) fire regime	1:100		■	■	■	■	■	■	■	■
	Grazing allotments	1:100		■	■			Part			
	Landfill	1:24			■						
Remotely sensed/base layers	Quad boundaries	1:24	■	■	■	■	■	■	■	■	■
	Quad boundaries	1:100	■	■	■	■	■	■	■	■	■
	Digital OrthoPhoto quads	Varies	■	■	■	■	■	■			■
	Digital raster graphics	Varies	■	■	■	■	■	■			■
	Aerial photos	Varies	■	■					■	■	
	SPOT panchromatic	2.5 m		■	■	■	■	Part			
	SPOT panchromatic	10 m		■	■	■	■	Part			
	ASTER	15 m	■	■	■	■	■	■	■	■	■
	LandSat	30 m	■	■	■	■	■	■	■	■	■
	NAIP	1 m	■	■	■	■	■	■	■	■	■

Appendix E.3. Regional Monitoring

Air and Climate

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 six criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, particulate matter and lead), in addition to other variables.

Department of Environmental Quality, Department of Ecology
Air quality programs are administered in all four 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.

SNOTEL, Natural Resources Conservation Service
Since 1980, the NRCS'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. While no sites are located in UCBN parks, the parks are situated within a network of regional sites and data generated are applicable.

Western Regional Climate Center, National Oceanic and Atmospheric Administration
The WRCC is one of six 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 Network 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 covers 230,509 ha (569,600 acres) 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 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 3,000 randomly established roadside routes to monitor the status and trends of North American bird populations. Routes are 39.4 km (24.5 mi) long with observers stopping every 0.8 km (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 24 km (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 shrub-steppe

systems. More recently, SAGEMAP has become a repository for information related to the monitoring of greater sage-grouse.

State Fish and Wildlife 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 (e.g., elk, mule deer, whitetail deer, moose, bighorn sheep, mountain goat) and fish. Areas surveyed for each species vary annually, but often include areas on or near 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.

Partners in Flight
Begun in 1990, the goal of PIF is to focus resources on 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 Cooperative
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.

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 . The program has recently been expanded into Washington, Idaho, and Montana, and is moving toward a comprehensive monitoring strategy that may be appropriate for adoption in the UCBN.

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; provide a mechanism by which current information regarding bat ecology, distribution, and research techniques can be readily accessed; and 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.

Vegetation

Idaho National Engineering and Environmental Laboratory
The INEEL in southeast Idaho covers 230,509 ha (569,600 acres) of fairly pristine 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, USDA 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 2,428 ha (6,000 acres). Few, if any, plots occur in Network parks.

Forest Health Monitoring, USDA Forest Service
In addition to the forest stand information collected at FIA plots, a subset (one plot every 38,850 ha) 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 four 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 four 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.

Appendix F
Protocol Development Summaries

Appendix F.1. Aspen Protocol Development Summary

Protocol: Aspen

Parks Where Protocol Will Be Implemented: CIRO and CRMO

Justification/Issues being addressed:
Quaking aspen is declining rapidly in the western United States with an estimated loss of 61% in Idaho (Bartos 2001). Aside from riparian ecosystems, aspen communities are the most biologically rich areas in the intermountain west. Aspen decline cascades into losses of vertebrate species and vascular plants as well as invertebrates and nonvascular organisms. The aesthetics of aspen brings visitors to western mountains and parks. Quaking aspen provide an oasis of lush vegetation and cool shade on hot summer days and offer a spectacular panorama of fall colors in autumn. Aspen is a particularly important attraction for visitors to CIRO. Aspen is a seral fast growing shade intolerant species commonly replaced by shade tolerant conifers. Current fire intervals, extents, and intensities are not regenerating aspen at historic rates, and are likely causes to the aspen decline observed today. Secondarily, shade-tolerant conifer encroachment and overtopping is contributing to aspen decline. Our aspen monitoring program will address overall aspen abundance, conifer encroachment, and aspen regeneration. Management thresholds for sapling stems per hectare are available from the literature and our monitoring program will allow park managers to direct appropriate actions to maintain park aspen populations.

Initial signs of aspen decline can manifest as reduced regeneration and aspen canopy cover within the clone. Bartos and Campbell (1998) suggest that regeneration levels greater than 1,200 stems/ha is sufficient for the long-term maintenance of aspen clones. Regeneration is here defined as the number of stems 1.5 to 4.6 m (5 to 15 ft) tall. It is well established that conifer encroachment is a stressor that can reduce aspen regeneration to levels jeopardizing the long-term survival of the clone (Bartos and Campbell 1998; Kaye et al. 2005).

Preliminary visual examination of time series aerial photography (1950, 1977, 1990, and 2004) for a central area in CIRO, reveals a reduction in aspen density within several clones although the extent of the clones through time appear similar. It is desirable to detect declines in regeneration and canopy cover at an early stage where management may more effectively turn around a negative trend. Monitoring aspen and conifer cover and regeneration is important for determining when active management is necessary for the long-term maintenance of aspen stands in CIRO and CRMO.

Monitoring Questions and Objectives to be addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- Are changes in aspen aerial extent and clone density evident within the time period 1950 and 2004 as determined through analysis of available historical aerial photography for CIRO?
- Are aspen clones within CIRO and CRMO regenerating at rates at or above 1,200 stems/ha? What is the long-term trend in regeneration of park aspen populations as well as individual stands?
- What is the status and trend in conifer density within CIRO and CRMO aspen stands?
- What is the variability of regeneration in sub-plots within an aspen stand and between different aspen stands?

Monitoring objectives addressed by this protocol include:

1) Estimate status and trend in aspen abundance, as measured by stem density of live and dead trees, within CIRO and CRMO aspen stands.
Justification: *Low density of live aspen or a trend towards dead stems along with lack of recruitment will eventually jeopardize the long-term survival of the aspen clone (Bartos and Campbell 1998).*
2) Estimate status and trend in conifer density within CIRO and CRMO aspen stands.
Justification: *High levels of conifer encroachment in aspen stands (greater than 25% cover) affect the reproduction of aspen and the stand may eventually be permanently converted to a conifer stand (Bartos and Campbell 1998).*
3) Estimate status and trend in regeneration of park aspen populations as well as individual stands within CIRO and CRMO.
Justification: *Declines in aspen have been detected on time series aerial photos for CIRO. However, remotely sensed data will not readily detect changes in population structure of aspen within a clone and field assessments are therefore necessary.*

Basic Approach:
We will generate a list-based sampling frame from aspen stands identified on current satellite imagery and aerial photography and further delineated on the ground using GPS technology. All available stands larger than 0.2 ha will be sampled (time permitting) in a panel design with a 5-year sampling interval. Within stands permanent and temporary circular sub-plots will be established along transects. Variogram analysis will determine the distance between sub-plots required for spatial independence between sub-plot data. The number of sub-plots required in each stand will be determined via power analysis to allow for detection of trend with statistical confidence and power while minimizing the sampling effort. The number of sub-plots placed in each stand will further be weighted by the size of the stand. Historical aerial photographs from the 1950's, 1970's, and 1990's for CIRO will be scanned and orthorectified for further visual analysis of change in aspen cover.

Regional-level protocols exist for assessment of regeneration and conifer encroachment in aspen stands. The Wyoming Department of Fish & Game (Kilpatrick et al. 2003) has developed a peer reviewed sampling methodology for aspen with the goal of assessing aspen regeneration at stages along a successional gradient, pre- and post-fire treatments. This sampling protocol describes established sampling techniques for acquiring a statistically reliable measure of aspen stem densities by tree size class and photo points. Thresholds for desirable levels of aspen regeneration and canopy cover and acceptable levels of conifer encroachment have been identified by Bartos and Campbell (1998) and will serve as guidelines for long-term maintenance of park aspen populations. Another resource is the Aspen Delineation Project, an interagency effort involving the BLM, the USFS and the California Department of Fish & Game, with the goal of providing agency personnel with information and tools they need to achieve long-term aspen conservation objectives. We will adapt these existing protocols to meet NPS standards (Oakley et al. 2003) and incorporate protocol narrative and SOPs, analysis and reporting procedures specific to CIRO and CRMO.

Principal Investigators and NPS Lead:
Protocol development will be done through a cooperative agreement with the Department of Rangeland Ecology and Management, College of Natural Resources, University of Idaho (975 W. Sixth Street, Moscow, Idaho, 83844, 1-208-885-7103). Principal Investigators: Stephen C. Bunting and Eva Strand (1-208-885-5779). NPS Lead: Lisa Garrett, NPS Network I & M Coordinator (1-208-885-3684).

Development Schedule, Budget, and Expected Interim Products:
The project extends from August 1, 2005 to September 1, 2007. Detailed scope of work reports including sampling protocols and field sheets are due in May of 2006 and 2007 before the field-work commences. An annual report was completed in September 2006, and the completed protocol will be ready for peer review in 2007. We have budgeted $18,532.00 for the 2-year project.

Literature Cited:

Bartos, D. L. 2001. Landscape Dynamics of Aspen and Conifer Forests. Pages 5-14 *in* Sustaining Aspen in Western Landscapes: Symposium Proceedings; 13-15 June 2000; Grand Junction, CO. USDA Forest Service Proceedings RMRS-P-18.

Bartos, D. L., and R. B. Campbell. 1998. Decline of Quaking Aspen in the Interior West – Examples from Utah. Rangelands **20**:17-14.

Kaye, M. W., D. Binkley, and T. J. Stohlgren, 2005. Effects of conifers and elk browsing on quaking aspen forests in the central Rocky Mountains, USA, Ecological Applications, **15**:1284-1295.

Kilpatrick, S., D. Clause, and D. Scott, 2003. Aspen response to prescribed fire, mechanical treatments, and ungulate herbivory. USDA Forest Service Proceedings RMRS-P-29.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin **31**:1000-1003.

Appendix F.2. Bats Protocol Development Summary

Protocol: Bats

Parks Where Protocol will be Implemented: JODA, CRMO, and CIRO

Justification/Issues being addressed:
Properties of faunal assemblages and populations are important indicators of environmental change because fauna serve a great diversity of ecological functions that affect ecosystem productivity, resilience, and sustainability (Marcot 1996). Terrestrial fauna are desirable subjects for long-term ecological monitoring because they have widespread public appeal, and changes in the park's fauna are likely to garner a high level of public interest and generate support for corrective or remedial management actions. Bats exhibit high fidelity to foraging and roosting sites and extreme longevity, making them well-suited candidates for long-term monitoring (Fenton 2003). Changes in bat species presence and activity patterns at monitoring sites in the UCBN will serve as good indicators of environmental change, especially for riparian and aquatic focal systems because bats concentrate foraging around riparian and open aquatic habitats. In the UCBN, maternity roosts of the Townsend's big-eared bat and pallid bat, both sensitive colonial species, are located in cliffs and caves that experience heavy visitation. Monitoring of these sites over time will provide invaluable information to managers about visitor impacts on these resource areas.

Like many networks in the continental United States, bats in the UCBN represent one of the most diverse mammalian orders, second only to the rodents. As many as 14 species of bats have been documented in Network parks, and over half of those are listed as federal and/or state species of concern. Important pup-rearing, hibernation, and foraging resources have also been documented. Recent research conducted by the UCBN in JODA has demonstrated that several large cliff complexes provide summer roosting for at least six species, including large maternity colonies of the pallid bat, a unique desert species sensitive to human disturbance (Rodhouse and Wright 2004; Rodhouse et al. 2005). Likewise at CRMO, research conducted by Keller (1997) and the UCBN has clearly demonstrated importance of a cluster of lava tubes in the north end of the monument to a resident maternity colony of Townsend's big-eared bats and as winter hibernacula. This species is also a state and federal species of concern and is quite vulnerable to human disturbance, particularly to entry of caves by recreational spelunkers.

In addition to these specific focal points of bat conservation concern in the UCBN, there is an overall condition of vulnerability among the bat fauna. Information on distribution, roosting ecology, and conservation status is so poorly known for most bat species that it is imperative that basic trends begin to be established. Trends from long-term bird monitoring in the region show worrisome declines in many bird species due to habitat loss or alteration, pesticide exposure, and other human-caused stressors (Rich et al. 2004). There is no reason to expect regional bat populations are somehow immune to these same stressors, but we are left only to guess in the absence of reliable trend data.

Although bats are continually recognized as important components of regional mammalian diversity, are essential providers of important ecosystem services, and have an uncertain conservation status, few I&M networks are actually addressing bat fauna in their monitoring program. This is in large part due to the lack of efficient and cost-effective protocols available. A recent review of bat monitoring in the United States underscored this situation and emphasized the critical need for developing and testing monitoring protocols in the immediate future (O'Shea et al. 2003). The NPS I&M program is well positioned to spearhead bat monitoring protocol development. The program is dedicated to long-term ecosystem monitoring, has relatively secure funding, has access to experts in the field of bat biology and conservation, and has already invested a significant amount of time, money, and energy into establishing well-grounded conceptual and organizational frameworks. Recent technological advances in acoustic tools designed to record and analyze bat echolocation calls have now made it possible for efficient and cost-effective long-term monitoring of almost any type of habitat used by bats, including both aquatic and upland areas as well as areas strategically impossible to conduct bat capture efforts. This monitoring protocol will be based on application of state-of-the-art acoustic tools.

The UCBN will incorporate acoustic monitoring of bat occupancy (interpreted alternatively as "use" for these volant animals) in park riparian zones as part of its integrated riparian and water quality monitoring program. Taken together, monitoring of riparian vegetation, stream channel morphology, water quality, and bats will provide for more complete understanding of long-term trends in UCBN aquatic and riparian systems. The conceptual model in Figure F.2.1 illustrates more directly the relationships between these vital signs.

