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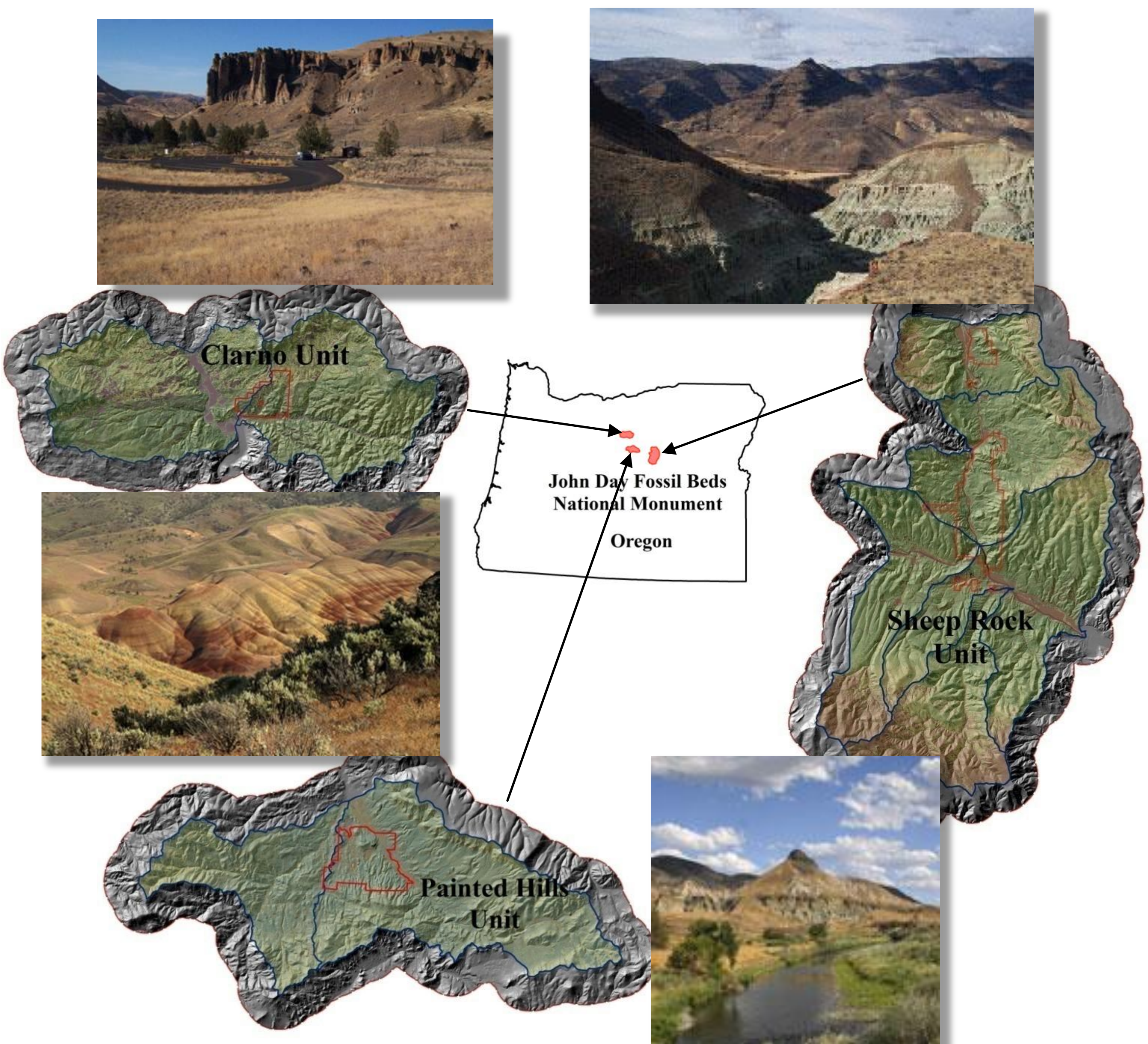
Natural Resource Condition Assessment

John Day Fossil Beds National Monument

Natural Resource Report NPS/UCBN/NRR—2010/174



ON THE COVER
Map of three park units in the John Day Fossil Beds National Monument located in north-central Oregon with insets of pictures from the John Day Fossil Beds National Monument website.

Natural Resource Condition Assessment

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January 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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The Natural Resource Report Series is used to disseminate 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.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Please cite this publication as:

Bell, J. and D. Hinson. 2010. Natural resource condition assessment: John Day Fossil Beds National Monument. Natural Resource Report NPS/UCBN/NRR—2010/174. National Park Service, Fort Collins, Colorado.

NPS 177/100904, December 2010

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Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue (p. xv) for more information.

Executive Summary

This Natural Resource Condition Assessment (NRCA) report and accompanying geodatabase is designed to give the resource managers of John Day Fossil Beds National Monument (JODA) a better understanding of the condition of natural resources within and adjacent to their park. Assessment of the natural resources was accomplished by conducting a thorough literature review, evaluating existing data, and also collecting new data on areas of the park where sufficient, reliable data for an assessment was not available. Aquatic and upland habitats were assessed and treated separately in the report. Selected threats and stressors to JODA's natural resources were evaluated for the entire park. Information gained from this report will form the basis for development of actions to reduce and prevent impairment of JODA's natural resources and assist in the development of desired future conditions through park planning processes.

The study identified 3 project areas composed of 6th level Hydrologic Unit Code (HUC) watersheds surrounding each park unit with a 2 km buffer. All available geographical information (GIS) was acquired for the project area to create an ArcGIS Map Project File and Geodatabase. This product is used to make all maps used in the report and analysis of geographically based data. All site-specific data was compiled in GIS. Upland data is available in digital database and the aquatic data is attached to this report. Maps and pictures were provided for each upland and aquatic sample site along with a description of the site and assessment of condition.

Upland sites were sampled at 25 sites distributed in 3 park Units; Sheep Rock, Painted Hills, and Clarno. All were evaluated based on the ecological site, as defined by soil type, and an established reference condition (Pellant 2005). Each ecological site received a 5 level rating for condition in 3 landscape attributes; soil stability, hydrologic function, and biotic integrity. Overall, the soil stability and hydrologic function attributes were in good condition, with all but one site rated none-slight departure from reference conditions. The biotic integrity attribute indicated many areas are not in good condition. Only 5 sites were rated in the none-slight departure category (<21%), 9 fell into the slight-moderate category (21%-40%), and 11 in the moderate category (41%-60%). The main reason for the poor condition was attributed to past land use practices, the presence of noxious weeds, and wild/prescribed fires.

Evaluation of on-site aquatic resources at JODA included an assessment of instream condition and water quality of the John Day River, Rock Creek, and Bridge Creek based upon benthic macroinvertebrate (BMI) indicators. BMI data were analyzed using an Eastern Oregon Benthic Index of Biotic Integrity (IBI) developed for northeastern Oregon. An on-site wetland condition assessment was conducted within JODA in 2007 (NPS 2008) and included riparian (or riverine) wetlands. As such, additional riparian evaluations were not conducted as part of this study. Instead, BMI sites evaluated as part of this study were selected to overlap with riverine wetland sites assessed as part of the 2007 study in an effort to identify a relationship between instream and riparian condition.

IBI scores ranged from 18 to 28 among the 6 samples. These scores fall into the ―high" or ―severe" impairment classes using current impairment-class categories for eastern Oregon. While Oregon DEQ has used this index to evaluate ecological conditions in eastern Oregon streams

outside of the Grande Ronde basin, they do not refer to this index as the eastern Oregon index because of its limited applicability. The Rock Creek site, R15, and John Day River Site, R14B, received the highest IBI scores of 28, while Bridge Creek received the lowest score of 18.

Based on the Eastern Oregon IBI, Hilsenhoff Biotic Index (HBI) values for the 6 sites ranged from 3.0 to 4.6, which correspond to good-excellent water quality conditions and minimal organic pollution. This translates to minimal organic decomposition and oxygen consumption resulting in moderate-high dissolved oxygen concentrations for fish. The Rock Creek site, R15, received the highest quality HBI score of 3.0, while the John Day River, R14A, received the lowest quality score of 4.6.

Past studies identified 25 noxious or invasive species as either potentially or physically existing in the park. Of these only 3 have not physically been identified through data collection projects reviewed for this report. Of the 25, 19 are listed as Class B noxious weeds by the Oregon State Weed Board and yellow starthistle is the only one classified as high priority for control, Class T. Accurate mapping of weeds on surrounding lands would allow JODA's staff to be more strategic in the noxious weed management by being prepared for possible new invaders and cooperating on control of existing species. Cooperation with adjacent landowners, private and public, is the most effective method to prevent and control noxious weeds. To this end, JODA is a member of the recently formed Grant County Weed Management Area, which has members of local, state, federal, and private organizations.

Climate in the Pacific Northwest is predicted to have warmer, wetter winters with an increase of 3.1° F. by 2030 and 5% increase in precipitation (Mote et al. 2005). Precipitation is predicted to come more in the form of rain with smaller snow packs with seasonal stream flows shifting markedly toward larger winter and spring flows and smaller summer and autumn flows. The 43 sub-basins in the Columbia River basin have their own sub-basin management plans for fish and wildlife but none comprehensively addresses reduced summertime flows under climate change. Possible impacts to ecosystem processes, communities, and/or species can only be addressed through future natural resource planning and enhanced monitoring programs based on the predicted climate changes.

Overall, JODA has many future challenges to achieve the stated desired goal for resource management (NPS 2006). Results of this report should assist park managers in identifying when, where, and how to improve management practices, justify additional resources, and prepare for the changes in environment that will directly impact JODA natural and cultural resources.

Acknowledgements

We wish to begin by thanking Shirley Hoh, Natural Resource Manager at John Day Fossil Beds National Monument for her time and courteous help in all stages of the project. Ms. Hoh was extremely helpful providing pertinent information to field crews on access points in the park. We owe a great deal of appreciation to our dedicated field staff, including Drake Barton and Kathy Elliot, Northwest Management, Inc., and Nicole Neumiller and Gerald Ladd of AMEC. Vaiden Bloch, GIS Specialist, with Northwest Management, Inc. was invaluable in preparing the Geodatabase and map project files. We would like to thank the many staff at Northwest Management, Inc. for their edits and insightful comments on the manuscript, especially Diane Corrao, Administrative Manager. Finally, we are very thankful for all the support and help from Lisa Garrett, NPS Upper Columbia Basin Network, and Jason Lyon, NPS Nez Perce National Historical Park. They had the vision to develop and implement this project and the professionalism and dedication to guide it to completion.

Prologue

Publisher's Note: This was one of several projects used to demonstrate a variety of study approaches and reporting products for a new series of natural resource condition assessments in national park units. Projects such as this one, undertaken during initial development phases for the new series, contributed to revised project standards and guidelines issued in 2009 and 2010 (applicable to projects started in 2009 or later years). Some or all of the work done for this project preceded those revisions. Consequently, aspects of this project's study approach and some report format and/or content details may not be consistent with the revised guidance, and may differ in comparison to what is found in more recently published reports from this series.

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Introduction

Purpose and Scope

The mission of the National Park Service is ―to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (National Park Service 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (National Park Service 1999). Through the challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The Upper Columbia Basin Network (UCBN) consists of nine widely separated NPS Units located in western Montana, Idaho, eastern Washington, and central Oregon. Parks of the Upper Columbia Basin Network include: Big Hole National Battlefield (BIHO), City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), John Day Fossil Beds National Monument (JODA), Lake Roosevelt National Recreation Area (LARO), Minidoka Internment National Monument (MIIN), Nez Perce National Historical Park (NEPE), and Whitman Mission National Historic Site (WHMI).

As part of the Natural Resource Challenge, the NPS Water Resources Division received an increase in funding to assess natural resource conditions in national park Units. Management oversight and technical support for this effort is provided by the division’s Watershed Condition Assessment (WCA) Program. The WCA Program partnered with the Pacific West Region to fund and oversee an assessment at each park in the Upper Columbia Basin Network (UCBN). This report documents the results of the Natural Resource Condition Assessment (NRCA) completed for the John Day Fossil Beds National Monument (JODA).

Natural resource condition assessments are broad-scope ecological assessments intended to synthesize ―information products” readily usable by park managers for: a) resource stewardship planning and b) reporting to performance measures such as the DOI Strategic Plan’s ―land health” goals. Three elements are key to making these assessments useful for both planning and performance reporting:

1. Build on data, information, and knowledge already assembled through efforts of the NPS Inventory and Monitoring Program, NPS science support programs, and from partner collaborators working in and near parks;
2. Emphasize a strong geospatial component for how the assessment is conducted and in the resulting information products;
3. Provide narrative and/or semi-quantitative descriptions of science-based reference conditions for park resources that will assist parks as they work to define Desired Future Conditions through park planning processes. These reference conditions will become more refined and quantitative over time.

Information gained from this report will form the basis for development of actions to reduce and prevent impairment of park resources through park and partnership efforts. The goals of the natural resource condition assessment are to:

- Determine the state of knowledge concerning overall natural resource condition
- Identify information gaps and resource threats
- Assess overall ecosystem health
- Set the stage to establish the context for management actions and collaboration

This report is designed to give park staff a moment-in-time assessment of the natural resources of JODA. This report will describe the natural resources of the park (both aquatic and upland), determine the state of knowledge on their condition using existing data or new data collected at priority sites for this project, identify information gaps, draw conclusions or hypotheses on the condition of natural resources (unknown, degraded, unimpaired), identify resource threats or potential issues affecting ecosystem health, and recommend further studies.

Study Area

Park Setting

Within the heavily eroded volcanic deposits of the scenic John Day River basin is a well-preserved fossil record of plants and animals. The fossil record spans more than 40 of the 65 million years of the Cenozoic Era (the "Age of Mammals and Flowering Plants") and is known throughout the world. John Day Fossil Beds National Monument (JODA) was authorized by Congress on October 26, 1974, and established in 1975. The park's purpose is to identify, interpret, and protect the geologic, paleontological, natural, and cultural resources along the mainstem of the John Day River and to provide facilities that will promote and assist visitor recreational enjoyment and understanding of the monument.

JODA covers 14,056 acres and is geographically divided into three widely separated Units; the Sheep Rock Unit, the Painted Hills Unit, and the Clarno Unit. Sheep Rock is the largest Unit, located a few miles northwest of Dayville in Grant County, Oregon. The next biggest Unit is Painted Hills, lying 10 miles northwest of Mitchell in adjacent Wheeler County. Also in Wheeler County, is the smallest Unit, Clarno, which is approximately 20 miles southwest of Fossil, Oregon. All three Units support similar plant communities, though individual species in these communities vary from Unit to Unit. The plant communities are classified as "intermontane sagebrush steppe" with a mixture of dryland grasses, forbs, shrubs and Western juniper (*Juniperus occidentalis*) (McAdams 1999).

The Sheep Rock Unit (8,916 acres) includes 3 subunits Sheep Rock, Cathedral Rock, and Foree and is bisected by the John Day River (Figure 1). The river meanders north through the gorge and traverses the length of the Unit. The flanks of these hills are composed of sagebrush, grasses, and juniper. Weathering and landslides have exposed raw earth colors that typify these paleosols and volcanically derived geologic formations. Six prominent groups of strata occur: the Rattlesnake, Mascall, Picture Gorge basalt, Clarno, Goose Rock, and John Day. Flora and fauna fossils of the Tertiary period have been found in the Sheep Rock Unit. This Unit also includes the 200-acre James Cant Ranch that includes ranch structures and hay fields, and the park's administrative offices. Cant Ranch is listed on the National Register of Historic Places as representative of local ranching activity. Approximately 74 acres of the ranch bottomlands are leased and continue to be irrigated and harvested for hay.

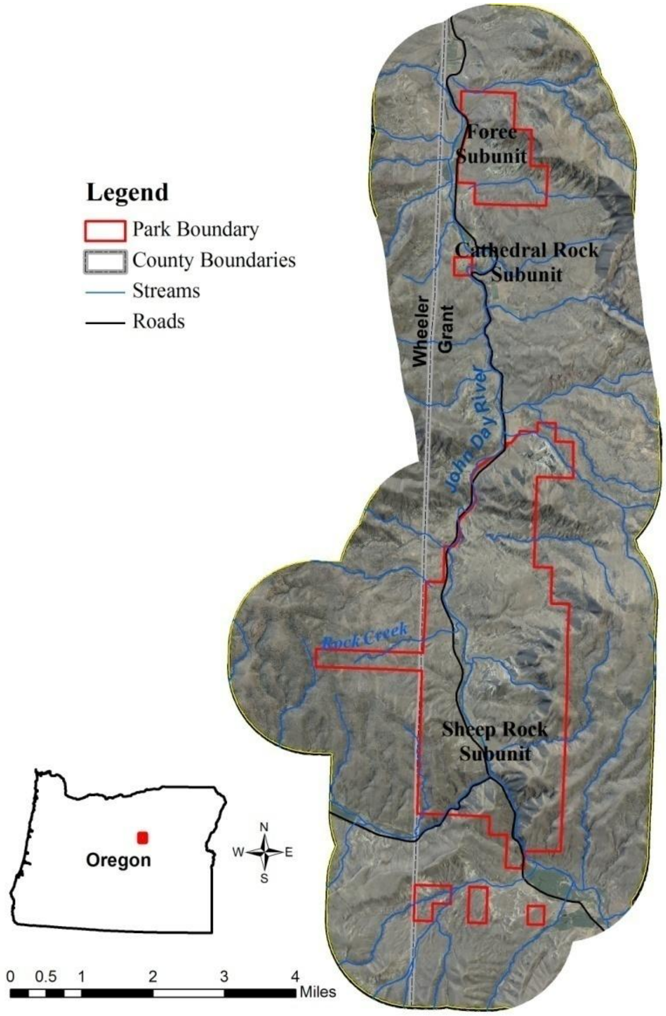

Figure 1. Map of the Sheep Rock Unit in JODA.

The Painted Hills Unit (3,129 acres) is a series of smoothly sculptured hills and ridges that are rounded, folded, and colored in deep pastel reds, golds, and buffs (Figure 2). The hills are virtually devoid of vegetation except for specially adapted flowering plants found in narrow draws. The Painted Hills include the oldest part of the John Day Formation - an intermediate age in the John Day Fossil Beds story. The multi-colored hills of this Unit result from volcanic ash depositions metamorphosed over time by physical and chemical interactions. Significant leaf imprint and mammalian fossils are found in this Unit. The formations of the Painted Hills Unit are extremely fragile and vehicular traffic is limited to maintained roads.

The Clarno Unit covers 1,969 acres and is the northernmost of the three Units. The most prominent feature is the towering palisades, rising sharply from the valley floor and forming craggy pinnacles (Figure 3). The palisades are a series of sharp cliffs, up to 150 feet high, formed from a series of volcanic ash-laden mud-flows. Located within the Unit is Camp Hancock, a 10

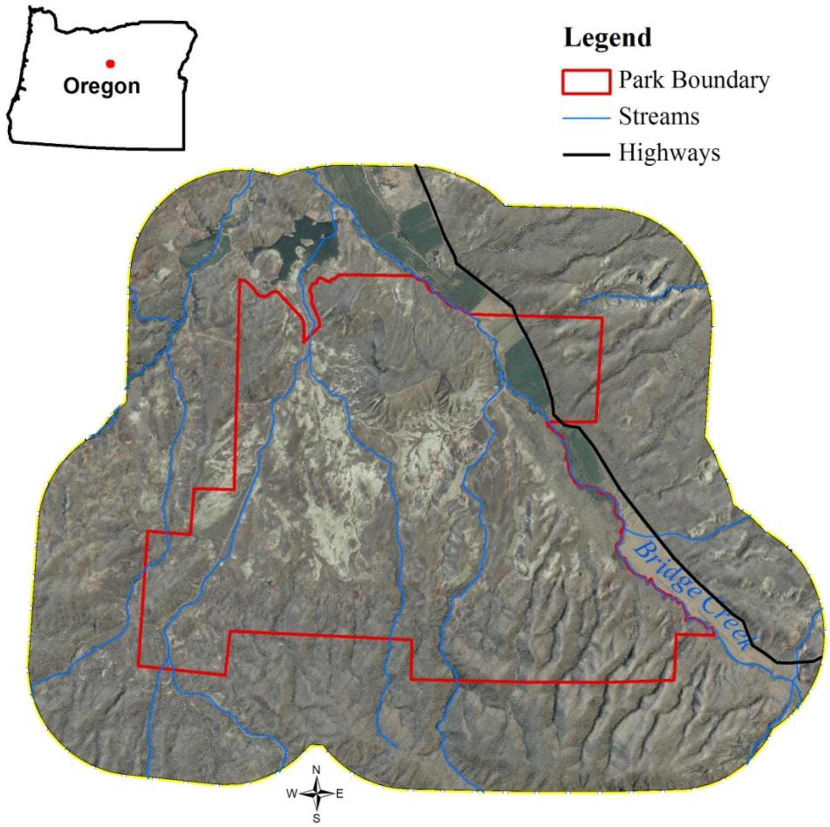

Figure 2. Map of the Painted Hills Unit in JODA.

acre facility owned and managed by the Oregon Museum of Science and Industry. The ground cover in the Clarno Unit is dominated by big sagebrush (*Artemisia tridentata*), scattered western junipers (*Juniperus occidentalis*) and grasses. Interest in this area has historically been centered upon the fossils of the Clarno nut beds and mammal quarry. The Clarno nut beds are an important occurrence because the plant remains are premineralized seeds and nuts (most fossil floras yield mainly impressions of leaves). The Clarno Mammal Quarry contains a good representation of large mammals.

Elevation at JODA ranges from approximately 1,380 feet in the Clarno Unit to a high point of approximately 4,114 feet along the eastern boundary of the Sheep Rock Unit. The majority of the monument, including much of the Painted Hills, lies within 2,000' to 2,500' elevation.

Eight plant species found in JODA are considered rare or threatened (Youtie and Winward 1977). These plants include John Day milkvetch (*Astragalus diaphanus*), pauper milkvetch (*Astragalus misellus var. misellus*), yellow hairy paintbrush (*Castilleja xanthotricha*), John Day chaenactis (*Chaenactis nevii*), Henderson's lomatium (*Lomatium hendersonii*), barrel cactus (*Pediocactus simpsonii var. robustior*), crested tongue penstemon (*Penstemon eriantherus var. argillosus*) and belled cinquefoil (*Potentilla glandulosa var. cinquefoil*).

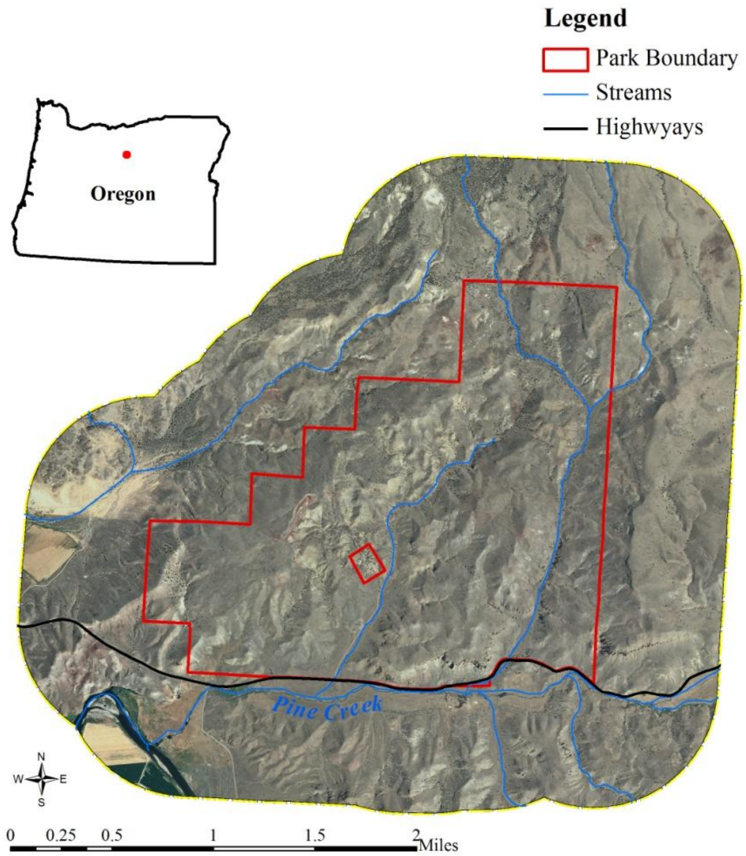

Figure 3. Map of the Clarno Unit in JODA.

A total of 5 species of amphibians and 12 species of reptiles were documented in the monument in 2002 and 2003 (Rodhouse et al. 2004). Only two expected species of herpetofauna, the pygmy short horned lizard and the rubber boa were not confirmed in JODA. A unique and isolated population of western whiptail lizard was found in the Foree portion of the Sheep Rock Unit.

Over 30 species of vertebrates listed as state or federal species of concern have been documented in JODA during recent inventories. However, only the bull trout (*Salvelinus confluentus*) and steelhead (*Oncorhynchus mykiss*) are listed as threatened under the federal Endangered Species Act.

From 1986 to 2008, over 110,621 people annually visited John Day Fossil Beds National Monument (Figure 4). Over half of the park's visitation occurs between May and September. A 2004 visitor study, conducted by the University of Idaho, found the majority of visitors to the park were there for the first time. An overwhelming number do not visit the park with a guided tour group, but rather travel on their own to view the spectacular scenery and world famous fossil beds. More than half of the park's visitors hail from Oregon with the remainder visiting primarily from neighboring states and a small percentage from other countries (NPS 2006).

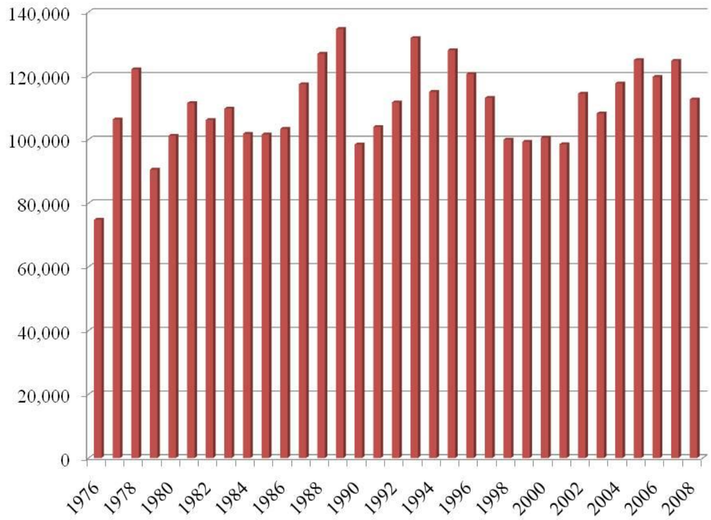

Figure 4. Visitor use per year for JODA from 1976-2008.

Land Cover

The primary vegetation type in JODA is sagebrush steppe consisting of sagebrush or shadscale and a variety of bunchgrasses. Moist alkaline flats support alkali-tolerant greasewood. Along the John Day River and tributaries that flow through the monument, vegetation consists of willows, cottonwoods, and a variety of sedges and forbs. Juniper woodlands are also an important vegetation type in the monument that has expanded over the past 100 years due to fire suppression.

Vegetation data was available from the LANDFIRE program (USFS and USGS 2008). Vegetation maps were created through predictive modeling using a combination of field reference information, 1999-2004 Landsat imagery, and spatially explicit biophysical gradient data. Map units were derived from National Vegetation Classification System (NVCS) Ecological Systems classification (Comer et.al. 2003). The data was clipped by the watershed boundaries (described in the following ―Watersheds" section), then summarized by class and mapped for each of the JODA Units watershed area.

The Clarno Unit watersheds (51,398 acres) are dominated by Wyoming sagebrush – bluebunch wheatgrass (*Pseudoroegneria spicata*) (32.51%) and Wyoming big sagebrush (*Aretimisia tridentata* spp. *wyomingensis*) (23.59%) with little agriculture or developed areas (Table 1, Figure 5). The Painted Hills watersheds (39,864 acres) are dominated by Big Sagebrush-bluebunch wheatgrass (*Agropyron spicatum*) (40.34%) and Wyoming big sagebrush (33.06%) also with less than 2% of the watersheds in agriculture or developed lands (Table 2, Figure 6). The Sheep Rock watersheds (113,429 acres) are dominated by big sagebrush-bluebunch wheatgrass (36.59%) and wyoming big sagebrush (13.63%) also with less than 3% of the watersheds in agriculture or developed lands (Table 3, Figure 7). Over 25% of the Sheep Rock watersheds are occupied by tree dominated vegetation, mainly ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*).

Table 1. List of ecological systems found in the JODA Clarno Unit watersheds.

NVCS Ecological Systems	Acres	Percentage
Agriculture	1,074	2.09%
Barren	214	0.42%
Big Sagebrush-Bluebunch Wheatgrass	16,712	32.51%
Bluebunch Wheatgrass	64	0.12%
Bluegrass Scabland	11,163	21.72%
Cottonwood-Willow	527	1.03%
Curlleaf Mountain-Mahogany	21	0.04%
Developed	541	1.05%
Idaho Fescue	139	0.27%
Interior Douglas-Fir	92	0.18%
Interior Ponderosa Pine	200	0.39%
Introduced Upland Vegetation - Herbaceous	3,508	6.82%
Low Sagebrush	2,708	5.27%
Mountain Big Sagebrush	448	0.87%
Rough Fescue-Bluebunch Wheatgrass	720	1.40%
Western Juniper-Big Sagebrush-Bluebunch Wheatgrass	853	1.66%
Wyoming Big Sagebrush	12,125	23.59%
Total	51,398	

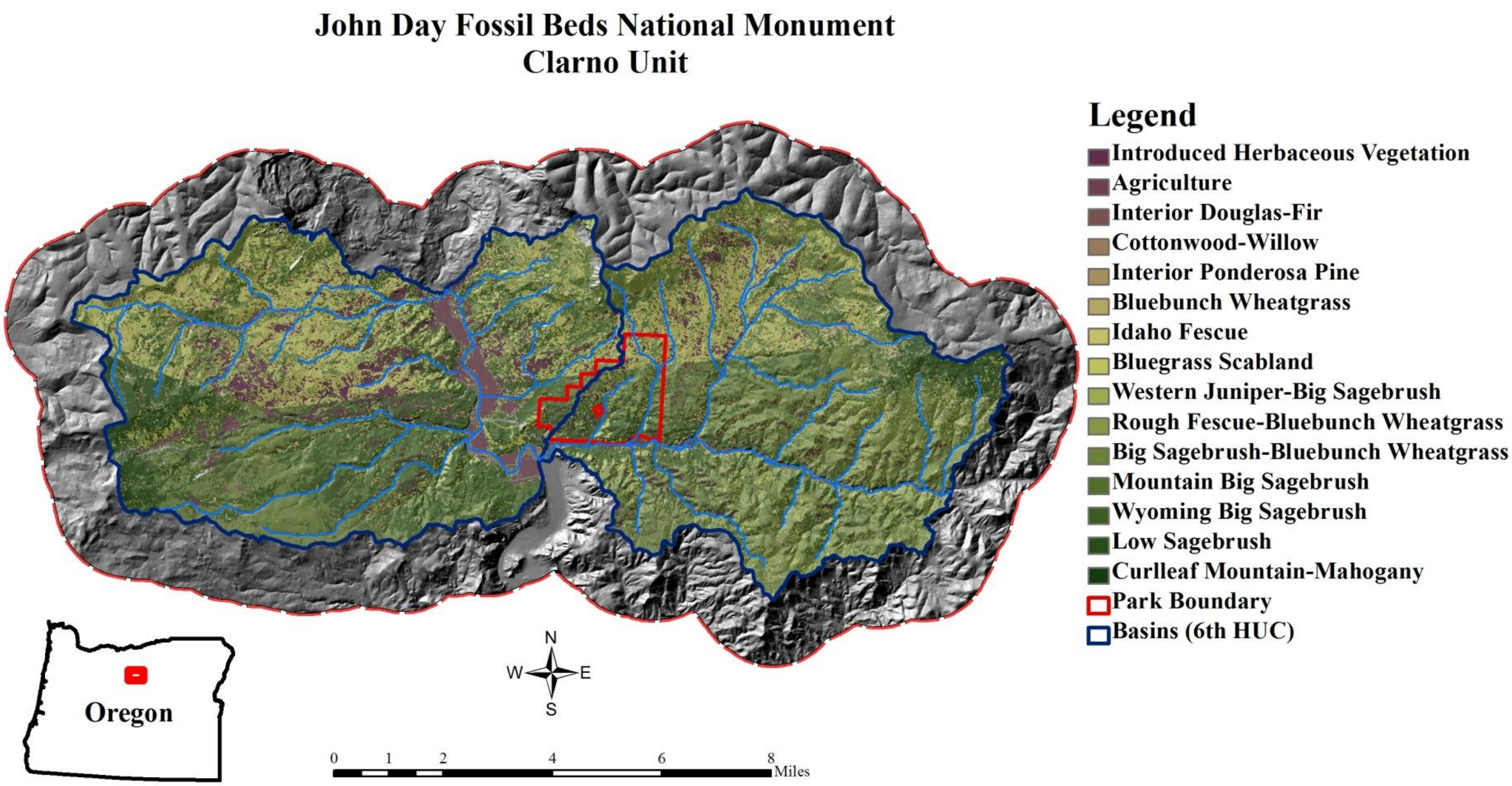

Figure 5. Map of NVCS Ecological Systems in the Clarno Unit watersheds.

Table 2. List of ecological systems found in the JODA Painted Hills Unit watersheds.

NVCS Ecological Systems	Acres	Percentage
Agriculture	478	1.20%
Barren	22	0.06%
Big Sagebrush-Bluebunch Wheatgrass	16082	40.34%
Bluebunch Wheatgrass	39	0.10%
Bluegrass Scabland	1674	4.20%
Cottonwood-Willow	172	0.43%
Curlleaf Mountain-Mahogany	13	0.03%
Developed	334	0.84%
Idaho Fescue-Bluebunch Wheatgrass	207	0.52%
Interior Ponderosa Pine	918	2.30%
Introduced Upland Vegetation - Herbaceous	2163	5.43%
Low Sagebrush	1594	4.00%
Mountain Big Sagebrush	28	0.07%
Saltbush-Greasewood	42	0.11%
Western Juniper-Big Sagebrush-Bluebunch Wheatgrass	2785	6.99%
Wyoming Big Sagebrush	13181	33.06%
Total	39,864	

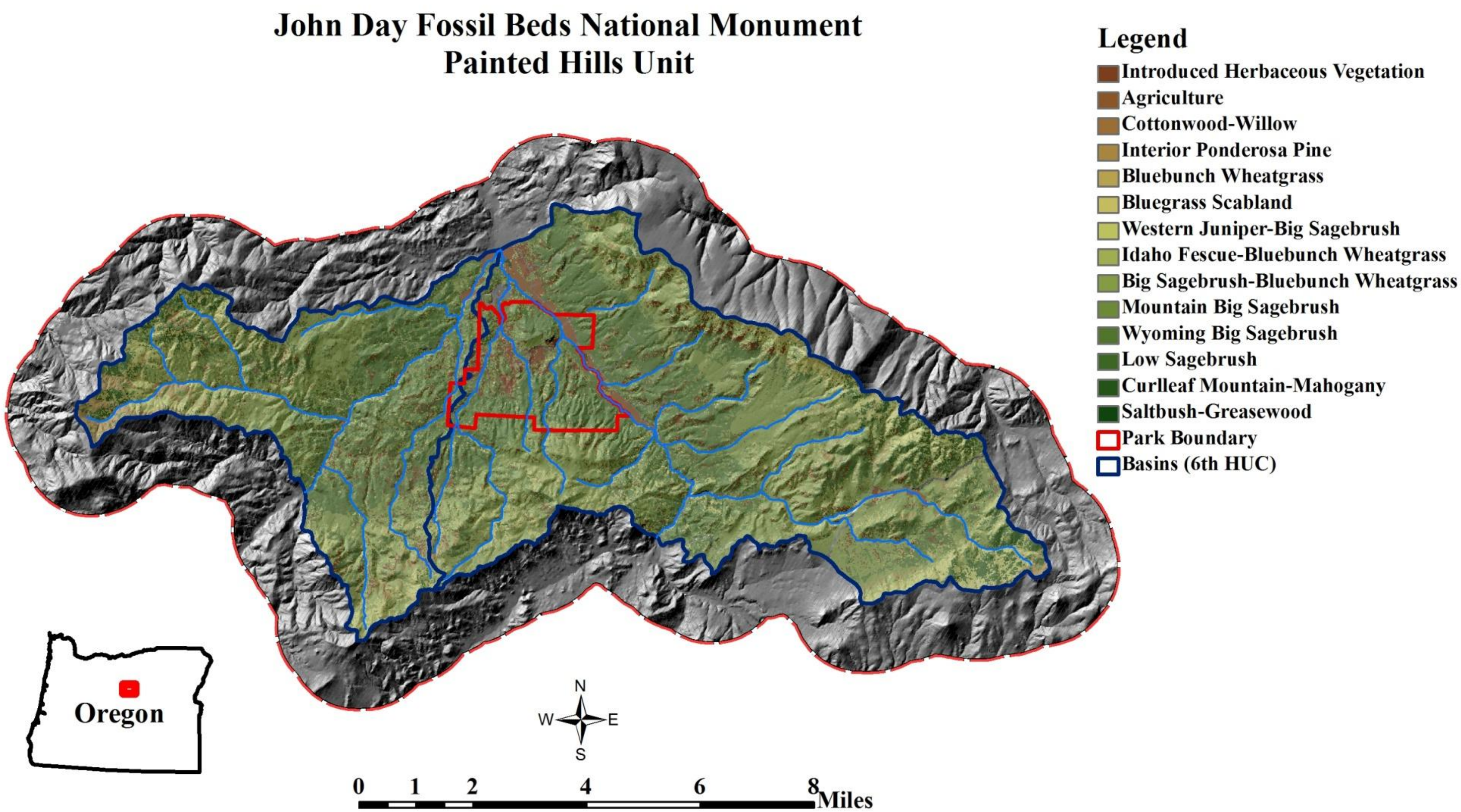

Figure 6. Map of NVCS Ecological Systems in the Painted Hills Unit watersheds.

Table 3. List of ecological systems found in the JODA Sheep Rock Unit watersheds.

NVCS Ecological Systems	Acres	Percentage
Agriculture	1518	1.34%
Aspen	963	0.85%
Barren	105	0.09%
Big Sagebrush-Bluebunch Wheatgrass	41509	36.59%
Bluebunch Wheatgrass	55	0.05%
Bluegrass Scabland	2994	2.64%
Cottonwood-Willow	1557	1.37%
Curlleaf Mountain-Mahogany	185	0.16%
Developed	1783	1.57%
Grand Fir	1550	1.37%
Idaho Fescue-Bluebunch Wheatgrass	619	0.55%
Interior Douglas-Fir	14134	12.46%
Interior Ponderosa Pine	11969	10.55%
Introduced Upland Vegetation - Herbaceous	1528	1.35%
Lodgepole Pine	263	0.23%
Low Sagebrush	5417	4.78%
Mountain Big Sagebrush	264	0.23%
Riparian	442	0.39%
Saltbush-Greasewood	93	0.08%
Sparsely Vegetated	123	0.11%
Water	64	0.06%
Western Juniper-Big Sagebrush-Bluebunch Wheatgrass	10685	9.42%
Wyoming Big Sagebrush	15461	13.63%
Total	113,429	

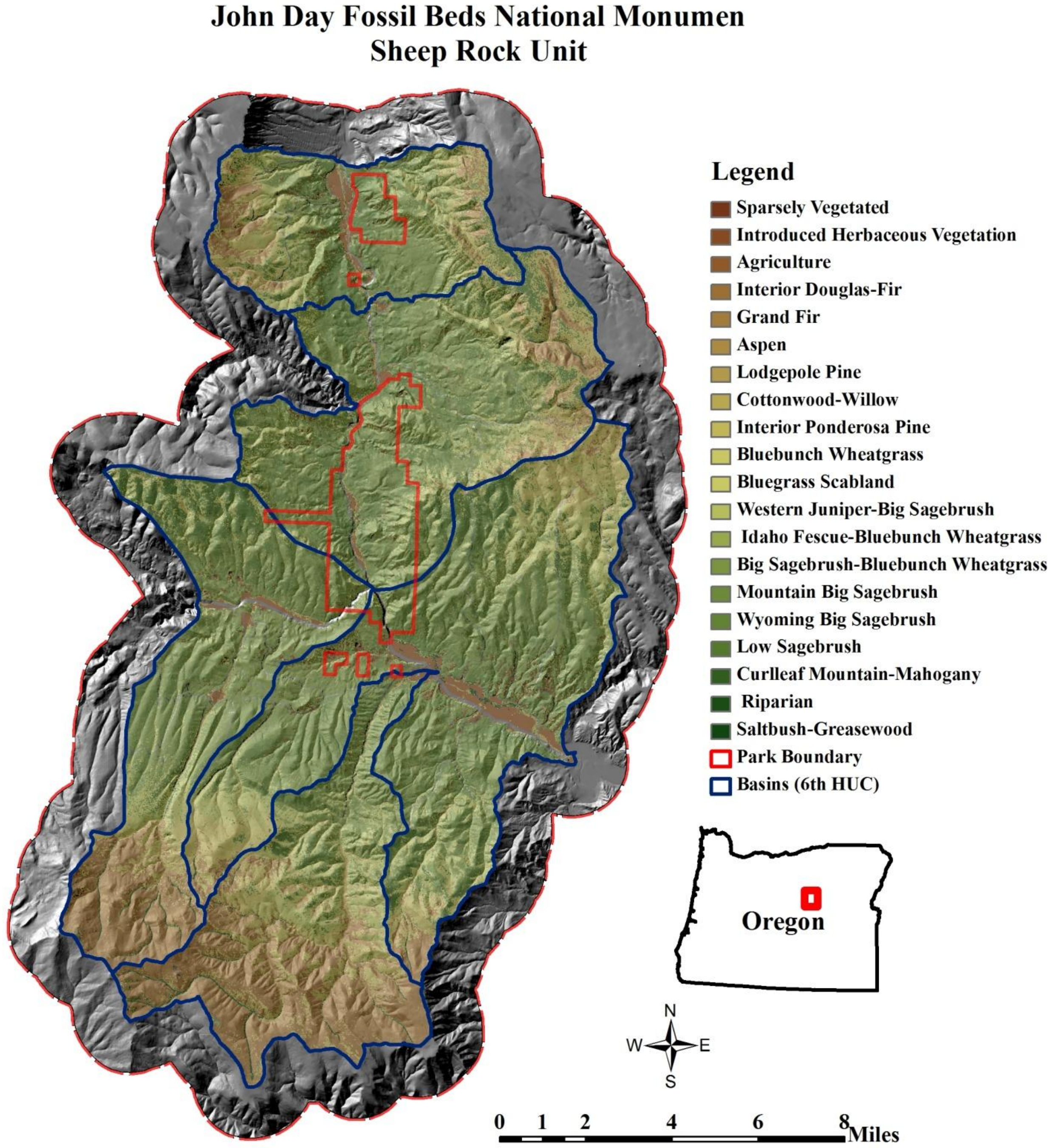

Figure 7. Map of NVCS Ecological Systems in the Sheep Rock Unit watersheds.

The estimates of existing vegetation within the park boundaries may have been modified by an intensive effort to restore the natural process of fire to the landscape. In 1998, a fire management plan was adopted by JODA that initiated a series of prescribed fires from 1999 to 2007 (McAdams1999). The plan was not to eradicate junipers, but to maintain the natural checks and balances that prehistorically developed this region into a grass/sagebrush community (NPS 2006). A total of 7,437 acres were burned by prescribed fire within the park boundaries during this period (Table 4). Many of the prescribed fires were cooperative efforts and the burn boundaries extended onto private and federal lands outside of JODA. There were 6 prescribed fires implemented in the Sheep Rock Unit and 1 in the Painted Hills Unit (Figure 8). The majority of the Clarno Unit experienced wildfires in 1994 and 1995.

Table 4. List of prescribed fires in JODA from 1999 to 2007.

Prescribed Fire Name	Unit	Date	Acres Burned in Park	Total Acres Burned
Windy Point	Sheep Rock	September 7-8, 1999	1,737	1,737
Picture Gorge	Sheep Rock	October 2, 2001	845	1,286
Sand Mountain	Painted Hills	September 20-22, 2002	1,762	5,351
Middle Mountain	Sheep Rock	September 24-25, 2002	1,120	3,380
Rock Creek	Sheep Rock	September 5, 2004	1,103	4,600
Branson South	Foree	September 1, 2005	800	800
Branson North	Foree	September 14, 2007	70	70

Most of the monument lands have been subject to livestock grazing for the past 100 years and other related agricultural uses. During this time fire suppression activities throughout the region have allowed for increases in big sagebrush and western juniper. Subsequently, many of the native plants, including grasses, have been severely reduced in their distribution. Population diversity has been reduced as well. Exotic species such as cheat grass (*Bromus tectorum*) have begun replacing the native grasses and forbs. Other introduced exotic species, such as knapweeds (*Centaurea spp.*), white top (*Cardaria draba*), and medusahead (*Taeniatherum caput-medusae)* are present and spreading. Dalmation toadflax (*Linaria dalmatica*) and yellow star-thistle (*Centaurea solstitialis*), listed noxious plants, can also be found in the monument and are a major concern for park weed management efforts.