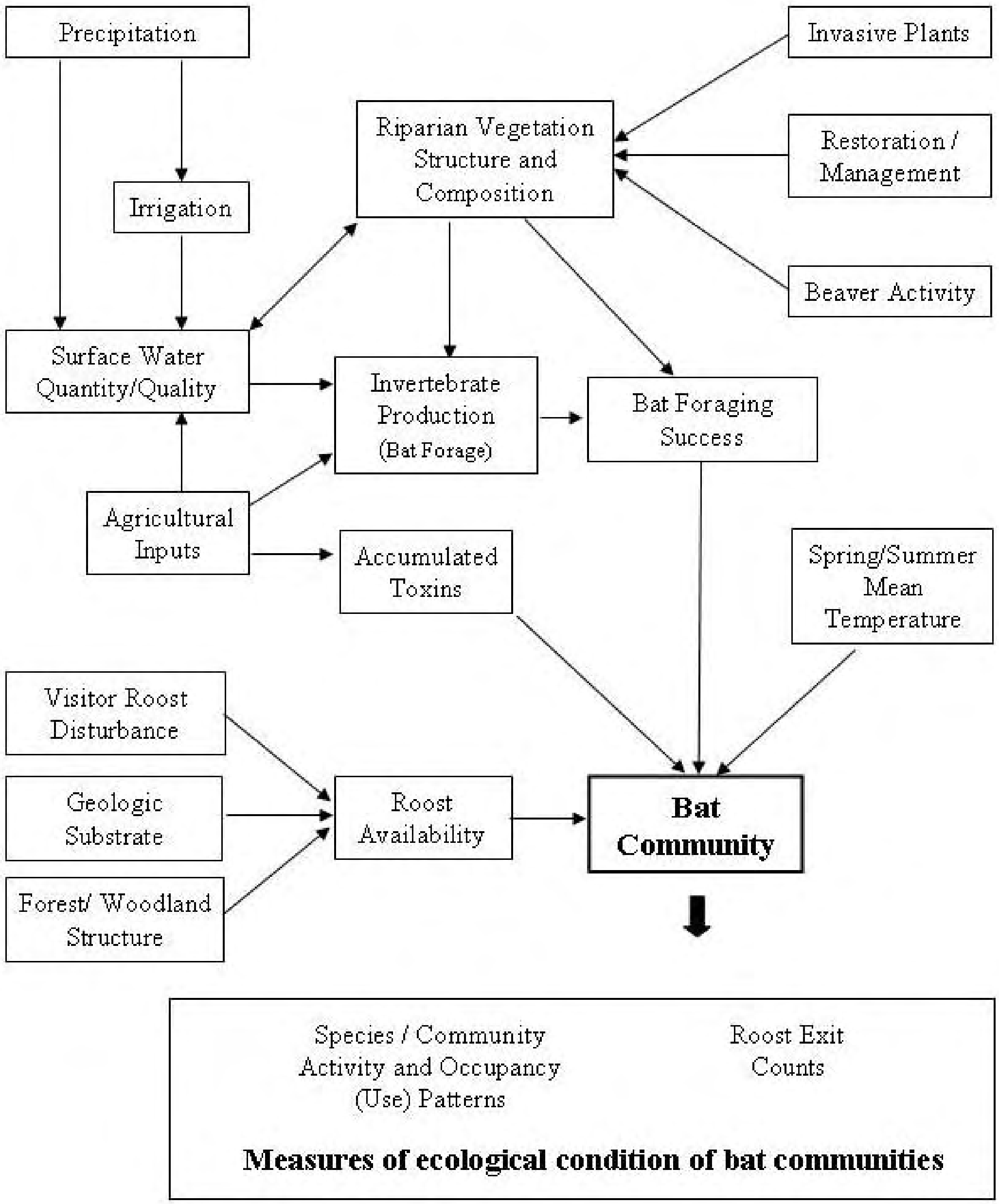


Figure F.2.1. Conceptual model showing known or hypothesized linkages between aquatic and riparian systems, upland roost conditions, and environmental stressors on the UCBN bat community.

Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- What are the nightly, seasonal, and annual patterns and dynamics of species occupancy (use) among bats in UCBN riparian foraging areas?
- Is bat species richness in riparian foraging areas in decline?
- Are there declining trends of occupancy and activity by bats in foraging and roosting areas in the UCBN?
- Are Townsend's big-eared bat populations, as indicated by annual roost exit counts at CRMO's North Cave Complex, declining?
- Are trends in bat occupancy, activity, and species composition significantly correlated with trends in weather and climate, water quality, stream/channel morphology, and riparian vegetation?

Monitoring objectives addressed by this protocol include:

1) Estimate trends in the occupancy dynamics of individual bat species during summer pup-rearing in riparian areas of CIRO, CRMO, and JODA.
Justification: *Riparian corridors provide critical foraging and commuting habitat for all 14 bat species in the UCBN. Acoustic monitoring of these areas will provide opportunity for trend detection and possible correlation with other UCBN vital signs. Bat monitoring will provide an important vertebrate component to the UCBN's integrated riparian and water quality monitoring efforts.*
2) Estimate trends in Townsend's big-eared bat occupancy and abundance in lava tubes of CRMO's north caves complex during summer pup-rearing.
Justification: *Regionally significant maternity colonies of Townsend's big-eared bats exist within CRMO lava tubes, and acoustic monitoring will enable detection of declines over time. Exit counts may also be employed to complement automated acoustic methods.*

Basic Approach:
The UCBN will develop an occupancy modeling-based approach to bat monitoring following methods outlined by Mackenzie et al. (2006) in which trends in occupancy, local extinction and colonization rates, and detectability parameters will be estimated over time. Methods will be developed that permit estimation of trends in activity based on the number of calls or minutes of activity per unit time (e.g., minutes, hours, nights). Our primary method of detection will involve employment of solar-powered ANABAT bat detectors (Titley Electronics, Ballina, NSW, AUS). These are extremely cost-effective and efficient relative to the amount of information acquired and in contrast to manual roost exit counting and capture-based monitoring. Bat detectors will be rotated through an optimal number of sample sites for a series of nightly "revisits" as determined through power analyses (Mackenzie et al. 2006, Lewis 2006). Manual roost exit counts and some supplementary capture efforts may be required periodically to calibrate and aid in interpretation of acoustic results as well as to further develop the UCBN acoustic bat call library and assist with development of filters for acoustic data

processing. A probabilistic sampling design will be developed for locating acoustic monitoring stations in riparian areas in an integrated way with the UCBN riparian vegetation and stream/river channel characteristics vital signs. In particular, bat monitoring will occur at a subset of sampling locations selected through a spatially-balanced sampling procedure known as Generalize Random Tessellation Stratified (GRTS) that will support explicit integration of these three different vital signs monitoring designs along linear stream networks (Stevens and Olsen 2004; see Figure 2). CRMO roost monitoring will be restricted to the use of judgment sampling of selected cave index sites, due to the small number of known roost sites and difficulty in accessing many caves. Assigning species identification to call sequences remains the most challenging and time consuming aspect of acoustic monitoring and several strategies will be evaluated during protocol development, including the use of filters, use of "frequency groups" in lieu of resolution to species for difficult *Myotis* species (i.e., 40 KHz *Myotis*), and a double sampling approach in which only a randomly selected subset of monitoring periods are analyzed in detail for species resolution, which in turn informs an estimation procedure for minutes of activity per species based on overall bat activity patterns. Adaptation of occupancy models to support multi-state occupancy estimation involving multinomial or ordinal logistic regression will be investigated as a strategy to provide finer resolution in the detection of use patterns, increasing the sensitivity to detect biologically meaningful change. Of particular interest in this regard is the ability to discern sites and times of night with high levels of use and patterns of decline that would be obscured with simple presence/absence (i.e. 2 occupancy states).

Because of the relatively undeveloped methodologies related to long-term bat monitoring, the UCBN is collaborating closely with the Pacific Islands Network (PACN) I&M program and a similar effort underway in Sierra Nevada Network through the USGS Western Ecological Research Center. The Network is also closely following the development of a regional monitoring program in the USFS region 6, and may seek to nest the UCBN program within this larger regional program. A Microsoft Access database developed by Robert Peppard (Bechtel Nevada Co.) and Mike O'Farrell (O'Farrell Biological Consulting) will be employed during the initial pilot work and modified as needed to support data processing, management, and analysis. Anticipated benefits from collaboration extend beyond protocol development for UCBN purposes and include establishment of a regional acoustic bat monitoring network that will provide status and trend information at a much greater spatial scale. Field data collection will be required for protocol development, and will be implemented first in JODA and subsequently in CRMO and CIRO. Initial pilot work will focus on assessment of functionality, logistics, and data processing and management strategies of solar-powered Anabat stations in JODA along non-randomly selected riparian foraging sites. These sites will be selected based on historic capture records available for the park to maximize recording success and interpretation (Rodhouse et al. 2004, 2005). Other acoustic monitoring systems available or under development, including full-spectrum approaches (e.g. Sonobat/Petterson system), will also be considered as they become available.

Principal Investigators and NPS Lead:
NPS Lead: Tom Rodhouse, UCBN Ecologist, 541-312-8101. Primary collaborators are Marcos Gorresen (USGS), Leslie Haysmith (PACN), Heather Fraser (PACN), and Pat Ormsbee (USFS Region 6).

Development Schedule, Budget, and Expected Interim Products:
The NPS lead will complete a draft bat acoustic monitoring protocol ready for external peer review in spring 2008.

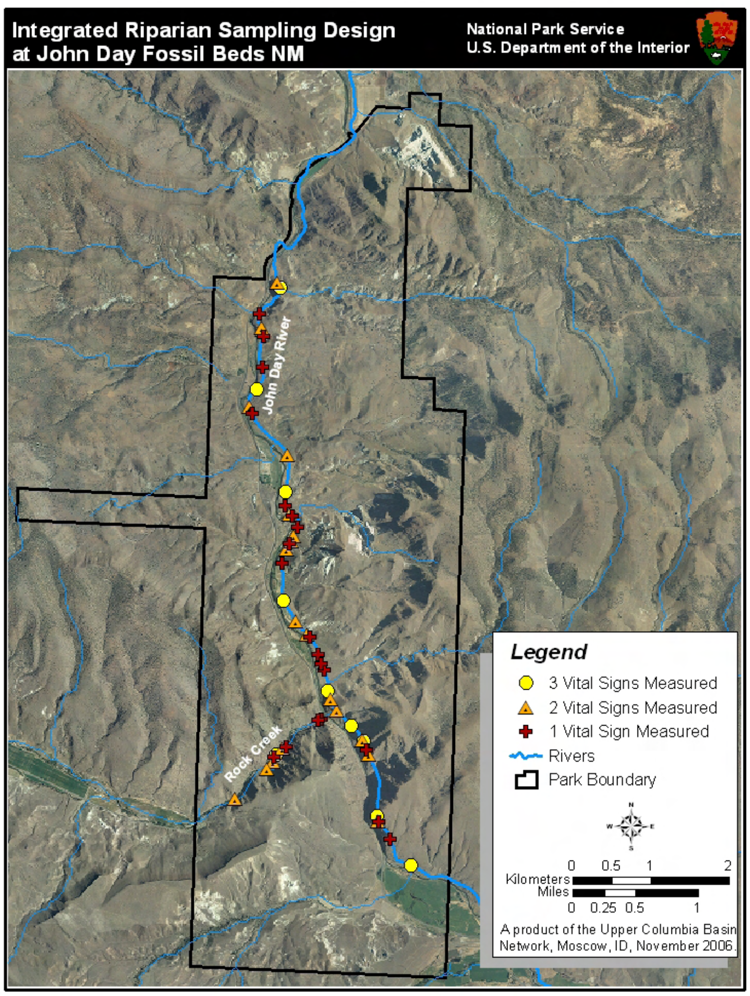


Figure F.2.2. An hierarchically nested and spatially-balanced sampling design for integrated riparian condition monitoring involving bats, riparian vegetation, and stream/river channel characteristics vitals signs in the UCBN. In this example, bat detectors would be placed only at the sites marked in yellow, co-located with riparian vegetation monitoring, which would be conducted at all sites (yellow, orange, and red), and stream bank morphology, which would be conducted at yellow and orange sites only. This approach allows for explicit integration of monitoring projects that require (or which logistical constraints dictate) different sampling efforts.

Literature Cited:

Fenton, M. B. 2003. Science and the conservation of bats: where to next? Wildlife Society Bulletin **31**:6-15.

Keller, B. 1997. Analysis of the thermal characteristics of maternity caves and bat species present at Craters of the Monument National Monument, Butte County, Idaho. Unpublished. Western Environmental Research Associates, Pocatello, ID.

Lewis, K.P. 2006. statistical power, sample sizes, and the software to calculate them easily. Bioscience **56**: 607-612.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier, London.

Marcot, B. 1996. An ecosystem context for bat management: a case study of the interior Columbia River Basin, USA. Pages 19-38 *in* R. M. R. Barclay and R. M. Brigham, Canada. B.C. Ministry of Forestry, Victoria, B.C.

O'Shea, T. J., and M.A. Bogan. 2003. Introduction. *In* Monitoring trends in bat populations of the United States and Territories: problems and prospects. T. J. O'Shea and M. A. Bogan (eds.). US Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR-2003-0003.

Rich ,T. D., C. J. Beardmore, and others. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology. Ithaca, NY.

Rodhouse, T. J., M. F. McCaffrey, and R. G. Wright. 2005. Distribution, foraging behavior, and capture results of the spotted bat (*Euderma maculatum*) in central Oregon. Western.North American Naturalist **65**:215-222.

Rodhouse, T. J., and R. G. Wright. 2004. 2003 study of bat roosts: John Day Fossil Beds National Monument. Report for cooperative agreement no. CA9088A00008. University of Idaho, Moscow, ID.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association **99**: 262–278.

Appendix F.3. Camas Lily Protocol Development Summary

Protocol: Camas Lily

Parks Where Protocol will be Implemented: NEPE and BIHO

Justification/Issues being addressed:
Camas lily was historically one of the most widely utilized plant foods of the Nez Perce people, and remains so for many tribal members today (Harbinger 1964; Hunn 1981; Turner and Kuhnlein 1983, Mastrogiuseppe 2000). Camas was also a focal resource at many of the significant historical events memorialized today by NEPE and BIHO. It was during the camas harvest at Weippe Prairie, a subunit of NEPE, that the Lewis and Clark Corps of Discovery first encountered the Nez Perce, and the battle at Big Hole occurred at a traditional Nez Perce camas lily harvesting campsite. It is also noteworthy that the botanical "type" specimen for the Camas genus as well as for camas lily itself was collected by the Lewis and Clark Expedition returning through the Weippe Prairie during the spring of 1806 (Gould 1942). Camas lily is therefore a central, important element of the cultural landscapes NEPE and BIHO seek to interpret for the public. The focal cultural resource status of camas is one of two driving rationales for establishing a camas lily monitoring program in the UCBN.

Camas lily, a facultative wetland species (Reed 1988), is also ecologically significant. It is strongly associated with seasonal wet prairie ecosystems of the interior Columbia Plateau, which are represented at Weippe Prairie and along the North Fork of the Big Hole River. The extent of the wet prairie ecosystem type has been drastically reduced in the Columbia Basin as a result of agricultural conversion, irrigation, and flood control development, and other land use practices, a pattern seen elsewhere (Dahl 1990; Taft and Haig 2003). Remaining wet prairies in the region are often structurally altered and compromised by non-native and woody native invasive species. The NPS-owned portions of Weippe Prairie and the Big Hole valley are no exception. Both sites have historic irrigation developments that have altered site hydrology, are infested by invasive weeds, and Weippe Prairie has also been used for intensive haying and grazing. Orange hawkweed, listed as a noxious plant in Idaho, and sulfur cinquefoil, an invasive species of concern to NEPE, are both present at Weippe Prairie and part of the focus of current park weed management. Despite the impacts of these anthropogenic stressors, such highly productive ecosystems exhibit a good potential for restoration (Taft and Haig 2003), and both sites continue to support a vigorous camas lily population.

Establishing a program to monitor the long-term trends in camas lily populations at Weippe Prairie and BIHO will provide important information to the parks for their adaptive management decisions and land health performance goals. Camas lily monitoring will be particularly important at Weippe Prairie because the site remains actively sprayed, mowed, and grazed; the impacts of which remain unknown. At BIHO, where the wetland ecosystem supporting camas lily is more intact and in a higher functioning condition, site management is less intense and camas lily monitoring will provide an invaluable indication of overall status and trend of wetland condition over time. It will also provide information on the impacts of weed control efforts periodically made by BIHO staff in that wetland community.

Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- Are the camas lily populations at NEPE and BIHO stable, declining, or increasing?
- What is the range of inter-annual variation in total stem density and flowering stem density observed at Weippe Prairie and along the Big Hole River at BIHO?
- What proportion of camas plants flower within a season, and what is the variation in that proportion?
- How does camas density respond to temporal variations in regional precipitation and temperature patterns?
- How does camas density respond to changes in specific management or restoration actions?

Monitoring objectives addressed by this protocol include:

1) Estimate the mean for stem and flowering stem densities (status) in the camas lily populations of Weippe Prairie and within the targeted portion of BIHO.
   Justification. *Camas lily population status estimates will inform near-term site management and will contribute to long-term trend detection. Camas lily abundance will be measured with stem density, the total number of plants and number of flowering plants . The number of plants, hence the number of camas lily bulbs, relates directly to the cultural importance of camas lily.*
2) Determine trends (net trend) in the densities of camas lily in Weippe Prairie and BIHO.
   Justification: *Net trend measures the total response or mean change and is an appropriate parameter for our objectives and for camas lily, a plant subject to high interannual variation in abundance. Long-term trend detection in camas lily, particularly the detection of downward trends, is of critical importance to park management of this fundamental park resource.*
3) Determine trends in the proportion of flowering to non-flowering camas lily plants, as a measure of population vigor, in Weippe Prairie and BIHO.
   Justification: *Flowering is a measure of population vigor, and, although camas lily reproduces asexually through bulb budding, it also invests a tremendous amount of energy into flowering and seed production. A number of issues justify monitoring of flowering rate trends, and include potential changes in phenology resulting from changing precipitation and soil moisture over time to competition from invasive plants and heavy graminoid thatch.*

4) Determine trends in frequency of occurrence of targeted invasive plant species.
 Justification: *Invasive plants pose the greatest threat to camas lily populations in NEPE and BIHO and include non-native exotic forbs as well as graminoids and secondary graminoid thatch depth. Monitoring these species will provide critical information to park resource managers and will contribute to the UCBN integrated invasive plant vital sign monitoring program.*
5) Determine the magnitude and direction of camas density response to measurable explanatory variables such as monthly mean precipitation, graminoid thatch depth, and specific management activities.
 Justification: *Articulating the relationship between camas density change and biophysical explanatory variables, some of which are stressors and other are management actions intended to benefit the resource, is important information to provide to park management. This will be conducted through modeling exercises. Our protocol will permit model-based relationships between camas lily abundance and these measurable drivers and stressors to be tested. Ultimately, these kinds of relationships, if present, will be directly relevant to management decisions, such as reintroduction of prescribed fire.*

Basic Approach:

No existing camas lily monitoring protocol is currently available for adoption from NPS or other relevant organizations. The UCBN camas lily monitoring protocol has been developed following NPS I&M standards as outlined by Oakley et al (2003). A probabilistic sampling design involving simple random sampling in each of five discrete camas lily populations within both parks has been developed that balances the need for maximum scope of inference and statistical power with logistical and financial efficiency. In particular, the design emphasizes rapid data collection in a large number of samples that produces simple and straightforward results directly applicable to status and trend detection and site management. In addition, the UCBN is incorporating camas lily monitoring into its "*citizen science*" program in which high school students and other volunteers directly participate in, and perhaps even sustain, field data collection. To that end, sampling methods that are effective toward meeting stated objectives but are as simple as possible and require minimal training have been selected. Required sample size for desired precision and power levels has been estimated *a priori* with data available from 2005 and 2006 field data collected at Weippe Prairie and BIHO. In accordance with management and monitoring objectives, minimizing the missed-change (type II) error has been emphasized and a higher false-change (type I) error rate tolerated. Our current sampling objective is to achieve at least 90% power to detect a 25% decline in estimates of camas lily abundance through the life of this monitoring program with a 10% false-change (type I) error rate. Thorough SOPs have been developed for all aspects of the monitoring program following recommendations in Oakley et al. (2003) and as demonstrated by other available peer-reviewed NPS I&M program protocols in order for the UCBN to implement and sustain long-term camas lily monitoring. The protocol has been submitted for peer review and copies can be obtained directly from the UCBN.

Principal Investigators and NPS Lead:
Principal Investigator: Dr. Mark Wilson, Ecological Consulting, Philomath, OR, 541-929-5281. NPS Lead: Tom Rodhouse, UCBN Ecologist, 541-312-8101.

Development Schedule, Budget, and Expected Interim Products:
The PI and NPS lead produced a draft monitoring protocol for field testing on June 12, 2006, which was revised following analysis of 2006 field data. A "pre-review" of the draft protocol was completed by Dr. Jeff Yeo, Idaho TNC, in September, 2006. The complete draft protocol was submitted for peer review through the NPW Pacific West Regional office in February 2007. Field testing of the revised protocol (following reviewer's comments) will occur in May and June 2007. We will consider the 2007 field work as "implementation". We have budgeted $19,150 for FY 2007 protocol implementation. Field testing has been accomplished through the UCBN citizen science VIP program in collaboration with the OMSI Salmon Camp program in June 2005 and 2006.

Literature Cited:

Dahl, T. E. 1990. Wetlands: losses in the United States: 1780's to 1980's. US Fish and Wildlife Service, Washington D.C.

Gould, F. W. 1942. A systematic treatment of the genus *Camassia* Lindl. American Midland Naturalist **28**:712-742.

Harbinger L. J. 1964. The importance of food plants in the maintenance of Nez Perce cultural identity. Unpublished MA thesis, Department of Anthropology, Washington State University, Pullman, WA.

Hunn E. S. 1981. On the relative contribution of men and women to subsistence among hunter-gathers of the Columbia Plateau: a comparison with *Ethnographic Atlas* summaries. Journal of Ethnobiology **1**:124-134.

MacDonald, T. 2003. Review of environmental monitoring methods: survey designs. Environmental Monitoring and Review **85**:277-292.

Mastrogiuseppe, J. 2000. Nez Perce ethnobotany: a synthetic review. Report to Nez Perce National Historic Park, Spalding, ID. Project # PX9370-97-024. Online http://www1.nature.nps.gov/im/units/ucbn/Documents/NEPE_EthnobotanyReport_Mastrogiuseppe_2000.pdf

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin **31**:1000-1003.

Reed, P. B. Jr. 1988. National list of plant species that occur in wetlands: 1988 national summary. US Fish and Wildlife Service. Biological Report **88** (24).

Taft, O. W., and S. M. Haig. 2003. Historical wetlands in Oregon's Willamette Valley: implications for restoration of winter waterbird habitat. Wetlands **23**:51-64.

Turner, N. J., and H. V. Kuhnlein. 1983. Camas (*Camassiah spp.*) and riceroot (*Fritillaria spp.*): two liliaceous "root" foods of the Northwest Coast Indians. Ecology of Food and Nutrition **13**:199-219.

Appendix F.4. Integrated Riparian Condition Protocol Development Summary

Protocol: Integrated Riparian Condition

Parks Where Protocol will be Implemented:
BIHO, CIRO, CRMO, HAFO, JODA, NEPE, and WHMI

Justification/Issues being addressed:
Riparian zones are transition areas between terrestrial and aquatic ecosystems and can be difficult to delineate because of high complexity and heterogeneity in form and function (Gregory et al. 1991; Naiman and Decamps 1997). These areas are often defined by the presence of hydrophilic vegetation and soils strongly dependent on adjacent surface or groundwater (i.e., Cowardin et al. 1979). Riparian zones often support much higher biological diversity than surrounding uplands. This is particularly true in arid portions of the western U.S. Gregory et al. (1991) provide a more integrated conceptual framework for considering riparian zones as a union of complex geomorphic and biotic components and processes. Functionally, riparian zones interact with adjacent terrestrial and aquatic systems in three dimensions; longitudinally along borders of aquatic areas, laterally away from aquatic areas into adjacent uplands, and vertically through the canopy of riparian vegetation (Gregory et al. 1991). In the arid west, riparian systems typically occur in narrow bands and gradients between aquatic, riparian, and upland systems can be quite steep.

Riparian areas are highly productive compared to upland areas (e.g. Kauffman et al. 2004), contain unique floral and faunal communities, act as seasonal migration corridors or refuges (Shirley 2004), and consequently increase regional biodiversity (Wright et al. 2002). While riparian areas only represent a small proportion of total land area in the UCBN, they have disproportionate influences on biological communities and ecosystem processes. Additionally, riparian ecosystems provide essential ecosystem services, including nutrient cycling, water purification, stream bank stability, and attenuation of floods (Kauffman et al. 1997; Wissmar 2004; Sweeney et al. 2004).

Significant alteration and degradation of interior Columbia Basin riparian ecosystems have occurred over the last 150 years (USFS 1996; Kauffman et al. 1997). Historic land use practices, including ranching and farming, have had long-term impacts on riparian hydrologic, geomorphic, and biotic structure and function. Anthropogenic stressors have led to interruptions between these links and triggered cascading ecosystem effects in terrestrial and aquatic systems as well as within riparian zones. In UCBN parks the cascading ecological effects triggered by historic degradation are particularly evident in riparian zones. Stream channels are often incised and entrenched and wholesale shifts in riparian plant communities have taken place and are now largely dominated by invasive exotic species. Vertebrate communities reflect these changes and numerous riparian associated species such as the spotted frog, willow flycatcher, and the yellow warbler have declined as a result of these changes. A remarkable exception is the condition of the North Fork Big Hole River which flows through BIHO. This reach is well connected to its floodplain, as evidenced by oxbows in various stages of succession, and supports a riparian community dominated by native shrubs and graminoids, a large population of native amphibians, and one of the countries last populations of arctic grayling in the contiguous US.

Because of the three-dimensional nature of riparian ecosystems, and particularly the inextricable relationship between riparian vegetation and stream channel morphology, the UCBN will develop an integrated riparian condition protocol to address monitoring objectives specific to the Network's riparian vegetation and stream/river channel characteristics vital signs. Bat and bird monitoring will also occur in riparian monitoring sites, along with monitoring of water chemistry and aquatic macroinvertebrates in a small subset of riparian monitoring sites. Surface water dynamics will also be monitored through data sharing with USGS gauges located downstream of park boundaries. This integration of six vital signs will lead to an extremely information-rich riparian condition monitoring program and serve UCBN constituent parks well.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- What are the trends in abundance and composition of species and horizontal strata (i.e., trees, graminoids, etc.) in UCBN riparian plant communities?
- What are the trends in the use, abundance, and composition of targeted riparian vertebrate species and communities?
- What are the trends in abundance and composition of targeted invasive plant species in UCBN riparian communities?
- What is the trend in streambank stability, shape, and width in UCBN perennial wadeable streams?
- Do trends differ among community types, as defined by dominant taxa, or among stream channel types (e.g., Rosgen 1996) or other classification systems?
- What is the relationship between long-term trends in stream flow, bank morphology, and community composition.

Monitoring objectives addressed by this protocol include:

1) Estimate the trends in abundance of targeted plant species and horizontal strata (i.e., trees, graminoids, etc.) and species and community composition in UCBN riparian zones.
   Justification: *UCBN riparian zones are disproportionately important to park ecosystems, complex, and inextricably linked to aquatic and upland ecological processes. Integrated monitoring of riparian vegetation, streambank morphology, and water quality (separate protocol) will provide a rich suite of information to park managers as well as regional trend assessments. Abundance and composition of species and communities of plants are fundamental and directly measurable*

community attributes, and will also specifically address objectives related to the UCBN's invasive plants vital sign.

2) Estimate trends in vertebrate community composition and occupancy dynamics of targeted riparian-obligate species in UCBN riparian areas.
   Justification: *Riparian corridors provide critical habitat for sensitive amphibian, bird, and bat species in the UCBN. Acoustic monitoring of these areas will provide opportunity for trend detection and possible correlation with other UCBN vital signs and will provide an important vertebrate component to the UCBN's integrated riparian and water quality monitoring efforts.*
3) Estimate trends in streambank channel morphology, including sinuosity, bank stability, and substrate composition, of UCBN perennial wadeable rivers and streams.
   Justification: *UCBN riparian zones are disproportionately important to park ecosystems, complex, and inextricably linked to aquatic and upland ecological processes. Integrated monitoring of riparian vegetation, streambank morphology, and water quality (separate protocol) will provide a rich suite of information to park managers as well as regional trend assessments. Streambank channel morphology, stability, and composition are fundamental and directly measurable attributes of lotic systems that directly affect riparian vegetation, water quality, and aquatic fauna, particularly macroinvertebrates and fish.*

<u>Basic Approach:</u>
The John Day Basin, in which JODA is located, is a pilot basin for a national riparian monitoring protocol development effort underway by the USFS (USFS 2005; Kershner et al. 2004) as a part of their Forest Health Monitoring and Forest Inventory and Analysis programs. This effort also includes partners from EPA Environmental Monitoring and Assessment Program (EMAP-West), Oregon Department DEQ, and the USFS Pacfish/Infish Biological Opinion Effectiveness Monitoring Team (PIBO). PIBO currently has protocols available for monitoring both biological and physical attributes of streams and we will begin our protocol development effort with those intermediate products (Heitke et al. 2006). Although our parks are small relative to the watersheds in which they are located, the UCBN hopes that by adopting protocols in use across the region, trends detected within UCBN parks will be made more meaningful within a larger watershed context. We also look forward to contributing to a regional monitoring effort. The UCBN will initiate its integrated riparian monitoring effort in JODA and then expand to include all parks in the Network.

<u>Principal Investigators and NPS Lead:</u>
Principle Investigators: To Be Determined. NPS Lead: Tom Rodhouse, UCBN Ecologist, 541-312-8101.