Healthy remnants of native plant communities still exist within the monument. For example, well developed stands of bluebunch wheatgrass occur along many north-facing mesic slopes. Removal of livestock grazing on most of the monument has eliminated the potential for overgrazing. Within the historic zone of the monument, the agricultural fields are in good condition. Three agricultural fields in the Sheep Rock Unit (57 acres) are managed for hay production. Also, within the historic district is the remnant of a ―homestead orchard” that is managed to maintain the cultural landscape of an early ranch home.

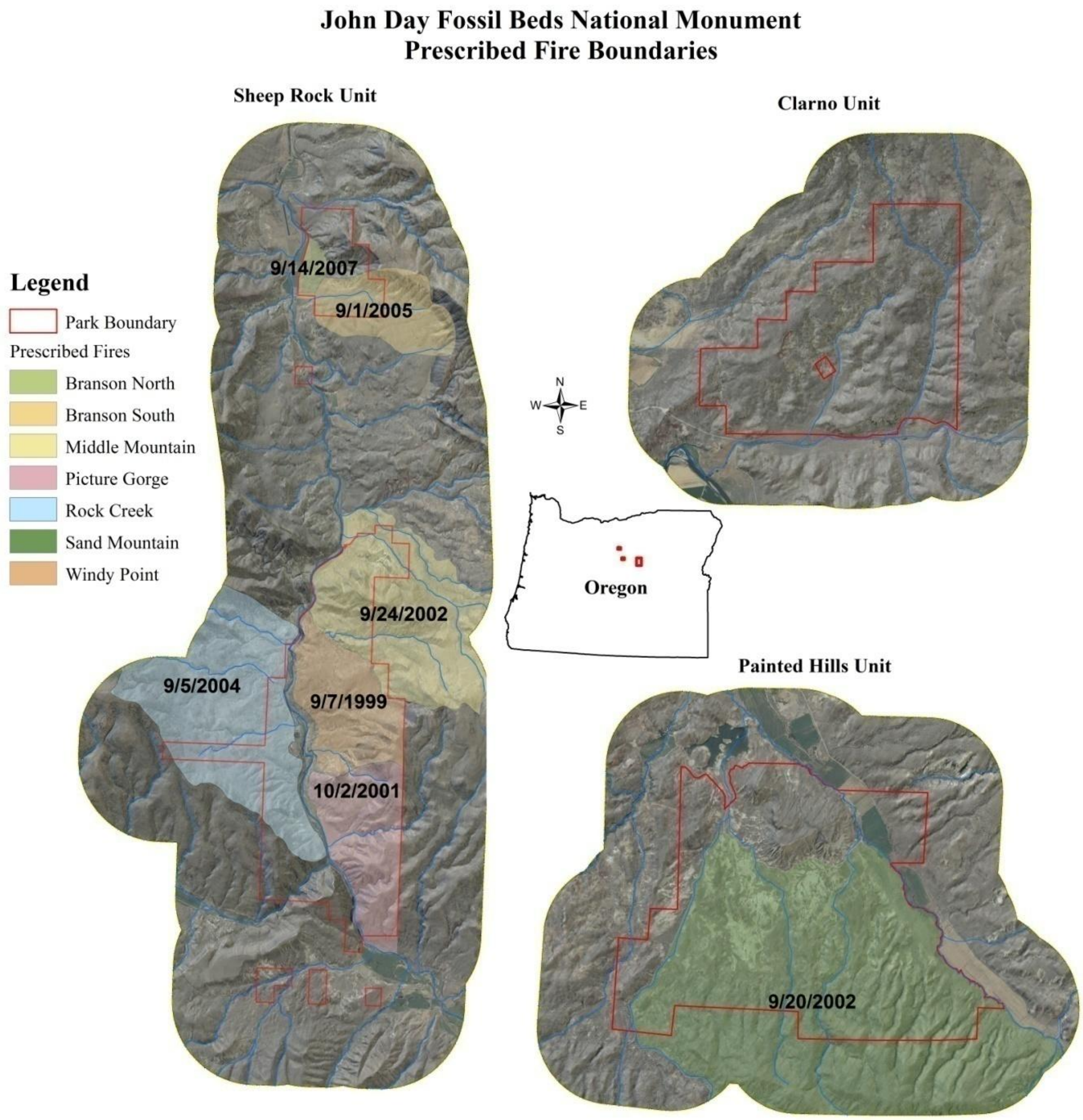

Figure 8. Maps of prescribed fire boundaries in the Sheep Rock, Clarno, and Painted Hills Units.

Upland Habitats/Species

Large mammals present in the monument include coyote (*Canis latrans*), mule deer (*Odocoileus hemionus)*, elk *(Cervus elephus*), mountain lion (*Puma concolor*), and bobcat (*Lynx rufus*). Smaller species include deer mouse (*Peromyscus maniculatus*), northern pocket gopher (*Thomomys talpoides*), Ord's kangaroo rat (*Dipodomys ordii*), Great Basin pocket mouse (*Perognathus parvus*), western harvest mouse, (*Reithrodontomys megalotis*), montane vole (*Microtus pennsylvanicus*), and bushy-tailed wood rat (*Neotoma cinerea*). Forty-six species of mammals were confirmed in the monument during 2002 and 2003 and one of these, the bighorn sheep (*Ovis Canadensis*), was not expected to occur there. All 14 species of bats expected to occur in the monument were documented. The discovery of the spotted bat (*Euderma maculatum*) in all 3 Units of the monument was unexpected and virtually unknown in Oregon (Rodhouse et al. 2004).

Numerous raptors occur in JODA, including the red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), prairie falcon (*Falco mexicanus*), American kestrel (*Falco sparverius*), great horned owl (*Bubo virginianus*), barn owl (*Tyto alba*), long-eared owl (*Asio otus*), and screech owl (*Otus kennicottii*). One hundred forty two species of birds have been confirmed in or adjacent to the monument (Rodhouse et al. 2004). During the 2002-2003 inventories, the first record of the peregrine falcon (*Falco peregrinus*) was made for JODA.

A deer population survey conducted in 1979 (Griffith 1980) concluded that there is a year-long resident population in JODA supplemented by a migratory wintering population. The winter population is present from November through April. Deer do not appear to make exclusive use of the monument as a refuge during hunting season since extensive vegetation exists on adjacent lands. Moderate predator control on adjacent lands may impact coyote and mountain lion populations within the park.

Watersheds

The John Day River basin drains approximately 5,067,500 acres (8000 mi^2) and is bound by the Columbia River to the north, the Blue Mountains to the east, the Aldrich Mountains and Strawberry Range to the south, and the Ochoco Mountains to the west. The John Day subbasin incorporates portions of Grant, Wheeler, Gilliam, Sherman, Wasco, Jefferson, Umatilla, Morrow, Crook, Harney, Baker, and Union Counties. The John Day River flows generally northwest for 284 miles from its origin in the Blue Mountains before joining the Columbia River at river mile (RM) 217.

River and stream drainages are uniquely identified by hydrologic unit codes (HUC). These are geographic areas based on surface topography containing a major river or a group of smaller rivers. The Pacific Northwest is number 17 of the 21 regions (HUC1) in the United States. The second level divides the 21 regions into 222 subregions. Subregions are areas drained by a river system, a reach of a river and its tributaries, a closed basin, or a group of streams forming a coastal drainage area. The third level subdivides the subregions into 352 basins. There are also 2,149 fourth level drainages, referred to as subbasins.

The John Day River basin is classified as a 3^{rd} level HUC with a number of 170702 (HUC3). The basin consists of four fourth level (HUC4) subbasins: the Upper John Day River (17070201), the North Fork John Day River (17070202), the Middle Fork John Day River (17070203), and the

Lower John Day River (17070204). These are further divided into 42 watersheds (HUC5) and 340 subwatersheds (HUC6). Figure 9 displays maps of the subwatershed boundaries (HUC6) in the Sheep Rock Unit (5 subwatersheds), Clarno Unit (2 subwatersheds), and Painted Hills Unit

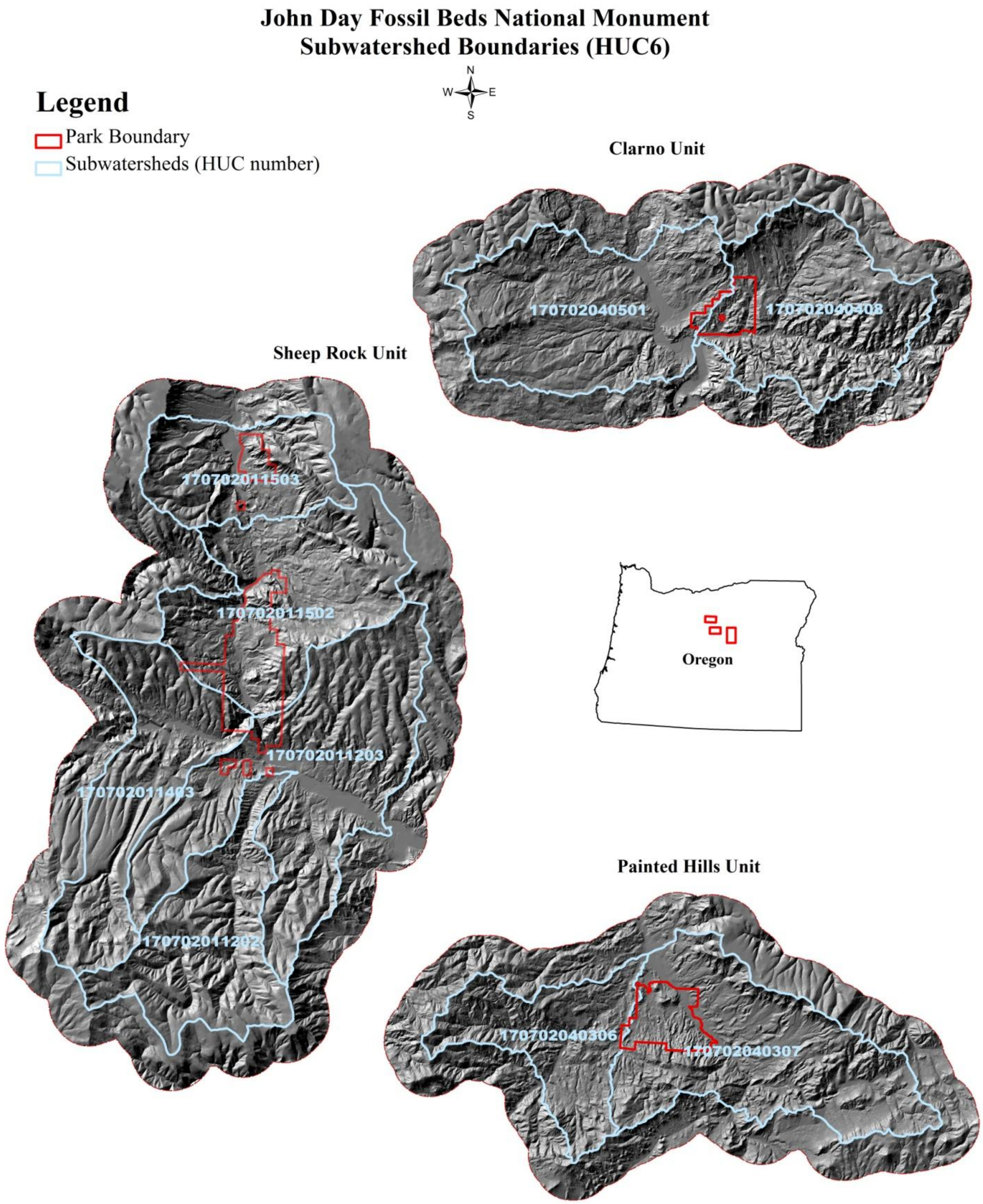

Figure 9. Maps of subwatershed (HUC6) boundaries in the Sheep Rock, Clarno, and Painted Hills Units project areas.

(2 subwatersheds) . The Sheep Rock Unit occupies 0.17% of the subbasin and 2.3% of the 6th level HUCs in the map project. The Clarno Unit occupies 0.04% of the subbasin and 3.8% of the 6th level HUCs in the map project. The Painted Hills Unit occupies 0.06% of the subbasin and 7.9% of the 6th level HUCs in the map project.

Most of the water in the John Day basin is derived from the upper watershed, primarily in the form of melting snow. Discharge from the free-flowing (no large-scale dams) John Day River is highly variable from peak to low flows. Flow data in the John Day River subbasin is currently being collected from 18 stations located on the river and various tributaries. The Oregon Water Resource Department (OWRD) operates and maintains 11 stream flow gauging stations. The USGS operates 6 and the BLM has assumed operation of one additional station. Historic gauging station stream flow data for all current stations as well as —real time" stream flows for some stations are available for download as average daily flows from the OWRD website at www.wrd.state.or.us. The USGS also publishes data from some of the stations in its annual report on stream flows in Oregon.

Stream flows on the mainstem John Day River are currently monitored at five locations: McDonald Ferry (RM 21), Service Creek (RM 157), Picture Gorge (RM 205), John Day (RM 253) and Blue Mountain Hot Springs (RM 275). Flows from the North Fork are monitored at a station near Monument (RM 16). Stream flows in the Middle Fork are recorded near Ritter (RM 15). Two stations are active on the South Fork: one near Dayville (RM 7) and the other near Izee (RM 34). Other streams currently being monitored include: Mountain Creek, Lone Rock Creek, Butte Creek, Murderer's Creek, Deer Creek, Canyon Creek, Strawberry Creek, Camas Creek and Bridge Creek.

The USGS-maintained gage at McDonald Ferry, Oregon (gage # 14048000), is the oldest gage in the subbasin and has been in operation since December 1904. The discharge measured at this station represents 7,580 square miles, or approximately 96% of the entire subbasin. Other long-standing gages in the subbasin include John Day River near John Day (#14038530), North Fork John Day River at Monument (#14046000), and John Day River at Service Creek (#14046500). As recorded at the McDonald Ferry station, the John Day River's mean annual discharge into the Columbia River is slightly more than 2,000 cubic feet per second (cfs). The average monthly discharge ranges from a high of 5,595 cubic feet/second (cfs) in April to a low of 178 cfs in September (Figure 10).

Peak stream flows in the John Day River usually occur from March through May while the seasonal low flows typically occur from August through October. The highest recorded discharge of the John Day River was 42,800 cfs on December 24, 1964, and was caused by warm rain melting large amounts of snow. The lowest recorded discharge from the McDonald Ferry station was zero cfs for part of September 2, 1966, August 15 to September 16, 1973, and August 13, 14 and 19 to 25, 1977. Peak flow at the McDonald Ferry gauging station is typically over 100 times greater than the lowest flows of the same year. From year to year, peak flows can vary as much as 300 to 700%. The hydrologic curve has shifted from historic times with peak flows greater than in the past and late season flows more diminished. It is suspected that these effects are due to greatly reduced rates of soil infiltration, reduced capacity for ground water/riparian storage, and diminished in-channel storage in beaver ponds (BPA 2005).

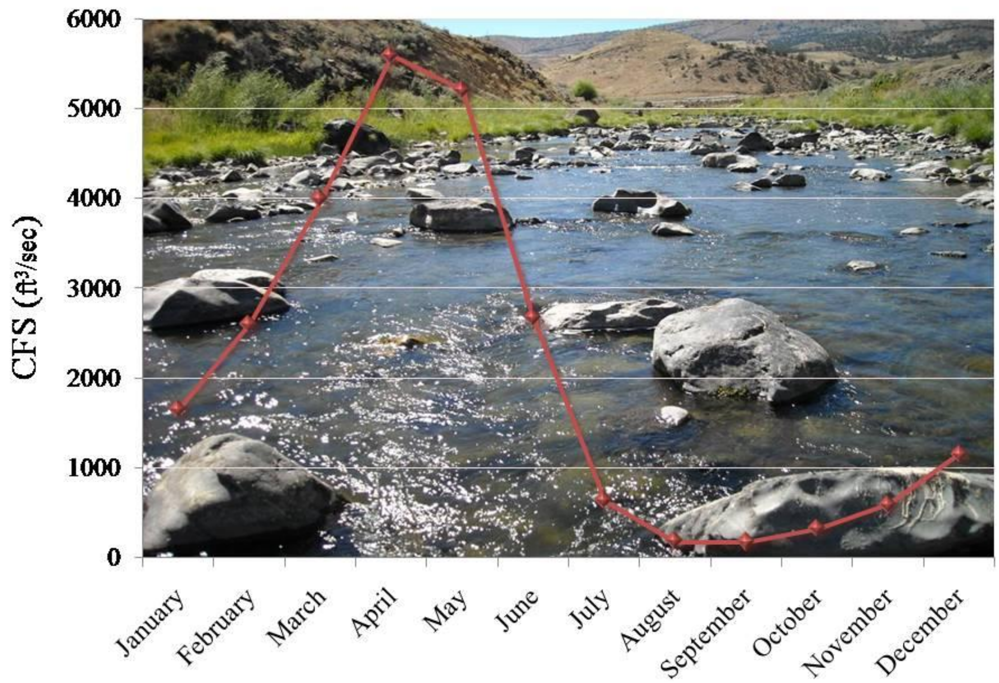

Figure 10. Average monthly flows (ft^3/sec) in the John Day River at the McDonald Ferry gaging station (#14048000) from 1906 to 2008.

Water quality standards are benchmarks established to assess whether river and lake quality is adequate to protect fish and other aquatic life, recreation, agriculture, industry, drinking water, and other uses. Water quality standards are also regulatory tools used by the Oregon Department of Environmental Quality (ODEQ) and the US Environmental Protection Agency (EPA) to prevent water pollution. States are required to adopt water quality standards by the federal Clean Water Act and to maintain a list of stream segments that do not meet the standards. This list is referred to as the 303(d) list, based on the applicable section of the Clean Water Act. The Clean Water Act requires states to develop water ability goals called Total Maximum Daily Loads (TMDL) along with an implementation plan and schedule to achieve the water quality goals for 303(d) listed water bodies**.**

The streams within the subwatersheds of the 3 JODA Units have segments listed for being water quality limited (Figure 12). Parameters include alkalinity, ammonia, chlorophyll a, dissolved oxygen, E Coli, fecal coliform, phosphate, sedimentation, temperature, pH, and others. These parameters are based on a beneficial use for cold water fish, recreation, and others. During the summer months from July to September, groundwater provides much of the base flow to the Lower John Day River. Many of the stream segments shown in Figure 12 have multiple parameters listed in the database. Although ODEQ has listed the lower section of the John Day River as water quality limited for temperature, other water quality constituents such as total phosphates, biochemical oxygen demand, and fecal coliform can also limit water quality during late summer when flows are the lowest and water temperatures are the greatest. Severe stream bank erosion and sedimentation exists in some tributaries. Most water quality problems in the John Day subbasin stem from vegetation disturbance, stream straightening and relocation, year-round livestock grazing, cumulative effects of timber harvest and road building, water withdrawals for irrigation and historical mining and dredging (BPA 2005).

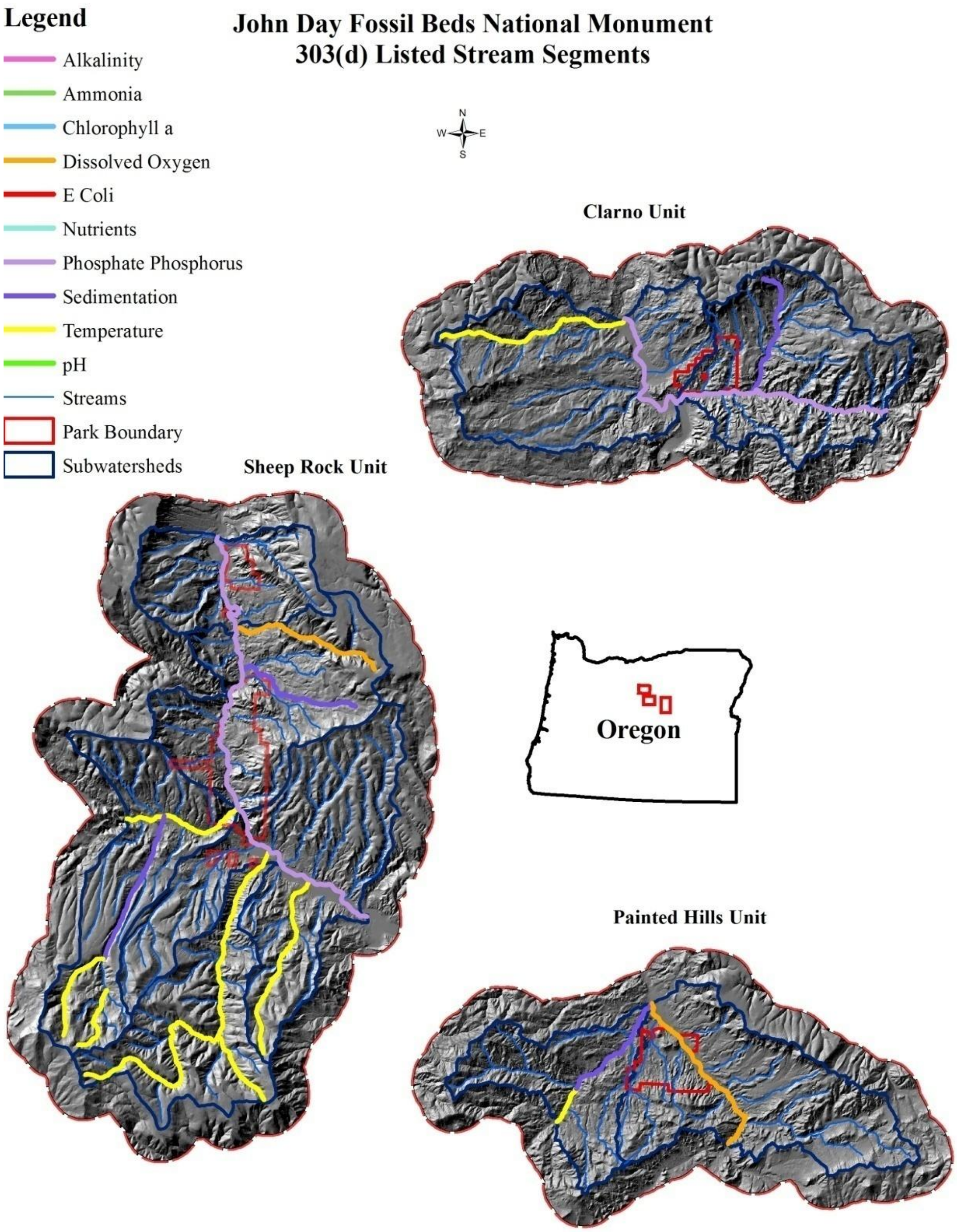

Figure 11. Maps of 303(d) stream segments that are water quality limited in the Sheep Rock, Clarno, and Painted Hills Units project areas.

Aquatic Habitats/Species
JODA presently lacks information to adequately assess the condition of fish populations within the monument. The Oregon Department of Fish and Wildlife have identified summer steelhead habitat in the project area basins, but did not list any streams as bull trout habitat (Figure 12). Recent efforts to improve riparian conditions within JODA are beneficial to fish populations. JODA is working cooperatively with the Bonneville Power Administration (BPA), National Oceanic and Atmospheric Administration Fisheries (NOAA), Bureau of Land Management (BLM), and Oregon Department of Fish and Wildlife (ODFW) on a restoration and monitoring project covering the lower 19 miles of Bridge Creek (NOAA 2007). Continuation of past agricultural practices such as year-round livestock grazing within riparian areas and clearing of all vegetation from the stream channels along the John Day River and Rock Creek above the monument likely threatens the condition of fish populations by raising temperatures and siltation levels.

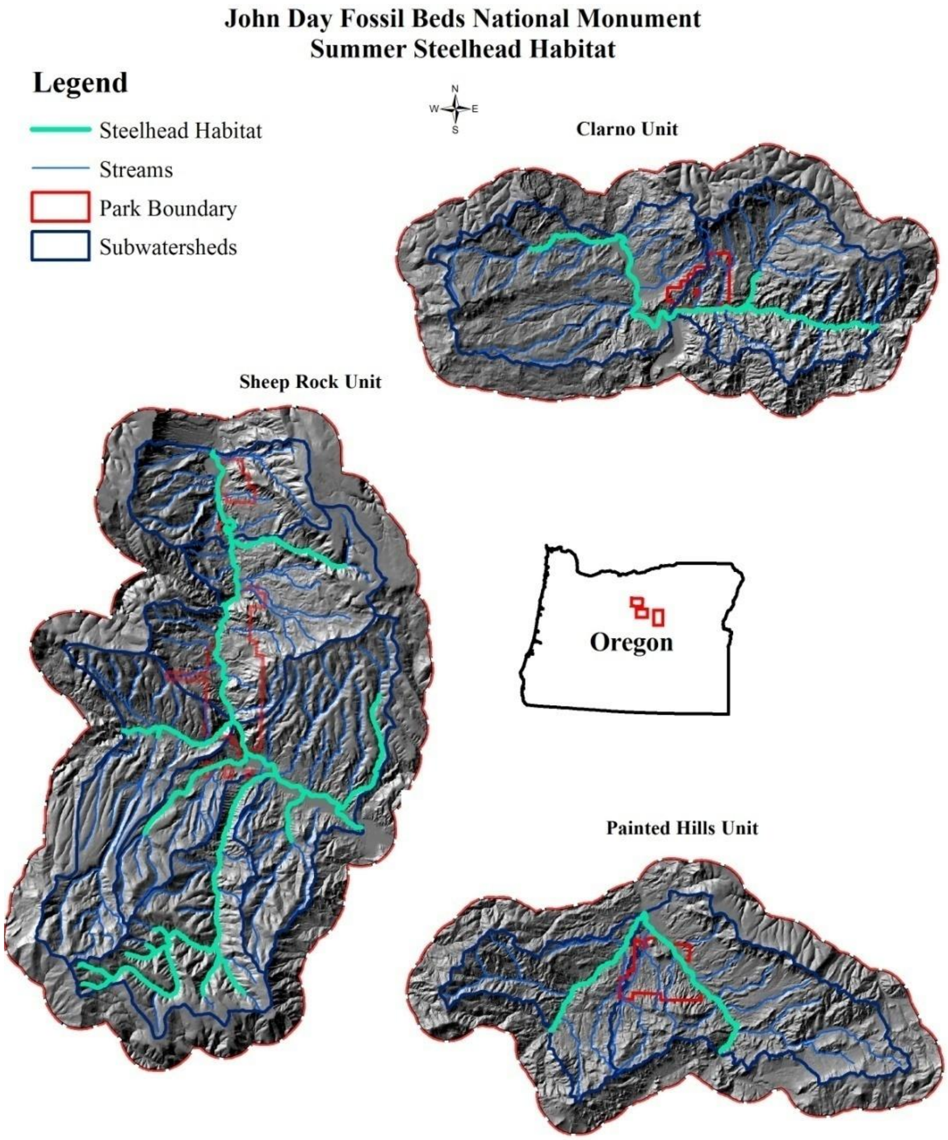

Figure 12. Maps of possible summer steelhead habitat in the Sheep Rock, Clarno, and Painted Hills Units project areas.

Climate

The extensive rain shadow cast by the Cascade and Ochoco mountains to the west dominates the climate of JODA. Winters are cool and dry and summers are hot and dry. Rainfall patterns are variable in the region, but most precipitation falls in the early spring and late fall. Long term averages (> 30 years) were available from the Western Regional Climate Center (http://www.wrcc.dri.edu/Climsum.html). Summary data was used from weather stations near Dayville; 8 miles east of the Sheep Rock Unit; Mitchell, 10 miles southeast of the Painted Hills Unit; and Fossil, 20 miles northeast of the Clarno Unit. The Sheep Rock Unit is the warmest in July and Clarno receives the most precipitation annually (Table 5). Data from the rain gauge at the monument headquarters indicate that rainfall there has been below average in recent years. Snowfall represents a significant proportion of the winter precipitation, but snowpack is ephemeral and rarely lasts more than a few days. Thirty-year January and July mean temperatures from Dayville are 36 and 71 degrees Fahrenheit, respectively. It is important to note that winter and summer temperature extremes frequently drop below freezing in the winter and rise above 100 degrees in the summer. Figures 13 and 14 show the distribution of temperature and precipitation zones within the project areas of each Unit.

Table 5. Summary of climate parameters at Dayville, OR (Sheep Rock Unit), Fossil, OR (Clarno Unit), and Mitchell, OR (Painted Hills Unit).

Area	Annual Mean Precipitation	Annual Mean Temperature (F)	January Average Maximum Temperature (F)	January Average Minimum Temperature (F)	July Average Maximum Temperature (F)	July Average Minimum Temperature (F)
Dayville, OR	11.36"	65.1°	43.0°	24.4°	88.9°	49.7°
Fossil, OR	14.42"	62.3°	41.7°	24.3°	85.2°	45.6°
Mitchell, OR	11.3"	62.9°	41.8°	23.8°	86.0°	49.9°

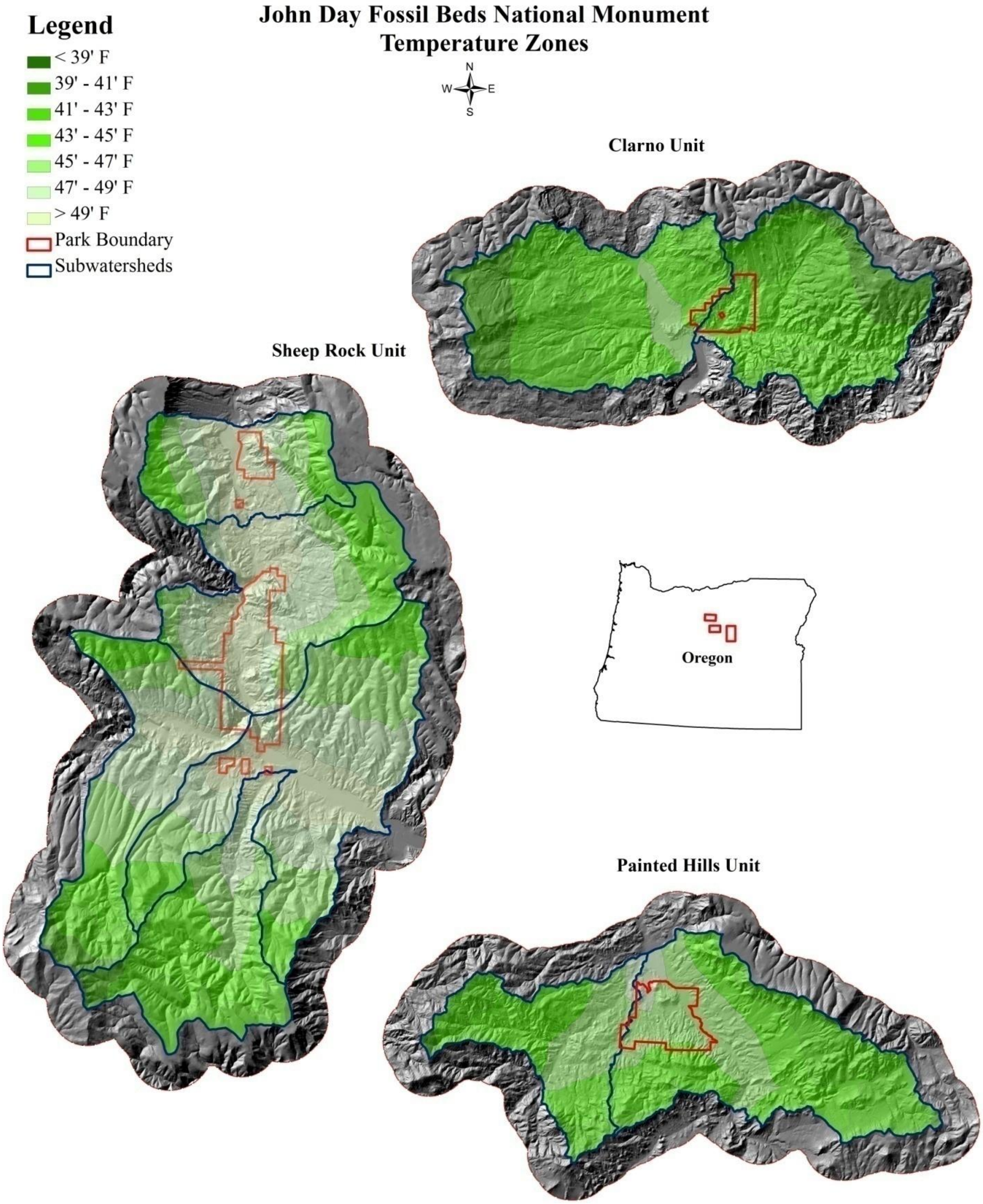

Figure 13. Maps of temperature zones (Fahrenheit) in the Sheep Rock, Clarno, and Painted Hills Units project areas.

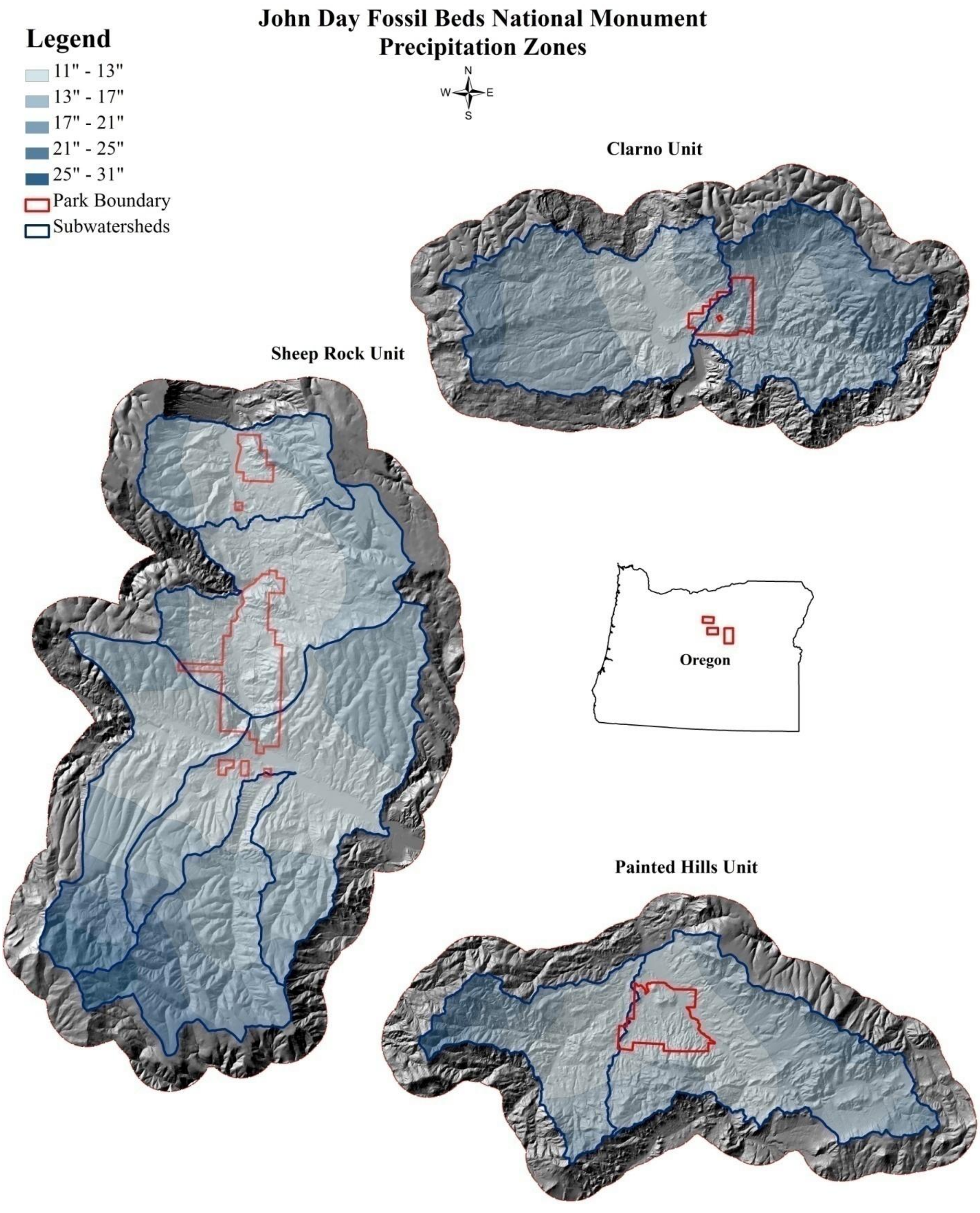

Figure 14. Maps of precipitation zones in the Sheep Rock, Clarno, and Painted Hills Units project areas.

Methods

GIS and Geodatabases

The majority of data used in this report is Geographical Information System (GIS) data in tabular form tied to spatial features, such as points, lines, and/or polygons. GIS software provides spatial analysis capabilities such as overlay, buffer, extraction, and modeling. Results can then be displayed in map and tabular form. GIS software ARCMap Version 9.3 was used to store, edit, and display data.

Map project files (Figure 15) were developed for JODA using ArcMap software that followed the behavioral rules for data in a single Microsoft Access database. Many types of geographic datasets can be collected within a map project file including feature classes, attribute tables, and raster data sets. The NPS ArcMap 8 1/2”x11” template was used in the 3 JODA map project files.

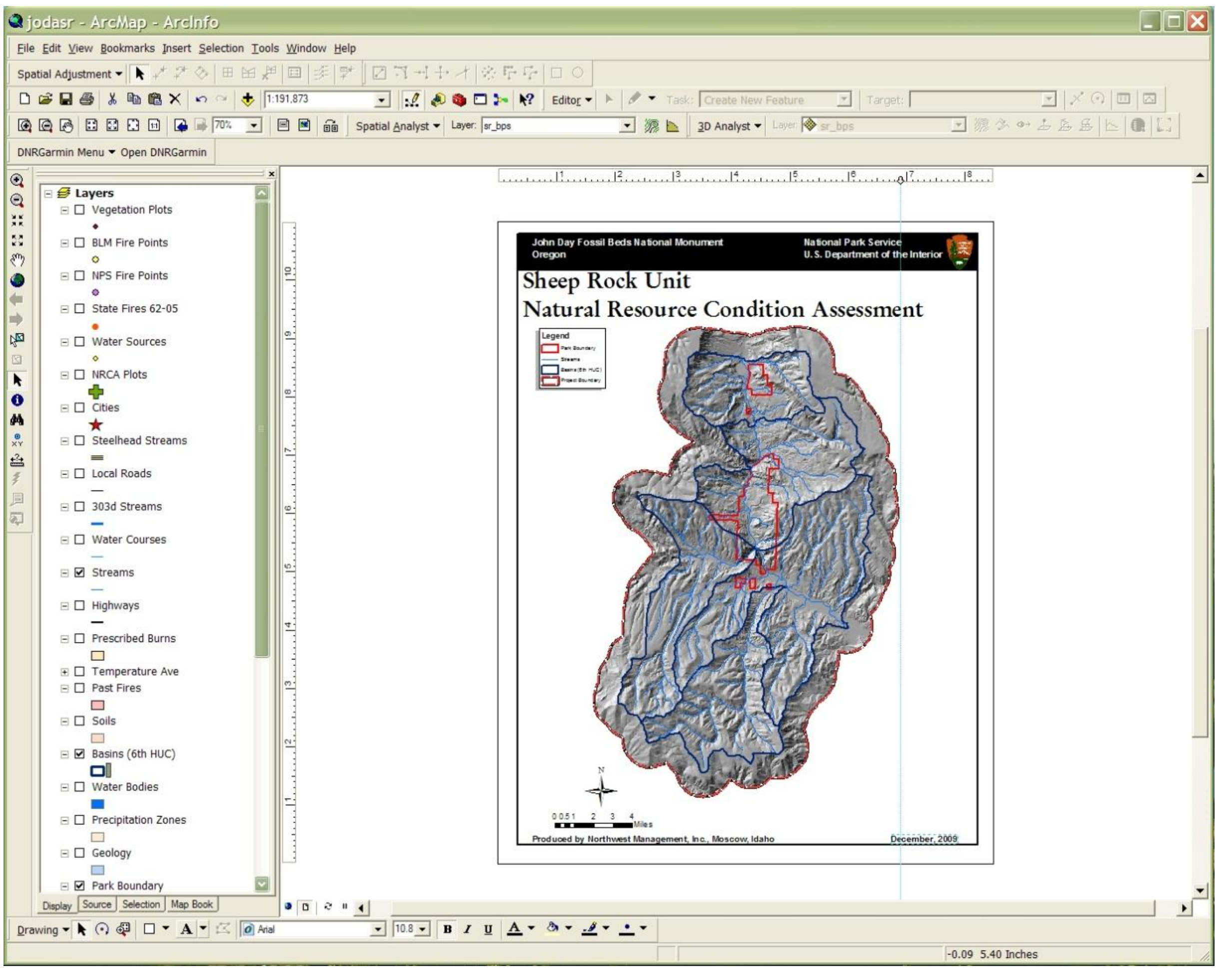

Figure 15. Screen capture of the ArcMap Project file for the JODA Sheep Rock project area.

Geographically defined project areas were created by selecting 6th level hydrologic unit code (HUC) watersheds surrounding the Sheep Rock, Clarno, and Painted Hills Units. A 2 kilometer buffer was added to each watershed for mapping purposes totaling 173,403 acres, 92,685 acres, and 79,394 acres, respectively, for each Unit. General base map layers and aerial photography were developed for the full project area extent. Most layers were clipped to the subwatershed basin for analysis and summarization of attributes.

The map project files were populated with GIS data through an extensive search of NPS sources and a multitude of local, state, and federal web sites. Data determined to be useful and accurate were re-projected into the North American Datum 1983 (NAD83) datum and the Universal Transverse Mercator (UTM) zone 11 projection for the Sheep Rock Unit and UTM zone 12 for the Clarno and Painted Hills Units. Metadata was generated for each layer in Federal Geographic Data Committee (FGDC) compliant format. Metadata describes the source, accuracy, data dictionary, projection, datum, and many other details about an individual layer. Aerial photography was processed and clipped to the project area using LizardTech GeoExpress software and converted into MG3 (MrSid Generation 3) format files.

Attribute information on the specific data layers clipped to the watershed basin extent were summarized in a spreadsheet based on the various attribute parts, lengths, acreage etc. of the various data layers in the map project files. The spreadsheets for each Unit can be found on the DVD under the respective Unit name and the subdirectory ―Project Summary.”

All GIS data layers were imported into an ArcGIS File Geodatabase using ArcCatalog ver. 9.3 (ESRI 2006). Feature Data Sets were created based on theme type. A geodatabase is an ArcMap file structure that stores geometry, spatial reference system, attributed datasets, network datasets, topologies, and many other features. This GIS format provides a uniform method for storing and using GIS data and provides the flexibility to add new information as it becomes available.

Map layers were organized into categories based on general theme type. Although data was not available for each theme type, the category directory is included to incorporate data that may become available in the future. The general themes used include:

- Air Resources
- Animal
- Climate
- Geography
- Geology
- Land Process
- Land Use
- Plant
- Stressors
- Water Resources

Aerial photography was not included in the geodatabase due to the limitations of processing MG3 file formats. Aerials are included in a separate directory outside the geodatabase. All the data, project file and summary table are included on a DVD disk for distribution with this report. As a by-product of this search, a Microsoft Access database (included on DVD) was created for websites with documented GIS data that could be downloaded in various formats compatible with ESRI's ArcMap software. The database has a custom query form for doing searches on the 3,000+ entries covering Oregon, Washington, and Idaho.

NPS Data Sources

Additional non-GIS data was acquired from searches on the internet, such as NPS NatureBib (https://science1.nature.nps.gov/naturebib), and from direct contact with local and state government agencies. Table 6 is the status of inventories of the species taxa groups for JODA. Available data from completed inventories were utilized where needed in the report. This information as well as additional data is available from the UCBN website http://science.nature.nps.gov/im/units/ucbn/inventory/index.cfm#table. Rare plant species inventories, a subset of vascular plant inventories, have only been completed for the Painted Hills Unit. An inventory of butterflies was completed by Anderson (2004) and only the Painted Hills Unit has an invasive plant species inventory.

Table 6. Status of inventories of species taxa for JODA maintained by the UCBN.

Species Taxa	Complete	Year Completed	In-Progress	Not Complete
Mammals	✓	2003		
Birds	✓	2003		
Amphibians	✓	2003		
Reptiles	✓	2003		
Fish	✓	Unknown		
Invertebrates				✓
Vascular Plants	✓	1977		
Rare Plants				✓
Invasive Plants				✓

Additional non-biological data sets have been identified by the UCBN as important for park management (Table 7). Both the biologic and non-biologic inventories were considered as baseline information for development of the UCBN vital signs monitoring plan (Garrett et al. 2007). Three data sets have not been completed by the UCBN however some park sites may have data available from other sources.

Table 7. Status of inventories of non-biological data for JODA maintained by the UCBN.

Non-Biologic Data Sets	Complete	Year Completed	In-Progress	Not Complete
Air Quality / Emissions				✓
Ozone Risk	✓	2001		
Water Quality	✓	1997		
Landcover				✓
Paleo Resources	✓	2005		
Geology			✓	
Soils	✓	2000		
Cultural Landscapes	✓	2009		

The UCBN Monitoring Plan (Garrett et al. 2007) identifies a suite of 14 vital signs chosen for monitoring implementation in the UCBN parks over the next 5 years. Vital signs are ~~a~~

subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values" (NPS-UCBN http://science.nature.nps.gov/im/monitor/). Not all vital signs are monitored at each park. JODA has 7 vital signs established for monitoring; stream/river channel characteristics, surface water dynamics, water chemistry, aquatic macroinvertebrates, invasive/exotic plants, riparian vegetation, sagebrush-steppe vegetation, bats, and land cover and use (Garrett et al. 2007).