Development Schedule, Budget, and Expected Interim Products:
Protocol development will begin in 2007 in concert with integrated water quality protocol development. A draft protocol will be complete and ready for peer-review in spring 2008.

Literature Cited:

Cowardin, L. M., V. Carter, F. C. Golet, and E. D. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Publication FWS/OBS-79/31. US Department of Interior Fish and Wildlife Service, Office of Biological Services, Washington D.C.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. Ecosystem perspective of riparian zones: Focus on links between land and water. Bioscience **41**:540-551.

Heitke, J. D., E. J. Archer, D. D. Dugaw, B. A. Bouwes, E. A. Archer, R. C. Henderson, J. L. Kershner. 2006. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished. Online. http://www.fs.fed.us/biology/fishecology/emp.

Kauffman, J. B., A. S. Thorpe, and E. N. J. Brookshire. 2004. Livestock exclusion and belowground ecosystem responses in riparian meadows of Eastern Oregon. Ecological Applications **14**:1671-1679.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries **22**:12-24.

Kershner, J. L., M. Coles-Ritchie, E. Cowley, R. C. Henderson, K. Kratz, C. Quimby, L. C. Ulmer, M. R. Vinson. 2004. A Plan to Monitor the Aquatic and Riparian Resources in the Area of PACFISH/INFISH and the Biological Opinions for Bull Trout, Salmon, and Steelhead. Gen. Tech. Rep. RMRS-GTR-121. US Department of Agriculture, USDA Forest Service, Rocky Mountain Research Station, Ogden, UT.

Naiman, R., and H. Decamps. 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics **28**:621-658.

Rosgen, Dave L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Shirley, S. 2004. The influence of habitat diversity and structure on bird use of riparian buffer strips in coastal forests of British Columbia, Canada. Canadian Journal of Forest Research **34**:1499-1510.

Sweeney, B. W. et al. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. Proceedings of the National Academy of Sciences of the United States of America **101**:14132-14137.

USDA Forest Service (USFS). 1996. Status of the Interior Columbia Basin: Summary of scientific findings. General Technical Report PNW-GTR-385. USDA Forest Service, Pacific Northwest Research Station and USDI Bureau of Land Management.

USDA Forest Service (USFS). 2005. Effectiveness monitoring for streams and riparian areas within the Pacific Northwest: stream channel methods for core attributes. Unpublished. Online. http://www.reo.gov/monitoring/watershed.htm.

Wissmar, R. C. 2004. Riparian corridors of Eastern Oregon and Washington: Functions and sustainability along lowland-arid to mountain gradients. Aquatic Sciences **66**:373-387.

Wright, J. P., C. G. Jones, and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia **132**:96-101.

Appendix F.5. Integrated Water Quality Protocol Development Summary

Protocol: Integrated Water Quality

Parks where Protocol will be implemented:
BIHO, CIRO, CRMO, HAFO, JODA, LARO, NEPE, and WHMI

Justification/Issues being addressed:
Monitoring of NPS water resources has been identified as a core objective of the national I&M program, as well as by the UCBN. Several UCBN parks have identified water quality improvement-related land health goals for performance reporting purposes. All Network waters assessed by state DEQ agencies are on 303(d) lists for impairment of at least one parameter, and the riparian and wetland areas supported by Network waterbodies are foci for biological invasions and other management challenges. Several parks have begun concerted riparian and stream channel restoration projects.

Although the UCBN contains more than 34 rivers, streams, ponds, and reservoirs within park boundaries, water resources actually represent a very small percentage of total land cover, except in the case of LARO. Unlike many water resources in the National Park system, most UCBN parks and waterbodies are only small proportions of their watersheds. Consequently, water quality and aquatic resources are strongly affected by activities outside of the park boundaries, and NPS management authority and capability for water quality improvement in waterbodies that pass through the parks is minimal. However, aquatic environments are disproportionately important in terms of biodiversity, biological productivity, and many other ecosystem functions and values. The UCBN has prioritized three water quality vital signs, surface water dynamics, aquatic macroinvertebrates, and water chemistry, and is committed to implementing a modest integrated water quality monitoring program that address those vital signs.

Water quantity and flow regime have overriding influence on stream channel morphology and stream and riparian biota. The strong alteration of flow regimes by human activity in the UCBN has altered biotic communities and ecosystem processes. UCBN parks are small relative to their watershed areas and few contain established flow monitoring sites within their boundaries. Consequently, monitoring of stream flow will compile and report available data from stations within and outside of UCBN unit boundaries. Aquatic macroinvertebrates are good indicators of ecosystem condition because they occur in all waterbodies, integrate point, nonpoint, pulse, and press disturbances, are trophically diverse, and are less mobile than fishes. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the watershed. The sampling of aquatic macroinvertebrates is relatively effective and efficient compared to other biotic indicators (e.g., algae and fish), and hence, is relatively cost-effective. Water chemistry and temperature have strong effects on aquatic biota. Consequently, direct and indirect human alteration of stream water chemistry and temperature is associated with altered biotic communities and ecosystem processes. Because of the direct relationship between water chemistry and biota, water chemistry is typically a central component of any water quality monitoring program. More recently, monitoring of stream water temperatures has increased because of concerns over cold-water fish habitat (primarily salmonid fishes), the recognized influence of land- and water-use on stream thermal regime, and the need for baseline temperature information to monitor effects of climate change. For example, temperature was selected as one of two key parameters for monitoring in the John Day Basin by the NOAA research, monitoring, and effectiveness program and its partners.

The water monitoring protocol will be a single, integrated protocol because it will be modest in size and sampling locations and personnel will greatly overlap. Surface water dynamics will be monitored by compiling available data from other agencies, macroinvertebrates will be sampled directly from select UCBN waterbodies, and water chemistry will be monitored by both data compilation and sampling select waterbodies for a set of core water quality parameters using continuous water quality monitoring probes (“multiprobes”; temperature, pH, specific conductance, dissolved oxygen, and turbidity).

<u>**Specific Monitoring Questions and Objectives to be Addressed by the Protocol:**</u>
Monitoring questions addressed by this protocol include:

- What are the long term trends in flow regimes of selected waterbodies?
- Are UCBN waterbodies with 303(d) listed impairments related to surface water dynamics improving over time?
- What is the status of aquatic macroinvertebrate species and functional group composition and abundance in selected UCBN lotic waterbodies?
- Do any aquatic macroinvertebrate communities sampled within the UCBN indicate “pristine” or “reference” conditions according to regional criteria established by EPA and the states of Idaho, Oregon, Montana, and Washington?
- Do any aquatic macroinvertebrate communities sampled within the UCBN indicate polluted or otherwise impaired water quality?
- What are the long-term trends in aquatic macroinvertebrate species and functional group composition and abundance within selected UCBN lotic waterbodies?
- What are the long term trends in key water chemistry and temperature parameters in and adjacent to UCBN park units?
- Are 303(d) listed waterbodies in the UCBN with established TMDLs improving over time?

Monitoring objectives addressed by this protocol include:

1) Estimate trends in seasonal and annual flow regimes for (representative) lotic waterbodies within or near UCBN park units.
   Justification: *Water quantity and flow regime have overriding influence on stream channel morphology and stream and riparian biota. The strong alteration of flow regimes by human activity frequently alters biotic communities and ecosystem processes.*
2) Estimate status and trend in aquatic macroinvertebrate abundance, community composition, and functional feeding group composition in representative lotic UCBN waterbodies.
   Justification: *Aquatic macroinvertebrates are good indicators of ecosystem condition because they occur in all waterbodies, integrate point, nonpoint, pulse, and press disturbances, are trophically diverse, and are less mobile than fishes. Macroinvertebrate communities are also affected both by conditions in local stream reaches and those within the watershed.*
3) Estimate seasonal and annual means (status) in key water chemistry parameters for waterbodies within and near UCBN park units.
   Justification: *Water chemistry and temperature have strong effects on aquatic biota. Consequently, direct and indirect human alteration of stream water chemistry and temperature is associated with altered biotic communities and ecosystem processes. Because of the direct relationship between water chemistry and biota, water chemistry is typically a central component of any water quality monitoring program.*
4) Estimate interannual trends in key water chemistry parameters using historical and current data.
   Justification: *Water chemistry and temperature have strong effects on aquatic biota. Consequently, direct and indirect human alteration of stream water chemistry and temperature is associated with altered biotic communities and ecosystem processes. Because of the direct relationship between water chemistry and biota, water chemistry is typically a central component of any water quality monitoring program.*
5) Estimate status and trends in seasonal and annual temperature profiles of representative UCBN waterbodies.
   Justification: *Water chemistry and temperature have strong effects on aquatic biota. Consequently, direct and indirect human alteration of stream water chemistry and temperature is associated with altered biotic communities and ecosystem processes. Because of the direct relationship between water chemistry and biota, water chemistry is typically a central component of any water quality monitoring program.*

Basic Approach:

Historical flow and meteorological data for selected sites will be obtained from national databases (USGS, EPA STORET, NOAA). The monitoring protocol will specify criteria for selecting suitable sites (i.e., maximum distance from UCBN park boundary, etc.) and how and when to update 303(d) status of UCBN streams. The monitoring protocols will include SOPs describing how to obtain additional data annually once monitoring commences and procedures for screening data obtained from other agencies. Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs specifying statistical comparisons will include tests of long term change in flow parameters that describe magnitude and timing of flow, particularly for 303(d) listed streams. Methods for testing associations between stream flow and meteorological data will described.

Macroinvertebrate biomonitoring protocols are well developed and SOPs will be adapted from existing protocols developed by the EPA and the states of Idaho, Oregon and Washington, and other NPS monitoring Networks. Therefore, protocol development will not require field research and will primarily consist of writing protocols to meet NPS standards and to make existing national and regional protocols specific to UCBN parks. Site selection will be specified and will include protocols for selecting, permanently marking, photographing, and determining site coordinates using GPS. The type(s) of sampling device including type (Surber, Hester-Dendy, etc), size, and mesh size will be specified following consultation with local experts (EcoAnalysts, Moscow ID, Idaho DEQ, etc). Sample frequency and timing will probably be conducted using a rotating basin design, where one-third of UCBN waterbodies are sampled each year, resulting in the sampling of each unit every 3 years. Protocols will specify the frequency and sampling within year, and samples will be taken twice a year, in the spring before run-off and in the fall before winter rains. SOPs will also describe field sampling, sample preservation, processing, and archiving, field and laboratory data collection (including sample data sheets), data storage, sharing, and database management, and will include an SOP to ensure QA/QC. Following the first round of sampling, protocols for data summaries and statistical power analyses will be specified to determine the primary sources of variation in aquatic community structure and whether sampling levels are sufficient to meet monitoring goals. Additional SOPs will recommend potential sampling regime modifications, protocols for data analysis, including methods for testing for long-term trends, and suggested data summary and reporting formats.

Available water chemistry and temperature historical data will be evaluated to determine the best sites for monitoring. Criteria for site selection will include those listed above and will be fully documented. Water chemistry data for selected sites will be obtained from national databases (USGS, EPA STORET, Idaho DEQ, etc.). A core set of 10-20 water chemistry parameters will be selected for data analysis based on data availability. The monitoring protocol will specify how and when to update the 303(d) status. The monitoring protocols will include SOPs describing how to obtain additional data annually once monitoring commences. Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs specifying statistical comparisons will include tests of long term change in the magnitude and variability in parameters, and will emphasize reporting of trends in 303(d) listed streams. Where available, water temperature data will be complied, summarized and reported for the same sites.

The availability of relatively low cost multiprobes for water quality will allow water quality data for a core set of parameter to be estimated at high resolution from selected UCBN waterbodies. The core parameters will be estimated every 15 minutes to 1 hour by the multiprobe. Probes will be deployed in each stream for 2 weeks intervals, 4 times/year to characterize daily, weekly, seasonal, and interannual patterns in mean parameter values and variability. SOPs will describe multiprobe transport, calibration, storage, maintenance, data retrieval, analysis, and archiving. Data analysis, statistical testing, and data summarization and reporting protocols will be specified and SOPs will include examples. SOPs specifying statistical comparisons will include tests of long term change in the magnitude and variability in thermal regime, again emphasizing the importance of monitoring any 303(d) listed streams.

SOPs outlining data screening and QA/QC protocols will be included, as well as procedures for revising monitoring protocols and documenting any changes.

Principle Investigators and NPS Lead:
Principle Investigator: Dr. Christopher C. Caudill of the University of Idaho. NPS Lead: Lisa Garrett, 208-885-3684.

Development Schedule, Budget, and Expected Interim Products:
A final monitoring protocol will be produced after peer-review, revision with a target date of spring 2007 for peer review of the protocol and spring 2008 for protocol implementation. $48,800 will be transferred through the Cooperative Ecosystems Studies Units to The University of Idaho for protocol development during FY07.

Appendix F.6. Invasive/Exotic Plants Protocol Development Summary

Protocol: Invasive/Exotic Plants

Parks Where Protocol Will Be Implemented:
All UCBN Parks (BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, and WHMI)

Justification/Issues being addressed:
Invasions of exotic plant species represent one of the most serious threats to natural ecosystem integrity (NRC 2002). Biological invasions are occurring at accelerated rates in nearly every major ecosystem (Mooney and Hobbs 2000). Invasive exotic plant species are of concern given their ability to quickly expand into new areas, compete with and exclude native species, and alter ecosystem processes across multiple scales. The management and control of invasive non-native species has been identified as a high priority issue within the NPS and reduction of invasive plants is a goal for all UCBN park units under the Government Performance and Results Act of 1993. Executive Order 13112 signed on February 3, 1999, further identifies and strengthens the obligations of federal agencies to address significant economic and biological threats posed by non-native species. Additionally, the NPS has emphasized the importance of invasive species issues and their associated impacts by identifying non-native species as one of three major areas of focus under the Natural Resource Challenge. Most recently, the 2001 NPS Management Policies (NPS 2001) stated "high priority will be given to managing exotic species that have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controllable." In the UCBN, invasive plants, most of which are non-native exotic species, pose one of the greatest threats to natural and cultural resources of our parks and has been identified as a high-priority vital sign.

Prevention of plant invasions is the most effective, economical, and ecologically sound approach to managing invasive species (Center for Invasive Plant Management 2004). When preventative measures are not successful, early detection of new invasions is the next critical step. Hobbs and Humphries (1995) identified a significant time lag between the initial establishment of an invasive exotic plant and its rapid expansion toward local carrying capacity. Control efforts initiated during this lag phase are likely to cost less and achieve higher success rates compared to efforts begun later in the invasion cycle (Hobbs and Humphries 1995). Regular, comprehensive monitoring of the distribution and abundance of all exotic plant species within UCBN units is beyond the fiscal capabilities of the Network and parks. However, status and trend detection of a prioritized list of target species is important and will be accomplished in a cost-effective approach that will rely heavily on integration with other terrestrial vegetation monitoring efforts.

Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- What are the invasive plant species of greatest concern to UCBN parks management?
- Where are incipient populations of targeted (high-priority species of greatest management concern) invasive plants located in UCBN parks?
- Is the rate of invasion increasing across parks and target species?
- What is the status and trend of established target invasive plants in UCBN parks?

Monitoring objectives addressed by this protocol include:

1) Detect incipient populations and new occurrences of selected invasive nonnative plants before they become established.
   Justification: *Invasive plants are one of the greatest threats to natural and cultural resources in all UCBN parks and are a major focus of the UCBN vital signs monitoring program. Our invasive plants monitoring will provide for early detection of incipient invasions and will address the status and trend of established species.*
2) Estimate the status and trend of established target weed species frequency and abundance in UCBN parks.
   Justification: *Invasive plants are one of the greatest threats to natural and cultural resources in all UCBN parks and are a major focus of the UCBN vital signs monitoring program. Our invasive plants monitoring will provide for early detection of incipient invasions and will address the status and trend of established species. Trend detection will be integrated into our camas lily, sagebrush-steppe vegetation, and integrated riparian vital signs monitoring protocols.*

Basic Approach:
We will follow guidelines drafted in the forthcoming invasive species early detection handbook (Geissler and Welch *in prep*) which provides recommended steps in the development of early detection protocols. One of the first steps is development of prioritized invasive plant lists for each park in the UCBN. Draft lists are currently available in Garrett et al. (2005), and these suggest that overlap of target species across network parks will be high and a network priority list may be feasible. A number of national and regional efforts are underway to develop consistent status and trend methodologies and protocols for invasive plants and we will rely heavily on those that are complete, or nearly so, when we initiate protocol development. This protocol will meet the standards for NPS I&M protocols as outlined by Oakley et al. (2003).

Our invasive species monitoring effort will involve two distinct parts. The first will involve the early detection of species of greatest management concern and will be conducted in park areas of greatest concern, typically weed-free areas exhibiting relatively high ecological integrity. The second part to our invasive species monitoring will involve estimation of status and trend in the frequency and abundance of targeted species. This will primarily be achieved through integration with existing terrestrial vegetation monitoring related to camas lily, sage-steppe, and riparian areas. Integration with existing protocols will be cost-effective and will allow additional network resources to be allocated to status and trend detection in remaining high-priority terrestrial park areas not included in other network vegetation sampling frames.

Principal Investigators and NPS Lead:
NPS lead: UCBN project lead to be determined. Collaborators for design and implementation for this protocol are being sought.

Development Schedule, Budget and Expected Interim Products:
A servicewide effort is underway to standardize NPS monitoring of invasive species. Protocols and a database are scheduled for completion in 2007. The UCBN will employ the national protocols (with modifications if necessary). Development of prioritized invasive plant lists will begin in FY 2008 and the UCBN protocol, adapted as necessary from the national template, will be produced in FY 2009. Monitoring of targeted established species (objective 2, above), will be included in three vegetation monitoring protocols, 2 of which are scheduled for completion in 2007, and the third in 2008.

Literature Cited:

Center for Invasive Plant Management. 2004. Invasive plant prevention guidelines. Online. http://www.weedcenter.org/prevention/prev_overview.htm.

Garrett, L., T. J. Rodhouse, L. Svancara, and C. Caudill. 2005. Phase II vital signs monitoring plan: Upper Columbia Basin Network. National Park Service Upper Columbia Basin Network, Moscow, ID.

Geissler, P. H., and B. A. Welch. In Prep. Early detection of invasive plants: A handbook. US Geological Survey, Reston VA and National Park Service, Ft. Collins, CO. Online. http://www.pwrc.usgs.gov/brd/invasiveHandbook.cfm.

Hobbs, R. J., and S. E. Humphries. 1995. An integrated approach to the ecology and management of plant invasions. Conservation Biology **9**: 761-770.

Mooney, H. A., and R. J. Hobbs editors. 2000. Invasive species in a changing world. A project of SCOPE, the Scientific Committee on Problems of the Environment. Island Press, Washington, D.C.

National Park Service. 2001. Management policies, 2001. Department of Interior, National Park Service, Washington, DC. Online. http://data2.itc.nps.gov/npspolicy/index.cfm. Accessed 9 December 2004.

National Research Council. 2002. Predicting invasions of nonindigenous plants and plant pests. National Academy of Sciences, Washington, DC.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin **31**:1000-1003.

Appendix F.7. Land Cover and Use Protocol Development Summary

Protocol: Land Cover and Use

Parks Where Protocol will be Implemented:
All UCBN Parks (BIHO, CIRO, CRMO, HAFO, JODA, LARO, MIIN, NEPE, and WHMI)

Justification/Issues being addressed:
Resiliency of biodiversity in a protected area is intimately tied to the ecological integrity of surrounding lands. Attributes of 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 short-term and long-term protection effectiveness (Schonewald-Cox 1988). Land cover composition, configuration, and connectivity help shape the complex of species occurring in an area, movements of individual organisms, and energy and material flows (Dunning et al. 1992; Taylor et al. 1993). Substantial changes in these land cover attributes occur in response to natural and anthropogenic processes. Natural disturbance regimes largely are driven by climatic factors (e.g., Swetnam and Betancourt 1998) and expected changes in climatic conditions may elevate the frequency and/or severity of natural disturbances such as wildfire and insect and disease outbreaks. Discerning between natural and anthropogenic forces of change is also critical to effective mitigation action. Management actions seldom can influence natural processes, but can be effective in mitigating human-induced changes. Anthropogenic disturbance along park boundaries is of special concern as increases in cross-border contrasts can lead to undesirable changes. For instance, habitat fragmentation has been associated with a variety of negative consequences to both wildlife and vegetative communities and also provides the opportunity for invasion of exotic or undesirable species (Wilcove et al. 1986; Yahner and Scott 1988).

Over 10 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 (NPS 1993). In fact, concerns over external influences 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; NPCA 1979; NPS 1980; Buechner et al. 1992). The majority of parks are dependent on adjacent lands simply because their boundaries fail to encompass habitats and processes (e.g., migratory species, fire regimes) necessary to maintain complete species communities (Myers 1972; Western 1982; Curry-Lindahl 1972; Garratt 1984). Therefore, threats from outside park boundaries can, and are, significantly modifying biodiversity within parks (NPCA 1979; Garratt 1984; Sinclair 1998).

Monitoring long-term changes in land cover composition, configuration, and connectivity will help establish a broader context for each park, and can help natural resource managers determine patterns in land use change which may threaten future ecological integrity within parks. Selecting an adequate scale at which to evaluate the effects of land cover change and fragmentation is difficult without first identifying what is being managed (e.g., what species or processes; Beatley et al. 2000) and the scales of disturbance to which those species/processes respond. By developing and implementing a protocol to efficiently and cost effectively monitor land cover change within and around UCBN parks at multiple spatial scales, the current knowledge of park ecosystem dynamics will be further advanced, allowing for better management practices and decision making in the future.

(*The following section is reproduced with permission from Townsend et al. 2006)*. The UCBN will use aerial photography and satellite imagery (collectively, remote sensing) to monitor the spatial extent of changes in land cover (i.e., conversion). The benefit of remote sensing for monitoring is it provides complete spatial coverage compared to point or plot samples. Remote sensing therefore complements survey data by providing information on the context of data sampled at points while also facilitating extrapolation of point measurements across landscapes. The results from remote sensing change detection analyses can also be used to identify areas of alteration to target management efforts. Although maps and mapping are inherently interesting for the purpose of developing comprehensive inventories, monitoring requires the derivation of meaningful information from those maps to interpret the nature and context of changes occurring between dates. Two approaches to landscape interpretation will be pursued: pattern analysis, which uses metrics of landscape pattern derived from categorical maps, and descriptive change detection via map-to-map or image-to-image comparisons. Not all methods are necessary to address all questions. The specific method will depend on the questions of interest, which are summarized below.

<u>Specific Monitoring Questions and Objectives to be Addressed by the Protocol:</u>
Monitoring questions addressed by this protocol include (*Reproduced with permission from Townsend et al. 2006*):

- What are the long-term trends in land cover distribution within and adjacent to the park, (i.e., how has land cover changed)?
- What are the patterns of relevant land cover types within and adjacent to the park (e.g., what are average patch sizes, densities, edge/core areas, inter-patch distances, etc.)?
- What are the appropriate temporal and spatial (grain size and map extent) resolutions for mapping and analyzing land cover in and adjacent to the parks?
- What is the relative proportion of streams and/or upstream catchment area with riparian buffers and how wide are those buffers?

- Are changes in water quality parameters or macroinvertebrate assemblage structure associated with changes in watershed land use/land cover?

Monitoring objectives addressed by this protocol include:

1) Determine long-term trends in land cover distribution within and adjacent to UCBN park boundaries.
Justification: (Reproduced with permission from Townsend et al. 2006) *Land cover distribution is a critical description of a park landscape, and may form the most obvious representation of the composition of resources within a park. Changes in land cover both within a park and adjacent to that park can dramatically influence a host of biological, physical and chemical resources within that park. Therefore, maps of land cover distribution and changes in those distributions are often a central component to assessing changes in other resources such as water quality, aquatic fauna, terrestrial vertebrates, and terrestrial vegetation communities.*

2) Determine patterns of relevant land cover types within and adjacent to UCBN park boundaries.
Justification: (Reproduced with permission from Townsend et al. 2006) *Objective measures of landscape pattern are required to assess changes in the amount and distribution of landscape resources in and around the parks (and/or their surrounding landscapes). The configuration and connectivity of land cover help shape the complex of species occurring in an area, movements of individual organisms, and energy and material flows.*

Basic Approach:

Several national and regional NPS efforts are underway to develop land cover change protocols. The UCBN will adopt, and adapt as necessary, pre-existing protocols. We are currently assessing the utility of the approach presented by Townsend et al. (2006) for the National Capital Region Network, which is similar to the UCBN in its makeup of many disparate and small parks. This same development team is also working with the Appalachian Highlands Network. There is also a protocol development effort underway in the North Coast Cascades Network that may be of use to the UCBN.

Principal Investigators and NPS Lead:

Principle Investigator(s): To be determined. NPS Lead: To be determined.

Development Schedule, Budget, and Expected Interim Products:

We will initiate protocol development in 2008. A draft protocol ready for peer-review will be complete in 2009.

Literature Cited:

Beatley, T. 2000. Preserving biodiversity: challenges for planners. Journal of the American Planning Association **66**:5-21.

Buechner, M., C. Schonewald-Cox, R. Sauvajot, and B. A. Wilcox. 1992. Cross-boundary issues for national parks: What works "on the ground." Environmental Management **16**:799-809.

Curry-Lindahl, K. 1972. Ecological research and management. Pages 197-213 *in* R. Osten, editor. World national parks: progress and opportunities. World Conservation Union, Brussels.

Dunning, J. B., B. J. Danielson, and H. R. Pulliam. 1992. Ecological processes that affect populations in complex landscapes. Oikos **65**:169-175.

Garratt, K. 1984. The relationship between adjacent lands and protected areas: Issues of concern for the protected area manager. Pages 65-71 *in* J. A. McNeely, and K. R. Miller, editors. National parks, conservation and development: the role of protected areas in sustaining society. Proceedings of the World Congress on National Parks, Bali, Indonesia, October 11-22, 1982. Smithsonian Institute Press, Washington, D.C.

Meffe, G. K., and C. R. Carroll. 1997. Conservation reserves in heterogeneous landscapes. Pages 305-346 *In* G. K. Meffe, and C. R. Carroll, editors. Principles of conservation biology. 2nd Edition. Sinauer Associates, Sunderland, MA.

Myers, N. 1972. National parks in savannah Africa. Science **178**:1255-1263.

National Park Service (NPS). 1980. State of the Parks -1980: A report to the congress. National Park Service, US Department of Interior, Washington, D.C.

National Park Service (NPS). 1993. Science and the National Parks II: Adapting to Change. Government Printing Office, Washington, DC

National Parks and Conservation Association (NPCA). 1979. NPCA adjacent lands survey: No park is an island. National Parks and Conservation Magazine **53**:4-9.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology **5**:18-32.

Schonewald-Cox, C. M. 1988. Boundaries in the protection of nature reserves: Translating multidisciplinary knowledge into practical conservation. BioScience **38**:480-486.

Shands, W. E. 1979. Federal resource lands and their neighbors. Conservation Foundation, Washington, D.C.

Sinclair, A. R. E. 1998. Natural regulation of ecosystems in protected areas as ecological baselines. Wildlife Society Bulletin **26**:399-409.

Swetnam, T. W., and J. L. Betancourt. 1998. Mesoscale disturbance and ecological response to decadal climatic variability in the American Southwest Journal of Climate **11**:3128-3147.

Taylor, P. D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity is a vital element of landscape structure. Oikos **73**:43-48.

Townsend, P.A., R.H. Gardner, T.R. Lookingbill, and C.C. Kingdon. 2006. Remote sensing and landscape pattern protocols for long-term monitoring of parks in the National Capital Region. Draft Protocols Report. January 2006. University of Maryland Center for Environmental Science, Appalachian Laboratory, Frostburg, MD. 12pp. plus appendices.

Western, D. 1982. Amboseli National Park: Enlisting landowners to conserve migratory wildlife. Ambio **11**:302-308.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pages 237-256 *in* M. Soulé, editor. Conservation biology: The science of scarcity and diversity. Sinauer Associates, Sunderland, MA.

Wright, G. M., J. S. Dixon, and B. H. Thompson. 1933. Fauna of the national parks: A preliminary survey of faunal relations in national parks. Fauna series No. 1. US Government Printing Office, Washington, D.C. Online. http://www.cr.nps.gov/history/online_books/fauna1/fauna.htm.

Yahner, R. H., and D. P. Scott. 1988. Effects of forest fragmentation on depredation of artificial avian nests. Journal of Wildlife Management **52**:158-161.

Appendix F.8. Limber Pine Protocol Development Summary

Protocol: Limber pine

Parks Where Protocol will be Implemented: CRMO and CIRO

Justification/Issues being addressed:
Limber pine, a subalpine five-needled pine similar to whitebark pine, is suffering extensive, heavy mortality throughout the foothills of the Rocky Mountains in the western United States and southern Canada. This severe die-off has been attributed to white pine blister rust, an invasive exotic fungal disease introduced to North America over a century ago. Blister rust infects the five-needled white pines causing cankers which often results in cessation of cone production and in some cases, death of the tree. Trees weakened by blister rust are also more susceptible to other problems such as mountain pine beetle and dwarf mistletoe infestations (Kendall et al. 1996).

North American five-needle pines have a low natural resistance to blister rust, which along with favorable climatic conditions, allows the disease to spread rapidly. Until recently, research tended to focus on blister rust infection of whitebark pine due to its high susceptibility and rate of decline in North America. But like its whitebark pine cousin, limber pine is also highly susceptible to blister rust. Surveys in northwestern Montana and southern Alberta found over one-third of the limber pine trees in those areas were dead and of the remaining trees, about 75% were infected with blister rust (Kendall et al. 1996).

Though it has traditionally received less research and attention, limber pine is vital to the forest communities in which it resides. It occupies and stabilizes dry habitats not likely to be occupied by other, less drought tolerant tree species, and is one of the first trees to colonize some areas after fire (Schoettle 2004). It often facilitates the establishment of high elevation late successional species and, having large, wingless, nutritionally-loaded seeds, is an important food source for several wildlife species, including Clark's nutcrackers and red squirrels. As with all of the white pines, loss of limber pine would result in an enormous ecosystem loss. Tomback et al. (2004) states that, "losses of these white pine ecosystems collectively represent significant reductions in forest biodiversity, especially considering geographic variation in habitat types, and the array of successional stages, understory plants, invertebrate and vertebrate species, and microbial and fungal communities that they harbor". Though blister rust will not likely cause the extinction of limber pine, over time it will impact the species' distribution, population dynamics, and functioning of ecosystems in which it is found (Schoettle 2004). Localized extirpations may also occur, particularly in areas peripheral to the species' core range, such as CRMO and CIRO.

Limber pine is the dominant tree species at CRMO, and while spatially limited, it accounts for much of the forested area within the monument. Small, isolated stands occur in the northern portion of the park and the monotypic stands tend to grow along the rocky exposed soils of north facing slopes of cinder cones and other volcanic features. Limber pine is more abundant on "aa" than "pahoehoe" flows, but in both cases is able to grow where water collects, and especially where the tree receives protection from fierce high desert winds. Kendall et al. (1996) reported finding no blister rust in the limber pine of CRMO. However in 2006, park natural resource managers found several infected trees within the park's boundary (NPS, Paige Wolken, CRMO Botanist, pers. comm., 2006). At CIRO, limber pine occurs noticeably on Graham Peak and is scattered throughout other areas of the park. To date, blister rust has not been identified in CIRO.

Monitoring of blister rust infection in UCBN limber pine populations is important to understand landscape and stand level changes in the vegetation and fuels structure. Early detection and trend monitoring data will provide park managers with information needed to assess current outbreak status and develop an appropriate management response. It will also allow contribution to region-wide investigations into five-needle pine disease dynamics. Currently, the Whitebark Pine Ecosystem Foundation is serving as a key research and management communication vehicle and has supported development of monitoring protocols. The NPS Greater Yellowstone Network (GRYN) I&M program has developed a monitoring protocol based on the Foundation's protocol, and we will adopt and adapt these as necessary. Common use of protocols will greatly facilitate information sharing across the northern Rocky Mountains and foothills region and provide managers with the best possible chance of combating blister rust infection.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- What is the extent of white pine blister rust infection in CRMO and CIRO and is the rate of infection increasing?
- What is the severity of existing infections of white pine blister rust on limber pine and is the severity increasing?
- What is the survival of mature limber pine trees infected with white pine blister rust and are mortality rates increasing?

Monitoring objectives addressed by this protocol include:

1) Conduct early detection status surveys for blister rust infection at CRMO and CIRO.
   Justification: *White pine blister rust has devastated limber pine in other areas of the Northwest (Kendall et al. 1996)) and has recently been discovered in CRMO (NPS, Paige Wolken, CRMO Botanist, pers. comm., 2006). Limber pine is an important floral species in these parks yet incomplete knowledge hinders our ability to conserve*

and manage it. Early detection can lead to better monitoring and possible containment or treatment of the disease.

2) Estimate trends in the proportion, severity, and survivorship of limber pine trees infected with white pine blister rust in CRMO and CIRO.
   Justification: *Determining the proportion of trees infected and the severity of infection provides an understanding of the magnitude of the problem. Depending on the infection location, infected trees may survive for a considerable time. For example, trees infected on or near the trunk will have a higher risk of mortality and loss of reproduction than trees with upper canopy or branch infections. Estimating survival will enable us to distinguish occurrence and severity of white pine blister rust from the ecological effect of infestation (i.e., loss of limber pine). As a result, we will be better able to determine the vulnerability of limber pine in our parks.*

Basic Approach:

There are existing protocols concerning whitebark pine and blister rust developed by GRYN and the Whitebark Pine Ecosystem Foundation (Tomback et al. 2004). The Whitebark Pine Ecosystem Foundation plans to produce another monitoring protocol specifically for limber pine for distribution in January 2007 and we will adopt and adapt this protocol as necessary. In the event this protocol is not completed, we will adapt the existing whitebark pine protocols for UCBN limber pine monitoring.

Surveys will be conducted from May through July, the best time for viewing the orange spore sacs, aecial blisters, produced by the active sporulating canker. These blisters may be visible to either the naked eye or with the aid of binoculars in the upper branches of the trees. Field crew will consist of two to three people with at least one person trained to recognize blister rust systems in limber pine and experienced in forestry sampling methods. Stands of mature (cone-bearing) trees will be prioritized for sampling and plots will be representative of the general area. The sampling unit will be a 50 m (164 ft) long by 30 m (98 ft) wide belt transect plot and selection of plots will chosen using either a simple random sample or a general stratified sample.

For each live tree, presence or absence of blister rust indicators will be recorded. We will consider the proportion of transects showing blister rust indicators as a surrogate for how widespread blister rust is within the parks. The proportion of trees infected and the number and location (branch or bole) of cankers will be interpreted as an index of severity of blister rust infections. The presence/absence of mountain pine beetle and dwarf mistletoe will also be noted.

Principle Investigators and NPS Lead:

Principle Investigators: To Be Determined. NPS Lead: To Be Determined

Development Schedule, Budget, and Expected Interim Products:
Protocol adoption and revision to UCBN application will begin following completion of a limber pine monitoring protocol by the Whitebark Pine Ecosystem Foundation. A UCBN protocol will be ready for peer-review in Fall 2008.

Literature Cited:

Kendall, K. C., D. Ayers, and D. Schirokauer. 1996. Limber pine status from Alberta to Wyoming. Nutcracker Notes 7:23-24. USDA Forest Service, Intermountain Research Station, IFSL. Missoula, MT.

Schoettle, A. W. 2004. Ecological roles of five-needle pines in Colorado: potential consequences of their loss. USDA Forest Service Proceedings RMRS-P-32.

Tomback, D. F., R. E. Keane, W. W. McCaughley, and C. Smith. 2004. Methods for surveying and monitoring whitebark pine for blister rust infection and damage. Missoula, MT: Whitebark Pine Ecosystem Foundation.

Appendix F.9. Osprey Protocol Development Summary

Protocol: Osprey

Parks Where Protocol will be Implemented: LARO

Justification/Issues being addressed:
Indicator species help researchers and resource managers by providing information on the overall condition of an ecosystem. For several reasons raptors can be extremely useful indicators of environmental change. Raptors occupy most ecosystems, cover large home ranges, are often migratory, top predators in complex food webs, and sensitive to environmental contaminants and other human disturbances (Bildstein 2001). The osprey is an excellent example of one of these potential indicator species.

North American osprey populations began to drastically decline in the early 1950s and declines continued through the early 1970s (Reese 1972; Poole 1989). Environmental pollutants such as Dieldrin, DDE, and PCB, have been listed as the primary cause of declines. These pollutants bioaccumulate in the aquatic flora and fauna and, since fish constitute 99% of an osprey diets, pollutants accumulate rapidly in osprey tissue. At high levels, these contaminants cause eggshell thinning and decreased egg viability (Ames 1966; Wiemeyer et al. 1978; Steidl et al. 1991). With restrictions and bans on many of these pollutants in the 1980s, osprey numbers appear to have rebounded and are flourishing in many areas (Titus and Fuller 1990). However, the presence of contaminants still remains a concern in many areas, including LARO.

The osprey is a common breeding resident in LARO and is at risk of environmental contamination. Contaminants found in the sediments of the Upper Columbia River consist of heavy metals such as antimony, arsenic, cadmium, copper, lead, mercury, and zinc, as well as organic contaminants such as polychlorinated dibenzo-p-dioxins (dioxins), polychlorinated dibenzofurans (furans) and PCBs (EPA 2006). Known and potential sources of contaminants in LARO include mining and milling operations, smelting operations, pulp and paper production, sewage treatment plants, and other industrial activities (EPA 2006). One of the largest sources of contamination in LARO is the TechCominco Smelter, located along the Columbia River approximately 16 km (10 mi) north of the US border. This smelter has been discharging pollutants for over 100 years, making it the single largest source of heavy metal contaminants in the Upper Columbia River (EPA 2006). Lake Roosevelt is currently being considered for addition to the EPA National Priorities List as a superfund site (USGS 2003).

Increased human recreational activity is an additional stressor on osprey populations in LARO. While reservoirs and man-made nesting structures such as telephone poles and artificial platforms benefit osprey, high levels of human activity in the vicinity of active nests may be adversely affecting successful reproduction (D'Eon and Watt 1994). The effect of human disturbance on osprey is dependent on several factors including the timing, frequency, and intensity of disturbance as well as the degree of osprey habituation. Recreational activity at LARO has been steadily increasing over time, and in 2005, LARO attracted over 1 million visitors. Most of these are summertime watercraft users, and because osprey typically nest on or near the lakeshore and forage exclusively over open water, an inherent conflict exists.

Monitoring of osprey is a critical element in the suite of information needed by LARO managers to adequately understand and manage park ecological condition. Though there have been several studies over recent years examining the presence of contaminants within LARO, little information is available regarding osprey in the area and few studies (if any) have researched the potential impacts of these contaminants on osprey and other avian wildlife (Henny 2005). The UCBN I&M Program seeks to support LARO staff by developing a simple and effective long-term monitoring protocol that will provide timely information on osprey nest occupancy and productivity. We will assist LARO in the identification of desired target values for occupancy and productivity, as well as conservative thresholds that, if crossed, might trigger management action. Because of the complexity of land ownership and management responsibilities in the Lake Roosevelt area, NPS management options are limited. However, osprey declines exceeding established thresholds may be used to garner support among other area stakeholders to support additional research or alternative management strategies.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- Are trends in occupancy and productivity associated with nest structure and human disturbance patterns?
- Is the phenology of osprey nesting and fledgling changing over time?
- What is the proportion of nests occupied in LARO? What is the trend in nest occupancy?
- What is the trend in productivity as measured by the number of fledglings per nest in LARO?

Monitoring objectives addressed by this protocol include:

1) Determine status and trend of nest occupancy for osprey in LARO.
   Justification: *Currently little information is available concerning osprey nesting activity in LARO. Osprey nests are relatively easy to locate and observe from the ground. Locating nests will provide information regarding nest structure, chronology, etc. It will also help to identify critical areas for increased protection.*
2) Determine status and trend of productivity (number of fledglings) for osprey in LARO.
   Justification: *Productivity is essential to maintaining a healthy population. Contaminants and human disturbance at LARO may be affecting osprey*

productivity. Knowing the level of productivity of this area will help managers better understand population condition and proceed to address issues of management concern.

Basic Approach:
The UCBN will follow an occupancy estimation approach as outlined by Mackenzie et al. (2006), which involves repeated within-season nest surveys to determine nest occupancy and detectability, if determined that detectability is not close to 1. Because detectability of osprey nests is assumed to be high this technique may not be necessary. Surveys for osprey nests in LARO will be conducted by boat and vehicle/foot during the period of egg incubation in May and June. Two surveys per season will be conducted for each survey area in order to permit detectability estimation. The lake will be divided into three sections, and surveys in each section will occur once every three years, in a [1-2] rotating panel design. Aircraft or helicopter will be used during the initial implementation of the protocol as a means to exhaustively survey the lake and identify all known historic and extant nests. Periodic resurveys of the lake with aircraft will be conducted to add newly established nests to the sample pool. The primary survey measure (response) will be occupancy as indicated by presence of birds in the nest. Our second objective related to productivity will be met by revisiting active nests within season (July) when fledglings are approximately 45 days old and conspicuous enough to allow accurate counts by observers on the ground or a boat. Additional covariate measures taken for each nest will include those related to structure (type, height), location (distance to water, distance to boat landings), weather, and visitation patterns. Our protocol will be developed and implemented in collaboration with other stakeholders in the lake vicinity and will include the Washington Department of Fish and Wildlife and the Confederated Tribes of Colville Indian Reservation. Existing protocols for osprey and analogous raptor monitoring efforts will be reviewed prior to allocating network funds for protocol development, and we will adopt and adapt suitable protocols to meet NPS I&M standards (Oakley et al. 2003).

Principle Investigators and NPS Lead:
Principle Investigators: To Be Determined. NPS Lead: To Be Determined.

Development Schedule, Budget, and Expected Interim Products:
A draft protocol ready for peer-review will be complete in Fall 2008.

Literature Cited:

Ames, P. L. 1966. DDT residues in the eggs of the osprey in the North-eastern United States and their relation to nesting success. Supplement: pesticides in the environment and their effects on wildlife. The Journal of Applied Ecology **3**:87-97.

Bildstein, K. L. 2001. Why migratory birds of prey make great biological indicators. Hawkwatching in the Americas. 169-179.

D'Eon, Robert G., and W. R. Watt. 1994. Osprey management guidelines in Northeastern Ontario: a review. MNR, Northeast Science and Technology. Timmins, Ont. TR-018.

Environmental Protection Agency. 2006. Phase I sediment sampling data evaluation, Upper Columbia River site. CERCLA RI/FS. Prepared by Ecology and Environment, Inc.

Henny, C. J. 2005. An assessment of the status of nesting Ospreys and waterbirds along Lake Roosevelt with special emphasis toward future contaminant studies. Research proposal.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier, London.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin **31**:1000-1003.

Poole, A. F. 1989. Ospreys: A natural and unnatural history. Cambridge University Press.

Reese, J. G. 1972. Osprey Nesting success along the Choptank River, Maryland. Chesapeake Science. **13**:233-235.

Steidl, R. J., C. R. Griffin, and L. J. Niles. 1991. Contaminant levels of osprey eggs and prey reflect regional differences in reproductive success. Journal of Wildlife Management **55**:601-608.

Titus, K., and M. R. Fuller. 1990. Recent trends in counts of migrant hawks from northeastern North America. Journal of Wildlife Management **54**:463-470.

US Geological Survey. 2003. Ospreys in Oregon and the Pacific Northwest. USGS FS-153-02, US Department of Interior, Washington, DC.