Upland Assessment

Ecological sites are the basis for evaluation of upland habitats using an assessment method co-developed by the Natural Resources Conservation Service (NRCS), Agricultural Research Service (ARS), Bureau of Land Management (BLM), and the United States Geological Survey (USGS). The method is described in the publication ―Interpreting Indicators of Rangeland Health" (Pellant et al. 2005). Ecological site is a land classification system based on the potential of land to produce distinctive kinds, amounts, and proportions of vegetation. They were used as sample units and were identified from soils maps. All 25 sample sites within the 3 Units; 14 in Sheep Rock, 5 in Painted Hills and 6 in Clarno; were assessed using the BLM rapid assessment for rangeland health methodology. The Sheep Rock Unit was also assessed by prescribed burn units.

The rangeland health rapid assessment methodology is designed to provide a preliminary evaluation of 3 landscape attributes; soil/site stability, hydrologic function, and integrity of the biotic community at the ecological site level. It was developed to assist land managers in identifying areas that are potentially at risk of degradation and assist in the selection of sites for developing monitoring programs. Definitions of these three closely interrelated attributes are:

> *Soil Site Stability*: The capacity of the site to limit redistribution and loss of soil resources including nutrients and organic matter by wind and water.
>
> *Hydrologic Function*: The capacity of the site to capture, store, and safely release water from rainfall, run-on (inflow), and snowmelt (where relevant); to resist a reduction in this capacity; and to recover this capacity following degradation.
>
> *Integrity of the Biotic Community*: The capacity of the site to support characteristic functional and structural communities in the context of normal variability, to resist loss of this function and structure due to disturbance, and to recover following disturbance.

This technique was developed as a tool for conducting a moment-in-time qualitative assessment of rangeland status and as a communication and training tool for assisting land managers and other interested people to better understand rangeland ecological processes and their relationship to indicators (Pyke at. el. 2002) This method uses soil survey information, ecological site descriptions, and appropriate ecological reference areas to qualitatively assess rangeland health. As part of the assessment process, 17 indicators relating to these attributes are evaluated and the category descriptor or narrative that most closely describes the site is recorded. ―Optional Indicators" may also be developed to meet local needs. The critical link between observations of indicators and determining the degree of departure from the ecological site description and/or ecological reference area is part of the interpretation process.

This technique does not provide for just one rating of rangeland health, but based upon a "preponderance of evidence" approach, it provides the departure from the ecological site description/ecological reference area(s) for the three attributes: soil site stability, hydrologic function, and biologic integrity. There are 5 categories of departure recognized: "none to slight", "slight to moderate," "moderate," "moderate to extreme," and "extreme."

A slight modification of the methodology was implemented so multiple assessments in each ecological site could be combined for analysis. A rating from 1 (none to slight) to 5 (extreme) was assigned to each category. For ecological sites or prescribed burn units with more than one sample, an average was calculated for each indicator and then summed for each landscape attribute. There are 10 indicators for soil site stability and hydrologic function and 9 for biotic integrity. The score for each landscape attribute was the sum of the indicators, minus the reference conditions. Reference condition was determined to be 10 for soil site stability and hydrologic function and 9 for biotic integrity (based on a score of 1 for each indicator per attribute). Percent departure for each attribute was a proportion calculated by dividing the score by the maximum departure value; 40 for soil stability and hydrologic function and 35 for biotic integrity. The results are displayed graphically as a percent departure from the reference condition. For the narrative, the percent departure values are converted back into the associated qualitative categories: none to slight (<20%), slight to moderate (20-39%), moderate (40-59%), moderate to extreme (60-79%), and extreme (≥80%).

An access database was developed for digitally storing site data, comments, and the 17 indicator values. A GPS point was collected at the center point of each sample site. Sample sites varied from 1 to 20 acres in size as noted in the database. Maps were generated for each ecological site sampled that show the sample site(s) and other land features.

Aquatic Assessments

Evaluation of on-site aquatic resources at JODA included an assessment of instream condition and water quality of the John Day River, Rock Creek, and Bridge Creek based upon benthic macroinvertebrate indicators (BMI). An on-site wetland condition assessment was conducted within JODA in 2007 (NPS 2008) and included riparian (or riverine) wetlands. As such, additional riparian evaluations were not conducted as part of this study. Instead, BMI sites evaluated as part of this study were selected to overlap with riverine wetland sites assessed as part of the 2007 study in an effort to identify a relationship between instream and riparian condition.

The condition of riparian areas often controls and dictates the quality of aquatic and wildlife resources that depend on these important zones of influence. Riparian habitat serves many functions including erosion control, aquatic shading and cooling, insect production, shoreline bank stabilization, and providing woody debris. Riparian areas are often the most diverse habitat areas within a watershed because they contain the greatest resource diversity and productivity (Barber 2005). Riparian areas serve as a buffer between aquatic habitats and upland activities that potentially affect those habitats. In addition, these areas often contain wetlands where water is filtered, retained, and slowly released to the surface throughout the year. Maintenance of properly functioning riparian habitat can influence the quality and quantity of surface waters and the species that depend upon these habitats.

Benthic macroinvertebrates (BMI) are well suited for biomonitoring assessments within rocky substrate stream habitats for several reasons such as (Morley 2000; Fore et al. 1996):

1. The macroinvertebrate community is extremely diverse, represented by thousands of different species with a variety of feeding strategies;
2. The pollution tolerance levels of macroinvertebrates range from very high to very low;
3. Sampling macroinvertebrates can be performed with relative ease with simple equipment;
4. The aquatic life spans of macroinvertebrates range from several weeks to several years, which provides an indication of stream quality over a period of time, not just the sampling window;
5. Unlike fish, macroinvertebrates are fairly limited in mobility, meaning they cannot avoid polluted areas. The adults lay the eggs and the benthic larvae are dependent upon the water quality and habitat to survive;
6. The methods for collecting, subsampling, preserving, and identifying macroinvertebrates are well established, facilitating comparison of data between sites;
7. Macroinvertebrates can be found in any aquatic habitat as long as the water quality is high enough to sustain them; and
8. Macroinvertebrate communities can recover rapidly from repeated sampling events, providing the ability for repeated sampling.

The primary objective in evaluating JODA instream and riparian habitat was to provide the NPS with a starting point for managing land use within their control. To achieve this objective, we set out to 1) identify existing stream and riparian wetland condition; 2) to identify the specific threats and stressors impacting stream and riparian wetland functions and values (e.g., wildlife habitat, water quality improvement, aquatic species protection, etc.); and 3) to recommend solutions to minimize or eliminate threats and stressors to onsite streams and riparian areas and associated aquatic resources.

The 2007 JODA wetland assessment (NPS 2008) utilized the California Rapid Assessment of Wetlands and Riparian Areas (CRAM) to assess wetland condition (NPS 2008). Wetland assessment biologists identified 15 riverine wetlands within the JODA Units. According to CRAM protocol, the wetlands were classified as riverine due to their position in the landscape and source of hydrology. Wetland observers defined an area within each of the 15 riverine wetland sites as the assessment area. For small wetlands, the assessment area included the entire wetland polygon. For larger wetlands, the assessment area was defined as a portion of the wetland polygon that was representative of habitat throughout the wetland. In all cases, the wetland assessment area was small enough for observers to assess its condition in two to four hours. After observers determined the wetland's CRAM type and defined the assessment area, field staff conducted the assessment. CRAM protocol included a series of questions (metrics) in four general categories (attributes): buffer and landscape context, hydrology, physical structure, and biotic structure. Based on the field observations, each wetland was given an assessment score between 25 and 100 to indicate its ecological integrity. Analysis of CRAM results placed wetlands into one of three condition classes: *Desirable, Good,* and *Poor*.

For the purposes of this study, the 15 CRAM riverine wetland sites assessed in 2007 were selected for instream benthic macroinvertebrate (BMI) sampling; however, 11 of the CRAM riverine wetland sites contain intermittent or seasonal surface water flows and were dry during our August 2008 sampling effort. As such, 4 CRAM sites containing flowing surface water (i.e., perennial streams) were sampled for BMI during the August 2008 assessment. One CRAM site was split into 3 sub-units for sampling due to its large size resulting in a total of 6 sites sampled for BMI.

Channel characteristics were observed and BMI samples were collected at the six JODA stream sites in August 2008. Based on Oregon Department of Environmental Quality (DEQ) methodology, a Surber sampler was used to collect 8 replicate BMI samples in a single, uniform riffle habitat unit at each site. A Surber sampler was selected to collect BMI because it allows sampling a uniform 1-square-foot (144 square inch) area. Sampling began in the downstream portion of the riffle and proceeded upstream for the eight replicates. At each replicate sampling location the following methodology was used:

1. Place Surber sampler on the selected sampling spot with the opening of the nylon net facing upstream. Brace the frame and hold it firmly on the creek bottom.
2. Lift the larger rocks resting within the frame and brush off crawling or loosely attached organisms so that they drift into the net.
3. Once the larger rocks are removed, disturb the substrate vigorously with a trowel or small rake for 60 seconds. This disturbance should extend to a depth of about 10 cm to loosen organisms in the interstitial spaces, washing them into the net.
4. Lift Surber out of the water. Tilt the net up and out of the water while keeping the open end upstream. This helps to wash the organisms into the receptacle.
5. On the creek bank, empty contents of Surber into large bucket. Rinse Surber and empty into bucket until all organisms are removed. Great care should be taken in this step to collect and preserve all organisms from the Surber sampler as well as from the rocks and water in the bucket. Use of a magnifying glass and tweezers is essential. Rinse bucket through sieve to remove water from sample. Pick out large debris (sticks and leaves) after carefully removing any invertebrates.
6. Use spatula to move sample from sieve into a plastic vial. Fill vial to the top with isopropyl alcohol. Put label on inside of vial with name of sampler, date, and location. Write location and date on top of vial lid.
7. Return to the location of the first sample; walk upstream and collect another sample of invertebrates. Repeat this process for a total of eight replicate samples from each site. The eight replicates are combined into one composite sample for shipment to the laboratory for analysis.

All BMI samples were shipped to ABR, Incorporated in Forest Grove, Oregon for sorting, identification, and analysis. Each sample was processed using standard laboratory sample handling and labeling protocols. A Caton gridded tray was used to subsample 500 organisms from original samples. Using this subsampling procedure, each sample was evenly distributed across a 30-square wire-mesh tray. Individual squares were randomly selected and the contents removed and placed into a Petri dish. Macroinvertebrates were removed from the sample material under a dissecting microscope. This process was repeated until 525-550 organisms were subsampled. The remainder of the sample (the unsorted fraction) was then inspected for large or rare taxa that were not encountered during the subsampling procedure; these large/rare taxa were recorded on the laboratory bench sheet as such and placed in a separate vial. The following products resulted from the sample sorting procedure:

1. 525-550 macroinvertebrates sorted into a series (4-7) of small vials by order, class, and/or phylum.
2. A separate vial containing organisms found during the large/rare search (if performed).
3. Sorted residue – material from which the 525-550 organisms were sorted.
4. Unsorted fraction – portion of the original sample that was not sorted.

Macroinvertebrate identification also followed standard protocols. Macroinvertebrates were identified to the lowest practical taxonomic level, generally genus or species for most taxonomic groups except mites, Oligochaetes, microcrustaceans, and *Chironomidae*.
All raw data were entered into Excel spreadsheets and were crosschecked against paper copies of the data for errors and omissions before the data were analyzed. Data were analyzed with a multimetric index known as the Benthic Index of Biotic Integrity or B-IBI. The B-IBI utilizes information concerning the abundance and composition of a stream’s benthic macroinvertebrate community to assess the overall biological integrity of the stream ecosystem. As such, “biological integrity” is defined as “the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of natural habitat of the region” (Karr and Dudley 1981). In practice, the B-IBI provides quantitative scores for 10 metrics that describe individual key attributes of the benthic macroinvertebrate community. Scores for the 10 metrics are summed and the cumulative site score is categorized into a level of impairment based on a pre-determined scale.

Since macroinvertebrate communities differ from region to region, multimetric indexes have been developed and calibrated for use within particular regions or states. JODA BMI data were analyzed using an Eastern Oregon Benthic Index of Biotic Integrity (IBI) developed for northeastern Oregon. Multimetric indexes have been developed for both eastern and western Oregon. The eastern Oregon index was developed from data collected in the Grande Ronde basin, northeast Oregon (Hubler 2006). While this index was used to analyze the data in JODA streams, the results should be interpreted with caution due to index calibration occurring outside of the John Day basin. Categorical scales established for the eastern Oregon IBI are detailed in Table 8.

Table 8. Eastern Oregon Index of Biotic Integrity (IBI) Impairment Categories.

Rating	Index Score Range
No Impairment	>41
Moderate Impairment	35-41
High Impairment	27-34
Severe Impairment	<27

One of the metrics used in the Oregon IBI as a basis for instream condition was the Hilsenhoff Biotic Index (HBI), which is a general biotic index used to identify a relationship between macroinvertebrates and instream water quality. The HBI was first developed in 1977 to assess low dissolved oxygen concentrations related to organic pollutant loading (1998). The HBI was improved in 1987 and modified further in 1998 to allow assessment of conditions throughout the year. Categorical scales established for water quality and degree of organic pollution based on the HBI are identified in Table 9.

Table 9. Water quality classifications for the modified Hilsenhoff Biotic Index (HBI).

Index Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution

Data from the six JODA samples were also analyzed using the Western Cordillera and Columbia Plateau (WCCP) predictive model to provide a more confident determination of benthic community condition at each sample location. Predictive models determine biological condition by comparing the list of taxa occurring at a site of interest to a list of taxa predicted to occur at that site in the absence of disturbance (Hubler 2008). This observed-to-expected comparison results in an ―O/E” score that ranges from 0 to greater than one. Scores lower than 1 indicate that not all taxa predicted to occur at a site were actually sampled. The further the score deviates towards 0 from 1, the higher the level of disturbance to the benthic community at that site. Oregon DEQ has developed biological condition class thresholds based on the deviation of individual test site O/E scores relative to the distribution of reference site scores (Hubler 2008).

Fire

The Sheep Rock, Clarno, and Painted Hills Units have similar vegetation. Fire regimes for sagebrush/bluebunch wheatgrass communities vary from 40 to over 200 years on very dry sites (Bunting et al. 2002, Kitchen and McArthur 2007). Until 1994 all three Units had experienced fire exclusion over the last 100 years. The Clarno Unit experienced 3 wildfires in 1994 and 1995. Prescribed fires were implemented within the Painted Hills and Sheep Rock Units in an attempt to return fire as a natural process, maintain historic/cultural scenes, and to reduce fuel loads (McAdams, 1999).

To analyze the condition of vegetation outside the park Units we utilized LANDFIRE (Landscape Fire and Resource Management Planning) tools. LANDFIRE is a multi partner project producing consistent and comprehensive maps and data describing vegetation, wildland fuel, and fire regimes across the United States. It is a shared project between multiple agencies that produces data products for vegetation composition and structure, surface and canopy fuel characteristics, and historical fire regimes. The methodologies are science based and include extensive field referenced data.

The LANDFIRE Project produces maps of simulated historical fire regimes and vegetation conditions using the LANDSUM landscape succession and disturbance dynamics model. Several LANDFIRE data layers were used to summarize various fire related characteristics for the JODA Unit project areas. LANDFIRE data sets are available by zones across the United States. The specific zone was acquired for each NRCA area. Surrounding 6th level hydrologic boundaries were used as an analysis area in each park for clipping raster data from the specified zone. Where more than one LANDFIRE zone was present within an analysis area, each zone was clipped then merged to create the data set for that analysis area. Tables summarizing key characteristics such as area and percentages were developed for each LANDFIRE data layer analyzed.

LANDFIRE data is a coarse scale depiction product intended for state and regional applications, however it is utilized here as a starting point or first pass estimate for general determination of conditions. Finer scale determinations should be derived locally using methodology described in the Fire Regime Condition Class (FRCC) Guidebook (Hann et al. 2004). The resulting products can then be appropriately applied to local Units for purposes such as fire management planning, land use planning, and other landscape analyses. Generally, FRCC derived locally using the guidebook process describes ecological departure at finer scales (LANDFIRE 2007).

FRCC is a widely accepted measure of change to key ecosystem components such as vegetation, fuels, fire frequency, and disturbance. In order to estimate FRCC, a determination of reference or historical natural landscape conditions are needed for comparison. LANDFIRE has attempted this by producing simulated data layers of historical conditions and the departures from current condition to produce condition class characteristics. These data layers include Bio Physical Setting (reference vegetation), Fire Regime Group (Historic Fire Regime), FRCC Departure, and Fire Regime Condition Class (departure from historic conditions). Each Unit is analyzed separately using the key LANDFIRE data layers related to FRCC and summarized by data layer along with other useful fire related data produced by LANDFIRE.

Noxious Weeds

Noxious weeds of importance to JODA were identified in Garrett et al. 2007. A complete list of Oregons's noxious weeds can be found at http://www.oregon.gov/ODA/PLANT/WEEDS/statelist2.shtml#A_List . They are classified into 2 categories based on control requirements; Class A (eradicate or contain) and Class B (control) (Oregon Department of Agriculture 2009). GIS data on noxious weeds was acquired from past investigations and placed in the JODA geodatabase under stressors. State and county level databases were searched for noxious weed locations and local county weed superintendents were contacted for unpublished data; however GIS data was not available from these sources. The Oregon Department of Agriculture (ODA) has a weed mapping website, www.weedmapper.org, for logging new locations and displaying existing locations of a specific weed species within the state or county.

Upland Assessment Results

GIS and Geodatabase

The JODA Geodatabase were populated with 38 shapefiles and images (Appendix A). These are all accessible from the ArcGIS Map Project file located on the DVD included with this report. Additional copies are available from the Upper Columbia Basin Network's website http://science.nature.nps.gov/im/units/ucbn/reports/.

Unit Specific Assessments

Unit specific assessments were made in the 3 park Units identified in the methods section. Seventeen ecological sites were identified and assessed. The following is an evaluation of each ecological site with maps of sample points and soils, which are the basis for the ratings of the 3 landscape attributes. All data collected at the 24 sample points were digitized into a Microsoft Access database and a shapefile was generated from GPS locations. The database is included with the enclosed DVD and the shapefile is located in the 3 JODA Geodatabases under the Geography category called nrca_plots.shp. Appendix B includes a table with all indicator ratings by plot. Appendix C is a species list with canopy cover by plot. Conclusions and recommendations that apply to all the sites sampled are discussed in the Summary and Recommendations section of this report.

Sheep Rock Unit

JD Droughty Fan, 9-12 PZ Ecological Site:

This ecological site is dominated by soils developed from colluvium parent material. The soils are loams over a gravelly loam dominated subsurface. Soil depth varies from 18” to >60” and is considered well drained. Two plots were sampled in the JD Droughty Fan, 9-12 PZ ecological site (R101XB053OR) in the Sheep Rock Unit. The plots were located near the John Day River in the middle of the Unit (Figure 16). The soil stability and hydrologic function attributes were rated as none-slight departure, 4% and 9%, respectively. The biotic integrity attribute was rated as moderate departure (46%) due to the presence of invasive plants, increased litter, and hampered reproductive capability of the native perennial grasses (Figure 17).

Both plots are in Haystack soils formed on alluvial fans from colluvium material. The historic climax plant community is big sagebrush (*Artemisia tridentata* ssp. *tridentata*)/Thurber needlegrass (*Achnatherum thurberianum*)-basin wildrye.

Plot 1 is within the Rock Creek prescribed burn (9/5/2004) and plot 18 is within the Picture Gorge prescribed burn (10/2/2001). Both plots exhibit similar landscape attribute departure values even though they had been treated by fire 3 years apart. The current vegetation is dominated by cheatgrass (*Bromus tectorum*) and bulbous bluegrass (*Poa bulbosa*) with shrubs broom snakeweed (*Gutierrezia sarothrae*) and green rabbitbrush (*Chrysothamnus viscidiflorus*) scattered within the sample plot. The dominance of these species along with the noxious weeds, field bindweed and Dalmatian toadflax, accounted for the moderate departure in the biotic integrity attribute. No western junipers were noted around the plots. The relatively poor biotic integrity could be due to over-grazing by livestock in the past and prescribed fire would have improved conditions for annual grasses and green rabbitbrush over perennial grasses and sagebrush (Pellant 1996). Both plots were in good condition for soil stability and hydrologic function.

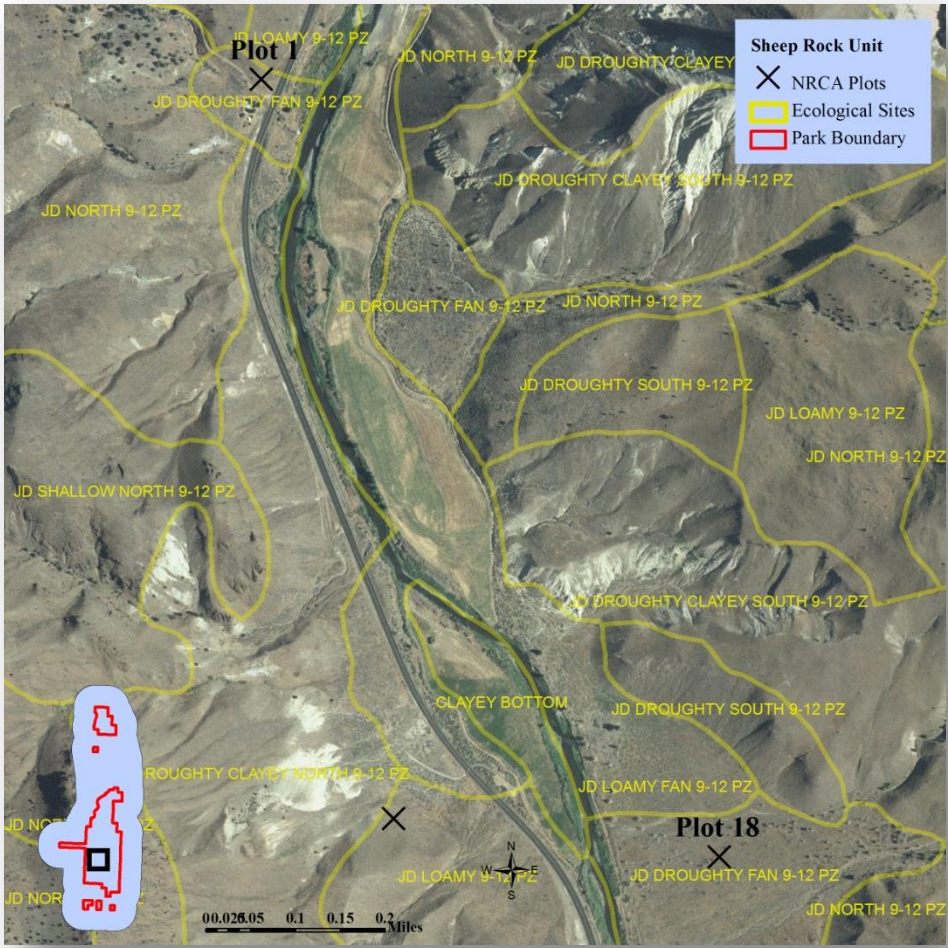

Figure 16. Map of ecological site sample plots 1 and 18 in the Sheep Rock Unit, JODA.

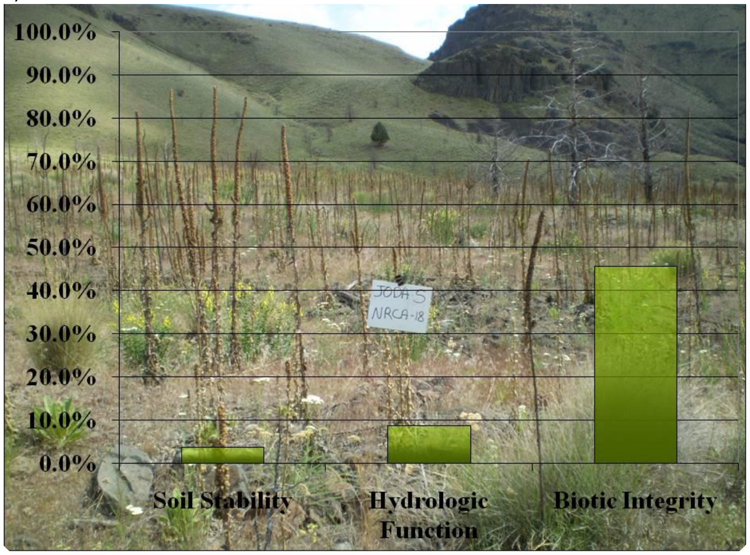

Figure 17. Departure from reference condition of the 3 landscape attributes in the JD Droughty Fan, 9-12 PZ ecological site, Sheep Rock Unit, JODA (background is plot 18).

JD Droughty North, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from weathered tuffaceous sediments. The soils are ashy loams over a clay dominated subsurface. Soil depth varies from 18” to 60” and is considered well drained. Two plots were sampled in the JD Droughty North, 9-12 PZ ecological site (R010XB064OR) in the Sheep Rock Unit. Plot 6 was located on the east side of Blue Basin and plot 25 was in the southeast portion of the Unit (Figure 18). All 3 landscape attributes; soil stability, hydrologic function, and biotic integrity were rated as none-slight departure; 1.3%, 6.3%, and 15.7%, respectively (Figure 19).

Both plots are on Simas soils formed on south-facing slopes from loess and colluvium material. The historic climax plant community based on ecological site is predicted to be bluebunch wheatgrass-Idaho fescue (*Festuca idahoensis*) with a minor overstory of basin big sagebrush (<10%). Disturbed vegetation types will see an increase in western juniper, big sagebrush, and cheatgrass.

Plot 6 was within the Middle Mountain prescribed burn (9/24/2002) and plot 25 was in the Picture Gorge prescribed burn (10/2/2001). Plot 25 had none-slight departure in all landscape attributes (0%, 2.5%, and 5.7%) with a healthy stand of bluebunch wheatgrass and Idaho fescue. However western juniper were invading with >10% cover. Plot 6 had a slight-moderate departure in the biotic integrity attributes (25.7%) due to the increase in cheatgrass and western juniper. Big sagebrush was a minor component in both plots. Both sites are in good condition but seem to be trending away from reference condition with the presence of cheatgrass and western juniper. All sites were in good condition for soil stability and hydrologic function.

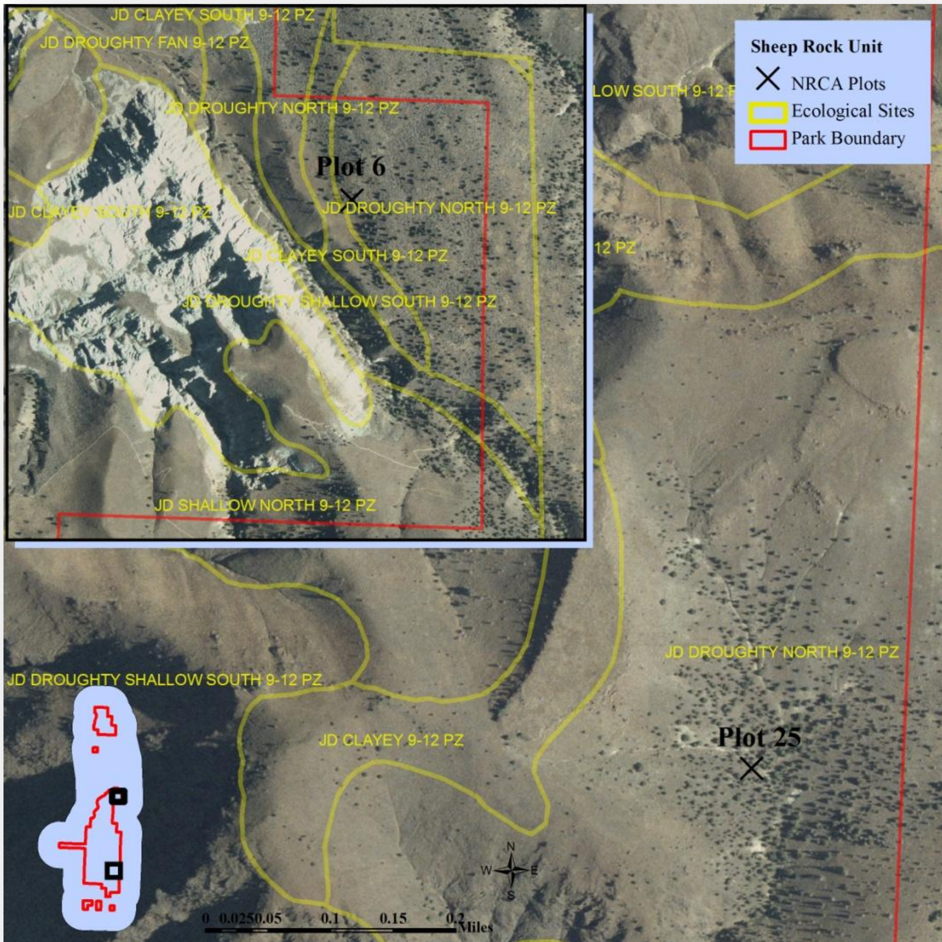

Figure 18. Map of ecological site sample plots 6 and 25 in the Sheep Rock Unit, JODA.

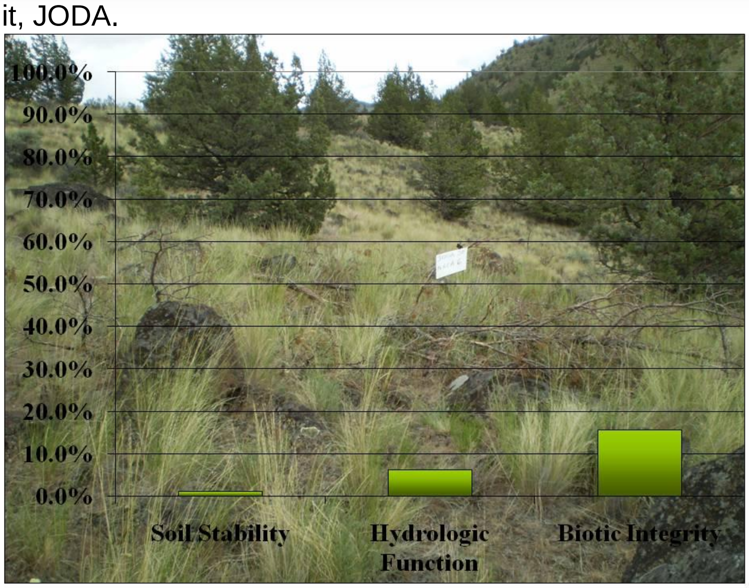

Figure 19. Departure from reference condition of the 3 landscape attributes in the JD Droughty North, 9-12 PZ ecological site, Sheep Rock Unit, JODA (background is plot 6).

JD Loamy, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material with basaltic origin. The soils are stony loam to loam over a loam dominated subsurface. Soil depth varies from 16” to 62” and is considered well drained. Three plots were sampled in the JD Loamy, 9-12 PZ ecological site (R010XB034OR) in the Sheep Rock Unit. There are 4 plots recorded for this site; 3 located south of Blue Basin and one located south of the Mascall Formation Overlook (Figure 20). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 2.5% and 6.3%, respectively. The biotic integrity attribute was rated as moderate departure (29.3%) due to the presence of invasive plants and hampered reproductive capability of the native perennial grasses (Figure 21).

The plots south of Blue Basin (13, 14, and 15) were in a Twickenham loam soil formed on south-facing slopes and ridges from clayey colluvium material. The plot south of the Mascall Formation Overlook (4) is a Buffaran stony loam formed from alluvium of mixed sources on fan remnants. The historic climax plant community based on ecological site is big sagebrush/bluebunch wheatgrass–Sandberg bluegrass (*Poa secunda*). Disturbed vegetation types will see an increase in western juniper, cheatgrass, and medusahead (*Taeniatherum caput-medusae*).

Plots 13, 14, and 15 were all within the Windy Point prescribed burn (9/7/1999). Individual plot landscape attribute values varied considerably within the burn. Plot 15 was representative of a relatively good condition site based on the landscape attribute departure ratings (0%, 0%, and 14.3%, respectively). The site was dominated by bluebunch wheatgrass and Sandberg bluegrass, with <10% big sagebrush, which had some evidence of being burned. Plot 13 showed more signs of departure in biotic integrity attribute (20%) due to presence of western juniper and cheatgrass. Plot 14 was the most disturbed with a moderate departure in biotic integrity (48.6%) and cheatgrass and medusahead were the dominant grasses. Western juniper was not present in plot 14. Plot 4 had a slight-moderate biotic integrity rating (34.3%) and was dominated by big sagebrush, broom snakeweed, and cheatgrass. There was no evidence of fire but it has been grazed heavily in the past. All sites were in good condition for soil stability and hydrologic function.

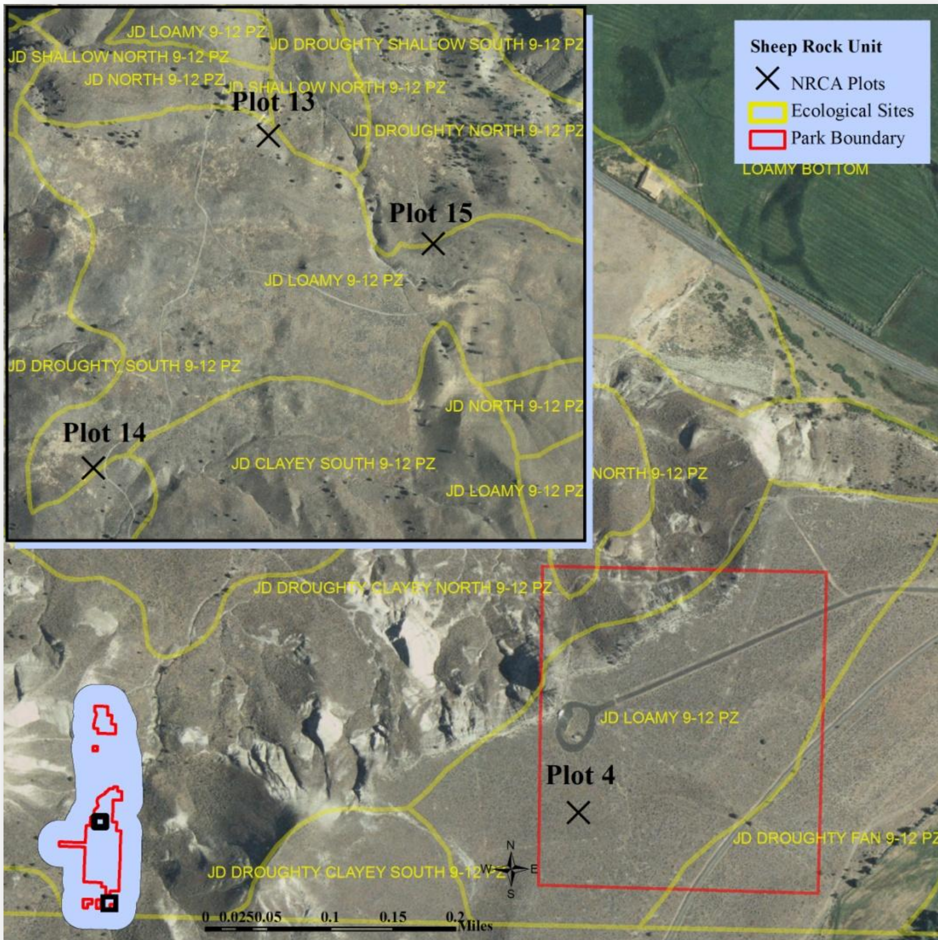

Figure 20. Map of ecological site sample plots 4, 13, 14, and 15 in the Sheep Rock Unit, JODA.

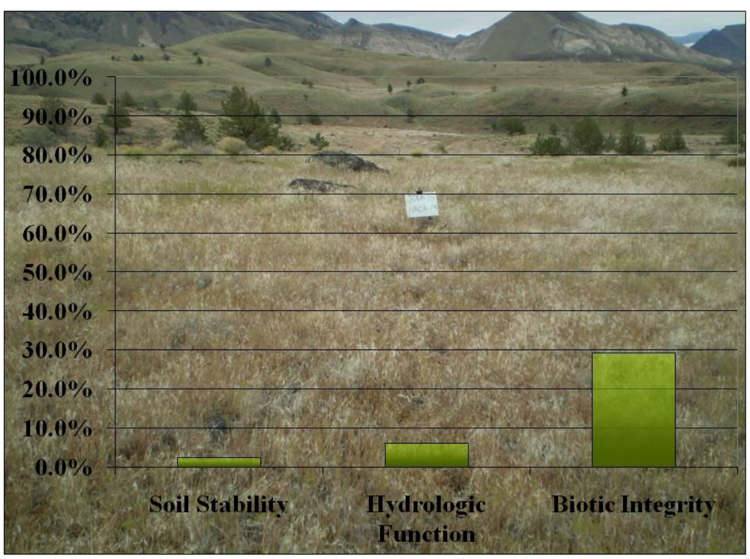

Figure 21. Departure from reference condition of the 3 landscape attributes in the JD Loamy, 9-12 PZ ecological site, Sheep Rock Unit, JODA (background is plot 13).

JD North, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material from an acidic tuff origin. The soils are gravelly loams over clay dominated subsurface. Soil depth varies from 18” to 62” and is considered well-drained. One plot was sampled in the JD North, 9-12 PZ ecological site (R010XB063OR) in the Sheep Rock Unit. Plot 16 was located west of the Thomas Condon Paleontology Center (Figure 22). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 0% and 5.0%, respectively. The biotic integrity attribute was rated as slight-moderate departure (31.4%) (Figure 23).

The plot is in a Gooserock complex soil formed on north-facing slopes from loess and colluvium material. The historic climax plant community based on ecological site is Idaho fescue-bluebunch wheatgrass with a minor overstory of basin big sagebrush (<3%). Disturbed vegetation types will see an increase in western juniper, big sagebrush, and cheatgrass.

Plot 16 is in the Rock Creek prescribed burn (9/5/2004). The plot had a slight-moderate departure in the biotic integrity attributes due to the dominance of big sagebrush and an understory dominated by cheatgrass. Western juniper was present but considered a minor component of the community. The site was in good condition for soil stability and hydrologic function. No noxious weeds were identified in the site.

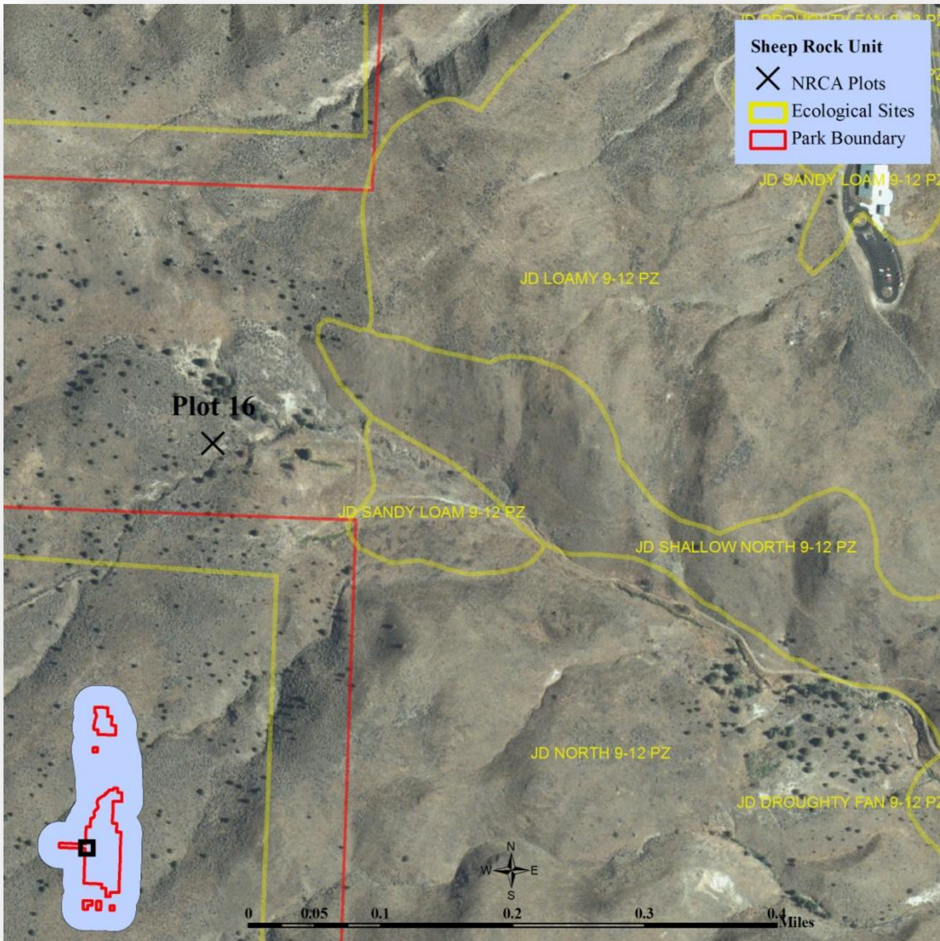

Figure 22. Map of ecological site sample plot 16 in the Sheep Rock Unit, JODA.

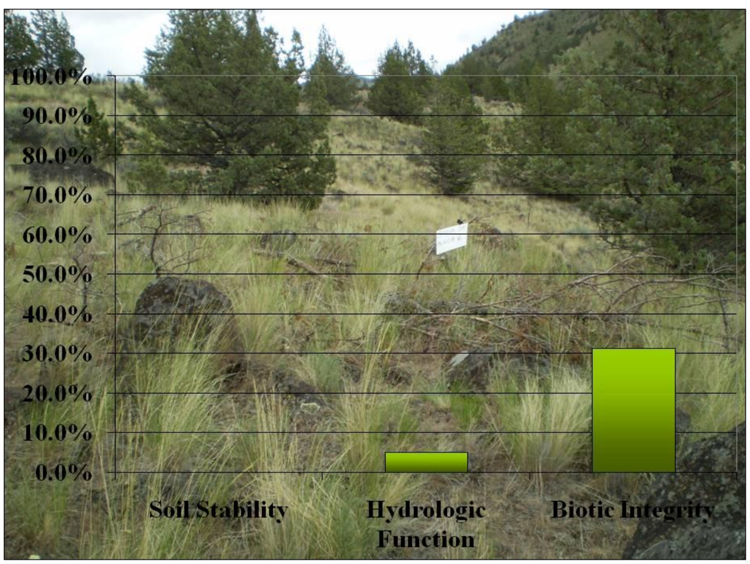

Figure 23. Departure from reference condition of the 3 landscape attributes in the JD North, 9-12 PZ ecological site, Sheep Rock Unit, JODA (background is plot 16).

JD Droughty Clayey North, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material from an acidic tuff origin. The soils are gravelly loams over clay dominated subsurface. Soil depth varies from 18” to 62” and is considered well-drained. One plot was sampled in the JD Droughty Clayey North, 9-12 PZ ecological site (R010XB065OR) in the Sheep Rock Unit. Plot 17 was located west of State Route 19 and south of the Thomas Condon Paleontology Center (Figure 24). All 3 landscape attributes; soil stability, hydrologic function, and biotic integrity; were rated as none-slight departure; 0%, 5.0%, and 17.1%, respectively (Figure 24).

The plot is in a Gooserock complex soil formed on north-facing slopes from loess and colluvium material. The historic climax plant community based on ecological site is shadscale saltbush (*Atriplex confertifolia*)/bluebunch wheatgrass. Disturbed vegetation types will see an increase in western juniper, big sagebrush, and cheatgrass.

Plot 17 is in the Rock Creek prescribed burn (9/5/2004). The plot had a none-slight departure in the biotic integrity attributes. The climax community based on soil type is bluebunch wheatgrass with a minor shadscale saltbush component. The site responded well to the prescribed burn but cheatgrass was a sub-dominant (10-40%) in the understory. Western juniper was not present and there was evidence of burned big sagebrush. No seedlings were observed in the plot. The site was in good condition for soil stability and hydrologic function. No noxious weeds were identified in the plot. The plot was located on the upper third of a relatively steep north-facing slope. Historic grazing most likely had a minor impact on the vegetation and the site was probably in good condition prior to the prescribed fire

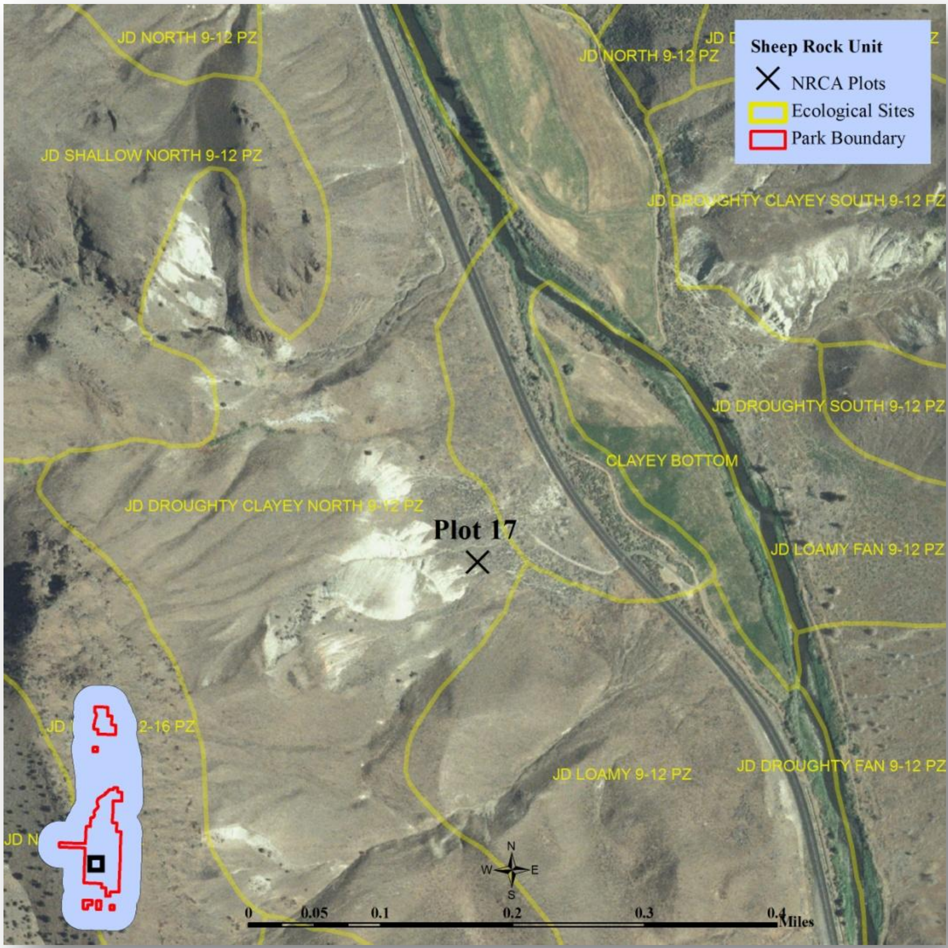

Figure 24. Map of ecological site sample plot 17 in the Sheep Rock Unit, JODA.