Wiemeyer, S. N., D. M. Swineford, P. R. Spitzer, and P. D. McLain. 1978. Organochlorine residues in New Jersey osprey eggs. Bulletin of Environmental Contamination and Toxicology **19**:56-63.

Appendix F.10. Sagebrush-steppe Vegetation Protocol Development Summary

Protocol: Sagebrush-steppe Vegetation

Parks Where Protocol will be Implemented: CIRO, CRMO, HAFO, JODA, and LARO

Justification/Issues being addressed:
The sagebrush-steppe region has undergone radical and extensive changes during the last 150 years (USFS 1996; West and Young 2000; BLM 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 the ecological condition 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).

In the UCBN, sagebrush-steppe is the most extensive ecosystem type, occupying over 50% of land cover in CIRO, HAFO, and JODA. At CRMO, where bare lava rock comprises 81% of the total land cover, sagebrush-steppe represents over 90% of existing vegetation cover. Sagebrush-steppe covers most of the southern half of LARO. The degradation of sagebrush-steppe resulting from biological invasion, altered fire regimes, and other stressors so widespread throughout the intermountain west has also occurred within UCBN parks. Historic and current land use practices both within and adjacent to the parks continue to fragment and alter steppe ecosystems, and predicted climate change scenarios for the region will likely exacerbate these stressors (Smith et al. 2000; Wagner et al. 2003). Long-term vegetation trends from the INL near CRMO provide substantial evidence of the importance of climate patterns on sagebrush-steppe vegetation dynamics (Anderson and Inouye 2001). Monitoring on the INL has demonstrated a multi-decadal plant community response to prolonged drought during the mid- 20th century that has important implications for management within the context of a changing climate.

The heterogeneity of sagebrush community types (i.e., alliances and associations defined by *Artemisia* subtaxa) presents management challenges because community response to fire and drought, vulnerability to invasion, and potential for restoration and recovery can differ significantly (Reid et al. 2002; BLM 2002). Understanding these differences at the park level is critical for effective management strategies to be developed. This underscores the need for a long-term monitoring program that provides for periodic evaluation of the status of steppe communities and for identification of trends over time both within parks and across the Network.

Tying network monitoring objectives to park management objectives is important to ensure the monitoring program provides relevant information to managers. Specific management objectives related to sage-steppe plant communities have not been explicitly articulated at this time. However, all parks addressed by this protocol share a common overarching management goal to maintain and restore native ecosystems and ecological processes. Plant invasion and shifting community composition and species abundance is the overarching concern for UCBN park managers. This protocol will be focused on this concern and will provide managers with information necessary to evaluate progress in activities related to maintaining and restoring native plant communities. However, it is equally important to recognize that shifting park management priorities and unanticipated ecological change over the life of the monitoring program require a generalized and flexible protocol with an accommodating design. This protocol will attempt to balance these potentially competing short-term and long-term needs.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- What are the trends in abundance and composition of species and horizontal strata (i.e. perennial grass, shrub, etc.) in UCBN sagebrush-steppe plant communities?
- Do trends differ among community types, as defined by Artemisia subtaxa?
- What are the trends in abundance and composition of invasive plant species in UCBN sagebrush-steppe communities?
- Are trends observed in sagebrush-steppe vegetation significantly correlated with trends in weather and climate?

Monitoring objectives addressed by this protocol include:

1) Estimate status and trends in the abundance of targeted plant species, groups (e.g. *Artemisia spp*.) and horizontal strata (e.g., perennial grass, shrub, etc.) in UCBN sagebrush-steppe communities.
   Justification: *Sagebrush-steppe ecosystems are some of the most threatened in the intermountain west. Biological invasions, altered fire regimes, and other stressors continue to cause major, possibly irreversible, changes in steppe ecosystem structure and function and create difficult challenges for UCBN land managers. Determining trends in sagebrush-steppe communities is essential for understanding the Network's ecosystems and conducting effective adaptive management.*
2) Estimate the status and trends in diversity and species composition of UCBN sagebrush-steppe communities.
   Justification: *Sagebrush-steppe ecosystems are some of the most threatened in the intermountain west. Biological invasions, altered fire regimes, and other stressors*

continue to cause major, possibly irreversible, changes in steppe ecosystem structure and function and create difficult challenges for UCBN land managers. Determining trends in sagebrush-steppe communities is essential for understanding the Network's ecosystems and conducting effective adaptive management.

Basic Approach:

No existing sagebrush-steppe monitoring protocol is currently available for adoption from the NPS or other relevant organizations. The UCBN sagebrush-steppe vegetation monitoring protocol will be developed following NPS I&M standards as outlined by Oakley et al. (2003). A probabilistic sampling design will be developed, balancing the need for maximum scope of inference and statistical power with logistical and financial efficiency. Sampling methods will be adopted that support these criteria, following techniques established in the literature, such as line and point intercept sampling for cover estimation (Herrick et al. 2005; Elzinga et al. 2001). We will also draw upon relevant information from the coordinated NCPN/SCPN integrated upland monitoring protocol development effort as it becomes available. We are currently drawing excellent information from an evaluation of field methods conducted by Miller et al. (2006) for the NCPN. Effort will be made to ensure UCBN sagebrush-steppe vegetation sampling methods produce results comparable with those used by INL, BLM, NPS Fire Effects Monitoring Program, and other monitoring projects in the region to increase regional application of UCBN monitoring data. Power analysis and sample size requirements will be calculated *a priori* with data available from INL, NPS Fire Effects Monitoring Program, and other partners with suitable data sets, including the PI's previous research at CRMO. Lessons learned from long-term monitoring at the INL and other programs underscore the need for an efficient and flexible protocol that will accommodate revisions and adjustments necessary to sustain this program over many decades. It is expected that the protocol sampling design and field methods will be refined during several years of implementation and protocol testing following peer-review. A cooperative task agreement between the UCBN and Idaho State University, issued through the Great Basin Cooperative Ecosystem Studies Unit, has been written to support the development of this protocol.

Principal Investigators and NPS Lead:

Principal Investigator: Dr. Nancy Huntly, Idaho State University, 208-282-2149; NPS ATR: Tom Rodhouse, UCBN Ecologist, 541-312-8101.

Development Schedule, Budget, and Expected Interim Products:

The PI and NPS UCBN staff will produce a draft monitoring protocol ready for external peer review by September 2007. We anticipate implementing the protocol in 2008. We have budgeted $30,000 for protocol development in FY 2006 and which will sustain protocol developments through 2007.

Literature Cited:

Anderson, J. E., and R. S. Inouye. 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush-steppe over 45 years. Ecological Monographs **71**:531-556.

Bunting, S. C., J. L. Kingery, M. A. Hemstrom, M. A. Schroeder, R. A. Gravenmier, and W. J. Hann. 2002. Altered rangeland ecosystems in the Interior Columbia Basin. General Technical Report PNW-GTR-553. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Bureau of Land Management (BLM). 2002. Management considerations for sagebrush (*Artemisia*) in the western United States: A selective summary of current information about the ecology and biology of woody North American sagebrush taxa. USDI Bureau of Land Management, Washington, DC.

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 2001. Measuring and monitoring plant populations. BLM Technical Reference 1730-1. Bureau of Land Management, Denver, CO.

Herrick, J. E., J. W. Van Zee, and others. 2005. Monitoring manual for grassland, shrubland, and savannah ecosystems. USDA-ARS Jornada Experimental Range, Las Cruces, NM.

Keane, R. E., K. C. Ryan, T. T. Veblen, C. D. Allen, J. Logan, and B. Hawkes. 2002. Cascading effects of fire exclusion in the Rocky Mountain ecosystems: A literature review. General Technical Report RMRS-GTR- 91. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Miller, M. E., D. Witwicki, and R. Mann. 2006. Field-based evaluations of sampling methods for long-term monitoring of upland ecosystems on the Colorado Plateau – 2005 annual report. USGS Southwest Biological Science Center. 31 March 2006.

Mack, R. N., and C. M. D'Antonio. 1998. Impacts of biological invasions on disturbance regimes. Trends in Ecology and Evolution **13**:195-198.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin **31**:1000-1003.

Reid, M., P. Comer, H. Barrett, S. Caicco, R. Crawford, C. Jean, G. Jones, J. Kagan, M. Karl, G. Kittel, and others. 2002. International classification of ecological communities: Terrestrial vegetation in the United States. Sagebrush vegetation of the western United States. Final Report for the USGS Forest and Rangeland Ecosystem Science Center, Boise, ID. NatureServe, Arlington, VA.

Smith, S. D., T. E. Huxman, S. F. Zitzer, T. N. Charlet, D. C. Housman, J. S. Coleman, L. K. Fenstermaker, J. R. Seemann, and R. S. Nowak. 2000. Elevated CO_2 increases productivity and invasive species success in an arid ecosystem. Nature **408**:79-82.

USDA Forest Service (USFS). 1996. Status of the Interior Columbia Basin: Summary of scientific findings. General Technical Report PNW-GTR-385. USDA Forest Service, Pacific Northwest Research Station and USDI Bureau of Land Management.

Wagner, F. H., R. Angell, M. Hahn, T. Lawlor, R. Tausch, and D. Toweill. 2003. Natural ecosystems III. The Great Basin. Pages 207-240 *in* F. H. Wagner, editor. Rocky Mountain/Great Basin regional climate-change assessment. Report for the US global change research program. Utah State University, Logan, UT.

West, N. E., and J. A. Young. 2000. Intermountain valleys and lower mountain slopes. Pages 255-284 *in* M. G. Barbour and W. D. Billings, editors. North American terrestrial vegetation. Cambridge University Press, Cambridge, UK.

Wisdom, M. J., R. S. Holthausen, B. C. Wales, C. D. Hargis, V. A. Saab, D. C. Lee, W. J. Hann, T. D. Rich, M. M. Rowland, W. J. Murphy, and M. R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the Interior Columbia Basin: Broadscale trends and management implications. Volume 1-Overview. General Technical Report PNW-GTR-485. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Appendix F.11. Sage Grouse Protocol Development Summary

Protocol: Sage grouse

Parks Where Protocol will be Implemented: CIRO and CRMO

Justification/Issues being addressed:
The greater sage grouse is decreasing in numbers and range throughout much of the western United States (Connelly and Braun 1997; Connelly et al. 2003; Schroeder et al. 2004; ISGAC 2006). Researchers estimate the sage grouse has been extirpated from 44% of its presettlement range (Schroeder et al. 2004). This level of decline has been demonstrated in Idaho, where greater sage grouse populations declined at a rate of approximately 1.5% per year from 1965 to 2003 (ISGAC 2006). These losses have led to several petitions to list certain populations, subspecies, or species of sage-grouse as endangered or threatened under the Endangered Species Act. The species is considered a sagebrush-steppe habitat obligate, and as such, depends heavily on sagebrush for cover and forage. Declines in sage grouse numbers are attributed to the loss, fragmentation, and alteration of sagebrush-steppe vegetation across the intermountain west, particularly in southern Idaho (USFS 1996; West and Young 2000; BLM 2002; Reid et al. 2002; ISGAC 2006). Agricultural conversion, historic overgrazing, altered fire regime, and exotic plant invasion are the primary sources of this habitat loss (West and Young 2000; Bunting et al. 2002; ISGAC 2006).

Sagebrush-steppe vegetation comprises over 50% of CIRO land cover and more than 90% of vegetated portions of CRMO, much of which is suitable habitat for sage grouse. Sage grouse occur in these two parks during all seasons of the year, but the status of their occurrence is unknown. Currently, we are aware of three active lek breeding localities adjacent to the Castle Rocks unit of CIRO. Nests, broods, and wintering individuals are occasionally seen in both units of CIRO and in adjacent rangeland. At CRMO, over 36 historic or active leks occur within or in close proximity to the boundary of the jointly managed preserve portion of the monument. Use of CRMO by sage grouse at other times is confirmed but not well described.

It appears as though these parks do not support large numbers of sage grouse, and park areas used are largely on the periphery of more active habitat. However, it is important for NPS to monitor sage grouse and grouse habitat for several reasons. Being a sagebrush obligate species, sage grouse require a large area of sagebrush/grassland habitats with a significant amount of canopy cover for nesting and wintering habitat (ISGAC 2006). Biologists describe the greater sage grouse as an umbrella species, and its home range and habitat requirements are large enough that, if protected, will consequently bring other species under protection (ISGAC 2006). Also, sage grouse exhibit high fidelity to seasonal ranges. For example, hens tend to return to the same nesting area each year (Fischer et al. 1993). From a long-term perspective, the importance of CRMO and CIRO steppe habitat to sage grouse may increase as surrounding land cover shifts toward non-suitable habitat. Finally, the NPS can make an important contribution to existing state and regional efforts to assess the status and trend of this species range-wide. For these reasons, sage grouse monitoring will be conducted as a complement to the Network's sage-steppe vegetation monitoring effort and will add to the overall understanding of sagebrush-steppe ecological condition.

IDFG is currently monitoring sage grouse populations of southeastern Idaho on a broader scale. Considering their efforts and the expansive habitat used by the species, which crosses ownership and agency boundaries, collaboration with IDFG will be essential to the success of this monitoring program. Consequently, information found about sage grouse in the parks will benefit IDFG and contribute to efforts and understanding placed forth in the "Conservation Plan for the Greater Sage-grouse in Idaho," released by the Idaho Sage Grouse Advisory Committee (ISGAC) (2006) and the Idaho Fish and Game Commission.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Monitoring questions addressed by this protocol include:

- What is the status of sage grouse lek activity in CIRO and CRMO?
- What are the long-term trends of lek use in CIRO and CRMO, and are these trends proportional to those statewide?
- Where is the potential critical habitat for sage grouse in CRMO and CIRO?
- What is the status and trend of sage grouse occupancy in these critical park habitat areas?

Monitoring objectives addressed by this protocol include:

1) Cooperate with IDFG to estimate trends in occupancy and abundance of male sage grouse through annual lek counts in and adjacent to (within 3.2 km [2 mi] of park boundaries) CIRO and CRMO.
Justification: *Across the range, lek counts are the most common way to monitor sage-grouse populations. Leks are relatively easy to identify and survey. Also, state wildlife managers already have a lek monitoring program in place, providing an opportunity to work collaboratively and share information. Long-term lek count data provides insight into sage grouse population trends, and consequently, the condition of other sagebrush obligate species.*

2) Identify potential critical sage grouse habitat areas within the parks and conduct periodic status surveys in these areas to estimate occupancy and abundance.
Justification: *Sage grouse have different habitat requirements during each season. Loss or conversion of habitat is reported to be the primary cause of sage grouse declines. Each of these important habitats must be identified and protected in order to better manage for the species.*

Basic Approach:
The UCBN will develop and implement this protocol in two phases. The first phase will address the first objective pertaining to lek counts. The IDFG is currently monitoring leks in and around CIRO and CRMO. IDFG's monitoring protocol, as described by the Idaho Sage Grouse Advisory Committee (2006), will be adopted and if necessary, modified to meet the NPS I&M standards described by Oakley et al. (2003). NPS personnel will work cooperatively with the regional IDFG offices (Magic Valley, Upper Snake, and Southeast) to ensure the protocol is adopted and implemented properly, and information sharing is seamless. Annual ground and aerial lek searches will be coordinated with IDFG.