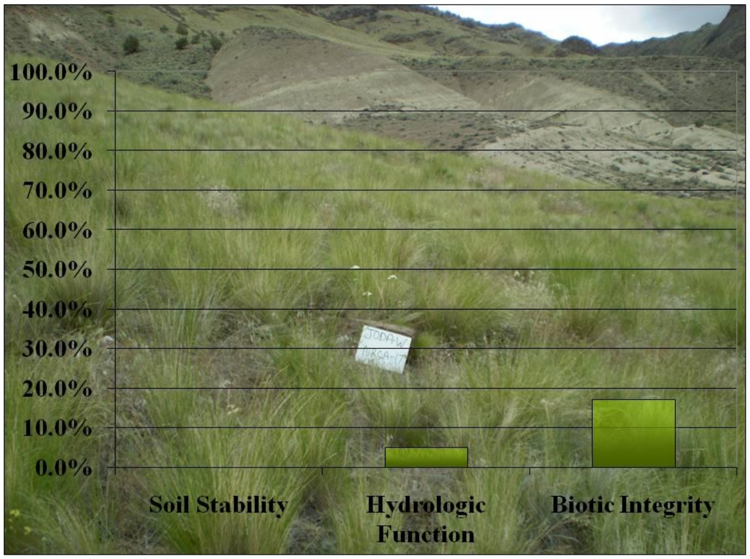

Figure 25. Departure from reference condition of the 3 landscape attributes in the JD Droughty Clayey North, 9-12 PZ ecological site, Sheep Rock Unit, JODA (background is plot 17).

JD Shallow North, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material with a basalt origin. The soils are stony loams over a gravelly clay loam dominated subsurface. Soil depth varies from 5” to 19” and is considered well drained. One plot was sampled in the JD Shallow North, 9-12 PZ ecological site (R010XB035OR) in the Sheep Rock Unit. Plot 7 was located east of Route 19 and west of Blue Basin (Figure 26). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 10.0% and 17.5%, respectively. The biotic integrity attribute was rated as moderate departure (48.6%) (Figure 27).

The plot is in a Lickskillet soil formed from stony colluvium material made up of loess, rock fragments, and weathered basalt. The historic climax plant community based on ecological site is bluebunch wheatgrass-Idaho fescue-Sandberg bluegrass with a minor overstory of big sagebrush and rubber rabbitbrush (*Ericameria nauseosa*) (<2%). Disturbed vegetation types will see an increase in western juniper, Sandberg bluegrass, and cheatgrass.

Plot 7 is in the Middle Mountain prescribed burn (9/24/2002). The plot had a moderate departure in the biotic integrity attribute and reflects a site that responded poorly to the prescribed burn. Cheatgrass is the dominant (>40%) species with bulbous bluegrass as a subdominant (10-40%). Western juniper was not present and there was evidence of burned big sagebrush. No seedlings were observed in the plot. No noxious weeds were identified in the plot. The site was on a flat north-facing terrace approximately 0.1 mile from the John Day River. The site was probably heavily grazed by livestock historically and was in poor vegetative condition prior to management by the park. The prescribed fire would have reduced the potential biotic integrity from pre-burn conditions by improving conditions for annual grasses over perennial grasses and sagebrush (Pellant 1996). The site was in good condition for soil stability and hydrologic function.

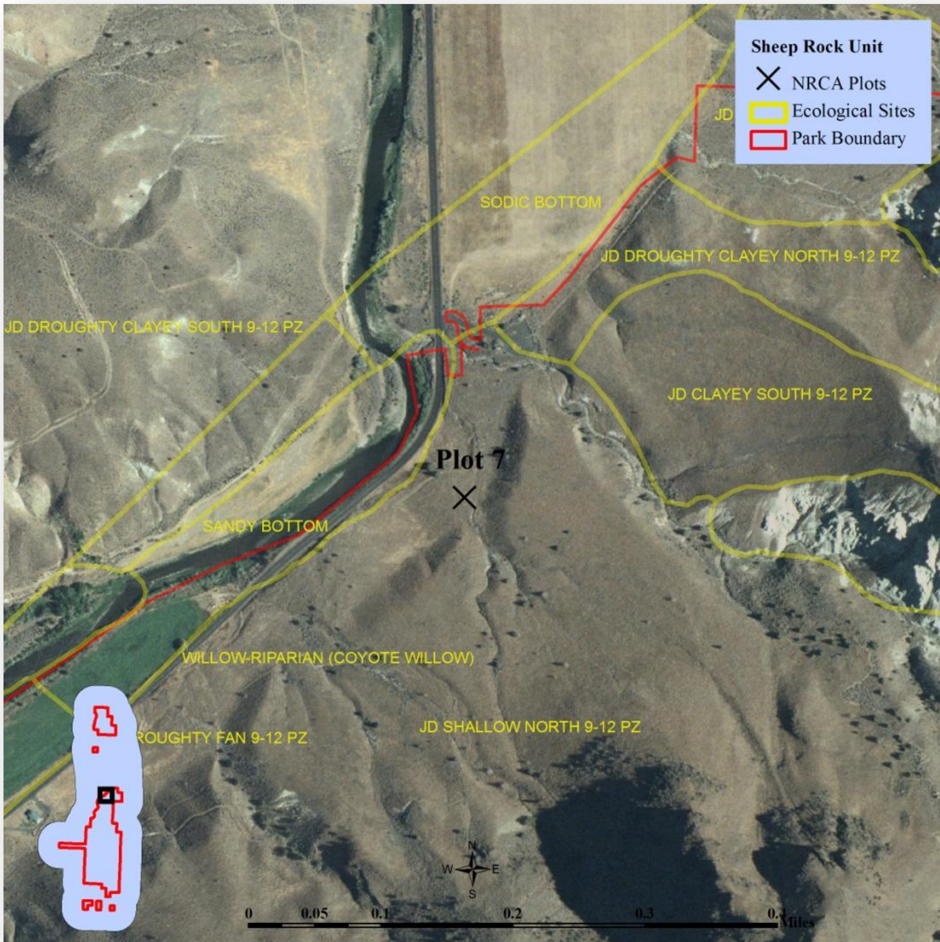

Figure 26. Map of ecological site sample plot 7 in the Sheep Rock Unit, JODA.

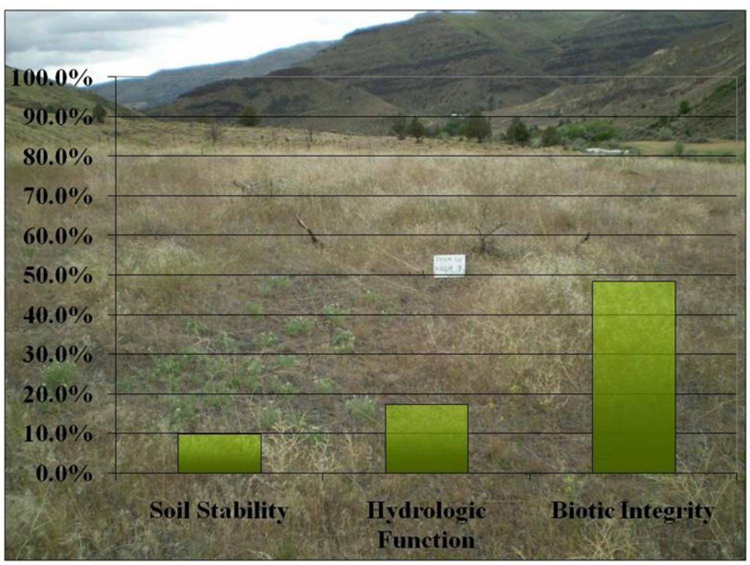

Figure 27. Departure from reference condition of the 3 landscape attributes in the JD Shallow North, 9-12 PZ ecological site, Sheep Rock Unit, JODA (background is plot 7).

JD Loamy, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material with basaltic origin. The soils are stony loam to loam over a loam dominated subsurface. Soil depth varies from 16” to 62” and is considered well-drained. One plot was sampled in the JD Loamy, 9-12 PZ ecological site (R010XB034OR) in the Foree portion of the Sheep Rock Unit. Plot 2 was located north of the parking lot for the Flood of Fire trail (Figure 28). The soil stability and hydrologic function landscape attributes were rated as slight-moderate departure, 20.0% and 37.5%, respectively. The biotic integrity attribute was rated as moderate departure (40.0%) (Figure 29).

The plot is in a Buffaran stony loam formed from alluvium of mixed sources of fan remnants. The historic climax plant community based on ecological site is big sagebrush/bluebunch wheatgrass-Sandberg bluegrass. Disturbed vegetation types will see an increase in western juniper, big sagebrush, and cheatgrass.

Plot 2 is in the Branson North prescribed burn (9/14/2007). The plot had a moderate departure in the biotic integrity attributes and reflects a site that responded somewhat poorly to the prescribed burn. Cheatgrass is the co-dominant (10-40%) species with Sandberg bluegrass (10-40%). Bluebunch wheatgrass and Thurber’s needlegrass resprouted in areas where the fire intensity was low, but not near burned western juniper or big sagebrush. Western juniper and big sagebrush were not present. No seedlings were observed in the plot. The site was on a gently sloping west-facing hillside approximately 0.4 mile from the John Day River. The site was probably grazed by livestock historically and was not in climax condition prior to management by the park. The prescribed fire would have reduced the potential biotic integrity from pre-burn conditions by improving conditions for annual grasses over perennial grasses and sagebrush (Pellant 1996). The recent burn impacted soil stability and hydrologic function probably due to the increased intensity around burned junipers and sagebrush but this condition should improve in 1-3 years. No noxious weeds were identified in the plot.

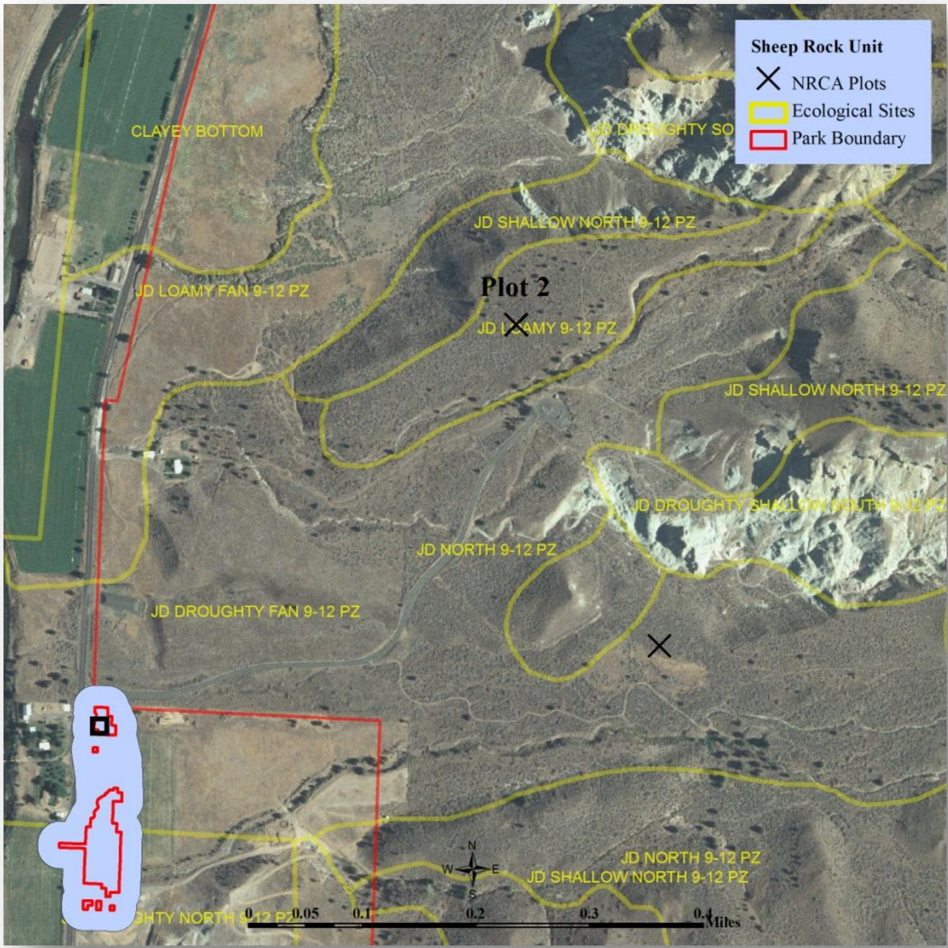

Figure 28. Map of ecological site sample plot 2 in the Foree portion of the Sheep Rock Unit, JODA.

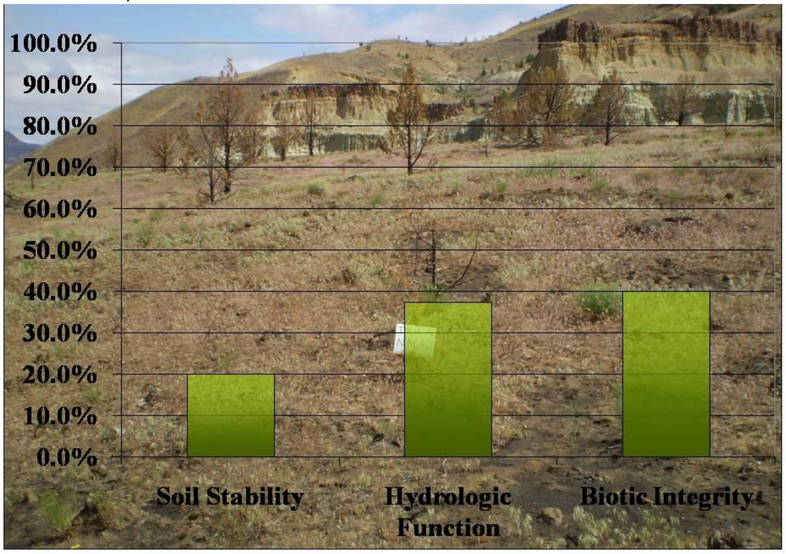

Figure 29. Departure from reference condition of the 3 landscape attributes in the JD Loamy, 9-12 PZ ecological site, Foree portion of the Sheep Rock Unit, JODA (background is plot 2).

JD Droughty Fan, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material. The soils are loams over a gravelly loam dominated subsurface. Soil depth varies from 18” to >60” and is considered well-drained. One plot was sampled in the JD Droughty Fan, 9-12 PZ ecological site (R101XB053OR) in the Foree portion of the Sheep Rock Unit. Plot 3 was located south of the parking lot for the Story in Stone trail (Figure 30). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 2.5% and 10.0%, respectively. The biotic integrity attribute was rated as moderate departure (54.3%) (Figure 31).

The plot is in Haystack soil formed on alluvial fans from colluvium material. The historic climax plant community based on ecological site is big sagebrush/Thurber’s needlegrass-basin wildrye. Disturbed vegetation types will see an increase in western juniper, bulbous bluegrass, and cheatgrass.

Plot 3 is in the Branson South prescribed burn (9/1/2005). The plot had a moderate departure in the biotic integrity attribute and reflects a site that responded poorly to the prescribed burn. Cheatgrass is the dominant (>40%) species with Sandberg bluegrass as a minor species (2-10%). No other perennial grass species were noted in the plot. Western juniper and big sagebrush were not present. No seedlings were observed in the plot. No noxious weeds were identified in the plot. The site was on a gently sloping west-facing bench located at mid-slope. The site was probably grazed by livestock historically and was not in climax condition prior to management by the park. The prescribed fire would have reduced the potential biotic integrity from pre-burn conditions by improving conditions for annual grasses over perennial grasses and sagebrush (Pellant 1996). The soil stability and hydrologic function were in good condition and had recovered from the burn.

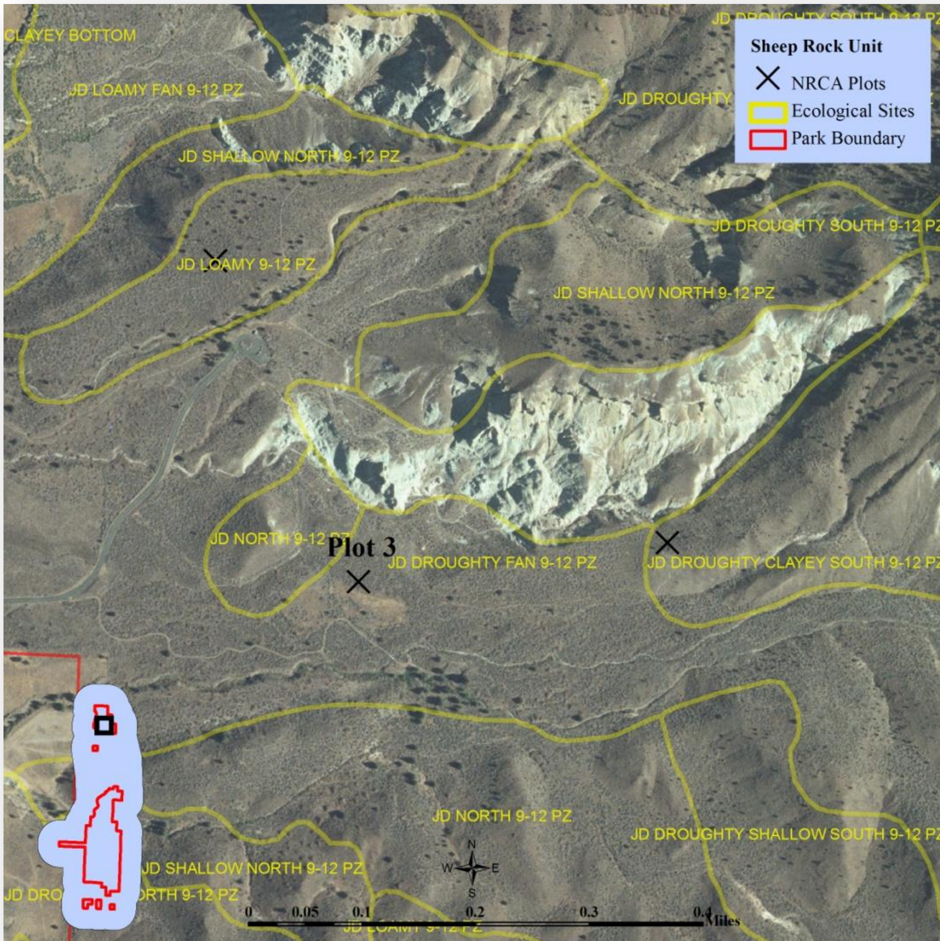

Figure 30. Map of ecological site sample plot 3 in the Foree portion of the Sheep Rock Unit, JODA.

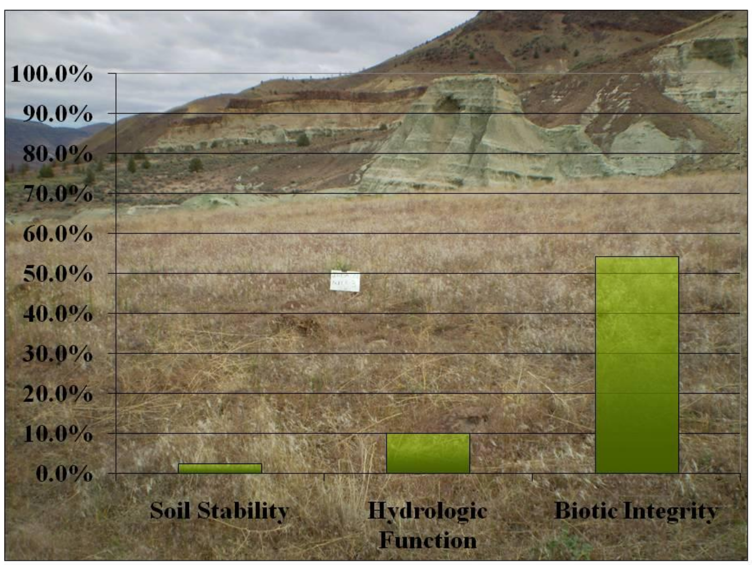

Figure 31. Departure from reference condition of the 3 landscape attributes in the JD Droughty Fan, 9-12 PZ ecological site, Foree portion of the Sheep Rock Unit, JODA (background is plot 3).

JD Droughty Clayey South, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium and loess parent material. The soils are cobbly clay loams over clay dominated subsurface. Soil depth varies from 9" to 60" and is considered well-drained. One plot was sampled in the JD Droughty Clayey South, 9-12 PZ ecological site (R101XB043OR) in the Foree portion of the Sheep Rock Unit. Plot 5 was located southeast of the parking lot for the Story in Stone trail (Figure 32). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 5.0% and 12.5%, respectively. The biotic integrity attribute was rated as slight-moderate departure (28.6%) (Figure 33).

The plot is in a Brisbois soil formed on basaltic colluvium and loess material. The historic climax plant community based on ecological site is shadscale saltbush/bluebunch wheatgrass. Big sagebrush, shadscale saltbush, and purple sage (*Salvia dorrii*) can be a minor overstory (<2%). Disturbed vegetation types will see an increase in western juniper, basin big sagebrush, broom snakeweed, and cheatgrass.

Plot 5 is in the Branson South prescribed burn (9/1/2005). The plot had a slight-moderate departure in the biotic integrity attribute and reflects a site that responded fairly well to the prescribed burn. Bluebunch wheatgrass and Sandberg bluegrass are the dominant (>40%) species with cheatgrass as a subdominant species (10-40%). No other perennial grass species were noted in the plot. Western juniper and big sagebrush were not present, but burned remnants were present. No seedlings were observed in the plot. No noxious weeds were identified in the plot. The site was on a moderate northwest-facing hillside over 0.7 mile from the John Day River. The site was probably lightly grazed by livestock historically and was near climax condition prior to management by the park. The prescribed fire probably did not reduce the potential biotic integrity from pre-burn conditions but it may improve conditions for annual grasses over perennial grasses and sagebrush (Pellant 1996). The soil stability and hydrologic function were in good condition and had recovered from the burn.

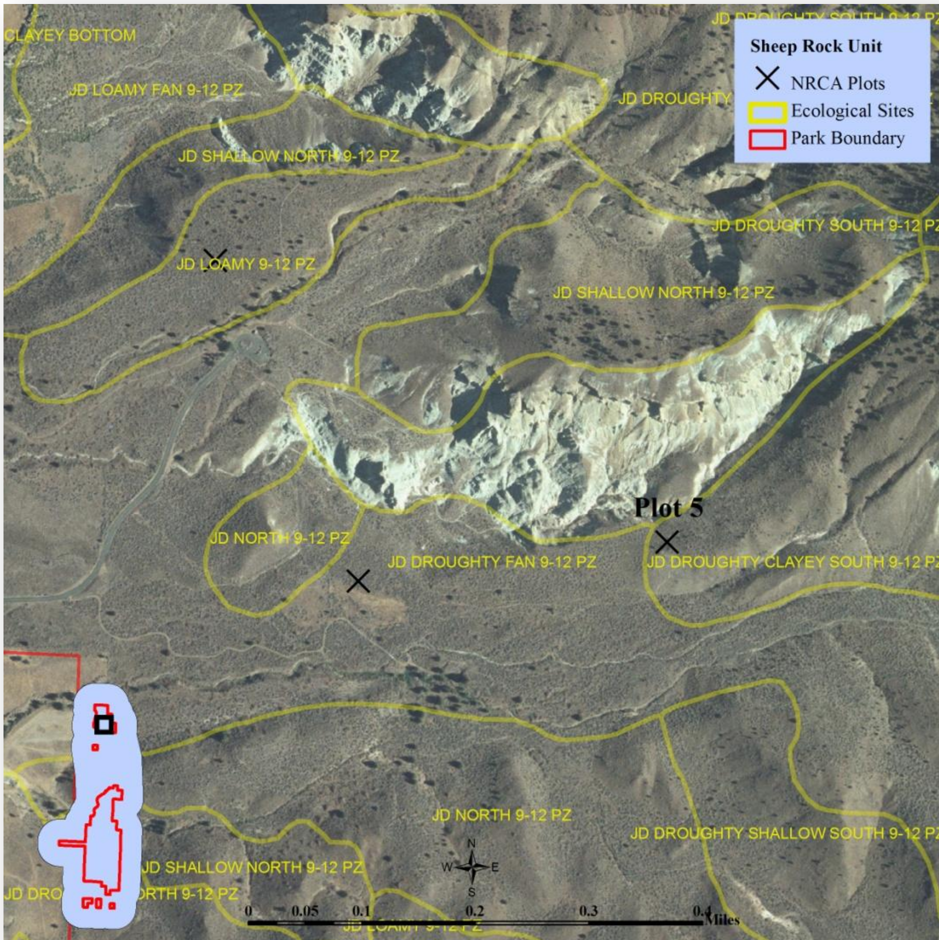

Figure 32. Map of ecological site sample plot 5 in the Foree portion of the Sheep Rock Unit, JODA.

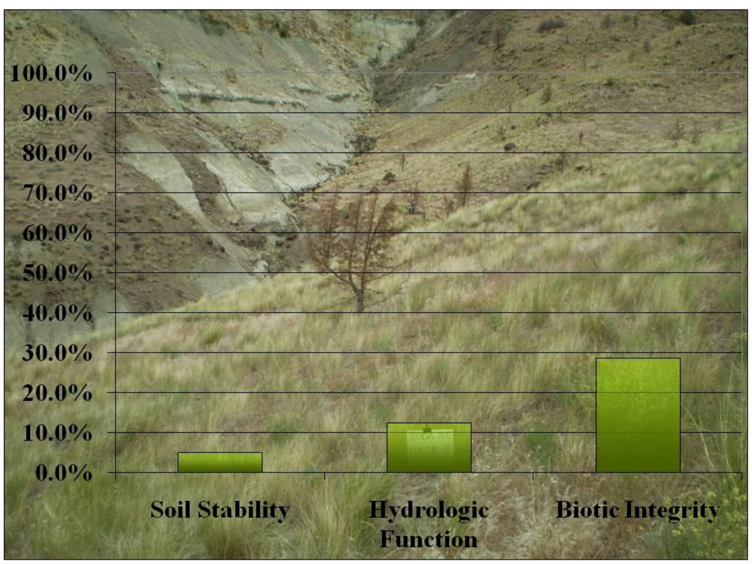

Figure 33. Departure from reference condition of the 3 landscape attributes in the JD Droughty Clayey South, 9-12 PZ ecological site, Foree portion of the Sheep Rock Unit, JODA (background is plot 5).

Painted Hills Unit

JD Clayey, 9-12 PZ Ecological Site:

This ecological site is dominated by soils developed from colluvium and loess parent material. The soils are stony clay loam over a cobbly clay loam dominated subsurface. Soil depth varies from 30" to 60" and is considered moderately well-drained. One plot was sampled in the JD Clayey, 9-12 PZ ecological site (R101XB022OR) in the Painted Hills Unit. Plot 8 was located in the northwest portion of the unit (Figure 33). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 0% and 5.0%, respectively. The biotic integrity attribute was rated as slight-moderate departure (34.3%) (Figure 34).

The plot is in a Simas-Day soil formed on colluvium and loess material. The historic climax plant community based on ecological site is big sagebrush/bluebunch wheatgrass-Thurber needlegrass. Disturbed vegetation types will see an increase in western juniper, basin big sagebrush, green rabbitbrush, and cheatgrass.

Plot 8 was not within a prescribed burn unit during the past 10 years. The plot had a slight-moderate departure in the biotic integrity attribute due to the dominance of cheatgrass and medusahead in the understory (>40%). Wyoming big sagebrush and shadscale saltbush are the dominate shrub species (10-40%) with minor amounts (2-10%) of perennial grass species, mainly Sandberg bluegrass. Western juniper was not present. Past use of the site for livestock grazing may explain the dominance of annual exotic grasses, but the area seems to be improving and the soil stability and hydrologic function were in good condition. Medusahead was the only noxious weed identified in the plot.

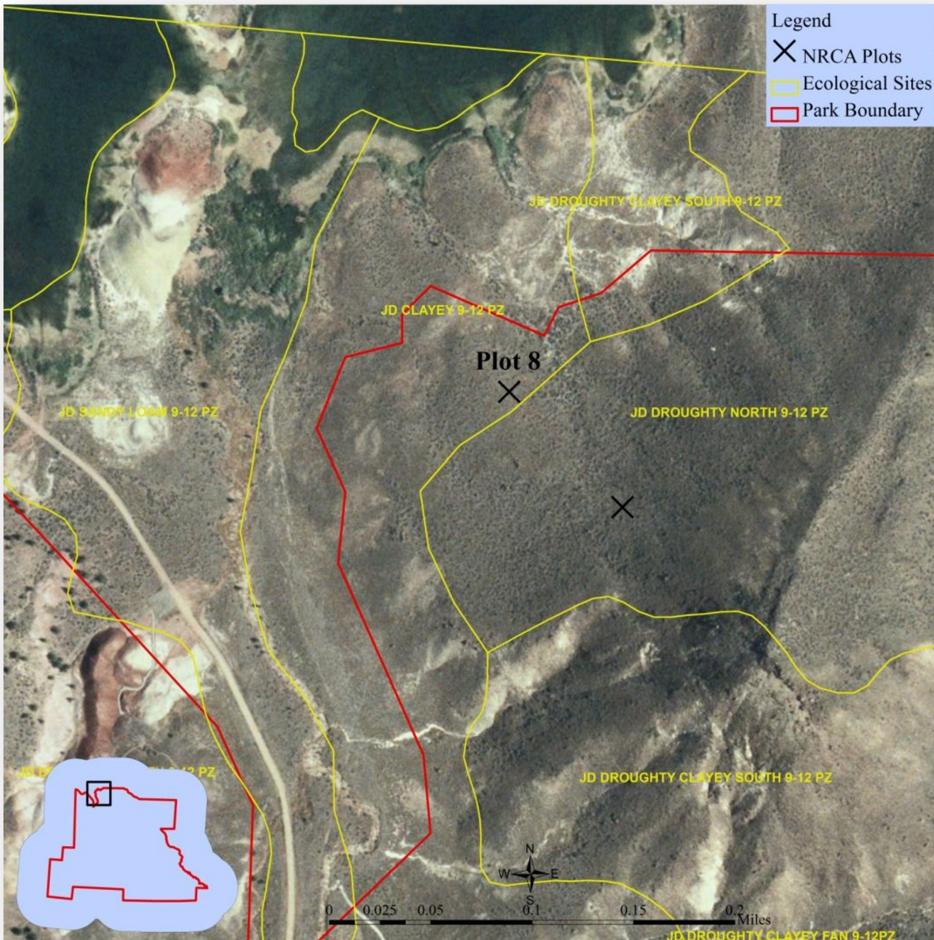

Figure 34. Map of ecological site sample plot 8 in the Painted Hills Unit, JODA.

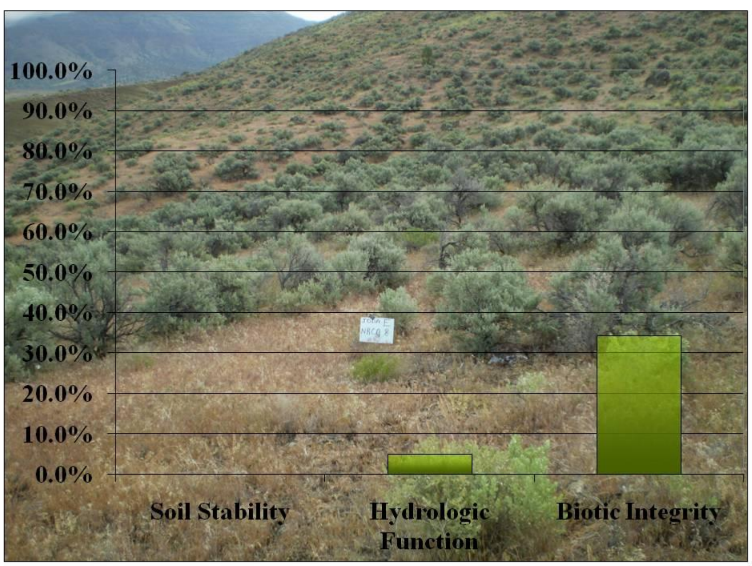

Figure 35. Departure from reference condition of the 3 landscape attributes in the JD Clayey, 9-12 PZ ecological site, Painted Hills Unit, JODA (background is plot 8).

JD Droughty North, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material from an acidic tuff origin. The soils are ashy loams over a clay dominated subsurface. Soil depth varies from 18” to 60” and is considered well-drained. Two plots were sampled in the JD Droughty North, 9-12 PZ ecological site (R101XB064OR) in the Painted Hills Unit. Plot 9 was located in the northwest portion of the unit and plot 11 was in the southwest portion of the Unit (Figure 36). All 3 landscape attributes; soil stability, hydrologic function, and biotic integrity; were rated as none-slight departure, 0%, 1.3%, and 10.0%, respectively. The biotic integrity attribute was rated as slight-moderate departure (34.3%) (Figure 37).

The plot is in a Simas soil formed on colluvium and loess material. The historic climax plant community based on ecological site is bluebunch wheatgrass-Idaho fescue with basin big sagebrush occurring as a minor overstory component (<3%). Disturbed vegetation types will see an increase in western juniper, basin big sagebrush, green rabbitbrush, and cheatgrass.

Plot 9 was not within a prescribed burn unit during the past 10 years but plot 11 was in the Sand Mountain prescribed burn (9/20/2002). Both plots were in good condition with none-slight departure and were dominated by bluebunch wheatgrass with cheatgrass and medusahead as a minor component (2-10%) of the community. Wyoming big sagebrush was a moderate component (10-40%) of plot 9, but was not present in plot 11. Dead burned western junipers were present outside plot 11. In both areas it was noted that there were patches dominated by cheatgrass but it was not the dominant community. Medusahead was the only noxious weed identified in plot 11.

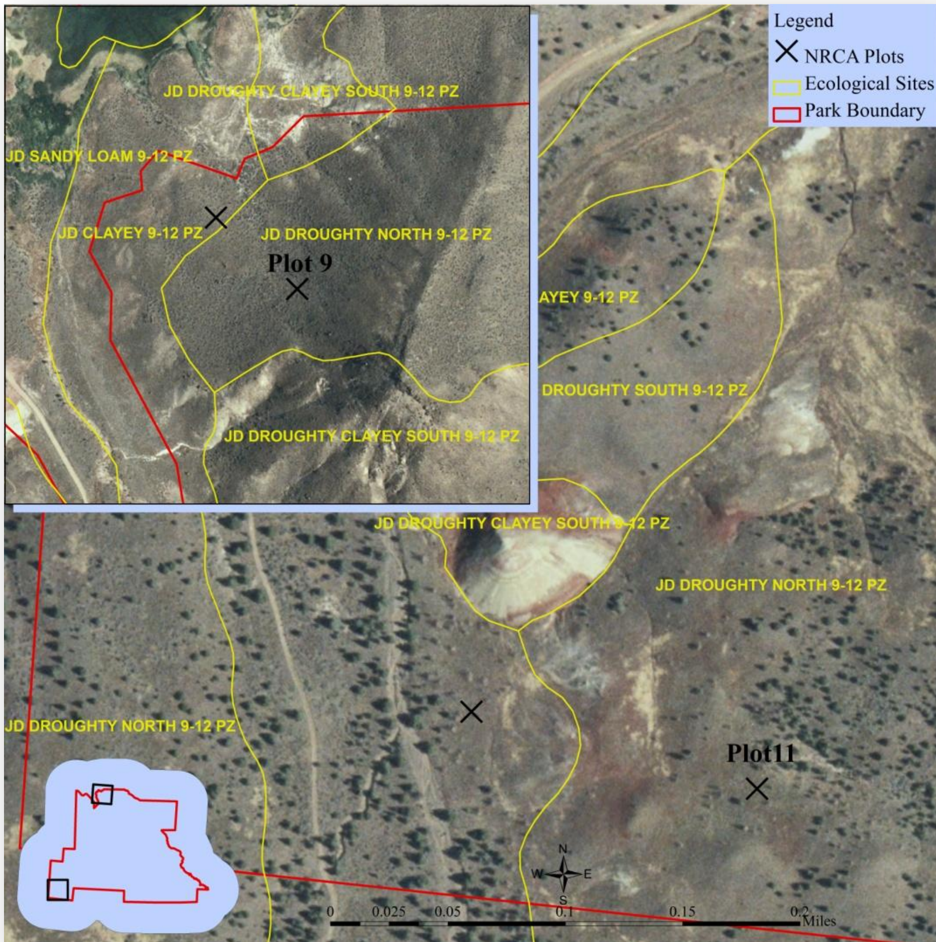

Figure 36. Map of ecological site sample plots 9 and 11 in the Painted Hills Unit, JODA.

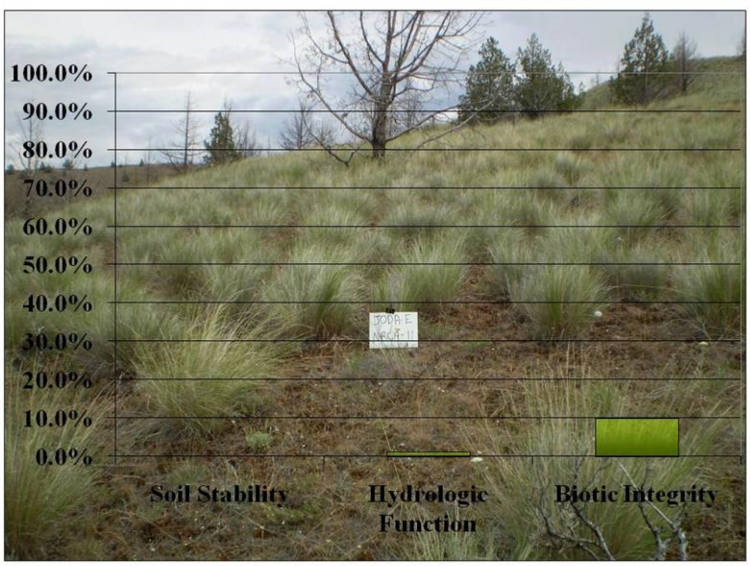

Figure 37. Departure from reference condition of the 3 landscape attributes in the JD Droughty North, 9-12 PZ ecological site, Painted Hills Unit, JODA (background is plot 11).

JD, Sandy Loam, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium that originated from basalt parent material. The soils are sandy loams with a fine sandy loam subsurface. Soil depth varies from 62" to 72" and is considered well-drained. One plot was sampled in the JD Sandy Loam Fan, 9-12 PZ ecological site (R101XB025OR) in the Painted Hills Unit. Plot 10 was located in the southwest portion of the unit (Figure 38). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 2.5% and 10.0%, respectively. The biotic integrity attribute was rated as slight-moderate departure (31.4%) (Figure 39).

The plot is in a Drewsey soil formed on gentle slopes (2-8%). The historic climax plant community based on ecological site is needle and thread grass (*Hesperostipa comata*)-basin wildrye-sand dropseed (*Sporobolus cryptandrus*) with big sagebrush occuring as a minor overstory component (<2%). Disturbed vegetation types will see an increase in western juniper, broom snakeweed, rubber rabbitbrush, and cheatgrass.

Plot 10 was in the Sand Mountain prescribed burn (9/20/2002). The plot had a slight-moderate departure in the biotic integrity attribute due to the dominance of cheatgrass and medusahead in the understory (>40%). Native grasses, bluebunch wheatgrass and Thurber's needlegrass, composed minor amounts (2-10%) of the community. There were trace amounts (<2%) of shadscale saltbush and western juniper. Burned western juniper was present in the plot. Medusahead was the only noxious weed identified in the plot. There were patches of unburned areas that were dominated by bluebunch wheatgrass.

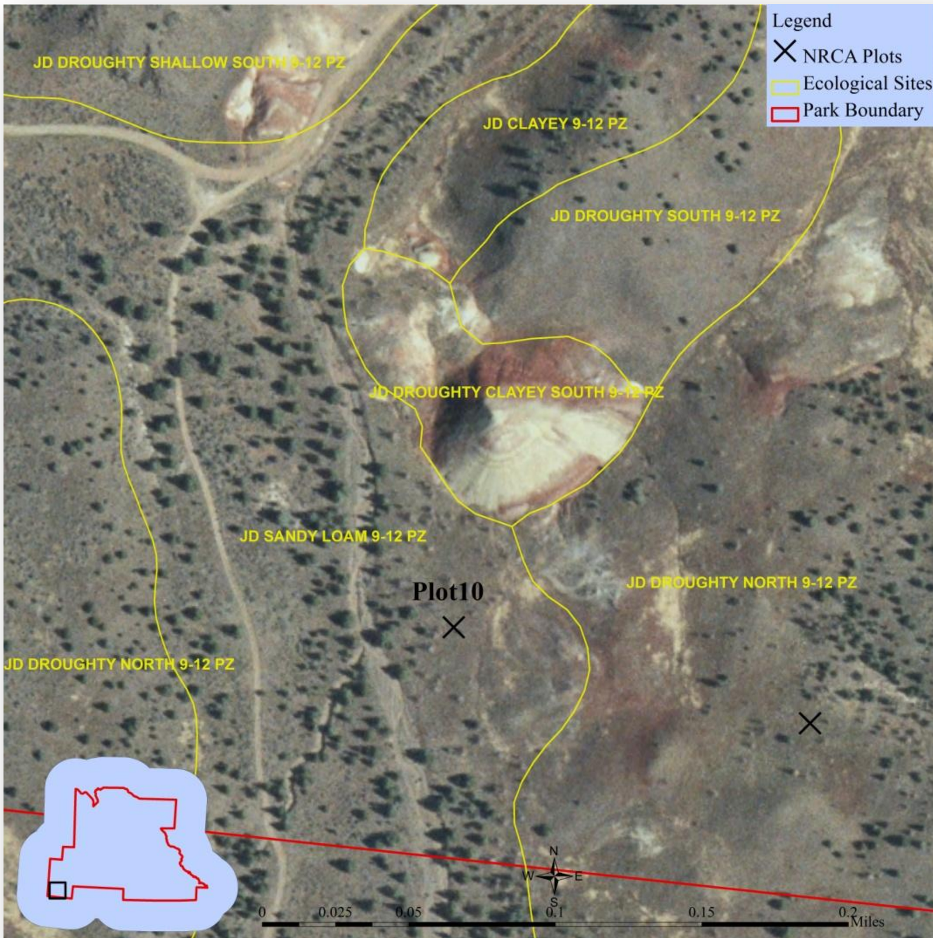

Figure 38. Map of ecological site sample plot 10 in the Painted Hills Unit, JODA.

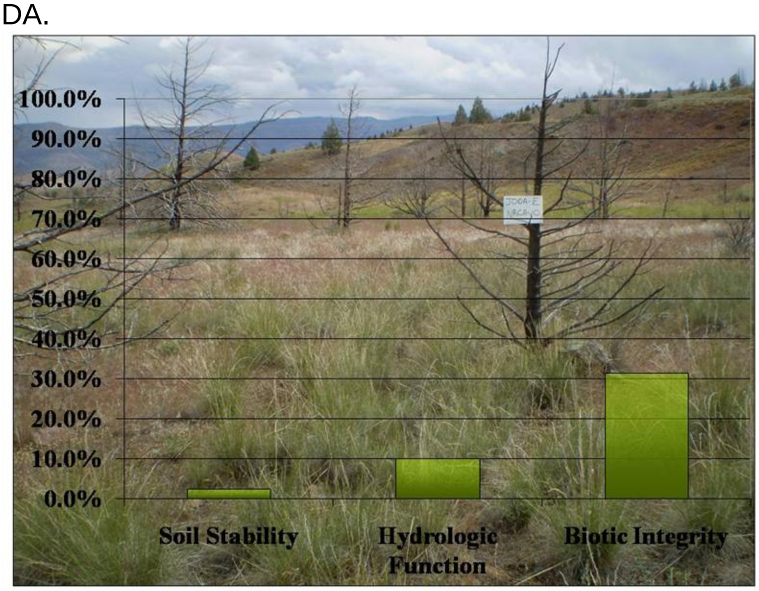

Figure 39. Departure from reference condition of the 3 landscape attributes in the JD Sandy Loam, 9-12 PZ ecological site, Painted Hills Unit, JODA (background is plot 10).

JD, Sodic Bottom, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from fine textured, interbedded sediments. The soils are silty clay loam with a silt loam subsurface. Soil depth varies from 40" to 60" and is considered well-drained. One plot was sampled in the JD Sandy Loam Fan, 9-12 PZ ecological site (R101XY007OR) in the Painted Hills Unit. Plot 12 was located in the southwest portion of the unit (Figure 40). The soil stability and hydrologic function landscape attributes were rated as none-slight departure, 0% and 7.5%, respectively. The biotic integrity attribute was rated as slight-moderate departure (40.0%) (Figure 41).

The plot is in a Beeman soil that has formed in a flood plain or alluvial fan. The historic climax plant community based on ecological site is greasewood (*Sarcobatus vermiculatus*)/basin wildrye (*Leymus cinereus*)-saltgrass (*Distichlis spicata*) with big sagebrush occuring as a minor sub-dominant (<2%). Disturbed vegetation types will see an increase in green rabbitbrush, horsebrush (*Tetradymia canescens*), and cheatgrass.

Plot 12 was in the Sand Mountain prescribed burn (9/20/2002). The plot had a moderate departure in the biotic integrity attribute due to the dominance (>40%) of a non-native grass, tall wheatgrass (*Thinopyrum ponticum*), with a minor component of cheatgrass (2-10%). Basin wildrye, basin big sagebrush, and greasewood occurred in trace amounts in the plot (<2%). Medusahead, hoarycress (*Cardaria draba*) , Russian knapweed (*Centaurea repens*), and burning bush (*Kochia scoparia*) occurred in minor amounts (2-10%) in the plot. This area seems to have been reseeded to tall wheatgrass in the past, but this treatment has not eliminated competition from non-native grasses and noxious weeds.

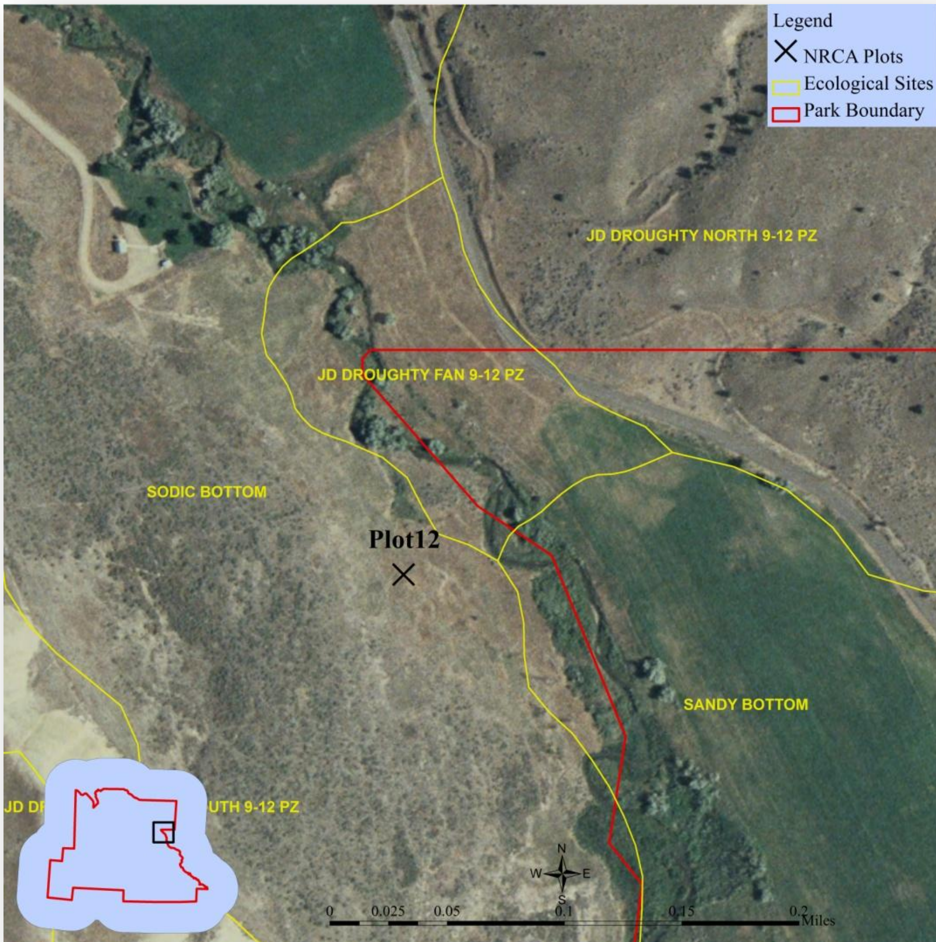

Figure 40. Map of ecological site sample plot 12 in the Painted Hills Unit, JODA.

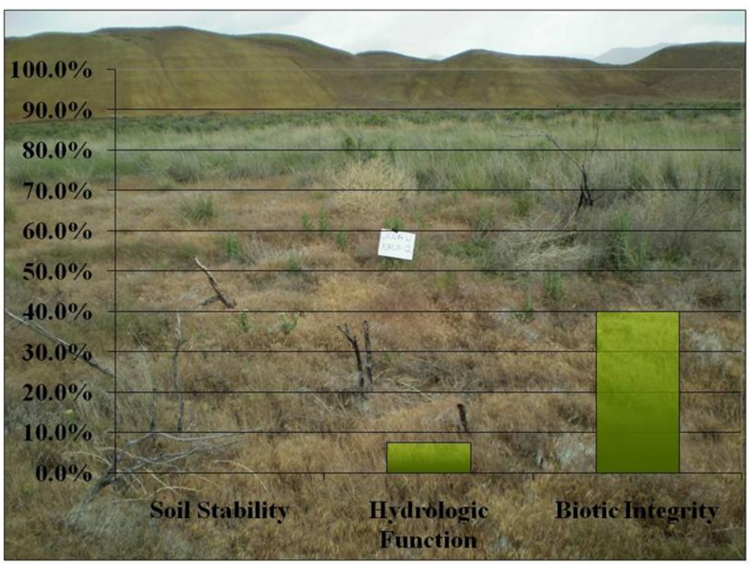

Figure 41. Departure from reference condition of the 3 landscape attributes in the JD Sodic Bottom, 9-12 PZ ecological site, Painted Hills Unit, JODA (background is plot 12).

Clarno Unit

JD Droughty South, 9-12 PZ Ecological Site:

This ecological site is dominated by soils developed from clay colluvium formed from tuffaceous sediments. The soils are loams over a clay dominated subsurface. Soil depth varies up to 60" and is considered well-drained. Two plots were sampled in the JD Droughty South, 9-12 PZ ecological site (R101XB044OR) in the Clarno Unit. Plot 19 was located in the southwest portion of the unit and plot 23 was in the southeast portion of the Unit (Figure 42). All 3 landscape attributes; soil stability, hydrologic function, and biotic integrity were rated as none-slight departure, 1.3%, 3.8%, and 17.1%, respectively (Figure 43).

These plots are in a Twickenham loam soil formed on south-facing slopes and ridges from clayey colluvium material. The historic climax plant community based on ecological site is Thurber needlegrass-bluebunch wheatgrass with a minor overstory of basin big sagebrush (<2%). Disturbed vegetation types will see an increase in western juniper, broom snakeweed, cheatgrass, and medusahead.

Plots 19 and 23 were burned by a wildfire in 1995 and 1994, respectively. Individually, plot 19 was in good condition with none-slight departure for biotic integrity (5.7%) and was dominated by Thurber needlegrass and bluebunch wheatgrass with cheatgrass and medusahead making up a minor component (2-10%) of the community. Plot 23 was in poorer condition than plot 19 with a biotic integrity departure of 28.6%. Cheatgrass and medusahead were the dominant species (>40%) with Thurber needlegrass and bluebunch wheatgrass occurring in smaller amounts (10-40%). Basin big sagebrush and antelope bitterbrush (*Purshia tridentata*) were also a moderate component (2-10%) of plot 23, but was not present in plot 19. Western junipers occurred in trace amounts (<2%) in both plots. Medusahead was the only noxious weed identified in both plots.

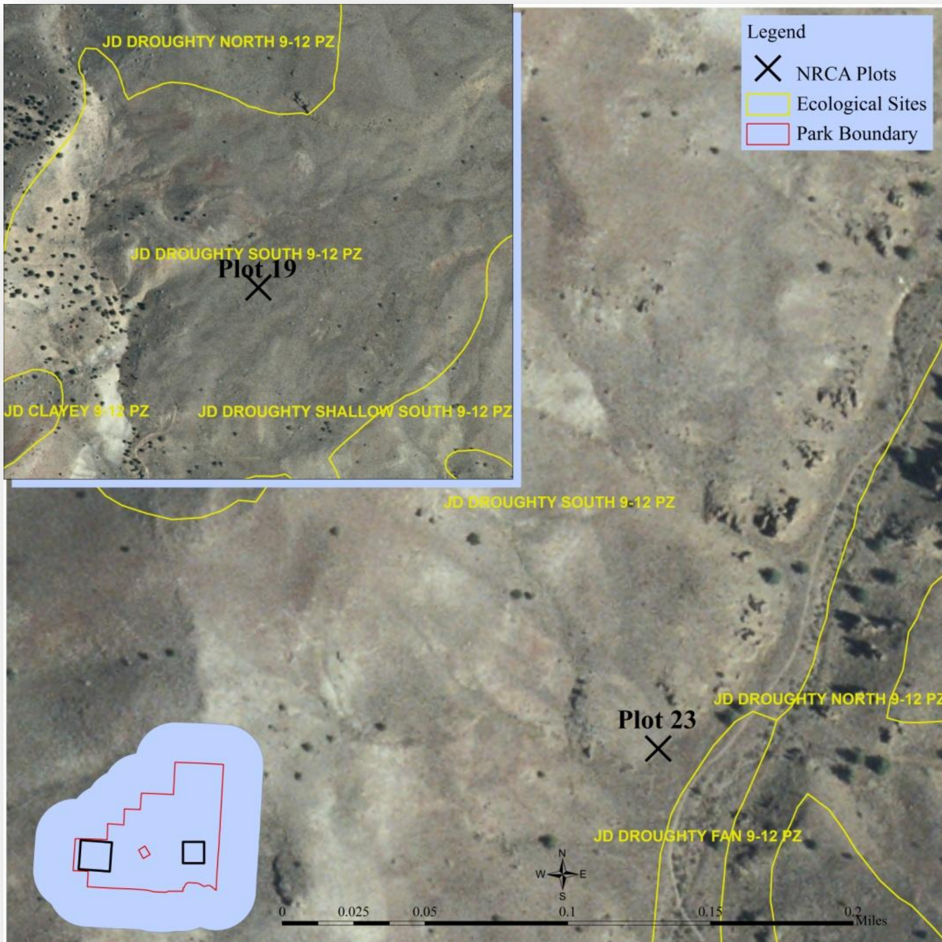

Figure 42. Map of ecological site sample plots 19 and 23 in the Clarno Unit, JODA.

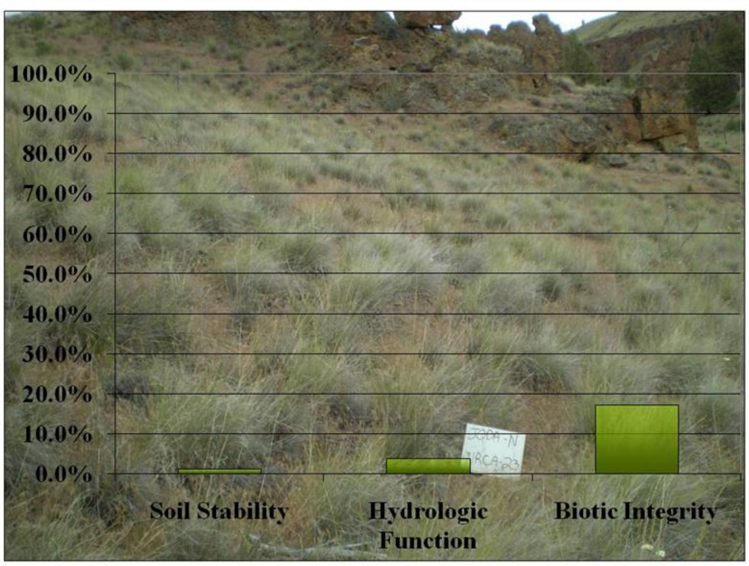

Figure 43. Departure from reference condition of the 3 landscape attributes in the JD Droughty South, 9-12 PZ ecological site, Clarno Unit, JODA (background is plot 23).

JD Droughty Fan, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from colluvium parent material. The soils are loams over a gravelly loam dominated subsurface. Soil depth varies from 18" to >60" and is considered well-drained. Two plots were sampled in the JD Droughty Fan, 9-12 PZ ecological site (R101XB053OR) in the Clarno Unit. Plot 20 was located in the south central portion of the unit just north of Oregon Highway 218 and plot 22 was in the southeast portion of the Unit (Figure 44). The soil stability and hydrologic function landscape attributes were rated none-slight departure, 1.3% and 7.5%, respectively. The biotic integrity was rated as slight-moderate departure (28.6%) (Figure 45).

These plots are in a Sorefoot soil formed on alluvial fans from clayey alluvium material weathered from tuffaceous sediments in the John Day and Clarno formations. The historic climax plant community based on ecological site is big sagebrush/Thurber needlegrass-basin wildrye. Disturbed vegetation types will see an increase in western juniper, broom snakeweed, cheatgrass, and medusahead.

Plots 20 and 22 were burned by a wildfire in 1995 and 1994, respectively. Individually, plot 20 was in poor condition with moderate departure for biotic integrity (40.0%) and was dominated by medusahead and cheatgrass with native Thurber needlegrass and Sandberg bluegrass making up a minor component (2-10%) of the community. Plot 22 was in better condition than plot 20 with a biotic integrity departure of 17.1%. Thurber needlegrass and bluebunch wheatgrass were the dominant species (>40%) with cheatgrass occurring in smaller amounts (10-40%). Basin big sagebrush and antelope bitterbrush (*Purshia tridentata*) were also a moderate component (10-40%) of plot 22 but were not present in plot 20. Western junipers occurred in trace amounts (<2%) in both plots. Medusahead and Russian knapweed were the only noxious weeds identified and both were in plot 20.

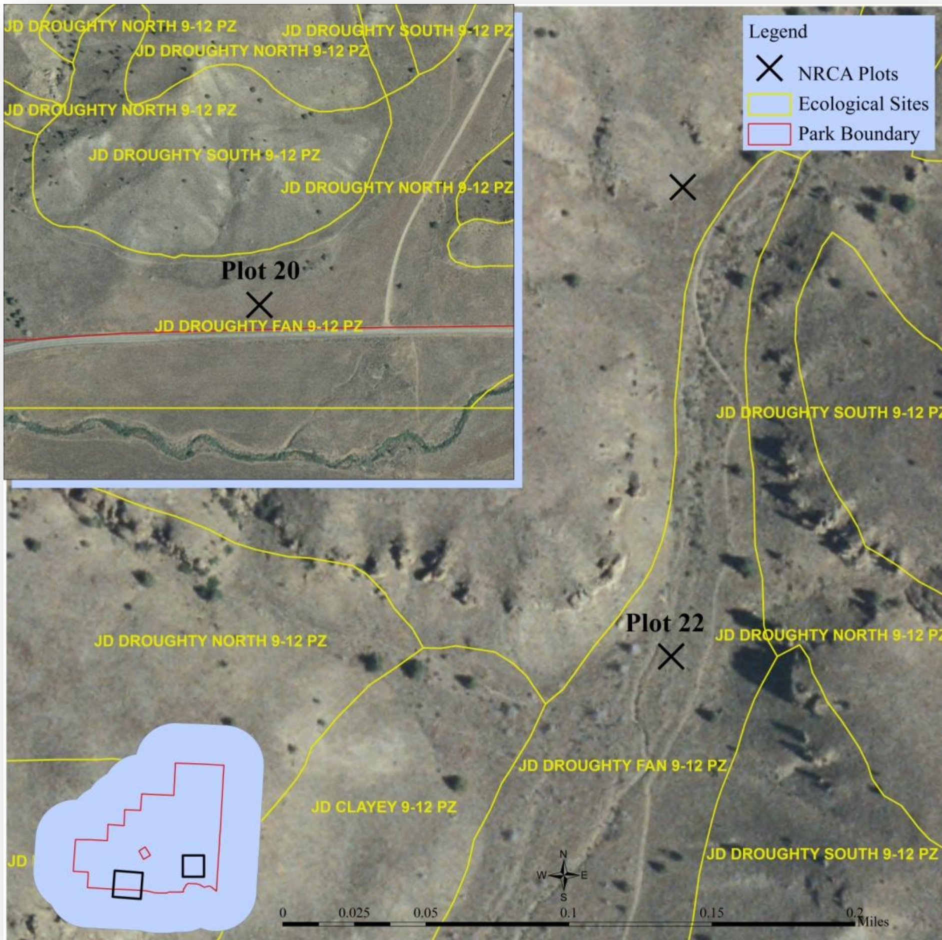

Figure 44. Map of ecological site sample plots 20 and 22 in the Clarno Unit, JODA.

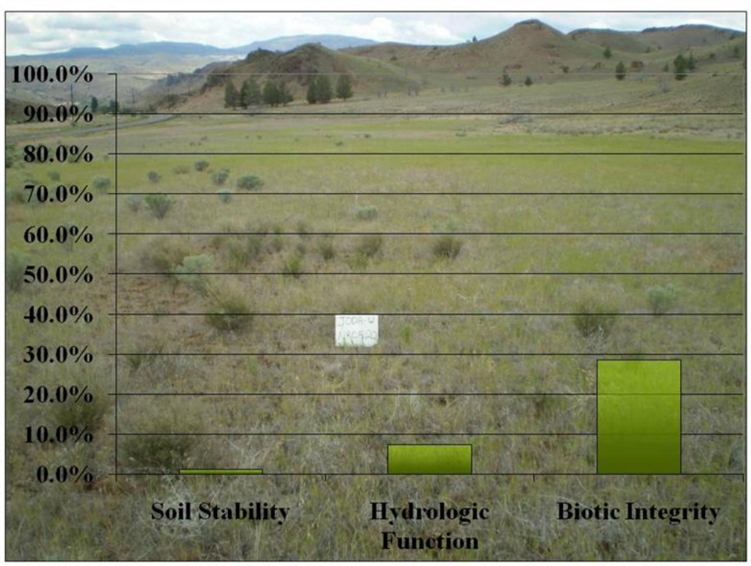

Figure 45. Departure from reference condition of the 3 landscape attributes in the JD Droughty Fan, 9-12 PZ ecological site, Clarno Unit, JODA (background is plot 20).

JD Droughty North, 9-12 PZ Ecological Site:
This ecological site is dominated by soils developed from clay colluvium formed from tuffaceous sediments. The soils are loams over a clay dominated subsurface. Soil depth varies up to a depth of 60" and is considered well-drained. Two plots were sampled in the JD Droughty North, 9-12 PZ ecological site (R101XB064OR) in the Clarno Unit. Plot 21 was located in the south central portion of the unit and plot 24 was in the southeast portion (Figure 42). All 3 landscape attributes; soil stability, hydrologic function, and biotic integrity; were rated as none-slight departure, 1.3%, 6.3%, and 22.9%, respectively (Figure 43).

These plots are in a Simas soil formed on south-facing slopes and ridges from clayey colluvium material. The historic climax plant community based on ecological site is bluebunch wheatgrass-Idaho fescue with a minor overstory of basin big sagebrush (<2%). Disturbed vegetation types will see an increase in western juniper, broom snakeweed, cheatgrass, and medusahead.

Both plot 21and 24 were burned in a wildfire in 1994. Individually, plot 21 was in very good condition with none-slight departure for biotic integrity (2.9%) and was dominated by Idaho fescue and bluebunch wheatgrass with cheatgrass and medusahead making up a trace amount (<2%) of the community. Plot 24 was in poorer condition with a biotic integrity departure of 42.9%. Cheatgrass and medusahead were the dominant species (>40%) with small patches of bluebunch wheatgrass occurring in minor amounts (2-10%). The only shrub was a trace amount (<2%) of horsebrush (*Tetradymia canescens*). Live western juniper did not occur in either plot, but some burned remnants were found in plot 21. Medusahead was the only noxious weed identified in plot 24.

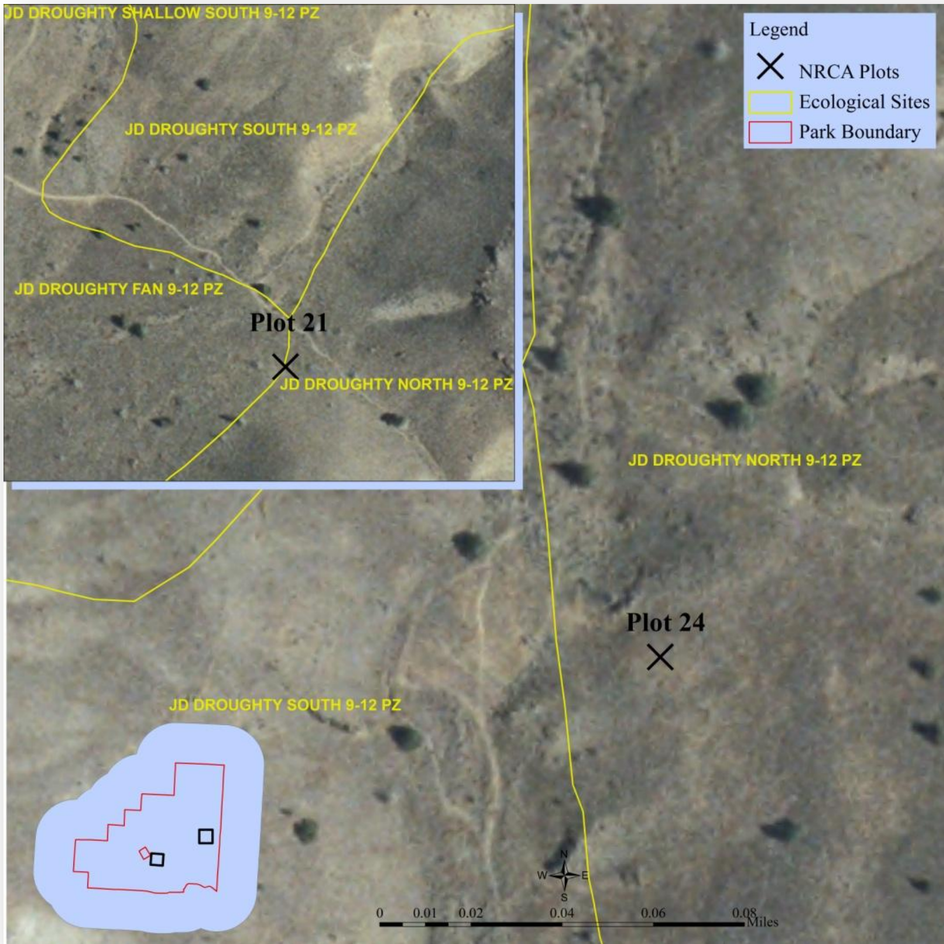

Figure 46. Map of ecological site sample plots 21 and 24 in the Clarno Unit, JODA.

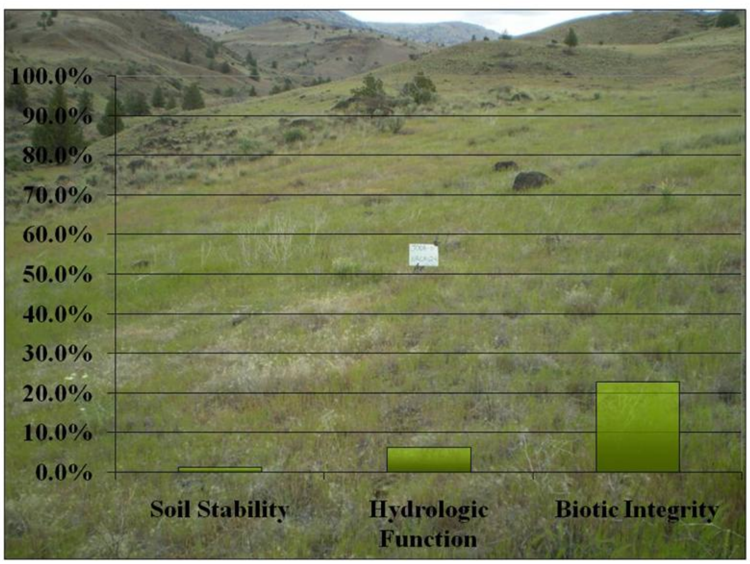

Figure 47. Departure from reference condition of the 3 landscape attributes in the JD Droughty North, 9-12 PZ ecological site, Clarno Unit, JODA (background is plot 24).

Summary of All Upland Sites

Table 10 is a summary of the departure values by plot for each landscape attribute along with site physiographic information such as slope, aspect, and elevation. All but 1 plot had a soil stability attribute rating of none-slight departure from reference condition. The hydrologic function attribute also only had 1 plot above the none-slight departure rating. Both attributes indicate the park land is in good condition, functioning properly and not contributing to soil erosion and water quality degradation. Rodhouse (2009) also found soil/site stability in good condition from data collected to monitor sagebrush-steppe vegetation. JODA lands make up a minority of the watersheds and non-park lands could not be assessed similar to those in the park. Based on current soil stability and hydrologic function ratings under current park management these 2 processes should remain stable into the future.

The biotic integrity attribute indicated many areas are not in good condition. Only 5 sites were rated in the none-slight departure category (<21%), 9 fell into the slight-moderate category (21%-40%), and 11 in the moderate category (41%-60%). Visual observations indicated areas lower in the valleys with less slope were in poor vegetative condition due to historic grazing patterns. Steeper slopes surrounding the valleys were generally in better condition. Unfortunately, the methodology described by Pellant (2005) is designed to rapidly assess areas represented by ecological sites which did not always follow topographic position or other physiographic conditions. The results could not be directly related back to physiographic values.

Analysis of physiographic relationship with biotic integrity was attempted statistically by correlating biotic integrity departure values with slope within management Units using a non-parametric statistic, Spearman's Rank Correlation coefficient (r_s). The results indicated increasing slope was not significantly correlated ($\alpha(2)=0.05$) with lower biotic integrity departure ratings in the Clarno Unit (n=6, $r_s=0.8000$), Painted Hills Unit (n=5, $r_s=0.8542$),or Sheep Rock Unit (n=14, $r_s=.2667$). Future projects, such as vegetation mapping and sagebrush steppe monitoring, will provide geographically-based information that will allow for more detailed analysis of vegetation succession and distribution. This information will provide the ability to compare physiographic and other landscape attribute relationships to vegetation patterns.

Table 10. Summary of departure ratings for landscape attributes and physiographic attributes for JODA upland sample plots.

Park Unit	Plot No	Soil Stability % Departure	Hydrologic Function % Departure	Biotic Integrity % Departure	Slope (%)	Aspect (degrees)	Elevation (ft)	Topographic Position
Clarno	19	0.0%	0.0%	10.0%	13	232	1709	Backslope
Clarno	20	0.0%	10.0%	50.0%	2	272	1406	Terrace
Clarno	21	0.0%	0.0%	6.7%	61	4	1569	Toeslope
Clarno	22	2.5%	5.0%	23.3%	4	210	1594	Valley Floor
Clarno	23	2.5%	7.5%	36.7%	37	124	1614	Backslope
Clarno	24	2.5%	12.5%	53.3%	11	276	1746	Backslope
Painted Hills	8	0.0%	5.0%	43.3%	5	6	1943	Toeslope
Painted Hills	9	0.0%	2.5%	23.3%	37	304	2016	Backslope
Painted Hills	10	2.5%	10.0%	40.0%	3	352	2184	Toeslope
Painted Hills	11	0.0%	0.0%	6.7%	35	350	2353	Backslope
Painted Hills	12	0.0%	7.5%	50.0%	3	38	1968	Valley Floor
Sheep Rock	1	5.0%	7.5%	60.0%	7	85	2240	Toeslope
Sheep Rock	2	20.0%	37.5%	50.0%	12	230	2246	Toeslope
Sheep Rock	3	2.5%	10.0%	66.7%	6	260	2280	Step in Slope
Sheep Rock	4	2.5%	7.5%	43.3%	5	360	2486	Step in Slope
Sheep Rock	5	5.0%	12.5%	36.7%	38	315	2475	Backslope
Sheep Rock	6	2.5%	10.0%	33.3%	26	225	2667	Backslope
Sheep Rock	7	10.0%	17.5%	60.0%	5	360	2157	Terrace
Sheep Rock	13	5.0%	5.0%	26.7%	32	16	2380	Backslope
Sheep Rock	14	2.5%	12.5%	60.0%	11	258	2406	Backslope
Sheep Rock	15	0.0%	0.0%	20.0%	17	272	2605	Backslope
Sheep Rock	16	0.0%	5.0%	40.0%	8	104	2699	Toeslope
Sheep Rock	17	0.0%	5.0%	23.3%	43	8	2349	Backslope
Sheep Rock	18	2.5%	10.0%	53.3%	3	242	2236	Terrace
Sheep Rock	25	0.0%	2.5%	10.0%	4	140	3213	Toeslope

Aquatic Assessment Results

For this study, 4 of the 15 CRAM riverine wetland sites assessed in 2007 (NPS 2007) were selected for instream benthic macroinvertebrate (BMI) sampling. The 11 CRAM riverine wetland sites not used were intermittent or seasonal surface water flows and were dry during our August 2008 sampling effort.

Eastern OR IBI scores ranged from 18 to 28 among the six Oregon samples (Table 11). While all of these scores fall into the “high” or “severe” impairment classes using current impairment-class categories for eastern Oregon, reliance on these results alone could be misleading because of the small and regionally limited data set used to develop the eastern OR IBI and impairment classes. While Oregon DEQ has used this index to evaluate ecological conditions in eastern Oregon streams outside of the Grande Ronde basin, they do not refer to this index as the eastern Oregon index because of its limited applicability. Among Oregon sites, Rock Creek site, R15, and John Day River site, R14B, received the highest IBI scores of 28, while Bridge Creek received the lowest score of 18.

Table 11. Summary of raw and metric BMI scores for the 6 JODA sample sites based on the Eastern Oregon IBI.

RAW SCORE (IBI)	Bridge Creek R11	Rock Creek R08	Rock Creek R15	John Day River R14A	John Day River R14B	John Day River R14C
Taxa Richness	30	29	28	30	32	31
Mayfly Richness	5	5	8	10	9	9
Stonefly Richness	3	2	3	2	4	3
Caddisfly Richness	5	6	5	4	5	5
Sensitive Taxa	1	0	0	0	1	1
Sediment Sensitive Taxa	0	0	1	0	0	1
Modified HBI	3.7	3.7	3.0	4.6	3.9	4.1
% Tolerant Taxa	64	73	53	44	56	53
% Sediment Tolerant Taxa	18	10	2	4	4	2
% Dominant	57.3	61.0	56.2	53.1	46.5	56.1
METRIC SCORE (HBI)						
Taxa Richness	1	1	1	1	1	1
Mayfly Richness	1	1	5	5	5	5
Stonefly Richness	1	1	1	1	1	1
Caddisfly Richness	3	5	3	3	3	3
Sensitive Taxa	1	1	1	1	1	1
Sediment Sensitive Taxa	1	1	3	1	1	3
Modified HBI	5	5	5	3	5	3
% Tolerant Taxa	1	1	1	1	1	1
% Sediment Tol Taxa	1	3	5	5	5	5
% Dominant	3	3	3	3	5	3
TOTAL SCORE	**18**	**22**	**28**	**24**	**28**	**26**

Based on the Eastern Oregon IBI, Hilsenhoff Biotic Index (HBI) values for the six sites ranged from 3.0 to 4.6 (Table 10), which correspond to good-excellent water quality conditions and minimal organic pollution. This translates to minimal organic decomposition and oxygen consumption resulting in moderate-high dissolved oxygen concentrations for fish in the sampled streams. Among Oregon sites, the Rock Creek site, R15, received the highest quality HBI score of 3.0, while the John Day River, R14A, received the lowest quality score of 4.6.

Data analyzed using the Western Cordillera and Columbia Plateau (WCCP) predictive model resulted in O/E values ranging between 0.662325 and 0.915316 (Table 12), which correspond to disturbed conditions at the six JODA sites.

Table 12. Summary of scores for the 6 JODA sample sites based upon the Western Dordillera and Columbia Plateau (WCCP) predictive model.

Site Name	O/E (P>0.5)	Biological Condition Class
Bridge Creek R11	0.914739	Moderately Disturbed
Rock Creek R08	0.662325	Most Disturbed
Rock Creek R15	0.662325	Most Disturbed
John Day River R14A	0.915316	Moderately Disturbed
John Day River R14B	0.910697	Moderately Disturbed
John Day River R14C	0.662325	Most Disturbed

John Day River

The John Day River flows to the north through the center of the Sheep Rock Unit of the John Day Fossil Beds National Monument. Local land uses include agricultural farming, ranching and grazing, and recreational uses by trail and road. These influences have resulted in channelization of the John Day River. The CRAM site on the John Day River was split into 3 sub-units for BMI sampling due to its large size (Figure 48).

John Day River R14A

The John Day River R14A site appeared greenish in color and contained substrate consisting of boulders, cobbles, gravels, sand and silt and substrate embeddedness of approximately 5 percent (Figure 48). An estimated 99 percent of the substrate was comprised of inorganic material. Organic substrate consisted of minor amounts of muck along the river margins. The steep river banks were stable and consisted of moderately compacted clay, silt, sand, and rock. Much of the left stream bank was armored with large boulders to protect road bed fill from mass wasting and erosion. The channel cross-section formed a rectangular to u-shape with no signs of undercut banks. Bank vegetation consisted mostly of grasses and shrubs with scattered herbaceous plants and deciduous trees providing very little shading to the river throughout the day.

At R14A the water contained no apparent odors or surface contamination. The stream averaged 10.8 m wide, 0.3 m deep, and flowed at approximately 0.4 m/s. The riffle from which the samples were collected was approximately 23.5 m long and 10.8 m wide. Each of the 8 replicate samples collected at the R14A site were approximately 2-3 m apart.

The Eastern Oregon IBI score of 24 corresponds to a ―severely impaired" ecological condition. However, reliance on these results alone could be misleading due to the small and regionally limited data set used to develop the Eastern Oregon IBI and impairment classes. The John Day River R14A site received a Hilsenhoff Biotic Index (HBI) value of 4.6, which corresponds to ―good" water quality conditions and ―some" organic pollution. Based on the WCCP predictive model, the R14A site received an O/E value of 0.915316, which corresponds to ―moderately disturbed" benthic biological conditions. Benthic index results suggest that this site is not currently supporting and maintaining a balanced community of organisms that has the composition, diversity, and functional organization comparable to that of natural habitat within the same region.

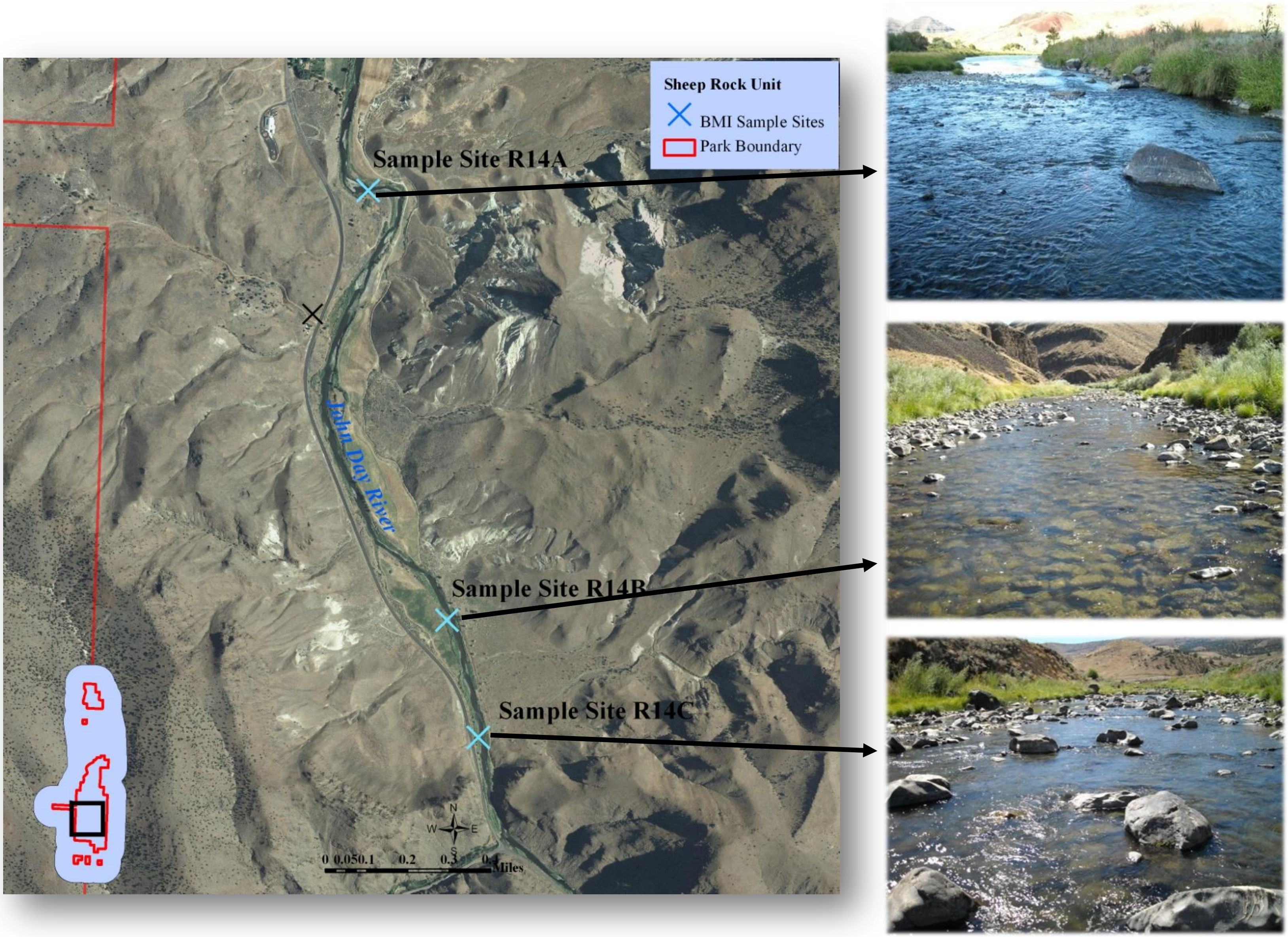

Figure 48. Map and pictures of aquatic sample sites R14A, R14B, and R14C along the John Day River in the Sheep Rock Unit, JODA.

John Day River R14B

The John Day River R14B site appeared greenish in color with substrate consisting of boulders, cobbles, gravels, sand and silt (Figure 48). Substrate embeddedness was estimated at 20 percent. Approximately 99 percent of the substrate at the R14B site was inorganic material. Organic substrate consisted of minor amounts of muck along the stream margins. The steep stream banks were stable and consisted of moderately compacted clay, silt, sand, and rock. The channel cross-section formed a rectangular to u-shape and contained no signs of undercut banks. Bank vegetation consisted mostly of grasses and shrubs with scattered herbaceous plants and deciduous trees providing very little shading to the river throughout the day

At the R14B sampling site the water contained no apparent odors or surface contamination. The stream averaged 15.38 m wide, 0.2-0.4 m deep, and flowed at approximately 0.48 m/s. The sampled riffle was 43 m long and 6 m wide. Each of the 8 replicate samples collected at the R14B site were approximately 5-6 m apart.

The site received an Eastern Oregon IBI score of 28, corresponding to ―highly impaired” ecological conditions. However, reliance on these results alone could be misleading due to the small and regionally limited data set used to develop the Eastern Oregon IBI and impairment classes. Based on the Eastern Oregon IBI, John Day River R14B received a Hilsenhoff Biotic Index (HBI) value of 3.9, which corresponds to ―very good” water quality conditions and ―slight” organic pollution. Based on the WCCP predictive model, the R14B site received an O/E value of 0.910697, which corresponds to ―moderately disturbed” benthic biological conditions. Benthic index results suggest that this site is not currently supporting and maintaining a balanced community of organisms that has the composition, diversity, and functional organization comparable to that of natural habitat within the same region.

John Day River R14C

The John Day River R14C site appeared greenish in color with foam on the surface and substrate consisting of boulders, cobbles, gravels, sand and silt (Figure 48). Substrate embeddedness was estimated at 30 percent. Approximately 95 percent of the substrate at the R14C site was inorganic material. Organic substrate consisted of minor amounts of muck along the stream margins. The moderately steep stream banks were stable and consisted of moderately compacted clay, silt, sand, and rock. Much of the left stream bank was armored with large boulders protecting road bed fill. The channel cross-section formed a rectangular to u-shape and contained no signs of undercut banks. Bank vegetation consisted mostly of grasses and shrubs with scattered herbaceous plants and deciduous trees providing very little shading to the river throughout the day.

At the R14C sampling site the water appeared normal with no apparent odors or surface contamination. The stream averaged 10 m wide, 0.2 m deep, and flowed at approximately 0.78 m/s. The sampled riffle was 32.5 m long and 2-5 m wide. Each of the 8 replicate samples collected at the R14C site were approximately 3-4 m apart. The site received an Eastern Oregon IBI score of 26, corresponding to ―severely impaired” ecological conditions. However, reliance on these results alone could be misleading due to the small and regionally limited data set used to develop the Eastern Oregon IBI and impairment classes. Based on the Eastern Oregon IBI, John Day River R14C received a Hilsenhoff Biotic Index (HBI) value of 4.1, which corresponds to

―very good" water quality conditions and ―slight" organic pollution. Based on the WCCP predictive model, the R14C site received an O/E value of 0.662325, which corresponds to ―most disturbed" benthic biological conditions. Benthic index results suggest that this site is not currently supporting and maintaining a balanced community of organisms that has the composition, diversity, and functional organization comparable to that of natural habitat within the same region.

The 2007 wetland study conducted throughout JODA concluded that the entire R14 site (sites R14A, R14B, and R14C), an approximately 80-acre riverine wetland, received a CRAM score of 85, which indicates that the wetland is in ―good" functional condition (NPS 2007).

Rock Creek

Rock Creek, a tributary to the John Day River, is located along the southern border of the Sheep Rock Unit of John Day Fossil Beds National Monument. Local land uses include farming, ranching, grazing, and recreational uses from trails and roads. These influences have channelized the stream as it flows through JODA. A small dam created for agricultural water diversion exists about 1.2 kilometers downstream of the R08 site and 35 m upstream of the R15 site. The confluence of Rock Creek with the John Day River is located approximately 50 m downstream of the R15 site.

Rock Creek R08

The Rock Creek R08 site appeared greenish brown in color and contained substrate consisting of boulders, cobbles, gravel, sand and silt (Figure 49). Substrate embeddedness was estimated at 5-10 percent. Approximately 95 percent of the substrate at the R08 site was inorganic material. Organic substrate consisted of minor amounts of muck along the stream margins. The steep stream banks were stable. The right bank consisted of moderately compacted clay, silt, sand, and rock and the left bank consisted of a rock outcrop. The channel cross-section formed a v-shape and contained no signs of undercut banks. Bank vegetation consisted of grasses, shrubs, and scattered herbaceous plants with dense growths of deciduous trees providing 40-50 percent stream shading throughout the day, although many of the white alder (*Alnus rhombifolia*) are dead or dying but the cause was unknown.

At the Rock Creek R08 sampling site the water appeared normal with no apparent odors or surface contamination. The stream averaged 5.5 m wide, 0.05-0.25 m deep, and flowed at approximately 0.28 m/s. The sampled riffle was 28 m long and 4 m wide. Each of the 8 replicate samples collected at the R08 site were approximately 3-4 m apart.The site received an Eastern Oregon IBI score of 22, corresponding to ―severely impaired" ecological conditions. However, reliance on these results alone could be misleading due to the small and regionally limited data set used to develop the Eastern Oregon IBI and impairment classes. Based on the Eastern Oregon IBI, Rock Creek R08 received a Hilsenhoff Biotic Index (HBI) value of 3.7, which corresponds to ―very good" water quality conditions and ―slight" organic pollution. Based on the WCCP predictive model, the R08 site received an O/E value of 0.662325, which corresponds to ―most disturbed" benthic biological conditions. Benthic index results suggest that this site is not currently supporting and maintaining a balanced community of organisms that has the composition, diversity, and functional organization comparable to that of natural habitat within the same region.

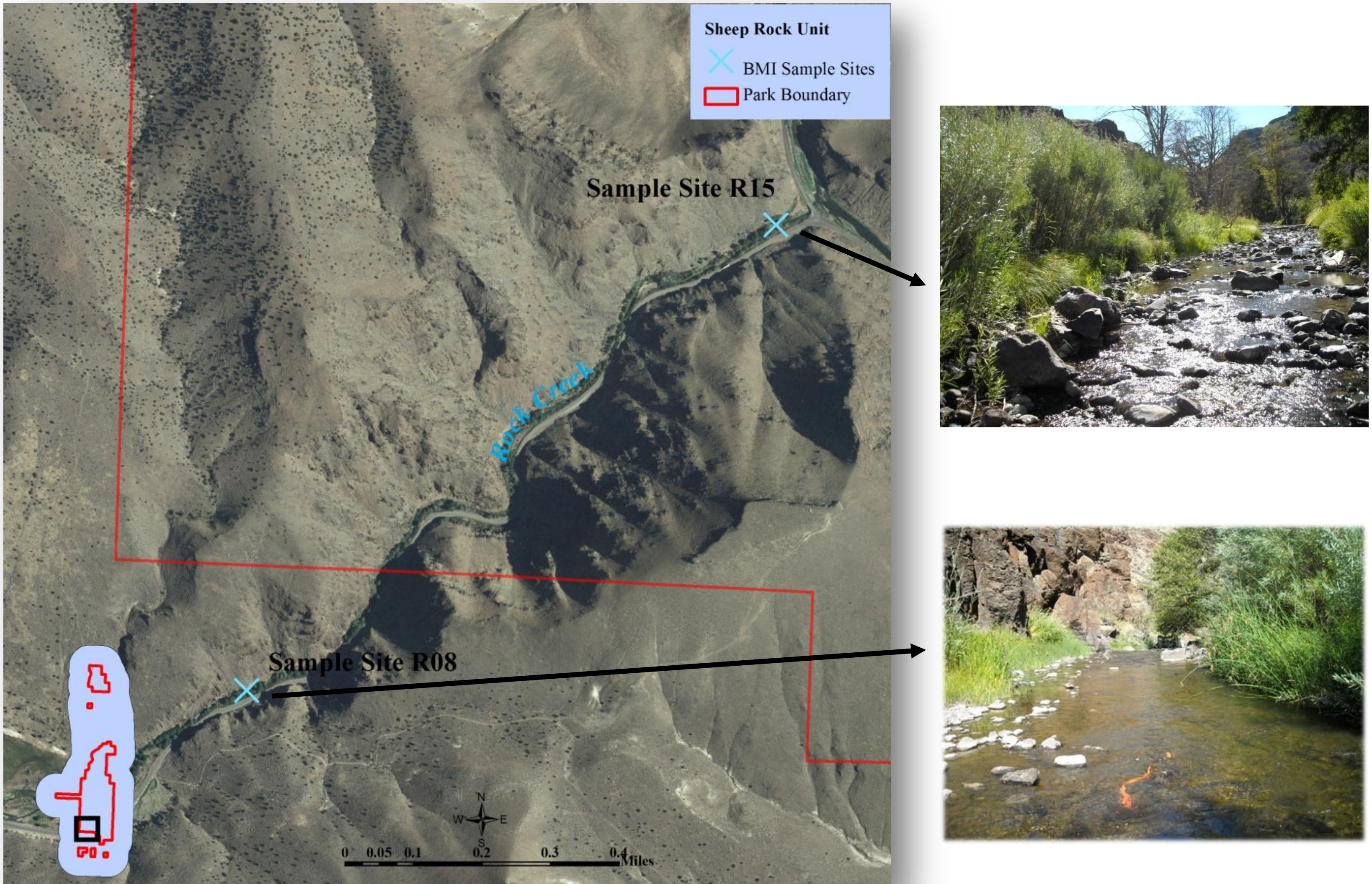

Figure 49. Map and pictures of aquatic sample sites R08 and R15 along Rock Creek in the Sheep Rock Unit, JODA.

Rock Creek R15
The Rock Creek R15 site appeared greenish in color and contained substrate consisting of boulders, cobbles, gravel, and sand (Figure 8). Substrate embeddedness was estimated at 10 percent. Approximately 97 percent of the substrate at the R15 site was inorganic material. Organic substrate consisted of minor amounts of muck along the stream margins. The moderately steep stream banks were slightly eroded and consisted of moderately compacted dirt, rock, and fill material from the road embankment. The channel cross-section formed a u-shape and contained no signs of undercut banks. Bank vegetation consisted of grasses, shrubs, and scattered herbaceous plants with scattered growths of deciduous trees providing approximately 10 percent stream shading throughout the day. Burned junipers were also observed near the Rock Creek streambanks and many of the white alder are dead or dying but the cause was unknown.

At the Rock Creek R15 sampling site the water appeared normal with no apparent odors or surface contamination. The stream averaged 4.7 m wide, 0.2-0.8 m deep, and flowed at approximately 0.24 m/s. The sampled riffle was 32.8 m long and 4.5 m wide. Each of the 8 replicate samples collected at the R15 site were 2-4 m apart.

The site received an Eastern Oregon IBI score of 28, corresponding to ―highly impaired” ecological conditions. However, reliance on these results alone could be misleading due to the small and regionally limited data set used to develop the Eastern Oregon IBI and impairment classes. Based on the Eastern Oregon IBI, Rock Creek R15 received a Hilsenhoff Biotic Index (HBI) value of 3.0, which corresponds to ―excellent” water quality conditions and ―no apparent” organic pollution. Based on the WCCP predictive model, the R15 site received an O/E value of 0.662325, which corresponds to ―most disturbed” benthic biological conditions. Benthic index results suggest that this site is not currently supporting and maintaining a balanced community of organisms that has the composition, diversity, and functional organization comparable to that of natural habitat within the same region.

The 2007 wetland study conducted throughout JODA concluded that the Rock Creek R15 site, an approximately 0.2-acre riverine wetland, received a CRAM score of 61, which indicates that the wetland is in ―poor‖ functional condition (NPS 2007). This low score is likely due to the homogeneity of this small wetland, which lacked the functional micro-habitats common in larger wetland systems.

Bridge Creek
Bridge Creek, a tributary of the John Day River, is located along the eastern border of the Painted Hills Unit. Local land uses include farming, ranching, grazing, and recreational uses by trail and road. These influences have resulted in Bridge Creek being channelized as it flows through JODA. A culvert is located approximately 35 meters downstream of the Bridge Creek R11 sampling site.

Bridge Creek R11
The Bridge Creek R11 site appeared greenish in color and contained substrate consisting of cobbles, gravel, sand, and silt (Figure 50). Substrate embeddedness was estimated at 10 percent. Approximately 90 percent of the substrate at the R11 site was inorganic material. Organic substrate consisted of minor amounts of muck along the stream margins and low gradient

pockets. The steep stream banks were slightly eroded and consisted of moderately compacted dirt and rock. The channel cross-section formed a u-shape and contained slightly undercut banks. Bank vegetation consisted of tall grasses, willow shrubs, and scattered herbaceous plants providing approximately 80 percent stream shading throughout the day. No large trees were present along the banks and had been previously removed by prescribed fire in 2002.

At the Bridge Creek R11 sampling site the water appeared normal with no apparent odors or surface contamination. The stream averaged 3.3 m wide, 0.15 m deep, and flowed at approximately 0.15 m/s. The sampled riffle was 23.2 m long and 3.3 m wide. Each of the 8 replicate samples collected at the R11 site were approximately 2.5 m apart.

The site received an Eastern Oregon IBI score of 18, corresponding to ―severely impaired” ecological conditions. However, reliance on these results alone could be misleading due to the small and regionally limited data set used to develop the Eastern Oregon IBI and impairment classes. Based on the Eastern Oregon IBI, Bridge Creek R11 received a Hilsenhoff Biotic Index (HBI) value of 3.7, which corresponds to ―very good” water quality conditions and ―slight” organic pollution. Based on the WCCP predictive model, the R11 site received an O/E value of 0.914739, which corresponds to ―moderately disturbed” benthic biological conditions. Benthic index results suggest that this site is not currently supporting and maintaining a balanced community of organisms that has the composition, diversity, and functional organization comparable to that of natural habitat within the same region.

The 2007 wetland study conducted throughout JODA concluded that the Bridge Creek R11 site, an approximately 11.5-acre riverine wetland, received a CRAM score of 81, which indicates that the wetland is in ―good” functional condition (NPS 2007).

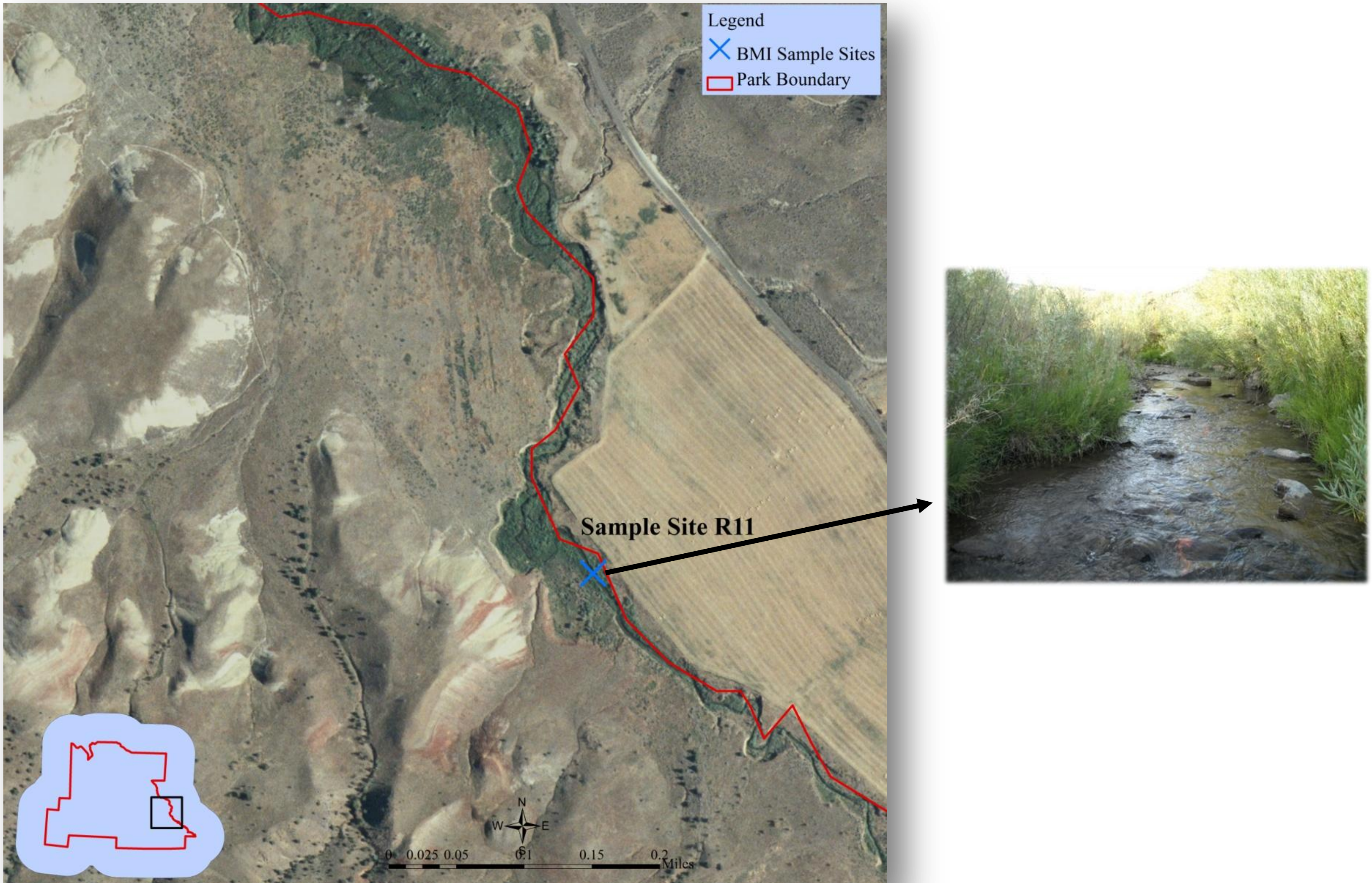

Figure 50. Map and picture of aquatic sample site R11 along Bridge Creek in the Painted Hills Unit, JODA.

Threats and Stressors

Threats and stressors are defined as a condition or situation, occurrence, or factor causing a negative impact to a natural resource. These can be further divided into naturally occurring or human-caused depending on their source. This section reports on 2 upland, fire and noxious weeds, and 4 aquatic; flow diversions, recreational land use, agricultural land use, and fine sediments; threats and stressors. Climate change is addressed as a threat to both upland and aquatic natural resources.

Upland Resources

The 2 major threats to upland resource at JODA are wildfire and noxious weeds. Each upland resource threat is described in more detail below as well as discussions of potential strategies to address upland resource risks.

Fire

Wildfire is a dominant ecosystem process in most natural temperate North American grasslands and forests. The sagebrush /bunchgrass ecosystem of JODA exemplifies one of these systems where fire has a major influence. Historically, fire was the most prevalent natural disturbance process in this ecosystem, and in general, these systems have evolved with fire as a dominant process influencing composition, diversity, energy, and nutrient cycles (Kauffman, et al 1997).

Wildfire Starts

Wildfire is a threat to the upland resources at JODA from fires igniting on or adjacent to park lands. Fire history at JODA is not well documented, but the Bureau of Land Management (BLM) and Oregon Department of Forestry (ODF) have recorded fire starts since 1983 and 1974, respectively. The park service also has maintained fire start records since establishment in 1975. Because of the recent establishment of JODA and the fact that very few fires have occurred during that time, there is inconclusive data to establish frequency, character, or intensity within the monument boundaries. Table 13 lists a breakdown of the 160 wildfire starts recorded by the BLM, ODF, and NPS over the past 34 years within the project areas surrounding and within the park (Figure 51). The majority of starts (66%) were naturally-caused, mainly by lightning. JODA's fire season runs from the first of June through mid-September.

Table 13. Number of wildfire starts in the 3 JODA project areas from 1974-2008.

Park Unit	BLM	ODF	NPS	Human Caused	Naturally Caused
Sheep Rock	23	69	16	42	66
Clarno	28		2	12	18
Painted Hills	16	1	5	7	15
Totals	67	70	23	61 (38%)	99 (62%)

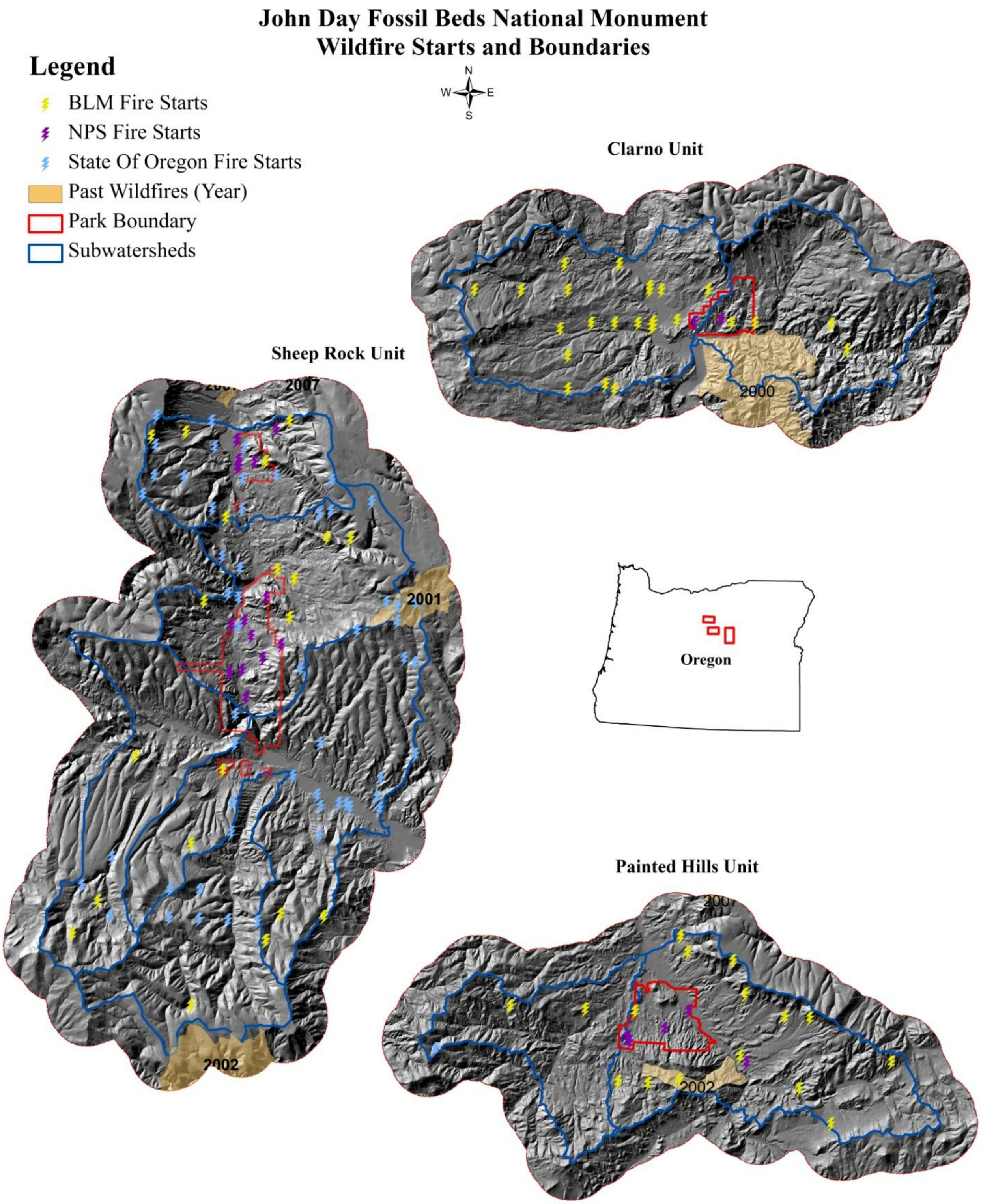

Figure 51. Maps of wildfire starts and fire boundaries in Sheep Rock, Clarno, and Painted Hills Units project areas.

Biophysical Setting

Biophysical Setting is a LANDFIRE data layer that describes or references the potential natural vegetation that may have been dominant on the landscape prior to Euro-American settlement and is based on both the current environment and an approximation of the historical disturbance regime. This layer attempts to incorporate knowledge of ecological processes prior to indigenous human influence. Map units are based on NatureServe's Ecological Systems classification, which is a nationally consistent set of mid-scale ecological units (Comer and others 2003).

Within the Sheep Rock Unit the predicted dominant classes are shrubland (59.6%) and conifer (32.8%) (Table 14). The Clarno and Painted Hills Units are dominated by the shrubland class, 87.4% and 85.4%, respectively (Table 14). Figure 52 displays maps of the spatial distribution of biophysical setting by JODA Unit.

Table 14. Summary of acres of Biophysical Setting classes for each Unit in JODA.

	Sheep Rock		Clarno		Painted Hills	
Biophysical Setting	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**
Barren-Rock/Sand/Clay	105.2	0.1%	217.5	0.4%	22.0	0.1%
Conifer	37,246.7	32.8%	1,304.8	2.5%	3,971.8	9.9%
Grassland	4,313.3	3.8%	4,043.7	7.9%	1,427.9	3.6%
Hardwood	683.8	0.6%	0.7	0.0%	8.7	0.0%
Hardwood-Conifer	264.3	0.2%	0	0.0%	2.7	0.0%
Open Water	64.5	0.1%	102.0	0.2%	54.1	0.1%
Riparian	3,013.8	2.7%	794.4	1.5%	305.4	0.8%
Shrubland	67,614.1	59.6%	44,932.1	87.4%	34,069.3	85.4%
Sparse	123.2	0.1%	2.9	0.0%	2.2	0.0%

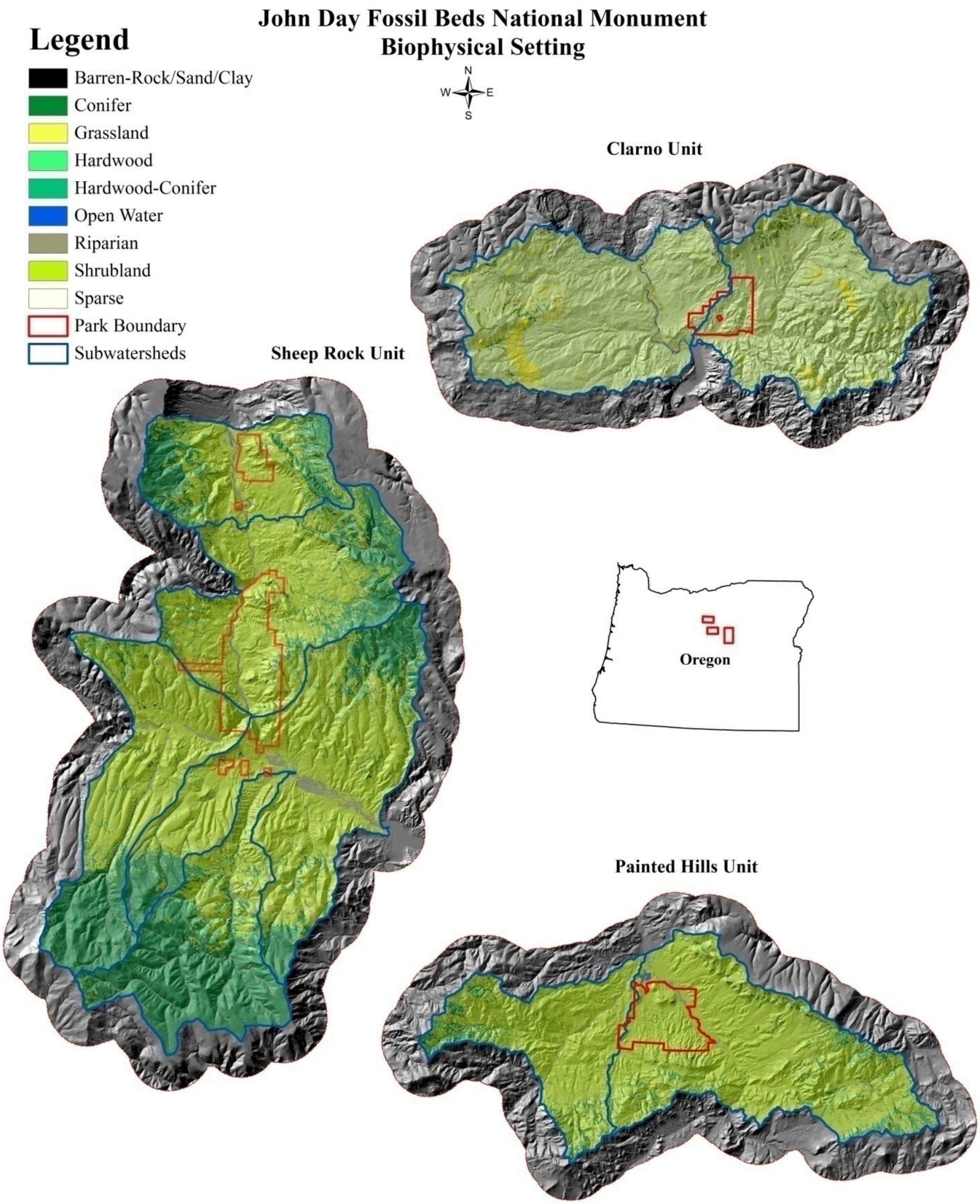

Figure 52. Maps of Biophysical Setting for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

Existing Vegetation

Existing Vegetation is a LANDFIRE data layer representing the vegetation currently present at a given site. The data is based on predictive models using field referenced information on plant community gradients; plot level dominant vegetation types, elevation model data and Landsat imagery. Final data values are compared and rectified through a series of quality measures. The existing vegetation type (EVT) data layer represents the current distribution of the terrestrial ecological systems classification developed by NatureServe for the western Hemisphere.

The Sheep Rock Unit is predominantly perennial graminoid steppe (44.3%) followed by evergreen open tree canopy (20.5%), evergreen shrubland (13.6%), and evergreen closed tree canopy (13.6%) (Table 15). This is a shift from shrubland/conifer cover historical vegetation types predicted in the LANDFIRE biophysical setting analysis. The Clarno Unit is dominated by perennial graminoid steppe (51.0%) and evergreen shrubland (23.6%), which is also a shift from the predicted historical vegetation types from the biophysical setting. The Painted Hills Unit is also dominated by perennial graminoid steppe (48.6%) and evergreen shrubland (33.3%). Biophysical setting predicted the historical vegetation type to be dominated by shrubland cover. Figure 53 displays maps of the spatial distribution of existing vegetation by JODA Unit.

Table 15. Summary of acres of Existing Vegetation classes for each Unit in JODA.

	Sheep Rock		Clarno		Painted Hills	
Existing Vegetation	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**
Annual Graminoid/Forb	1,252.2	1.1%	3,034.6	5.9%	1,938.7	4.9%
Deciduous open tree canopy	683.8	0.6%	0.7	0.0%	8.7	0.0%
Deciduous shrubland	10.9	0.0%	12.9	0.0%	0	0.0%
Evergreen closed tree canopy	15,394.8	13.6%	93.3	0.2%	8.5	0.0%
Evergreen dwarf-shrubland	2.9	0.0%	4,980.4	9.7%	0	0.0%
Evergreen open tree canopy	23,205.1	20.5%	1,056.7	2.0%	3,711.4	9.3%
Evergreen shrubland	15,473.5	13.6%	12,137.4	23.6%	13,260.0	33.3%
Evergreen sparse tree canopy	28.7	0.0%	2.0	0.0%	1.1	0.0%
Mixed evergreen-deciduous open tree canopy	2,024.1	1.8%	546.6	1.1%	189.2	0.5%
Mixed evergreen-deciduous shrubland	451.6	0.4%	17.1	0.0%	0.4	0.0%
No Dominant Lifeform	1,784.1	1.6%	533.7	1.0%	335.7	0.8%
Non-vegetated	169.7	0.1%	319.5	0.6%	76.1	0.2%
Perennial graminoid grassland	2,517.3	2.2%	2,455.7	4.8%	954.7	2.4%
Perennial graminoid steppe	50,307.1	44.3%	26,204.4	51.0%	19,378.8	48.6%
Sparsely vegetated	123.2	0.1%	2.9	0.0%	0.9	0.0%

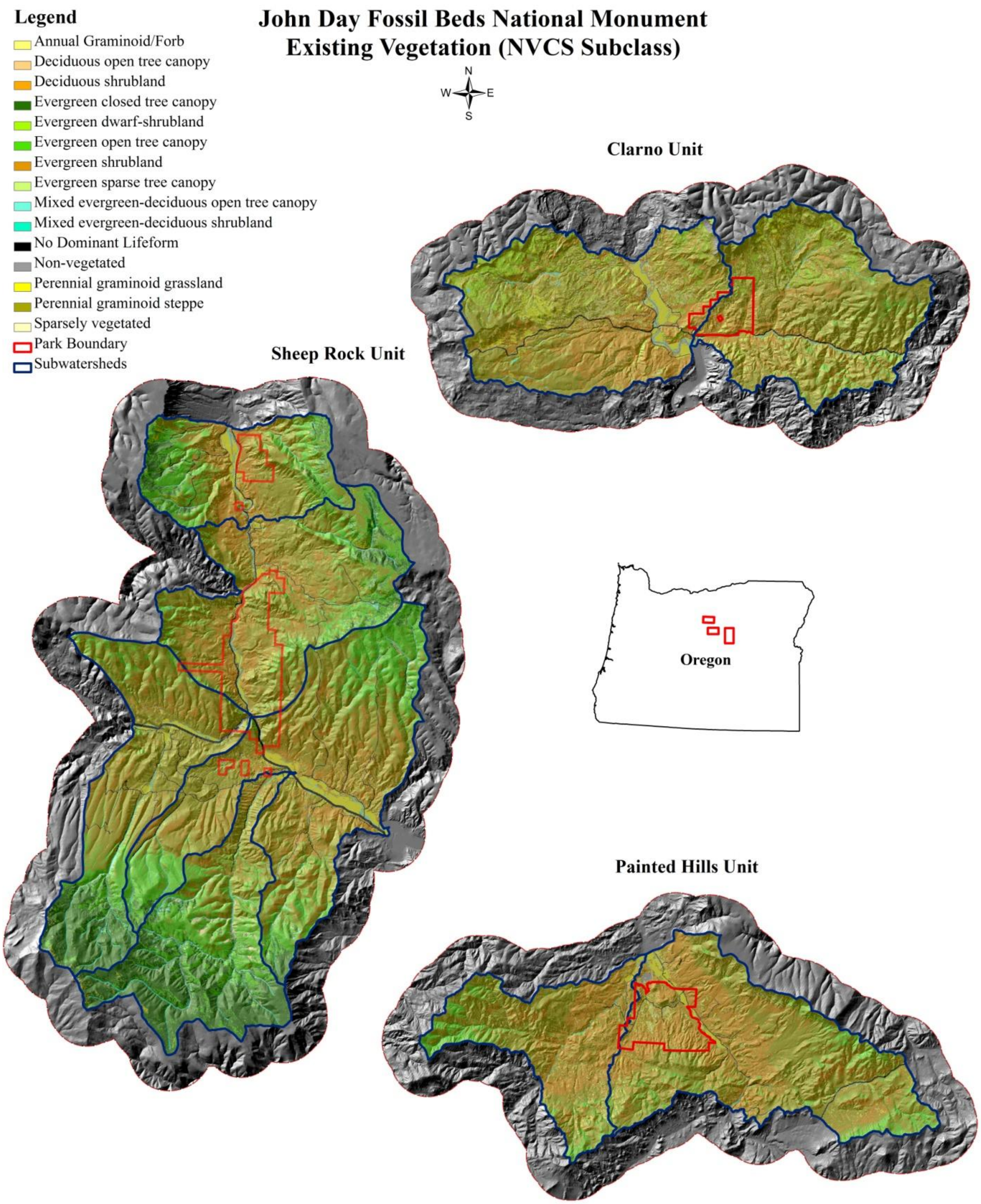

Figure 53. Maps of Existing Vegetation for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

Succession Class

Succession class is a LANDFIRE data layer that categorizes current vegetation composition and structure into five successional states that represent predicted landscapes that may have been dominant prior to Euro American settlement. The historical reference conditions of these successional states are simulated using the vegetation and disturbance dynamics model LANDSUM (Keane and others 2002). Vegetation conditions outside historical successional states are represented as uncharacteristic exotic vegetation that is not within the variables defined by the model, such as invasive weeds, and uncharacteristic situations created by native species such as tree encroachment into native grassland. The five successional classes as described in the FRCC handbook are (Hann and others 2004):

- Succession Class A = early–seral, post replacement condition
- Succession Class B = mid-seral, closed canopy condition
- Succession Class C = mid-seral, open canopy stands
- Succession Class D = late-seral, open canopy stands
- Succession Class E = late-seral, closed canopy stands

The Sheep Rock Unit succession class layer suggests 33.5% of the Unit contains uncharacteristic vegetation or exotic vegetation that is not found within the composition or vegetation that may have been dominant on the landscape prior to Euro-American settlement (Table 16). The Clarno and Painted Hills Units are predicted to have 60.4% and 50.9%, respectively, in the uncharacteristic native vegetation or uncharacteristic exotic vegetation classes prior to settlement. Figure 54 displays maps of the spatial distribution of succession classes by JODA Unit.

Table 16. Summary of acres of Succession Classes for each Unit in JODA.

	Sheep Rock		Clarno		Painted Hills	
Succession Class	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**
Succession Class A	2,784.0	2.4%	2,132.4	4.1%	1,624.0	4.1%
Succession Class B	30,672.1	27.0%	5,691.1	11.0%	4,724.3	11.8%
Succession Class C	26,058.0	23.0%	10,151.1	19.7%	10,614.1	26.6%
Succession Class D	7,954.4	7.0%	418.6	0.8%	749.7	1.9%
Succession Class E	4,281.5	3.8%	43.9	0.1%	940.0	2.4%
Uncharacteristic Native Vegetation Cover / Structure / Composition	3,115.7	2.7%	500.1	1.0%	296.9	0.7%
Uncharacteristic Exotic Vegetation	34,967.2	30.8%	30,530.2	59.4%	20,023.6	50.2%

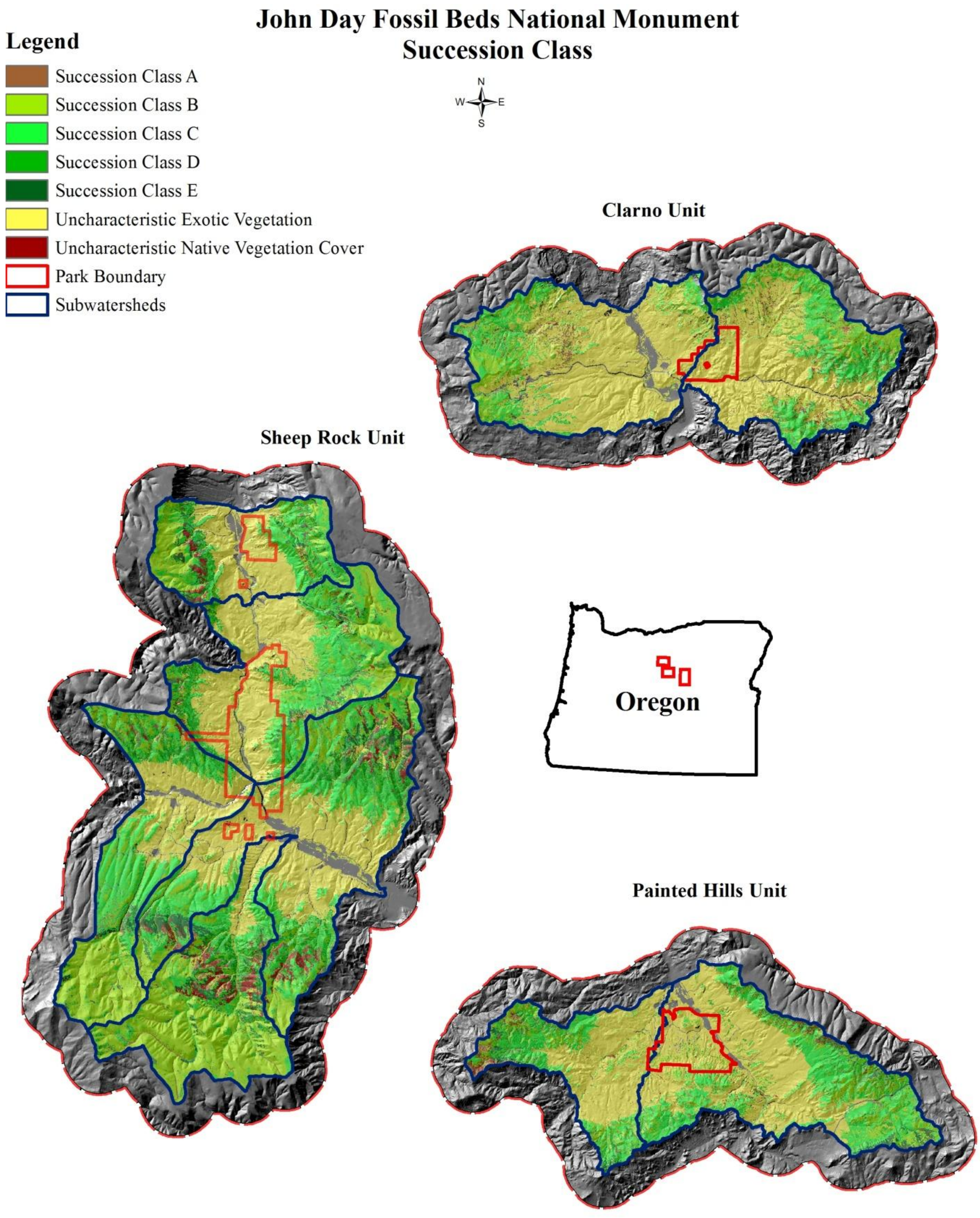

Figure 54. Maps of Succession Class for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

Mean Fire Return Interval

Mean fire return interval is a LANDFIRE data layer that quantifies the average period between fires under the presumed historical fire regime (LANDFIRE 2007). This frequency is derived from historical vegetation (biophysical settings) and disturbance dynamics simulations using the LANDSUM Model (Keane and others 2002, Hann and others 2004). The model predicts fire dynamics based on several indices and is intended to describe one component of simulated historical fire regime characteristics.

The Sheep Rock Unit has 33.7% in <50 year simulated mean fire return interval range with 60.0% of the area in the 50-100 year range, and 6.3% above 100 years (Table 17). In the Clarno Unit 62.6% is in the range from 46-70 years, with 10.9% in the 31-45 year range, and 26.5% above 70 years. The Painted Hills Unit has 17.1% in the <50 year range with 77.9% in the 50-100 year range and 5.0% above the 100 year range. Figure 54 displays maps of the spatial distribution of mean fire return interval by JODA Unit.

Table 17. Summary of acres of Mean Fire Return Interval classes for each Unit in JODA.

	Sheep Rock		Clarno		Painted Hills	
Mean Fire Return Interval	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**
11-15 Years	15.8	0.0%	0	0.0%	0	0.0%
16-20 Years	1,416.1	1.2%	0	0.0%	0	0.0%
21-25 Years	3,937.0	3.5%	0	0.0%	0	0.0%
26-30 Years	7,487.7	6.6%	0	0.0%	0	0.0%
31-35 Years	6,735.8	5.9%	135.2	0.3%	45.9	0.1%
36-40 Years	5,788.2	5.1%	1,327.3	2.6%	867.9	2.2%
41-45 Years	5,761.3	5.1%	4,094.2	8.0%	2,253.2	5.6%
46-50 Years	7,417.7	6.5%	6,106.1	11.9%	3,668.4	9.2%
51-60 Years	19,915.2	17.6%	14,653.7	28.5%	11,177.9	28.0%
61-70 Years	19,992.7	17.6%	11,398.2	22.2%	9,559.1	24.0%
71-80 Years	14,460.5	12.7%	6,228.6	12.1%	5,335.8	13.4%
81-90 Years	9,346.1	8.2%	3,412.2	6.6%	3,340.1	8.4%
91-100 Years	4,489.5	4.0%	1,609.4	3.1%	1,621.1	4.1%
101-125 Years	5,003.2	4.4%	1,505.8	2.9%	1,717.7	4.3%
126-150 Years	1,088.9	1.0%	343.8	0.7%	179.6	0.4%
151-200 Years	272.5	0.2%	161.4	0.3%	16.5	0.0%
201-300 Years	7.8	0.0%	57.2	0.1%	0.7	0.0%
301-500 Years	0	0.0%	32.7	0.1%	0	0.0%
501-1000 Years	0	0.0%	8.9	0.0%	0	0.0%

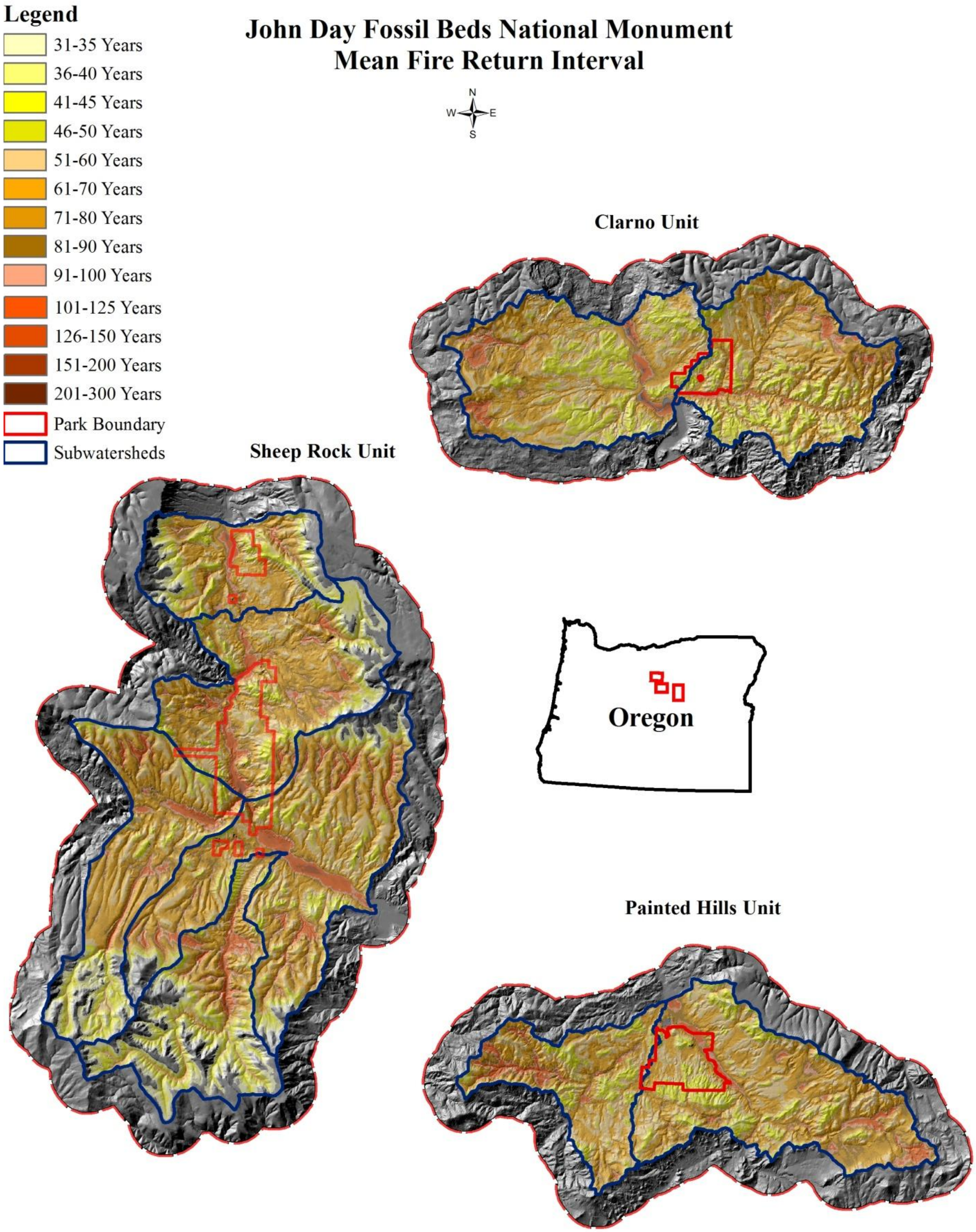

Figure 55. Maps of Mean Fire Return Interval for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

Fuel Loading Model

The Fuel Loading Model is a LANDFIRE classification system data layer based on sets of fuel characteristics that are used as inputs for fire effects models. Fuel Loading Models can be used to simulate smoke emissions and soil heating in fuel beds. A fuel bed is surface combustible materials and includes live and dead herbaceous and shrub material, down woody material, duff and litter. Fire effects are directly related to the combustion process of surface fuels. Fuel loading models are useful for prioritizing fuel treatments and evaluation of fire hazard (LANDFIRE 2007).

Fuel loads estimated from existing vegetation on the Sheep Rock Unit (Table 18) indicate that approximately 50% of the area is characteristic of the light fine woody debris with no duff fuel loading model, 32% the low load shrub-sagebrush and non sagebrush model, and 8% in the light logs, light duff model. Clarno Unit from LANDFIRE Fuel Loading Model indicate that approximately 52% of the area is characteristic of the light, fine woody debris fuel loading model, 35% the low load shrub-sagebrush model, and 8% in the low load shrub, non-sagebrush model. Figure 54 displays maps of the spatial distribution of mean fire return interval by JODA Unit.

Table 18. Summary of acres of Fuel Loading Model classes for each Unit in JODA.

	Sheep Rock		Clarno		Painted Hills	
Fuel Load Model	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**
Light FWD, light to no duff	56,718.8	50.0%	26,918.9	52.4%	21,447.2	53.8%
Moderate FWD, light litter	798.4	0.7%	94.2	0.2%	4.0	0.0%
Moderate FWD, light to moderate litter, light duff	1,234.8	1.1%	6.0	0.0%	0.9	0.0%
Shrub Sagebrush with low total load	33,347.1	29.4%	17,803.2	34.6%	14,508.6	36.4%
Shrub Non-sagebrush with low total load	3,289.4	2.9%	4,198.4	8.2%	2,572.8	6.4%
Light logs, light duff	9,870.9	8.7%	156.5	0.3%	217.9	0.5%
Moderate litter, light duff, light logs	1,668.8	1.5%	0.2	0.0%	11.1	0.0%
Moderate duff, light to heavy logs, light litter	95.7	0.1%	0	0.0%	0	0.0%
Moderate to heavy duff, light to heavy logs	1,626.6	1.4%	1.1	0.0%	1.3	0.0%
Moderate to heavy logs, light duff	173.7	0.1%	0	0.0%	0	0.0%
Moderate duff, light to heavy logs, moderate litter	158.4	0.1%	0.7	0.0%	4.5	0.0%
Heavy to very heavy logs, moderate duff	69.4	0.1%	0	0.0%	0	0.0%
Open Water	120.3	0.1%	153.4	0.3%	41.6	0.1%
Developed-Open Space	1,607.0	1.4%	370.1	0.7%	265.3	0.7%
Developed-Low Intensity	165.1	0.1%	157.9	0.3%	69.4	0.2%
Developed-Medium Intensity	0.7	0.0%	5.1	0.0%	0.4	0.0%
Barren/Rock/Sand/Clay	965.0	0.8%	466.5	0.9%	239.9	0.6%
Pasture/Hay	1,514.0	1.3%	862.6	1.7%	467.4	1.2%
Cultivated Crops and Irrigated Agriculture	4.9	0.0%	203.3	0.4%	11.4	0.1%

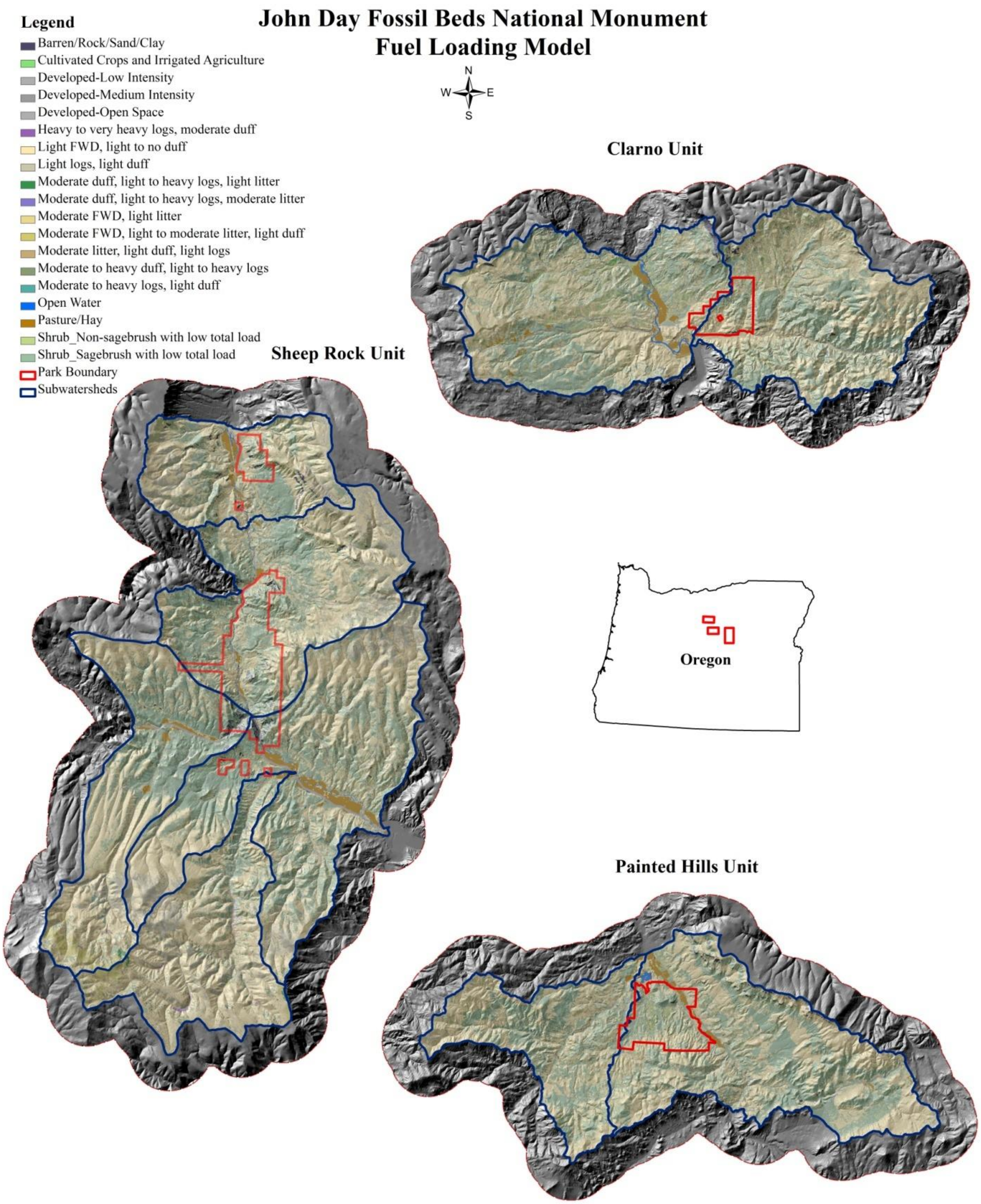

Figure 56. Maps of Fuel Loading Models for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

Fire Regime Group

Fire Regime Group is a LANDFIRE data layer that characterizes the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context. Historical fire regimes are separated based on frequency and severity. Fire Regimes create similar groups of cover types based on fire return intervals, and burning characteristics. There are five fire regime groups recognized in the literature based on similar fire return intervals and burning characteristics (LANDFIRE 2007). The 5 groups are:

- Fire Regime I: 0 to 35 year frequency, low to mixed severity
- Fire Regime II: 0 to 35 year frequency, replacement severity
- Fire Regime III: 35 to 200 year frequency, low to mixed severity
- Fire Regime IV: 35 to 200 year frequency, replacement severity
- Fire Regime V: 200+ year frequency, any severity

The majority (74%) of the Sheep Rock Unit historically has been within the 35-200 year fire return interval with low and mixed severity fires (Table 19). The Clarno Unit historically has been within the 35-200 year fire return interval with low, mixed and replacement severity fires (82.6%). The Painted Hills Unit also historically has been within the 35-200 year fire return interval with low, mixed and replacement severity fires (92.5%). Figure 57 displays maps of the spatial distribution of fire regime group by JODA Unit.

Table 19. Summary of acres of Fire Regime Group classes for each Unit in JODA.

	Sheep Rock		Clarno		Painted Hills	
Fire Regime Group	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**
Fire Regime I	17,703.9	15.6%	98.0	0.2%	33.2	0.1%
Fire Regime II	1,888.6	1.7%	37.2	0.1%	12.7	0.0%
Fire Regime III	84,084.7	74.1%	42,465.7	82.6%	36,867.6	92.5%
Fire Regime IV	9,451.1	8.3%	8,375.0	16.3%	2,869.5	7.2%
Fire Regime V	7.8	0.0%	99.1	0.2%	0.7	0.0%

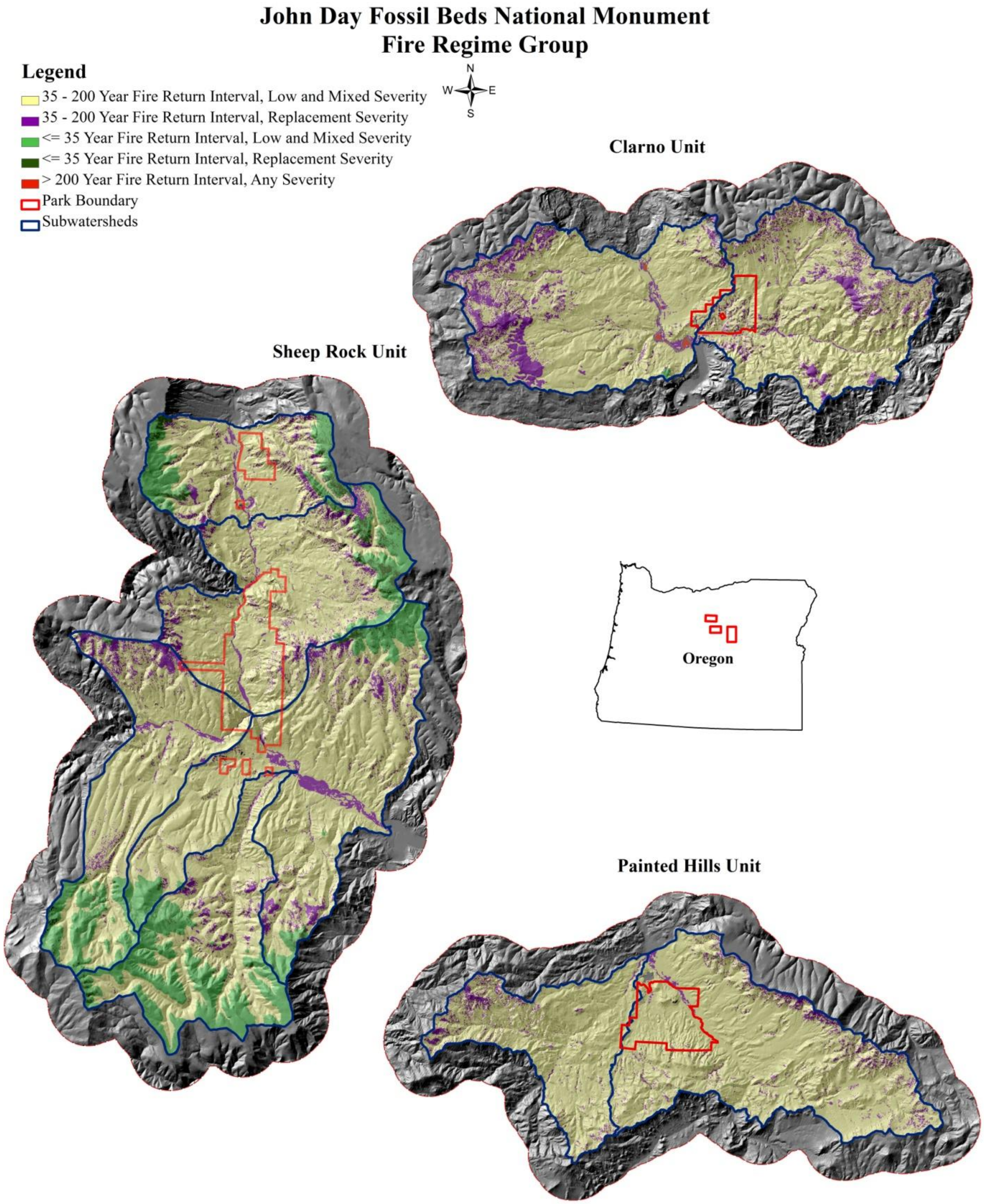

Figure 57. Maps of Fire Regime Groups for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

Fire Regime Condition Class Departure

An estimate of Fire Regime Condition Class Departure (FRCCD) from historic conditions was estimated using landscape succession and disturbance dynamics modeling techniques to measure vegetation change from reference conditions. Departure is identified as the percentage conditions have changed from simulated reference conditions to current conditions with 100 percent representing maximum departure. The percent departure is categorized based on 4 classes; 0-25%, 26-50%, 51-75% and 76-100%.

The Sheep Rock Unit has approximately half (53.2%) in <50% departure from reference condition and half >50% departure (43.6%) (Table 20). The majority of both the Clarno and Painted Hills Units are departed >50% from reference conditions, 81.6% and 83.2%, respectively. Figure 58 displays maps of the spatial distribution of FRCCD by JODA Unit.

Table 20. Summary of acres of Fire Regime Condition Class Departure for each Unit in JODA.

Fire Regime Condition Class Departure	Sheep Rock		Clarno		Painted Hills	
	Acres	% Total	Acres	% Total	Acres	% Total
0-25% (Very low)	13,851.6	12.2%	0.3	0.0%	0.0	0.0%
26-50% (Low)	46,483.1	41.0%	7,492.2	14.6%	5,784.7	14.5%
51-75% (Moderate)	13,086.9	11.5%	41,164.7	80.1%	33,111.9	83.0%
76-100% (High)	36,411.4	32.1%	797.5	1.5%	75.9	0.2%

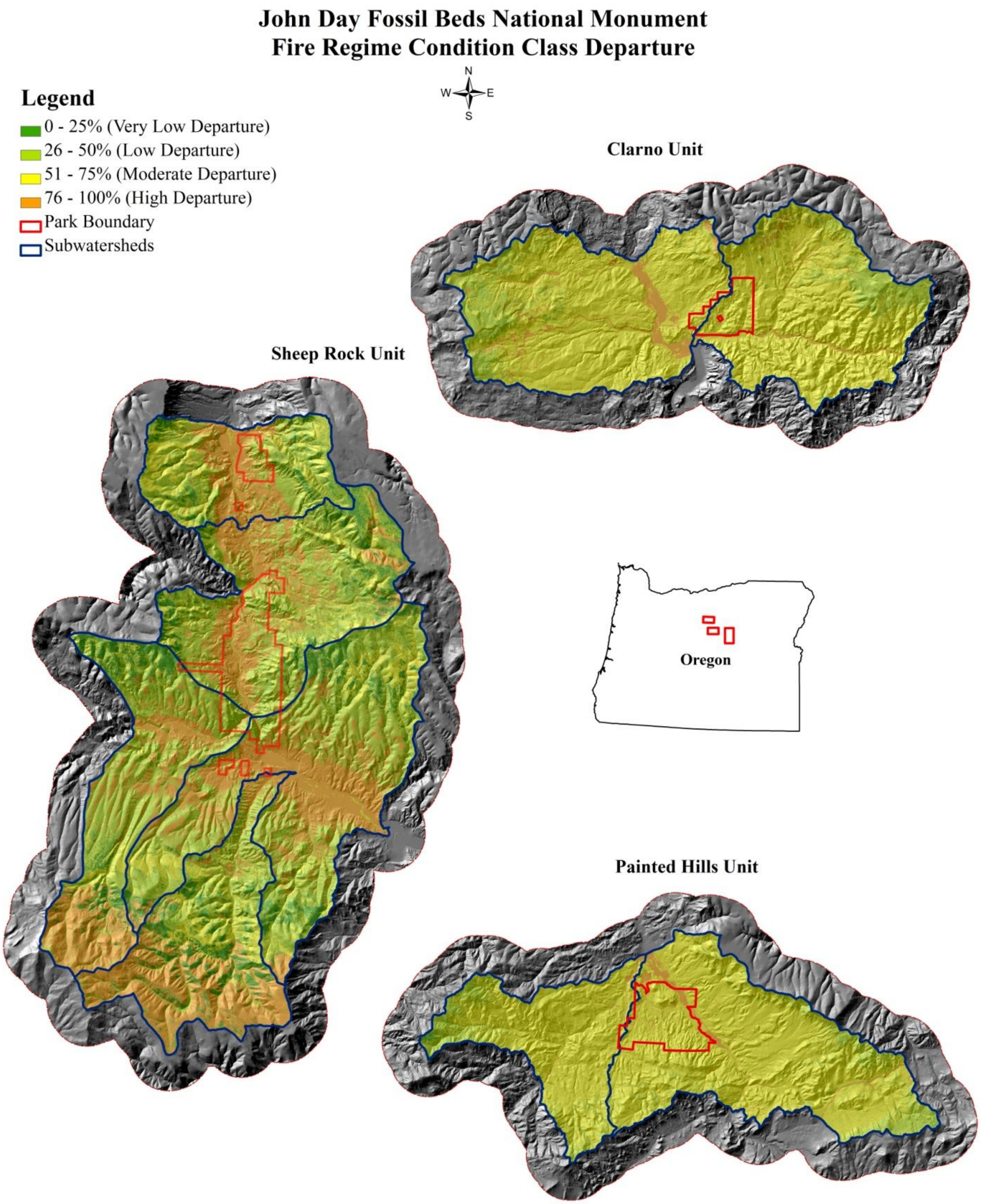

Figure 58. Maps of Fire Regime Condition Class Departure for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

Fire Regime Condition Class

Fire Regime Condition Class (FRCC) is a LANDFIRE data layer that categorizes the departure of current vegetation condition from reference or historical condition (LANDFIRE 2007). Alterations in the vegetative landscape due to fire management activities, fire exclusion, ungulate activity, insect and disease infestations, climate change and invasive plants have occurred over time to influence the existing cover vegetation. FRCC data simulates departure from reference conditions using the LANDSUM landscape succession and disturbance dynamics model. The three condition classes describe low departure (Condition Class I), moderate departure (Condition Class II), and high departure (Condition Class III). Within each Fire Regime Group (FRG) are the three different condition classes. The condition classes coarsely separate each FRG based on potential for change in smoke production; hydrologic function; vegetative composition, structure and resilience. Condition Class I indicates that the cover types are not a significant risk for change. Condition Class II indicates moderate risk and Condition Class III indicates high risk for change. This departure is calculated based on changes to species composition, structural stage, and canopy closure.

The Sheep Rock Unit is dominated by Condition Class II (42.6%) and Condition Class III (35.4%), indicating the vegetative cover in and around the Sheep Rock Unit is moderately to highly departed from reference conditions (Table 21). Both of the Clarno and Painted Hills Units did not have land in Condition Class I and had similar amounts of Condition Class II (39.9% and 49.1%, respectively) and Condition Class III (56.3% and 48.6%, respectively). Figure 59 displays maps of the spatial distribution of FRCC by JODA Unit.

Table 21. Summary of acres of Fire Regime Condition Class for each Unit in JODA.

Fire Regime Condition Class	Sheep Rock Acres	Sheep Rock % Total	Clarno Acres	Clarno % Total	Painted Hills Acres	Painted Hills % Total
Fire Regime Condition Class I	21,365.6	18.8%	0.4	0.0%	0.0	0.0%
Fire Regime Condition Class II	48,353.3	42.6%	20,526.7	39.9%	19,592.9	49.1%
Fire Regime Condition Class III	40,114.1	35.4%	28,940.2	56.3%	19,379.7	48.6%

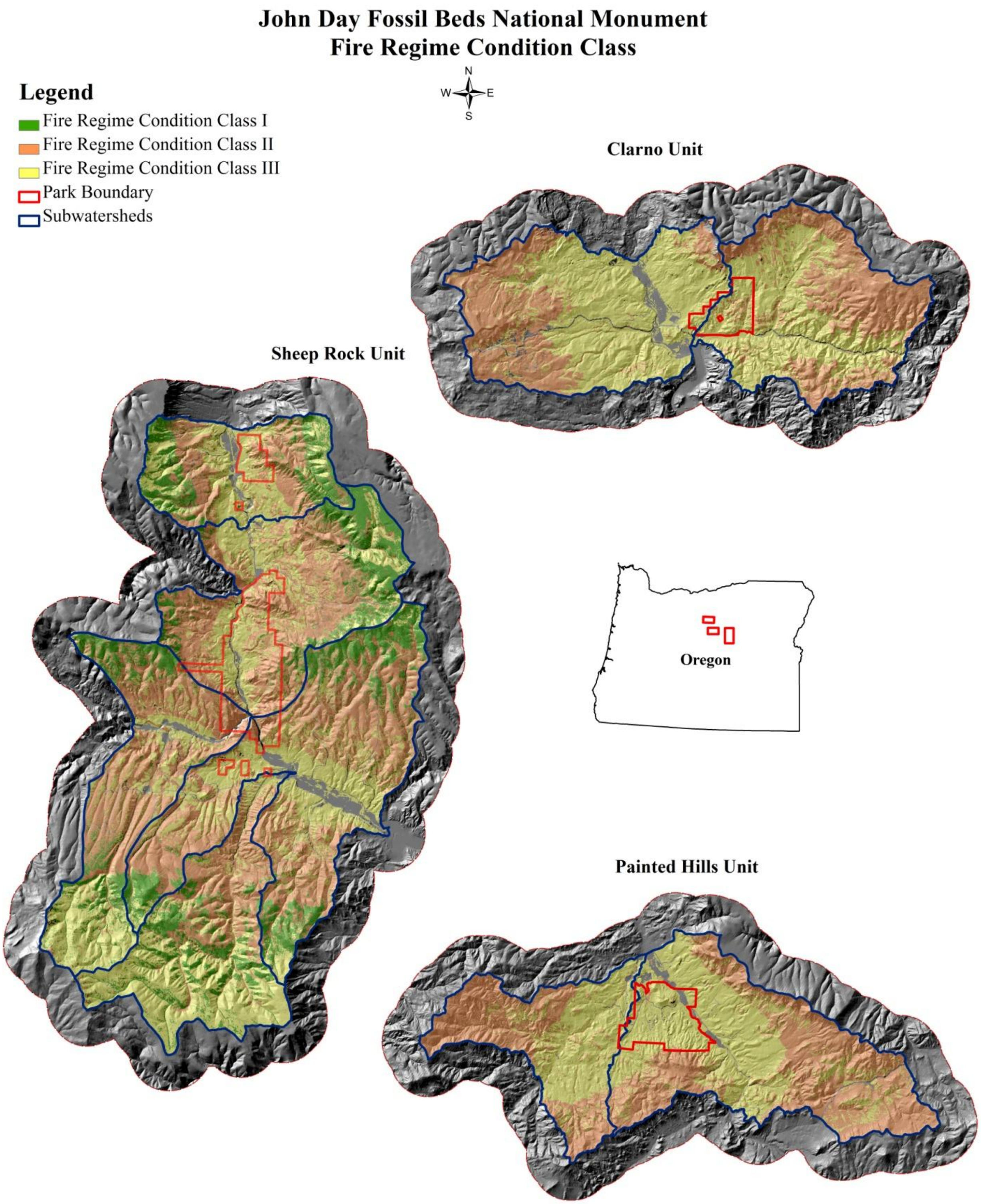

Figure 59. Maps of Fire Regime Condition Class for the Sheep Rock, Clarno, and Painted Hills Units in JODA.

LANDFIRE Analysis Summary

The LANDFIRE data presented in this report have been developed from complex models using existing data to calculate the 8 landscape parameters. Figure 60 is a simplistic diagram showing the relationships between these 8 parameters with the final parameter being the Fire Regime Condition Class. Each data set is found in the GIS geodatabase and can be used independent of the others or in combination for future analysis.

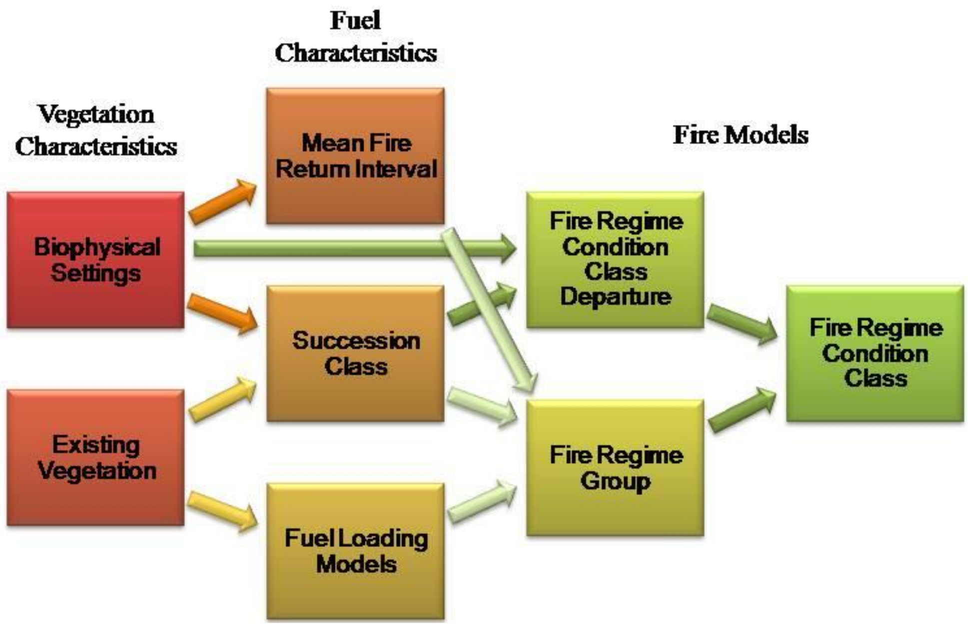

Figure 60. Flowchart of the relationship between 8 LANDFIRE landscape parameters.

Wildfires are a natural process in the region and can be expected to occur outside of the park boundaries. Table 22 is a subset of the data for the Fire Regime Group, Fire Regime Condition Class Departure, and Fire Regime Condition Class that represent over 96% of the project watersheds. The majority of land in all 3 units is in the Fire Regime Group III, indicating a 35-200 year fire frequency with a low to moderate severity. Over 80% of the Clarno and Painted Hills Units project watersheds are moderately departed (51-75%) from the vegetative reference condition. All 3 park Units have close to half of the project watersheds in a Fire Regime Condition Class III (high departure). All 3 landscape parameters indicate the project watersheds currently have an above normal probability of experiencing wildfire. Park management should consider updating portions of their Wildfire Management Plan based on conditions presented in this report.

Table 22. Summary of the acres and percent of area for 3 major LANDFIRE landscape parameters within the project watersheds of the Sheep Rock, Clarno, and Painted Hills Units.

	Sheep Rock		Clarno		Painted Hills	
Fire Regime Group	**Acres**	**% Total**	**Acres**	**% Total**	**Acres**	**% Total**
Fire Regime I	17,703.90	15.60%	98	0.20%	33.2	0.10%
Fire Regime III	84,084.70	74.10%	42,465.70	82.60%	36,867.60	92.50%
Fire Regime IV	9,451.10	8.30%	8,375.00	16.30%	2,869.50	7.20%
Total		**98.00%**		**99.10%**		**99.80%**
Fire Regime Condition Class Departure						
0-25% (Very low)	13,851.60	12.20%	0.3	0.00%	0	0.00%
26-50% (Low)	46,483.10	41.00%	7,492.20	14.60%	5,784.70	14.50%
51-75% (Moderate)	13,086.90	11.50%	41,164.70	80.10%	33,111.90	83.00%
76-100% (High)	36,411.40	32.10%	797.5	1.50%	75.9	0.20%
Total		**96.80%**		**96.20%**		**97.70%**
Fire Regime Condition Class						
Fire Regime Condition Class I	21,365.60	18.80%	0.4	0.00%	0	0.00%
Fire Regime Condition Class II	48,353.30	42.60%	20,526.70	39.90%	19,592.90	49.10%
Fire Regime Condition Class III	40,114.10	35.40%	28,940.20	56.30%	19,379.70	48.60%
Total		**96.80%**		**96.20%**		**97.70%**

Wildfire/Prescribed Fire Interaction

Big sagebrush communities have experienced major declines in the past 150 years principally from woodland (*Juniperus* spp.) expansion, land conversion, and increased fire frequencies created by invasion of annual grasses, like cheatgrass and medusahead (Kitchen and McArthur 2007). Mean fire return intervals for big sagebrush communities were estimated from post-fire succession rates to be from 40-80 years and up to 200 years for Wyoming sagebrush found in drier environments (Kitchen and McArthur 2007). Both subspecies are found in JODA and these are reasonable estimates of mean fire return intervals for JODA and surrounding lands. With the implementation of the JODA Wildland Fire Management Plan in 1999 lands within the park boundaries should not experience fire for the next 40-200 years.

The major objectives of the Wildland Fire Management Plan were to protect life, property and resources from wildfires, reduce hazardous fuel loads, restore fire to fire-dependent communities, and maintain cultural/historic landscapes. Prescribed fires in JODA have reduced the density and spatial distribution of juniper, which has a positive impact on the cultural/historic landscapes in JODA and prevents juniper invasion into big sagebrush communities. Unfortunately, it has also had a negative impact on big sagebrush communities where cheatgrass and medusahead are present. Cheatgrass and medusahead populations increase after fire (Whisenant 1990, Pellant 1996, Reid et al. 2008). Many sites in the park are in the moderate departure rating (>40%) for biotic integrity, due mainly to the dominance of cheatgrass and medusahead in areas formerly dominated by big sagebrush and perennial grasses. Rodhouse (2009) also found high frequencies of cheatgrass and medusahead in JODA when collecting baseline data for monitoring sagebrush-steppe vegetation. This study could not quantify the possible geographic expanse of these disturbed sites due to the lack of pre-prescribed burn monitoring data.

Several conclusions can be drawn from past research. The risk of negative impacts to natural vegetation and biotic integrity on park lands from fire, wildfire or prescribed, will be high for many years to come due to the time (>20 years) required for big sagebrush communities to recover (Kitchen and McArthur 2007, Bollinger and Perryman 2008). Cheatgrass and medusahead dominated communities are very difficult to rehabilitate and can significantly decrease fire return intervals from >70 years to <5 years (Billings 1990, Pellant 1996, Archer 2001). Current park management should maintain or improve biotic condition with the prevention of prescribed fires in degraded habitats and suppression of all wildfires.

Noxious Weeds

Garrett et al. (2007) developed a list of important noxious and non-native plant species based on the knowledge of NPS park staff. They identified 11 noxious weed species for JODA. This report begins with this list and then examined recent inventories, the data collected for the JODA vegetation inventory project and the field work for this report to assess site specific conditions.

An intense inventory of noxious and invasive weed species was conducted in the Painted Hills Unit during 2007 and 2008 by the Oregon Natural Heritage Information Center (Buechling 2008). In 2008 Northwest Management, Inc. (NMI) collected vegetation data on 362 plots throughout the park in conjunction with the vegetation inventory project. The following year, 2009, NMI collected an abbreviated version of vegetation data on 408 plots while conducting an accuracy assessment of a vegetation map. During the site-specific field investigations for this report in 2008, a complete species list was developed for each plot and the occurrence of noxious weeds was extracted from the list.

Table 23 summarizes the occurrence of noxious and invasive species for each study. A total of 25 species were identified from all lists and studies, with 19 listed as Class B noxious weeds by the state of Oregon (ODA 2009). Class B noxious weeds are defined as weeds with economic importance and are regionally abundant. Yellow starthistle is the only species designated Class T, which is a priority designation for control efforts within the state.

Only 5 of the 19 noxious weed species in Table 23 are found in the official vascular plant list for JODA (http://science.nature.nps.gov/im/units/ucbn/inventory/index.cfm#table). The list is in the process of being updated with information from the Painted Hills Unit inventory and vegetation inventory project. The increase in the number of noxious weed species is due mainly to the increased efforts by park staff to document existing conditions and not necessarily actual increases in noxious weed infestations.

Buechling (2008) documented 15 invasive species, 8 listed by Oregon as noxious (Class B), in the Painted Hills Unit. A total of 233.4 acres were infested, ranging from 0.005 for oneseed hawthorne (*Crataegus monogyna*) to 172.5 acres for medusahead. Buechling (2008) noted that 80% of all infestations were within ¼ mile of a road or creek. The 9 species, noxious and invasive, with an aerial extent of less than 1 acre could be relatively inexpensive to control through repeated treatments (Figure 61). For species >1 acre, control efforts would be more problematic depending on the species spatial distribution (Figure 62).

Clasping pepperweed (*Lepidium perfoliatum*) was the most abundant of the 15 invasive and noxious weed species and was found in 18.7% (362 plots) of the vegetation plots sampled in 2007 (Figure 63). Medusahead, common mullein (*Verbascum thapsus*), and Dalmatian toadflax were the next most prominent species at 13.8%, 6.1%, and 5.5%, respectively. Clasping pepperweed also had the broadest geographical distribution being found throughout JODA (Figure 64). Medusahead was the most abundant noxious weed in the Clarno Unit (Figure 64).

Table 23. List of invasive and noxious weed species identified as important or located within JODA boundaries.

Common Name	Scientific Name	Oregon State Class	Monitoring Plan 2007	Inventory PH 2008	Vegetation Inventory 2008	NRCA Plots 2009	Accuracy Assessment 2009	Species List
Quackgrass	Agropyron repens	B			x		x	
Hoarycress	Cardaria draba	B	x	x	x	x	x	
Diffuse Knapweed	Centaurea diffusa	B	x					
Spotted Knapweed	Centaurea maculosa	B	x					
Russian Knapweed	Centaurea repens	B	x	x	x	x	x	x
Yellow Starthistle	Centaurea solstitialis	B, T	x	x				x
Canada Thistle	Cirsium arvense	B	x	x	x			
Bull thistle	Cirsium vulgare	B		x	x			x
Poison Hemlock	Conium maculatum	B			x		x	
Field bindweed	Convuvulus arvensis	B			x	x		x
Oneseed Hawthorne	Crategus monogyna			x				
Houndstongue	Cynoglossum officinale	B	x	x				
Teasal	Dipsacus fullonum			x	x		x	
Russian Olive	Elaeagnus angustifolia			x				
St Johns-wort	Hypericum perfoliatum	B			x			
Kochia	Kochia scoparia	B			x	x	x	
Perennial Pepperweed	Lepidium perfoliatum		x		x	x	x	
Dalmatian Toadflax	Linaria dalmatica	B	x		x	x	x	
Yellow Toadflax	Linaria vulgaris	B	x					
Yellow Sweetclover	Melilotus officinalis			x				
Scotch Thistle	Onopordum acanthium	B		x	x			
Reed Canarygrass	Phalaris arundinacea			x	x		x	
Rabbitsfoot Grass	Polypogon monspeliensis			x				
Medusahead	Taeniatherum caput-medusae	B	x	x	x	x	x	x
Common mullein	Verbascum thapsus			x	x	x	x	x

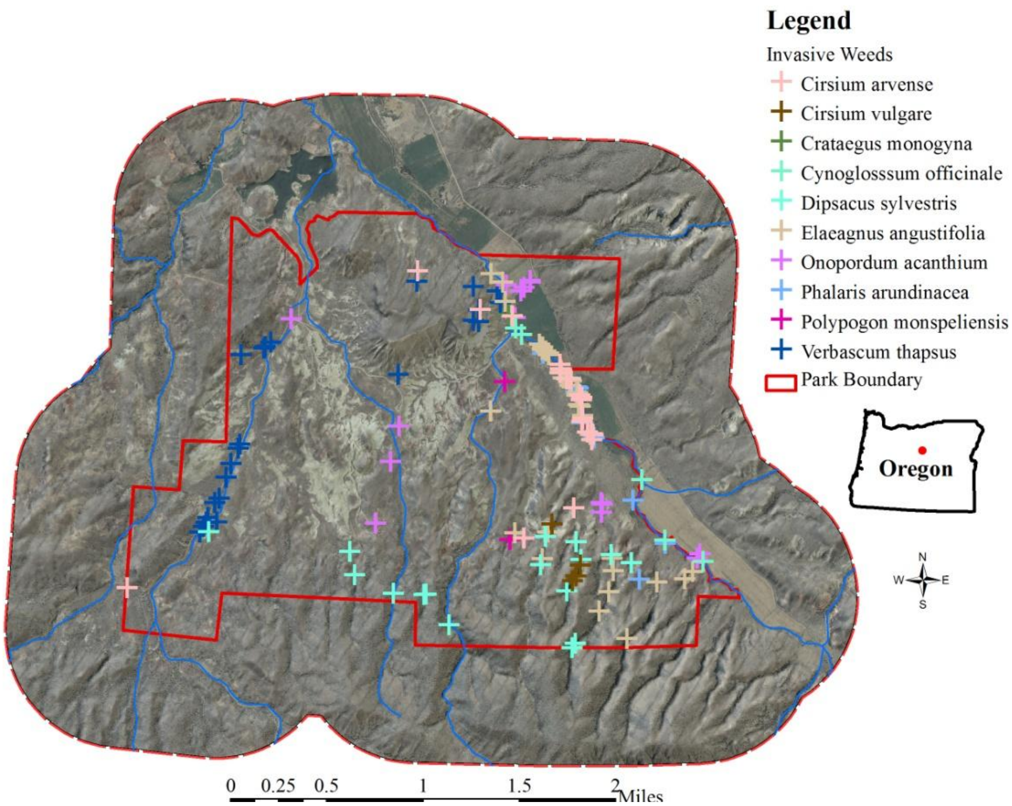

Figure 61. Distribution of invasive plant species (<1 acre) within the Painted Hills Unit, JODA.

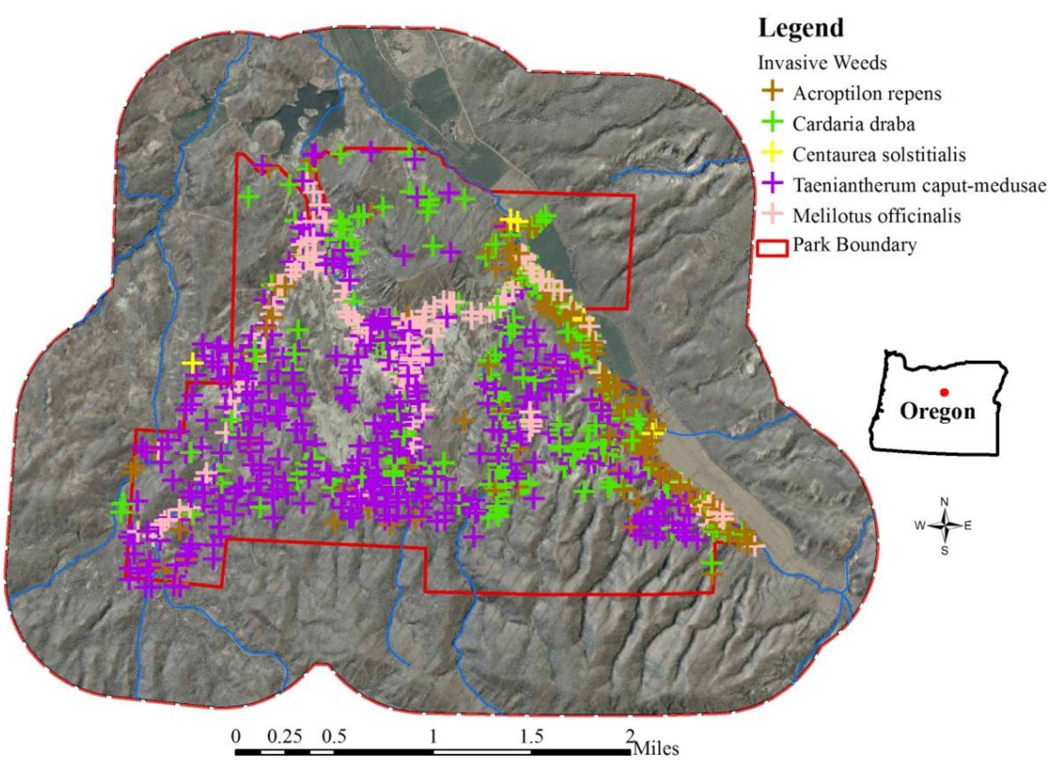

Figure 62. Distribution of invasive plant species (>1 acre) within the Painted Hills Unit, JODA.

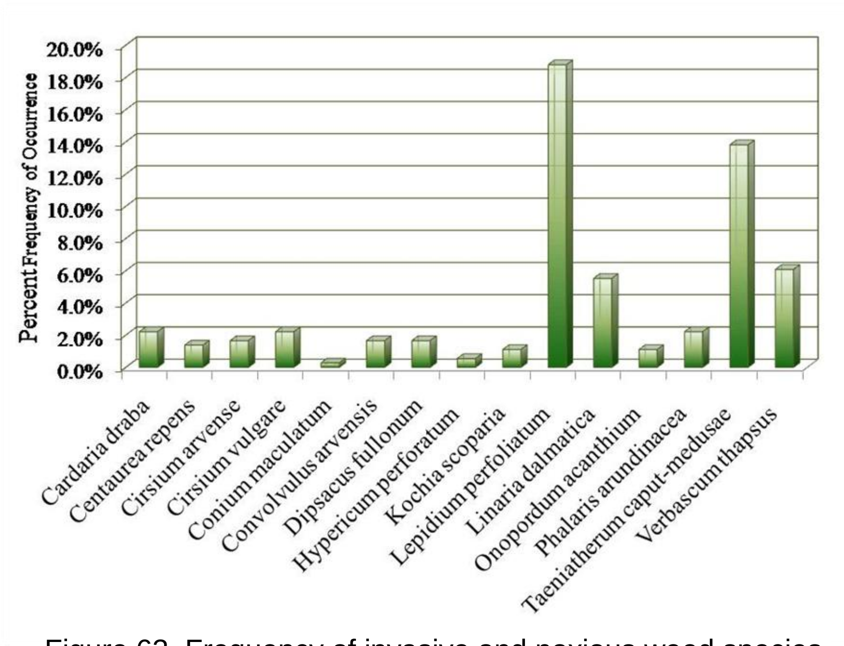

Figure 63. Frequency of invasive and noxious weed species in vegetation plots sampled in 2007 (total n=362), JODA.

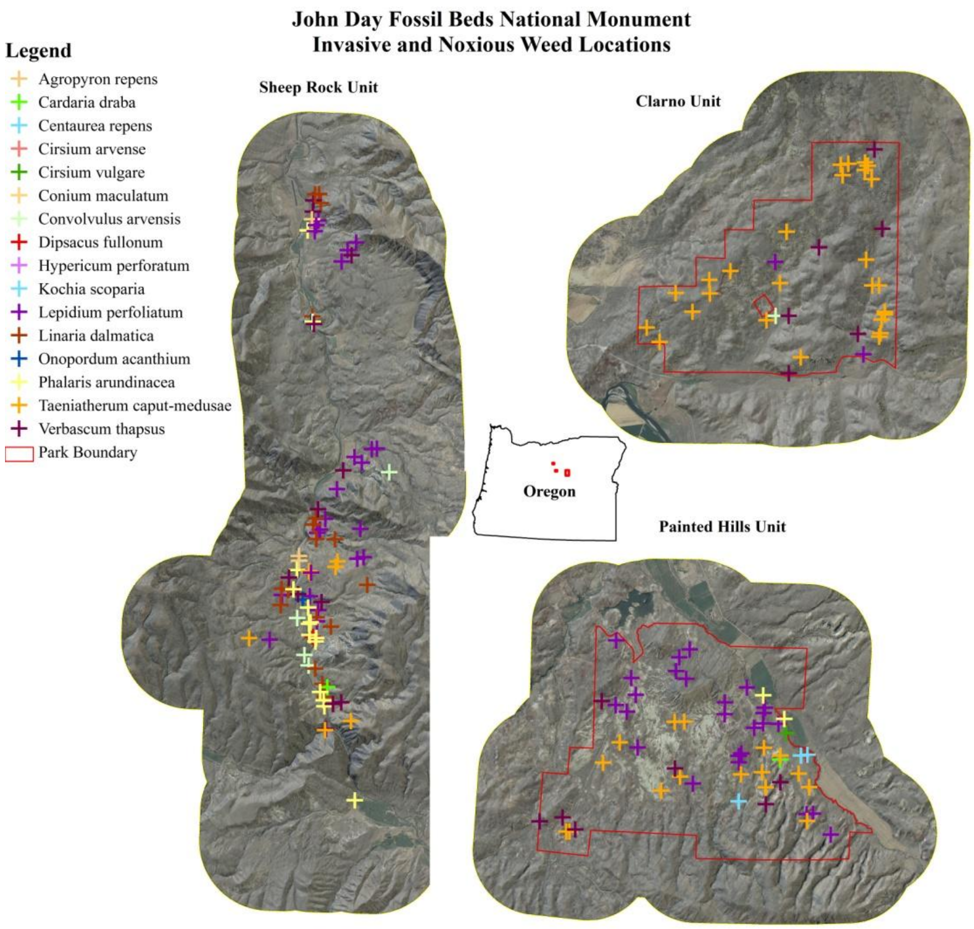

Figure 64. Map of invasive weeds found in vegetation plots, accuracy assessment plots, and NRCA plots, JODA.

Yellow starthistle is the only noxious weed species ranked as Class T by the state of Oregon and should be significant to managers. It is relatively rare compared to other species but in other locations in the Northwest they are very invasive and occupy millions of acres. It is currently only known to be in the Sheep Rock and Painted Hills Units. Noxious weed location maps outside JODA boundaries were not available in GIS data format. The state of Oregon's Weedmapper website (http://www.weedmapper.org/) does provide maps on screen for noxious weeds. Figure 65 is a composite of screen captured maps for Dalmatian toadflax, hoarycress, Russian knapweed, and yellow starthistle in Wheeler County outside the Painted Hills and Clarno Units boundaries.

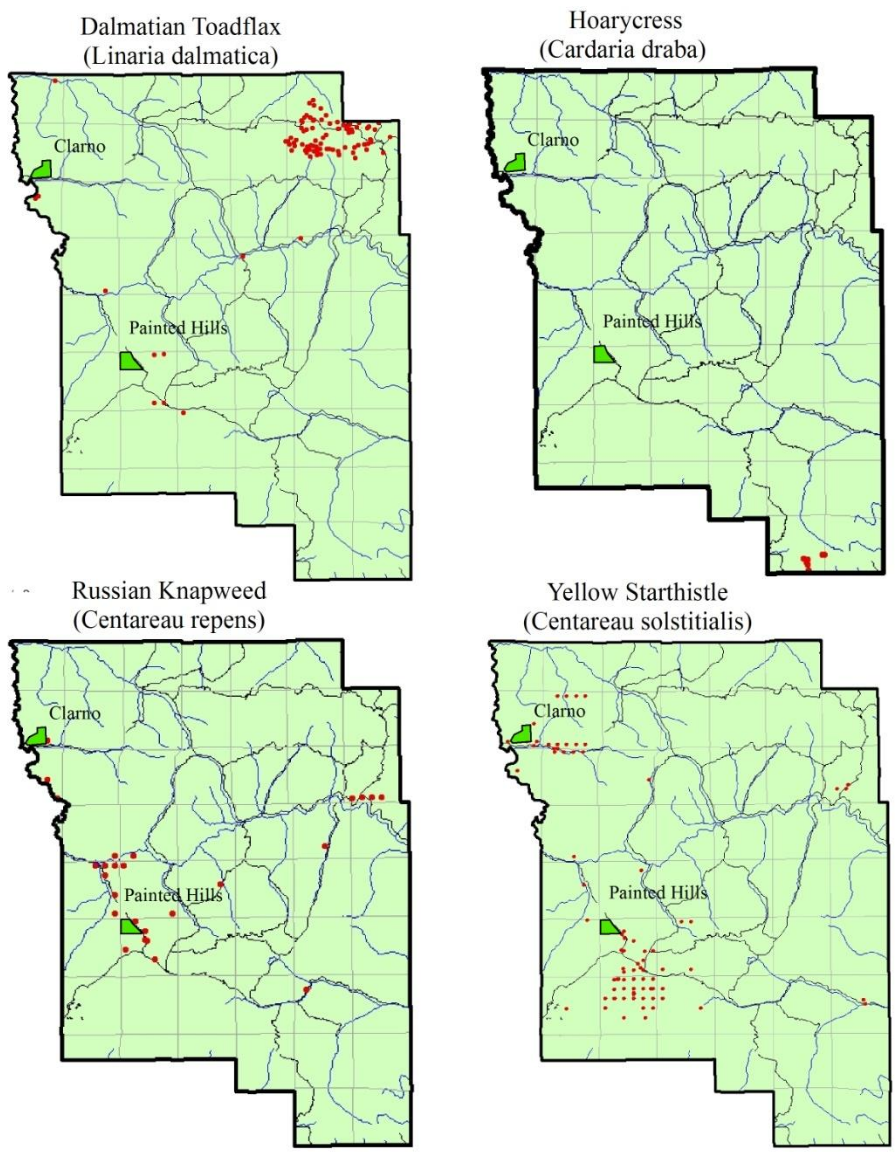

Figure 65. Maps of the locations of 4 noxious weeds in Wheeler County, Oregon, from the Oregon Department of Agriculture's Weedmapper website (http://www.weedmapper.org/).

Management of all species of noxious weeds is important for good stewardship of natural resources. Some species pose greater threats to the natural resources of JODA and are not necessarily the most abundant at the present time. The Pacific Northwest Weed Management Handbook (Peachey 2008) describes 5 major management options for land managers. Below is a summary of the options:

1. Prevention is the most cost effective method for management of noxious species.
2. Biological management is the use of other organisms against noxious or invasive weeds.
3. Cultural management techniques integrate numerous components to minimize the impact of noxious weeds.
4. Mechanical management physically manipulates the noxious weed directly or the ground to kill or prevent sprouting.
5. Herbicides are chemicals used in many forms, liquid or solids, to directly kill or prevent germination of noxious weeds.

Prevention is the most cost effective management option. All management planning involving ground disturbing activities should include a section on revegetation and invasive weed control. Most noxious and invasive weed species become initially established on disturbed sites so that preventing colonization should always be the goal. Another prevention option is to be actively involved with outside organizations focused on weed management.

The Oregon Department of Agriculture (ODA) has a Noxious Weed Program with a staff stationed in 8 cities throughout Oregon and a State Weed Board. The State Weed Board establishes priorities for management activities and award grant funds for county and local activities. Each county has one or more people responsible for noxious weed control on private lands. Complete descriptions of the ODA Noxious Weed Program can be found at http://www.oregon.gov/ODA/PLANT/WEEDS/.

Cooperation with adjacent landowners, private and public, is the most effective method to prevent and control noxious weeds. To this end, JODA is a member of the recently formed Grant County Weed Management Area, which has members of local, state, federal, and private organizations. This coordinated effort will reduce the cost of noxious weed management and increase the effectiveness of prevention and control activities. Formed in 2009, they have developed a draft ―Strategy Plan for Invasive Weed Management in Grant County.” The plan establishes 6 major areas for implementing an Integrated Pest Management (IPM) system to manage invasive weeds by eradication, control, containment, reduction, or custodial efforts.

Internally, JODA operates on an IPM plan for invasive weed species and other pests. The plan identifies the thresholds that must be reached prior to the use of mechanical, chemical, or biocontrol control methods. The park has been assisted in this effort by the NPS Exotic Plant Management Team operating out of North Cascades National Park for the past 2 years. Chemical control efforts in 2008 concentrated on 157 acres of high priority areas; like parking areas, floodplains, riparian areas, and backcountry sites; and targeted 9 species of noxious weeds. JODA's staff are actively implementing biocontrol for Dalmatian toadflax. In the past 3 years approximately 4,000 agents have been released in the Sheep Rock Unit with positive impact on the population resulting in no chemical control required in 2009.

Aquatic Resources

Based on information in the JODA wetland study conducted in 2007 (NPS 2007), stressors to aquatic resources within the park units include the following:

- Non-point source discharges
- Ditches
- Dams
- Flow obstructions
- Vegetation management
- Nutrient impairment
- Flow diversions or unnatural flows
- Engineered channel
- Urban residential
- Orchards/nurseries
- Passive recreation
- Mowing, grazing, excessive herbivory
- Lack of vegetation management to conserve natural resources
- Rangeland
- Irrigated crop agriculture
- Actively managed hydrology
- Treatment of non-native and nuisance plants
- Evidence of fire
- Evidence of flood
- Excessive human visitation
- Trash or refuse
- Dryland farming
- Groundwater extraction
- Transportation corridor
- Dike/levees

Based on results of the benthic macroinvertebrate sampling in 2008, the most critical threats to aquatic resources at JODA include flow diversions, recreational land use, agricultural land use, and fine sediments. Each aquatic resource threat is described in more detail below in addition to discussions of potential strategies to address the risks that are threatening onsite aquatic resources.

Flow Diversions

JODA water resources have been highly modified by past actions. The Painted Hills Unit has water held in a reservoir at the north boundary while water is diverted from Bridge Creek by neighboring farms. The Clarno Unit is not rich in hydrologic resources, but two of the wetlands that are found there are constructed stock ponds. In the Sheep Rock Unit there are networks of agricultural ditches that cross the historic ranch and water is extracted from a nearby spring to supply drinking water to the park. In the historic zone of the Sheep Rock Unit, water is diverted from Rock Creek and the John Day River to irrigate four historic hay fields. (NPS 2007)

Due to water withdrawals for irrigation, water quantity is often a critical concern for JODA streams, especially during the late summer. Water quantity can limit the ability of a stream to produce fish due to the lack of adequate fish passage, spawning, and rearing habitat. Water quality, especially water temperature, is often tied to water quantity in the arid regions of the western U.S. High water temperatures can inhibit a stream's ability to produce salmonid species, which require cool, clean water during all phases of their life history. In addition, fecal coliform bacteria problems within streams are often exacerbated by low flows and high stream temperatures. To address water quantity and quality concerns, it is recommended that managers prioritize maintenance of natural flows as much as possible during the summer low flow period (July – October).

Recreational Land Use

Recreational use of JODA by tourists and other visitors is due to the general interest in the fossil beds and the transportation corridors within the Monument. It is important to manage use of the onsite aquatic resources in a way that educates the public without compromising the integrity of the resource. This can be accomplished by ensuring healthy vegetated riparian buffers exist around all JODA streams to protect instream resources from surrounding land use impacts. Park managers should also educate the public about the importance of restricting access within riparian areas and staying on park trails. Signs at viewing areas informing the public about the newly emerging willows and cottonwoods along the John Day River riparian area in the Sheep Rock Unit and Bridge Creek riparian area in the Painted Hills Unit would be good educational improvements for the park. The educational signs would demonstrate to the public the importance of riparian areas and the intended benefits from willows and cottonwood tree plantings in riparian areas and the positive management activities of the park.

Agricultural Land Use
Agricultural activities within the John Day River watershed have resulted in channelization of the stream, loss of floodplain habitat, and a reduction in vegetative density and overall width of riparian areas. In addition, the fact that streams are often followed by roads and used as transportation corridors has exacerbated the channelized stream conditions. All channelized sections of JODA streams could be improved by setting back levees or road beds, where feasible, to allow for natural stream processes to occur (e.g., floodplain connection, sediment processing, fish habitat development, etc.). Widening riparian areas and increasing riparian plant density would also help cool stream water (through shading and groundwater reconnection) and minimize delivery of on-site fine sediment to the streams.

Fine Sediments
Fine sediment deposited in streambeds after salmonids have spawned will reduce the survival from egg to fry if levels are excessive. Fine sediment also affects the number and diversity of invertebrates, which provides an important food resource for salmonids. Fine material is generally produced in the uplands, transported towards a stream and is either deposited on the banks or enters the stream. As channels migrate laterally, streambanks are eroded and then the fine material enters the stream. Grazing, other agricultural practices, and roadway development have all resulted in accelerated sediment production and delivery to the greater John Day River basin’s surface waters and stream channels.

It is difficult to manage sediment loading within the park when it is due to upstream land use activities. It is possible to help control and prevent fine sediments from entering JODA streams from onsite sources. In some cases, particularly in smaller streams, wood can be used to retain sediment (creating step pools along steeper gradient reaches), promote bed and bank stability, and thereby reduce the volume of sediment delivered to downstream reaches. Another effective way to reduce non-point sources of sediment within JODA park units is to ensure densely vegetated riparian buffers exist to trap sediments prior to delivery to the streams. Much of the sediment problems in JODA watersheds exist due to channelization of the streams for roadways and agricultural activities adjacent to stream banks. Levee setback would be another way to allow some natural sediment processing to occur onsite. Levee setback would allow the streams to laterally migrate and deposit sediments into a network of secondary channels and/or floodplains during high flows.

Climate Change
The Intergovernmental Panel on Climate Change (IPCC) is a scientific intergovernmental body set up by the World Meteorological Organization and by the United Nations Environment Program. The IPCC Working Group II focuses on climate change impacts, adaptation, and

vulnerability. Parry et al. (2007) published a technical summary of their most recent findings. Listed below are a few of the notable findings from the report:

- Observational evidence from all continents and most oceans show that many natural systems are being affected by regional climate changes, particularly temperature increases.
- A global assessment of data since 1970 has shown it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems.
- Other effects of regional climate changes on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers.
- Some large-scale climate events have the potential to cause very large impacts, especially after the 21st century.
- Impacts of climate change will vary regionally but, aggregated and discounted to the present, they are very likely to impose net annual costs which will increase over time as global temperatures increase.
- Vulnerability to climate change can be exacerbated by the presence of other stresses.
- Future vulnerability depends not only on climate change but also on development pathway.
- Many impacts can be avoided, reduced or delayed by mitigation.

The IPCC Working Group II published a report on many areas of the world. North America was addressed by Field et al. (2007) and they documented three observable connections between climate change and terrestrial ecosystems. They found changes in seasonal timing of life-cycle events and phenology, plant growth or primary production, and biogeographic distribution. They also noted that direct impacts on organisms have indirect effects on ecological mechanisms (competition, herbivory, disease) and disturbance (wildfire, hurricanes, human activities).

Plants green-up and flower earlier in the spring and leaf fall occurs later in the fall. Primary production has increased in North American forests over the past 10 years (Boisvenue and Running, 2006). Nesting and breeding occurs earlier, migration is earlier for migratory species, and some species are shifting home ranges to higher elevations or to more northern latitudes.

A warming climate encourages wildfires through a longer summer period that further reduces fuel moisture, promoting easier ignition and faster spread (Running 2006). Westerling et al. (2006) found that in the last three decades the wildfire season in the western U.S. has increased by 78 days, and burn durations of fires greater than 2,500 acres in area have increased from 7.5 to 37.1 days, in response to a spring/summer warming of 0.87°C.

The Joint Institute for the Study of Atmosphere and Oceans (JISAO) is a cooperative institute between the National Oceanic and Atmospheric Administration (NOAA) and the University of Washington. JISAO has published a report titled ―Impacts of climate variability and change in the Pacific Northwest" (Mote et al. 2005). Their modeling predicts warmer, wetter winters, an increase of 3.1° F. by 2030 and a 5% increase in precipitation. Precipitation would come more in the form of rain with smaller snow packs.

The predicted climate changes forecast little change in the annual flow of the Columbia River, but seasonal flows will shift markedly toward larger winter and spring flows and smaller summer and autumn flows (Hamlet and Lettenmaier 1999). The changes in flows will likely coincide with increased water demand, principally from regional growth, but also induced by climate change. Climate change is also projected to impact urban water supplies within the basin. For example, a 3.6° F warming projected for the 2040s would increase demand for water in Portland, Oregon by 1.5 billion gallons per year with an additional demand of 5.5 billion gallons per year from population growth, while decreasing supply by 1.3 billion gallons per year (Mote et al. 2003). The 43 sub-basins in the Columbia River basin have their own sub-basin management plans for fish and wildlife but none comprehensively addresses reduced summertime flows caused by climate change.

The direct and indirect impact of these predicted changes in climate on natural resources at JODA is complex and difficult to manage. Changes could be positive or negative depending on the ecosystem processes, communities, and/or species under consideration. Listed below are specific effects on species and ecosystems attributed to global climate change (Mawdsley et al. 2009, The Heinz Center 2009):

1. Shifts in species distributions, often along elevational gradients.
2. Changes in the timing of life-history events, or phenology, for particular species.
3. Decoupling of coevolved interactions, such as plant-pollinator relationships.
4. Effects on demographic rates, such as survival and fecundity.
5. Reductions in population size.
6. Extinction or extirpation of range-restricted or isolated species and populations.
7. Direct loss of habitat due to sea-level rise, increased fire frequency, bark beetle outbreaks, altered weather patterns, glacial recession, and direct warming of habitats.
8. Increased spread of wildlife diseases, parasites, and zoonoses.
9. Increased populations of species that are direct competitors of focal species for conservation efforts.
10. Increased spread of invasive or non-native species, including plants, animals, and pathogens.

To deal with these potential impacts The Heinz Center (2009) recommends applying an adaptive management framework that (1) identifies actions to achieve management objectives, (2) uses modeling to predict outcomes of management, (3) implements management and monitoring activities, and (4) uses results from monitoring to update management activities. JODA has initiated this process through the implementation of the UCBN Vital Signs Monitoring Plan (Garrett et.al. 2007).

Mawdsley et.al. (2009) identified 16 adaptation strategies in the 4 major adaptive strategies (listed above) to conserve species and ecosystems from the effects of global climate change. Many of the strategies are focused at the national and regional level and would not be applicable to an individual park. The major category titled ―Strategies Related to Monitoring and Planning" identifies 4 adaptation strategies that could be implemented at the park-level and are listed below:

1. Evaluate and enhance monitoring programs for wildlife and ecosystems.
2. Incorporate predicted climate-change impacts into species and land-management plans, programs, and activities.

3. Develop dynamic landscape conservation plans.
4. Ensure wildlife and biodiversity needs are considered as part of the broader societal adaptation process.

Once species and ecosystems identified at risk to global climate change are identified, these 4 adaptive strategies can be implemented. The current monitoring plan and this watershed based report are the beginnings of meeting items 1 and 3. Future planning can incorporate more specific recommendations based on the results of monitoring efforts within the park and research conducted outside the park.

Summary and Recommendations

Upland Assessment

This report examined 25 upland sample sites in JODA covering all 3 park units using a rapid resource assessment methodology (Pellant 2005). The findings for each site are found in the results section of this report. All but 1 plot had soil stability attribute ratings of none-slight departure (<21%) from reference condition. The hydrologic function attribute also only had 1 plot above the none-slight departure rating. Both attributes indicate the park lands are in good condition and functioning properly and are not contributing to soil erosion and water quality degradation. This condition should continue for the near future under current management.

The biotic integrity attribute indicated many areas are not in good condition. Only 5 sites were rated in the none-slight departure category (<21%), 9 fell into the slight-moderate category (21%-40%), and 11 in the moderate category (41%-60%). Visual observations indicated that areas lower in the valleys with less slope were in poor vegetative condition, due to historic grazing patterns, relative to the steeper adjacent slopes. Statistical correlation was attempted between biotic integrity departure values and slope by management Unit using a non-parametric statistic, Spearman's Rank Correlation coefficient (r_s). The results indicated that increases in slope were not significantly correlated ($\alpha(2)=0.05$) with lower biotic integrity departure ratings in the Clarno Unit (n=6, r_s=0.8000), Painted Hills Unit (n=5, r_s=0.8542),or Sheep Rock Unit (n=14, r_s=.2667). Future projects, such as vegetation mapping and sagebrush steppe monitoring, will provide geographically-based information that will allow for more detailed analysis of vegetation succession and distribution. This information will provide the ability to compare physiographic and other landscape attribute relationships to vegetation.

Aquatic Assessment

For most of the 6 aquatic sites sampled at JODA, the instream and wetland results indicate that the existing riverine wetlands are functioning at an adequate level, but that instream conditions are not functioning at full potential. Perturbations occurring upstream of the benthic sampling sites are often the primary cause for poor conditions at the sampling sites. While the riparian wetlands immediately adjacent to the sites help protect certain instream functions, they are not capable of alleviating all impacts originating from upstream sources.

It is often very difficult to pinpoint the exact cause of degraded ecological conditions at a site based on an IBI score; however, several common correlations exist between an IBI score and conditions or practices occurring within a watershed. IBI scores have been shown to positively correlate with vegetative cover, riparian tree density, water quantity and quality, and substrate particle size (EVS Environmental 2004). Observations of conditions within the John Day River watershed match closely with these correlations. Vegetative cover and riparian tree density have been reduced throughout the watershed in the past century to provide opportunities for agriculture. Irrigation withdrawals and agriculture practices adjacent to streams and rivers have led to reduced water quantity and quality (NPS 2007), which is critical in an arid region such as the John Day River basin. Agricultural land use and road proximity have also increased erosion, which leads to sedimentation, cobble embeddedness, and reduced salmonid productivity.

Threats and Stressors

Threats and stressors thought to be the most important to management of JODA's natural resources were examined using available information and the conclusions and recommendations are summarized in the following sections.

Fire

Historically, fire was the most prevalent natural disturbance process in this ecosystem. Fire is the dominant process influencing composition, diversity, energy, and nutrient cycles (Kauffman et al. 1997). Wildfire originating within or adjacent to park lands is a threat to the upland resources at JODA. The data presented in the report indicates the watersheds surrounding the park units have not experienced wildfire for many years and have a higher likelihood for experiencing wildfire. Fire Regime Condition Class ratings are moderate to high in areas outside the park; however this situation does not exist on lands within the park boundaries due to the implementation of the JODA Wildland Fire Management Plan in 1999.

Big sagebrush communities have experienced major declines in the past 150 years principally from woodland (*Juniperus* spp.) expansion, land conversion, and increased fire frequencies created by invasion of annual grasses, like cheatgrass and medusahead (Kitchen and McArthur 2007). Mean fire return intervals for big sagebrush communities were estimated from post-fire succession rates to be from 40-80 years and up to 200 years for Wyoming sagebrush found in drier environments (Kitchen and McArthur 2007). Both sagebrush subspecies are found in JODA. Prescribe fires in JODA have reduced the density and spatial distribution of juniper, which has a positive impact on the cultural/historic landscapes in JODA and prevents juniper invasion in big sagebrush communities.

Unfortunately, prescribed fires have also had a negative impact on big sagebrush communities where cheatgrass and medusahead are present (Whisenant 1990, Pellant 1996, Reid et al. 2008). Cheatgrass and medusahead are especially competitive with perennial plants after a wildfire when additional nitrogen is released by the burning of standing biomass and litter (Pellant 1996). Cheatgrass and medusahead dominated communities are very difficult to rehabilitate and can significantly decrease fire return intervals from >70 years to <5 years (Billings 1990, Pellant 1996, Archer 2001). The risk of negative impacts to natural vegetation and biotic integrity on park lands from fire, wildfire or prescribed, will be high for many years to come due to the time (>20 years) required for big sagebrush communities to recover (Kitchen and McArthur 2007, Bollinger and Perryman 2008). Current park management should maintain or improve biotic condition with the prevention of prescribed fires in degraded habitats and suppression of all wildfires.

Noxious Weeds

Table 22 summarizes the occurrence of noxious and invasive species researched for this report. A total of 25 species were identified from local lists and past studies. The state of Oregon has designated 19 of these as noxious weeds (ODA 2009). Yellow starthistle is the only species designated Class T, which is a priority designation for control efforts by the State.

Management of all species of noxious weeds is important for good stewardship of natural resources. Some species pose greater threats to the natural resources of JODA but are not necessarily the most abundant at the present time. The Pacific Northwest Weed Management

Handbook (Peachey 2008) describes 5 major options for land managers. Below is a summary of the options:

1. Prevention is the most cost effective method for management of noxious species.
2. Biological management is the use of other organisms against noxious or invasive weeds.
3. Cultural management techniques integrate numerous components to minimize the impact of noxious weeds.
4. Mechanical management physically manipulates the noxious weed directly or the ground to kill or prevent sprouting.
5. Herbicides are chemicals used in many forms (liquid or solids) to directly kill or prevent germination of noxious weeds.

Cooperation with adjacent landowners, private and public, is the most effective method to prevent and control noxious weeds. To this end, JODA is a member of the recently formed Grant County Weed Management Area, which has members from local, state, federal, and private organizations.

Aquatic Habitat Threats

Due to water withdrawals for irrigation, water quantity is often a critical concern for JODA streams, especially during the late summer. Water quantity can limit the ability of a stream to produce fish due to the lack of adequate fish passage and spawning and rearing habitat. Water quality, especially water temperature, is often tied to water quantity in the arid regions of the western U.S. To address water quantity and quality concerns, it is recommended that managers prioritize maintenance of natural flows as much as possible during the summer low flow period (July – October).

Fine sediment deposited on streambeds after salmonids have spawned will reduce the survival from egg to fry if levels are excessive. Fine sediment also affects the number and diversity of invertebrates, which provides an important food resource for salmonids. It is difficult to manage sediment loading found in streams within the park resulting from upstream land use activities. However, it is possible to help control and prevent fine sediments from entering JODA streams from onsite sources. In smaller streams, wood can be used to retain sediment by creating step pools along steeper gradient reaches. Wood debris also promotes bed and bank stability. Another effective method for reducing non-point sources of sediment is to maintain densely vegetated riparian buffers that trap sediments prior to delivery into streams.

Climate Change

The direct and indirect impact of predicted changes in climate on natural resources at JODA is complex and difficult to manage. Changes could be positive or negative depending on the ecosystem processes, communities, and/or species under consideration. Listed below are specific effects on species and ecosystems attributed to global climate change (Mawdsley et al. 2009, The Heinz Center 2009):

1. Shifts in species distributions, often along elevational gradients.
2. Changes in the timing of life-history events, or phenology, for particular species.
3. Decoupling of coevolved interactions, such as plant-pollinator relationships.

4. Effects on demographic rates, such as survival and fecundity.
5. Reductions in population size.
6. Extinction or extirpation of range-restricted or isolated species and populations.
7. Direct loss of habitat due to sea-level rise, increased fire frequency, bark beetle outbreaks, altered weather patterns, glacial recession, and direct warming of habitats.
8. Increased spread of wildlife diseases, parasites, and zoonoses.
9. Increased populations of species that are direct competitors of focal species for conservation efforts.
10. Increased spread of invasive or non-native species, including plants, animals, and pathogens.

Mawdsley et al. (2009) identified 16 adaptation strategies in the 4 major adaptive strategy categories to conserve species and ecosystems from the effects of global climate change. Many of the strategies are focused at the national and regional level and would not be applicable to an individual park. The major category titled ―Strategies Related to Monitoring and Planning" identifies 4 adaptation strategies that could be implemented at the park-level, which are listed below:

1. Evaluate and enhance monitoring programs for wildlife and ecosystems.
2. Incorporate predicted climate-change impacts into species and land management plans, programs, and activities.
3. Develop dynamic landscape conservation plans.
4. Ensure wildlife and biodiversity needs are considered as part of the broader societal adaptation process.

General Threats and Stressors

Due to the lack of consistent quantitative information on many threats and stressors, impacts were evaluated in a qualitative manner. Table 24 is an overall estimate of the potential impact to the 3 major landscape attributes from the threats and stressors reported previously; fire and noxious weeds for upland habitats and flow diversions, recreational land use, agricultural land use, and fine sediments for aquatic habitats and climate change. The actual impact from these threats and stressors to any specific site will vary depending on the existing natural resource and landscape setting

Table 24. Matrix of potential impact from threats/stressors examined in this report to the major resources/processes at JODA.

Threats/Stressors	**Major Resources/Processes**		
Upland Habitats	**Soils**	**Hydrologic**	**Biotic**
Fire			
Noxious weeds			
Aquatic Habitats			
Flow Diversions			
Recreational Land Use			
Agricultural Land Use			
Fine Sediments			
All Habitats			
Climate Change			
Key to Rating for Threats/Stressors			
Potential impact to resource	High	Moderate	Low

Data Gaps

Many types of information were not available for this report. We have summarized below important data that would improve natural resource management by JODA staff. We did not estimate cost or indicate agency responsibility due to the extensive nature of the data. This hopefully will provide guidance to JODA staff on future data collection efforts within and outside the park.

1. Accurate and standardized land cover/use mapping for the project area that meets National Map Accuracy Standards (± 40') and is repeatable over time. This information is very important for any watershed modeling of water quality attributes, wildfire risk assessment, and other resource values.
2. Noxious weed maps in digital format on adjacent private and public lands within the project boundary. Currently no county, state, federal, or other organization collect and map noxious weed locations in the JODA project area. Managers would be more aware of possible new invaders and could develop better management strategies for existing species with this information.

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Appendix A – List of NRCA Geodatabase Data by Theme

Theme	Layer Name[1]
Air Resources	
Animal	
Steelhead habitat	jodasr_steelhead
Climate	
Precipitation	Precipitation
Temperature	tempave
Geography	
Roads	local_roads_jodasr
Highways	Highways_jodasr
NRCA Plots	joda_nrca_plots
Park Boundary	parkbndy_jodasr
Public Land Survey System	PLSS
Project Bounday	whmi_projbndy
Cities	Cities
Geology	
Geology	jodasr_geology_MUID
Park Soils	jodasr_soils
Land_Process	
Prescribed Burns	Prescribed_Burns
Landuse	
Land Ownership	ownership
Plant	
Plant Species by Vegetation Plots	vegplot_spp_jodasr
Vegetation Plots	jodasr_veg_plots
Vegetation Accuracy Assessment Plots	jodasr_AA_plots
Stressors	
BLM Fire Reports	blm_firepts
NPS Fire Reports	nps_firepts
Past Fires	past_fires
Wildfire Starts	stfires6205
Water Resources	
Watershed Basin - 6th HUC	basins_jodasr
Major Streams	jodasr_streams
Lakes	water_bodies
303d Listed Streams	jodasr_streams303d
Springs	water_sources
Streams (all)	jodasr_water_courses_all
NRCA Aquatic Plots	aquatic_plots

Appendix A – Continued

Theme	Layer Name[1]
Raster Data	
Digital Elevation Model	joda_sr_dem
Hillshade	joda_sr_hlsd
Existing Vegetation (LANDFIRE)	sr_evt
Anderson Fire Behavior Fuel Models (LANDFIRE)	sr_13fbfm
Biophysical Setting (LANDFIRE)	sr_bps
Fuel Loading Model (LANDFIRE)	sr_flm
Fire Regime Condition Class (LANDFIRE)	sr_frcc
Fire Regime Condition Class Departure (LANDFIRE)	sr_frcc_dep
Fire Regime Group (LANDFIRE)	sr_frg
Mean Fire Return Interval (LANDFIRE)	sr_mfri
Succession Class (LANDFIRE)	sr_scls
Color Aerial Imagery	joda_sr_aerial.sid

[1] – Each park Unit has a separate geodatabase and layers are name by the convention of ―joda” plus the 2 letter designate for each Unit; ―cl” = Clarno, ―ph” = Painted Hills, and ―sr” = Sheep Rock.

Appendix B – Landscape Indicator scores by Plot for Upland Assessment

Plot No.	Park Unit	Ecological Reference Code	Soil Name	1. Rills	2. Waterflow	3. Pedestal	4. Bare	5. Gullies	6. Wind	7. Litter	8. Soil Surface	9. Soil Degredation
1	Sheep Rock	010XB053 OR	Haystack	N-S	N-S	N-S	N-S	N-S	N-S	M	N-S	N-S
18	Sheep Rock	010XB053 OR	Haystack	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S
13	Sheep Rock	010XB034 OR	Twickenham	N-S	N-S	N-S	M	N-S	N-S	N-S	N-S	N-S
14	Sheep Rock	010XB034 OR	Twickenham	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S
15	Sheep Rock	010XB034 OR	Twickenham	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
4	Sheep Rock	010XB034 OR	Buffaran	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S
7	Blue Basin	010XB063 OR	Gooserock	N-S	N-S	N-S	M	N-S	N-S	N-S	M	N-S
16	Sheep Rock	010XB063 OR	Gooserock	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
17	Sheep Rock	010XB065 OR	Brisbois	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
25	Sheep Rock	010XB064 OR	Simas	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
6	Sheep Rock	010XB064 OR	Simas	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S
2	Foree	010XB034 OR	Buffaran	N-S	S-M	N-S	E	N-S	N-S	N-S	M-E	N-S
3	Foree	010XB053 OR	Haystack	N-S	N-S	N-S	N-S	N-S	N-S	N-S	S-M	N-S
5	Foree	010XB044 OR	Drinkwater	N-S	N-S	N-S	N-S	N-S	N-S	N-S	M	N-S
8	Painted Hills	010XB022 OR	Simas	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
9	Painted Hills	010XB064 OR	Simas	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
11	Painted Hills	010XB064 OR	Simas	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
10	Painted Hills	010XB021 OR	Day	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S
12	Painted Hills	010XY007 OR	Beeman	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
19	Clarno	010XB044 OR	Twickenham	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
23	Clarno	010XB044 OR	Twickenham	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S
20	Clarno	010XB053 OR	Sorefoot	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
22	Clarno	010XB053 OR	Sorefoot	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S
21	Clarno	010XB064 OR	Simas	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S	N-S
24	Clarno	010XB064 OR	Simas	N-S	N-S	N-S	S-M	N-S	N-S	N-S	N-S	N-S

Appendix B (continued).

Plot No.	Park Unit	Ecological Reference Code	Soil Name	10. Plant Canopy Cover	11. Compaction	12. Function Structure	13. Plant Mortality	14. Litter Amount	15. Annual Production	16. Invasive Species	17. Reproduction
1	Sheep Rock	010XB053 OR	Haystack	N-S	N-S	E	N-S	M-E	M-E	E	E
18	Sheep Rock	010XB053 OR	Haystack	N-S	N-S	E	N-S	M-E	M-E	E	M
13	Sheep Rock	010XB034 OR	Twickenham	N-S	N-S	M-E	N-S	N-S	S-M	M-E	S-M
14	Sheep Rock	010XB034 OR	Twickenham	S-M	N-S	E	N-S	M-E	M-E	E	E
15	Sheep Rock	010XB034 OR	Twickenham	N-S	N-S	M	N-S	N-S	S-M	M-E	N-S
4	Sheep Rock	010XB034 OR	Buffaran	N-S	N-S	M-E	N-S	M	M-E	M-E	M
7	Blue Basin	010XB063 OR	Gooserock	M	N-S	E	N-S	S-M	E	E	M-E
16	Sheep Rock	010XB063 OR	Gooserock	S-M	N-S	M-E	N-S	S-M	M-E	M-E	M
17	Sheep Rock	010XB065 OR	Brisbois	S-M	N-S	M	N-S	S-M	N-S	M-E	S-M
25	Sheep Rock	010XB064 OR	Simas	S-M	N-S	M	N-S	N-S	S-M	N-S	N-S
6	Sheep Rock	010XB064 OR	Simas	N-S	N-S	S-M	N-S	M-E	M	M-E	S-M
2	Foree	010XB034 OR	Buffaran	E	N-S	M	N-S	M-E	E	M-E	N-S
3	Foree	010XB053 OR	Haystack	N-S	N-S	E	M	M-E	M-E	E	M-E
5	Foree	010XB044 OR	Drinkwater	N-S	N-S	S-M	N-S	M-E	M	M-E	N-S
8	Painted Hills	010XB022 OR	Simas	N-S	N-S	M-E	N-S	M	M-E	M-E	M
9	Painted Hills	010XB064 OR	Simas	N-S	N-S	M	N-S	S-M	N-S	M-E	S-M
11	Painted Hills	010XB064 OR	Simas	N-S	N-S	S-M	N-S	N-S	N-S	S-M	N-S
10	Painted Hills	010XB021 OR	Day	N-S	N-S	M-E	N-S	M-E	S-M	E	S-M
12	Painted Hills	010XY007 OR	Beeman	N-S	N-S	E	N-S	M-E	M	M-E	M-E
19	Clarno	010XB044 OR	Twickenham	N-S	N-S	S-M	N-S	N-S	N-S	M	N-S
23	Clarno	010XB044 OR	Twickenham	N-S	N-S	M-E	N-S	M	M	E	N-S
20	Clarno	010XB053 OR	Sorefoot	M	N-S	M-E	N-S	M	M-E	E	M-E
22	Clarno	010XB053 OR	Sorefoot	N-S	N-S	M	N-S	S-M	S-M	M-E	N-S
21	Clarno	010XB064 OR	Simas	N-S	N-S	N-S	N-S	N-S	N-S	M	N-S
24	Clarno	010XB064 OR	Simas	S-M	N-S	E	N-S	M-E	M-E	E	M

Appendix C – List of Plant Species at NRCA Upland Assessment Points

				Aerial Cover by Plot											
Species Name	Growth Form	Non-Native	Noxious	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Juniperus occidentalis	tree								3		1	1	3	1	
Artemisia tridentata ssp. tridentata	shrub														1
Artemisia tridentata ssp. wyomingensis	shrub						70		3		30	30	2		
Atriplex confertifolia	shrub										30				
Chrysothamnus nauseosus	shrub									1			1		
Chrysothamnus viscidiflorus	shrub											30			
Eriogonum microthecum	shrub														
Eriogonum sphaerocephalum	shrub														
Gutierrezia sarothrae	shrub			1					3	1	30	30	1		
Purshia tridentata	shrub														
Ribes cereum	shrub														
Sarcobatus vermiculatus	shrub									1					1
Tetradymia canescens	shrub														
Agropyron spicatum	grass				30			70	70		3	70	30	70	
Bromus japonicus	grass														
Bromus tectorum	grass	X		30	30	70	70	30	30	70	70	30	70	3	3
Festuca idahoensis	grass														
Festuca microstachys	grass										3	1			
Koeleria macrantha	grass														
Leymus cinereus	grass	X													1
Poa bulbosa	grass			70	1				3	30	1		1		
Poa leibergii	grass														
Poa secunda	grass			1	30	3	30	70	70	3	3	70	30	70	
Sitanion hystrix	grass						30				3			70	
Sporobolus cryptandrus	grass												30		
Stipa thurberana	grass	X	X							3			30		
Taeniatherum caput-medusa	grass										70		70	3	
Thinopyrum ponticum	grass														70
Achillea millefolium	forb			1				3	3	3		1		3	
Alyssum alyssoides	forb	X			3						1		3		3
Alyssum desertorum	forb													1	
Amsinckia lycoposides	forb														
Amsinckia tessellata	forb														
Antennaria dimorpha	forb											1			
Astragalus conjunctus	forb												1	3	
Astragalus filipes	forb				3			3	3						
Astragalus lentiginosus	forb														

List of Plant Species for NRCA Upland Assessment Points (continued).

Species Name	Growth Form	Non-Native	Noxious	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Juniperus occidentalis	tree			1			3	1		1		1	1	1		70
Artemisia tridentata ssp. tridentata	shrub			70		3	70	60				3	30	10	1	1
Artemisia tridentata ssp. wyomingensis	shrub							1								1
Atriplex confertifolia	shrub															
Chrysothamnus nauseosus	shrub										3	3				
Chrysothamnus viscidiflorus	shrub			70		3		1	1			3				
Eriogonum microthecum	shrub									1						
Eriogonum sphaerocephalum	shrub												30			
Gutierrezia sarothrae	shrub				3	3	70		1	1	3	3	30		1	
Purshia tridentata	shrub												30	3		
Ribes cereum	shrub															1
Sarcobatus vermiculatus	shrub															
Tetradymia canescens	shrub					3										
Agropyron spicatum	grass			70	1	70		70	3	70		70	70	70	3	70
Bromus japonicus	grass												30			
Bromus tectorum	grass	X		30		30	70	30	70	3	70	1	30	70	70	
Festuca idahoensis	grass			70								70				70
Festuca microstachys	grass							1		30		1	3		1	
Koeleria macrantha	grass			70												
Leymus cinereus	grass	X														
Poa bulbosa	grass			1	1	1		1			1	1	3	1		
Poa leibergii	grass							70				70				
Poa secunda	grass			70		70	3	70	3	70	30	70	70		3	70
Sitanion hystrix	grass															
Sporobolus cryptandrus	grass				1								70	70		
Stipa thurberana	grass	X	X													
Taeniatherum caput-medusa	grass				70	30				3	70	1		70	70	
Thinopyrum ponticum	grass															
Achillea millefolium	forb			3		3		3	30	3	1	1	3	1	3	
Alyssum alyssoides	forb	X														`
Alyssum desertorum	forb															
Amsinckia lycoposides	forb				1											
Amsinckia tessellata	forb									3					3	
Antennaria dimorpha	forb						1									1
Astragalus conjunctus	forb							3				3				
Astragalus filipes	forb					3	1	3	30				3		3	3
Astragalus lentiginosus	forb									3						

List of Plant Species for NRCA Upland Assessment Points (continued).

Species Name	Growth Form	Non-Native	Noxious	Aerial Cover by Plot 1	2	3	4	5	6	7	8	9	10	11	12
Astragalus purshii	forb												1		
Balsamorhiza sagittata	forb														
Blepharipappus scaber	forb						1							1	
Calochortus macrocarpus	forb				3								1		
Cardaria draba	forb	X	X												3
Centaurea repens	forb	X	X												3
Cirsium undulatum	forb												1		
Collinsia parviflora	forb														
Convolvulus arvensis	forb	X	X	1											
Crepis atribarba	forb														
Crepis intermedia	forb														
Crepis occidentalis	forb											1			
Dalea ornata	forb												1		
Descurainia richardsonii	forb					1									
Draba verna	forb						1					1		1	
Erigeron filifolius	forb														
Erigeron pumilus	forb									3					
Eriogonum heradeoides	forb													3	
Eriogonum strictum	forb												1	3	
Erodium cicutarium	forb	X		3	3	30		3		3			3		
Fritillaria pudica	forb										1	1			
Helianthus nuttallii	forb														
Holosteum umbellatum	forb	X		3	3	30	1	3				1	3		
Kochia scoparia	forb	X	X												3
Lactuca serriola	forb														
Lepidium perfoliatum	forb	X													3
Lewisia rediviva	forb						1				1				
Linaria dalmatica	forb	X	X							1					
Lithophragma glabrum	forb														
Lomatium macrocarpum	forb						1		3						
Lomatium triternatum	forb														
Nothocalais troximoides	forb				3						1	1		3	
Opuntia polyacantha	forb												1		
Phacelia hastata	forb														
Phacelia linearis	forb														
Plectritis macrocera	forb						1					1			
Sedum lanceolatum	forb														

List of Plant Species for NRCA Upland Assessment Points (continued).

Species Name	Growth Form	Non-Native	Noxious	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Astragalus purshii	forb															
Balsamorhiza sagittata	forb									3						
Blepharipappus scaber	forb										1					
Calochortus macrocarpus	forb						1	3	30			1				
Cardaria draba	forb	X	X													
Centaurea repens	forb	X	X								1					
Cirsium undulatum	forb											1	3	1	3	
Collinsia parviflora	forb			3												
Convolvulus arvensis	forb	X	X		1											
Crepis atribarba	forb							3								
Crepis intermedia	forb						1									
Crepis occidentalis	forb										1					
Dalea ornata	forb										1		3			
Descurainia richardsonii	forb															
Draba verna	forb							1								
Erigeron filifolius	forb											1				
Erigeron pumilus	forb															
Eriogonum heradeoides	forb															
Eriogonum strictum	forb			3						3		1	3	1		3
Erodium cicutarium	forb	X				3	1		30				1	3		
Fritillaria pudica	forb															
Helianthus nuttallii	forb														3	
Holosteum umbellatum	forb	X		1	3	3	1	3		1		1		3		1
Kochia scoparia	forb	X	X													
Lactuca serriola	forb				3					1						
Lepidium perfoliatum	forb	X			3		1			1						
Lewisia rediviva	forb															
Linaria dalmatica	forb	X	X						30							
Lithophragma glabrum	forb			3												
Lomatium macrocarpum	forb				1					3						
Lomatium triternatum	forb						1									3
Nothocalais troximoides	forb				3							1				
Opuntia polyacantha	forb															
Phacelia hastata	forb								30				3	1		
Phacelia linearis	forb			3				1								
Plectritis macrocera	forb							1								
Sedum lanceolatum	forb			3												

List of Plant Species for NRCA Upland Assessment Points (continued).

Species Name	Growth Form	Non-Native	Noxious	Aerial Cover by Plot 1	2	3	4	5	6	7	8	9	10	11	12
Sisymbrium altissimum	forb	X		3	3	30		3		3					
Sphaeralcea munroana	forb			1		1									
Thysanocarpus curvipes	forb														
Tragopogon dubius	forb	X								3			3		
Verbascum thapsus	forb	X								3					

List of Plant Species for NRCA Upland Assessment Points (continued).

Species Name	Growth Form	Non-Native	Noxious	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Sisymbrium altissimum	forb	X				3		3	30	1						
Sphaeralcea munroana	forb				1	3				1				1		
Thysanocarpus curvipes	forb									1				1		
Tragopogon dubius	forb	X				3				1	1		1	3	1	
Verbascum thapsus	forb	X							30				1			

Appendix D – Benthic Macroinvertebrate Site Description Summaries

John Day River R14A

Name of Riparian-Wetland Area: ____JODA_______________________________
Date: __8/28/2008_Segment/Reach ID: R14A___ ____Stream: _ John Day River__
ID Team Observers: __ Ladd, Neumiller_______________________________________

Stream Channel

Description	Yes/No
Channelized	Y

Stream Substrate and Shoreline Condition

Description	Percent (%)
Inorganic Substrate	98
Organic Substrate	<2
Embeddedness	5
Sediment	10-15
Stream Shading	0

Site Measurements

Description	Meters
Stream Width	10.8
Surface Velocity (m/s)	0.4
Water Depth (Average)	0.3
Riffle Length	23.5
Riffle Width (Average)	10.8

John Day River R14B

Name of Riparian-Wetland Area: ____JODA________________________________

Date: __8/28/2008_Segment/Reach ID: R14B___ ____Stream: __John Day River__

ID Team Observers: __Ladd, Neumiller____

Stream Channel

Description	Yes/No
Channelized	Y

Stream Substrate and Shoreline Condition

Description	Percent (%)
Inorganic Substrate	95
Organic Substrate	3-5
Embeddedness	20
Sediment	25
Stream Shading	0

Site Measurements

Description	Meters
Stream Width	15.3
Surface Velocity (m/s)	0.5
Water Depth (Average)	0.3
Riffle Length	43.0
Riffle Width (Average)	6.0

John Day River R14C

Name of Riparian-Wetland Area: ____JODA________________________________
Date: __8/28/2008_Segment/Reach ID: R14C___ ____Stream: __John Day River__
ID Team Observers: __Ladd, Neumiller____

Stream Channel

Description	Yes/No
Channelized	Y

Stream Substrate and Shoreline Condition

Description	Percent (%)
Inorganic Substrate	95
Organic Substrate	3-5
Embeddedness	30
Sediment	50
Stream Shading	0

Site Measurements

Description	Meters
Stream Width	10.0
Surface Velocity (m/s)	0.7
Water Depth (Average)	0.2
Riffle Length	32.5
Riffle Width (Average)	3.5

Rock Creek R08

Name of Riparian-Wetland Area: ____JODA________________________________

Date: __8/27/2008_ Segment/Reach ID: R08________ Stream: __Rock Creek__

ID Team Observers: __Ladd, Neumiller____

Stream Channel

Description	Yes/No
Channelized	Y

Stream Substrate and Shoreline Condition

Description	Percent (%)
Inorganic Substrate	95
Organic Substrate	<5
Embeddedness	5-10
Sediment	5
Stream Shading	40-50

Site Measurements

Description	Meters
Stream Width	5.5
Surface Velocity (m/s)	0.3
Water Depth (Average)	0.2
Riffle Length	28.0
Riffle Width (Average)	4.0

Rock Creek R15

Name of Riparian-Wetland Area: ____JODA________________________________

Date: __8/27/2008_Segment/Reach ID: _R15________Stream: __Rock Creek__

ID Team Observers: __Ladd, Neumiller____

Stream Channel

Description	Yes/No
Channelized	Y

Stream Substrate and Shoreline Condition

Description	Percent (%)
Inorganic Substrate	95
Organic Substrate	<5
Embeddedness	5
Sediment	15
Stream Shading	10

Site Measurements

Description	Meters
Stream Width	4.7
Surface Velocity (m/s)	0.2
Water Depth (Average)	0.5
Riffle Length	32.8
Riffle Width (Average)	4.5

Bridge Creek R11

Name of Riparian-Wetland Area: ____JODA_______________________________

Date: __8/26/2008_Segment/Reach ID: _R11___ ____Stream: _ Bridge Creek__

ID Team Observers: __Ladd, Neumiller_______________________________________

Stream Channel

Description	Yes/No
Channelized	Y

Stream Substrate and Shoreline Condition

Description	Percent (%)
Inorganic Substrate	90
Organic Substrate	5-10
Embeddedness	10
Sediment	15
Stream Shading	80

Site Measurements

Description	Meters
Stream Width	3.3
Surface Velocity (m/s)	0.5
Water Depth (Average)	0.2
Riffle Length	23.2
Riffle Width (Average)	3.3

Appendix E. Macroinvertebrate Taxa List

	Stream	Bridge Creek	Rock Creek	Rock Creek	John Day River	John Day River	John Day River
	Site	R11	R08	R15	R14A	R14B	R14C
	Date	8/26/2008	8/27/2008	8/27/2008	8/28/2008	8/28/2008	8/28/2008
	Habitat	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide
	Percent Subsampled	100.00	100.00	100.00	100.00	100.00	100.00
	ABR Sample ID	08-610-04	08-610-05	08-610-06	08-610-07	08-610-08	08-610-09
OLIGOCHAETA		6		2	7	5	
Trombidiformes	Trombidiformes	2	3		2	4	
Amphipoda	*Crangonyx*						
Decapoda	Pacifasticus						
Isopoda	*Caecidotea*						
Coleoptera	*Microcylloepus*	33	31	70	36	56	74
	Optioservus	17	51	52	7	56	25
	Ordobrevia		1				
	Zaitzevia	1	6	36	3	7	10
	Psephenus		30	86	25	16	7
Diptera	*Atherix*	10	5		1	4	
	Chironomidae	6		1	2	2	
	Chironomini	3	3		1	5	1
	Polypedilum						
	Diamesinae	2				1	
	Diamesa						
	Orthocladiinae	34	14	9	7		4
	Brillia						
	Eukiefferiella						
	Limnophyes						
	Orthocladius/Cricotopus complex						
	Thienemanniella						
	Tanypodinae	7	4		1	3	1
	Tanytarsini	3		2	1		
	Tanytarsus/Micropsectra						
	