The second phase of protocol development will address the second objective related to identification and occupancy and abundance of grouse in critical habitat areas. Sage grouse populations in southern Idaho are migratory, have large annual ranges, and use different habitats at different times of the year (Connelly et al. 2000, 2003). The different requirements for breeding, nesting, summer/brood rearing, fall, and wintering habitats have been described and can be used to describe potential habitat for areas where sage grouse use is unknown (Fischer et al. 1993; Connelly et al. 2000; ISGAC 2006). The UCBN will work with the University of Idaho College of Natural Resources and IDFG to develop a GIS-based model of potential sage grouse habitat within parks. Current vegetation maps are being produced for CIRO and CRMO through assistance from the NPS national vegetation mapping program and are scheduled for completion in 2008 in time for use in this effort. The potential habitat will be stratified into seasonal usage categories and a sampling design relying on flush counts will be developed to support periodic assessment of status and trend in occupancy by habitat type.

Principle Investigators and NPS Lead:
Principle Investigators: To Be Determined. NPS Lead: To Be Determined.

Development Schedule, Budget, and Expected Interim Products:
Protocol development will begin in early 2008 and will be ready for peer-review by December 2008.

Literature Cited:

Bunting, S. C., J. L. Kingery, M. A. Hemstrom, M. A. Schroeder, R. A. Gravenmier, and W. J. Hann. 2002. Altered rangeland ecosystems in the Interior Columbia Basin. General Technical Report PNW-GTR-553. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Bureau of Land Management (BLM). 2002. Management considerations for sagebrush (*Artemisia*) in the western United States: A selective summary of current information about the ecology and biology of woody North American sagebrush taxa. USDI Bureau of Land Management, Washington, D.C.

Connelly, J. W., and C. E. Braun. 1997. Long-term changes in sage-grouse (*Centrocercus urophasianus*) populations in western North America. Wildlife Biology **3**:123-128.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin **28**:967-985.

Connelly, J. W., K. P. Reese, and M. A. Schroeder. 2003. Monitoring of greater sage-sage grouse habitats and populations. Station Bulletin 80. College of Natural resources Experimental Station, College of Natural Resources, Moscow, ID.

Fischer, R. A., A. D. Apa, W. L. Wakkinen, K. P. Reese, and J. W. Connelly. 1993. Nesting-area fidelity of sage grouse in southeastern Idaho. Condor **95**:1038:1041.

Idaho Sage-grouse Advisory Committee (ISGAC). 2006. Conservation plan for the greater sage-grouse in Idaho. Boise, ID.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin **31**:1000-1003.

Reid, M., P. Comer, H. Barrett, S. Caicco, R. Crawford, C. Jean, G. Jones, J. Kagan, M. Karl, G. Kittel, and others. 2002. International classification of ecological communities: Terrestrial vegetation in the United States. Sagebrush vegetation of the western United States. Final Report for the USGS Forest and Rangeland Ecosystem Science Center, Boise, Idaho. NatureServe, Arlington, VA.

Schroeder, M. A. C. L. Aldridge, A. D. Apa, J. R. Bohne, C. E. Braun, S. D. Bunnell, J. W. Connelly, P. A. Deibert, S. C. Gardner, M. A. Hilliard, G. D. Kobriger, S. M. McAdam, C. W. McCarthy, J. J. McCarthy, D. L. Mitchell, E. V. Rickerson, and S. J. Stiver. 2004. Distribution of sage-grouse in North America. The Condor **106**:363-376.

USDA Forest Service (USFS). 1996. Status of the Interior Columbia Basin: Summary of scientific findings. General Technical Report PNW-GTR-385. USDA Forest Service, Pacific Northwest Research Station and USDI Bureau of Land Management.

West, N. E., and J. A. Young. 2000. Intermountain valleys and lower mountain slopes. Pages 255-284 *in* M. G. Barbour and W. D. Billings, editors. North American terrestrial vegetation. Cambridge University Press, Cambridge, UK.

Appendix G
Species and Acronyms Lists

Appendix G.1. Species Common and Scientific Names

Common and scientific names of species mentioned in the monitoring plan and/or appendixes are listed below. Scientific names are consistent with the Integrated Taxonomic Information System (ITIS, http://www.itis.gov) as of December 1, 2006.

Common Name	Scientific Name
Vascular Plants	
Alder	*Alnus*
American bulrush	*Scirpus americanus*
Antelope bitterbrush	*Purshia tridentata*
Basin big sagebrush	*Artemisia tridentata* ssp. *tridentata*
Basin wildrye	*Leymus cinereus*
Big sagebrush	*Artemisia tridentata*
Bluebunch wheatgrass	*Pseudoroegneria spicata*
Bottlebrush squirreltail	*Elymus elymoides*
Camas genus	*Camassia* spp.
Camas lily	*Camassia quamash* (Pursh) Greene
Cedar	Family Cupressaceae
Cheatgrass	*Bromus tectorum*
Cinquefoil	*Potentilla* spp.
Cottonwood	*Populus* spp.
Crested wheatgrass	*Agropyron cristatum*
Douglas fir	*Pseudotsuga menziesii*
Dwarf mistletoe	*Arceuthobium americanum*
Eurasian milfoil	*Myriophyllum spicatum*
Grand fir	*Abies grandis*
Gray horsebrush	*Tetradymia canescens*
Gray rabbitbrush	*Chrysothamnus nauseosus*
Greasewood	*Sarcobatus vermiculatus*
Green rabbitbrush	*Chrysothamnus viscidiflorus*
Hardstem bulrush	*Scirpus lacustris* ssp. *glaucus*
Hawkweed	*Hieracium* spp.
Hemlock	*Tsuga* spp.
Horsebrush	*Tetradymia*
Idaho fescue	*Festuca idahoensis*
Knapweed	*Centaurea* spp.
Yellow floatingheart	*Nymphoides peltata*
Limber pine	*Pinus flexilis*
Lodgepole pine	*Pinus contorta*
Low sagebrush	*Artemisia arbuscula*
Medusahead	*Taeniatherum caput-medusae*
Mountain alder	*Alnus incana*
Mountain big sagebrush	*Artemisia tridentata* ssp. *vaseyana*
Obscure phacelia	*Phacelia inconspicua*
Orange hawkweed	*Hieracium aurantiacum*
Palouse milkvetch	*Astragalus arrectus*
Picabo milkvetch	*Astragalus oniciformis*
Pine	*Pinus* spp.
Pinyon pine	*Pinus edulis*

Common Name	Scientific Name
Vascular Plants continued	
Ponderosa pine	*Pinus ponderosa*
Purple loosestrife	*Lycopodium sabinifolium*
Quaking aspen	*Populus tremuloides*
Rabbitbrush	*Chrysothamnus*
Reed canary grass	*Phalaris arundinacea*
Rocky Mountain juniper	*Juniperus scopulorum*
Russian knapweed	*Centaurea repens*
Russian olive	*Eleagnus angustifolia*
Sandberg bluegrass	*Poa sandbergii*
Scouler's willow	*Salix scouleriana*
Silver sage	*Artemisia cana*
Softstem bulrush	*Scirpus lacustris* ssp. *validus*
Spike-rush	*Eleocharis* spp.
Subalpine fir	*Abies lasiocarpa*
Sulfur cinquefoil	*Potentilla recta*
Thistles	*Cirsium* spp.
Threadleaf sedge	*Carex filifolia*
Three-tip sage	*Artemisia tripartita*
Thurber's needlegrass	*Achnatherum thurberianum*
Utah juniper	*Juniperus osteosperma*
Western juniper	*Juniperus occidentalis*
Western larch	*Larix occidentalis*
Western white pine	*Pinus monticola*
Whitebark pine	*Pinus albicaulis*
Willow	*Salix* spp.
Wyoming big sage	*Artemisia tridentata* ssp. *wyomingensis*
Vertebrates	
American shad	*Alosa sapidissima*
Arctic grayling	*Thymallus arcticus*
Bald eagle	*Haliaeetus leucocephalus*
Beaver	*Castor canadensis*
Black bear	*Ursus americanus*
Black crappie	*Pomoxis nigromaculatus*
Black crowned night-heron	*Nycticorax nycticorax*
Bobcat	*Lynx rufus*
Brewer's sparrow	*Spizella breweri*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Brush mouse	*Peromyscus boylii*
Bullfrog	*Rana catesbeiana*
Bull trout	*Salvelinus confluentus*
Burbot	*Lota lota*
Canyon mouse	*Peromyscus crinitus*
Carp	
Centarchid sunfishes	*Lepomis* spp.
Clark's nutcracker	*Nucifraga columbiana*
Cliff swallow	*Hirundo pyrrhonota*
Columbia spotted frog	*Rana luteiventris*
Common garter snake	*Thamnophis sirtalis*
Cooper's hawk	*Accipiter cooperii*
Elk	*Cervus elaphus*

Common Name	Scientific Name
Vertebrates continued	
Feral cats	*Felis silvestris*
Ferruginous hawk	*Buteo regalis*
Freshwater Shrimp	*Branchinecta*
Gray wolf	*Canis lupus*
Great blue heron	*Ardea herodias*
Greater sage grouse	*Centrocercus urophasianus*
Kokanee/sockeye salmon	*Oncorhynchus nerka*
Largemouth bass	*Micropterus salmoides*
Long-legged myotis	*Myotis volans*
Merriam's shrew	*Sorex merriami*
Mountain lion	*Puma concolor*
Northern mockingbird	*Mimus polyglottos*
Osprey	*Pandion haliaetus*
Pallid bat	*Antrozous pallidus*
Peregrine falcon	*Falco peregrinus*
Pika	*Ochotona princeps*
Pinyon mouse	*Peromyscus truei*
Pygmy rabbit	*Brachylagus idahoensis*
Red fox	*Vulpes vulpes*
Red squirrel	*Tamiasciurus hudsonicus*
Ringtail	*Bassariscus astutus*
Rough-legged hawk	*Buteo lagopus*
Sage grouse	*Centrocercus urophasianus*
Sage sparrow	*Amphispiza belli*
Sage thrasher	*Oreoscoptes montanus*
Sagebrush vole	*Lemmiscus curtatus*
Sharp-shinned hawk	*Accipiter striatus*
Silver-haired bat	*Lasionycteris noctivagans*
Smallmouth bass	*Micropterus dolomieu*
Southwestern willow flycatcher	*Empidonax traillii* ssp. *extimus*
Spotted bat	*Euderma maculatum*
Steelhead	*Oncorhynchus mykiss*
Swainson's hawk	*Buteo swainsonii*
Townsend's big eared bat	*Corynorhinus townsendii*
Vesper sparrow	*Pooecetes gramineus*
Walleye	*Sander vitreus*
Water shrew	*Sorex palustris*
Western toad	*Bufo boreas*
Western whiptail	*Cnemidophorus tigris*
Yellow perch	*Perca flavescens*
Invertebrates	
Blind cave leiodid beetle	*Glacicavicola bathyscioides*
Bliss Rapids snail	*Taylorconcha serpenticola*
Desert valvata	*Valvata utahensis*
Fairy shrimp	Order: Anostraca
Idaho dunes tiger beetle	*Cicindela waynei*
Idaho point-headed grasshopper	*Acrolophitus pulchellus*
Mountain pine beetle	*Dendroctonus ponderosae*
New Zealand mudsnail	*Potamopyrgus antipodarum*

Common Name	Scientific Name
Invertebrates continued	
Pinyon ips beetle	*Ips confusus*
Snake River physa	*Physa natricina*
Whitepine blister rust	*Cronartium ribicola*

Appendix G.2. Acronyms used in the Monitoring Plan and their definitions

Acronym	Definition
AIC	Akaike's Information Criterion
AIRS	Aerometric Information Retrieval System
ARD	Air Resources Division
ATR	Agreements Technical Representative
BIHO	Big Hole National Battlefield
BLM	Bureau of Land Management
BOD	Board of Directors
CESU	Cooperative Ecosystem Studies Units
CIRO	City of Rocks National Reserve
CRMO	Craters of the Moon National Monument and Preserve
DEQ	Department of Environmental Quality
EMAP	Environmental Monitoring and Assessment
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency
EPMT	Exotic Plant Management Team
FOIA	Freedom of Information Act
FY	Fiscal Year
GIS	Geographic Information Systems
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GRYN	Greater Yellowstone Network
GTR	General Technical Report?
HAFO	Hagerman Fossil Beds National Monument
I&M	Inventory and Monitoring
IDFG	Idaho Department of Fish and Game
IMP	Information Management Plan
IMPROVE	Interagency Monitoring of Protected Visual Environments Program
INL	Idaho National Engineering and Environmental Laboratory
ISGAC	Idaho Sage Grouse Advisory Committee
IT	Information Technology
JODA	John Day Fossil Beds National Monument
LAN	Local Area Network
LARO	Lake Roosevelt National Recreation Area
MIIN	Minidoka National Monument
NADP	National Atmospheric Deposition Program
NAS	Network Attached Storage
NAST	National Assessment Synthesis Team
NCPN	Northern Colorado Plateau Network
NEPE	Nez Perce National Historical Park
NOAA	National Oceanic and Atmospheric Administration
NPCA	National Parks and Conservation Association
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
PACN	Pacific Islands Network
PCB	Polychlorinated Biphenyls
PDO	Pacific Decadal Oscillation
PI	Principal Investigator
PIBO	Pacfish/Infish Biological Opinion Effectiveness Monitoring Team

Acronym	Definition
PWR	Pacific West Region
QA/QC	Quality Assurance/Quality Control
SAC	Science Advisory Committee
SGCN	Species of Greatest Conservation Need
SOPs	Standard Operating Procedures
sp.	Species (singlar)
spp.	Species (plural)
ssp.	Subspecies
TMDL	Total Maximum Daily Loads
TNC	The Nature Conservancy
UCBN	Upper Columbia Basin Network
US	United States
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USFS	United States Forest Service
USGS	United States Geological Survey
VIP	Very Important Person
WAN	Wide Area Network
WASO	Washington Office (NPS)
WHMI	Whitman Mission National Historic Site
WRD	Water Resources Division

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

NPS D-025, July 2007

National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov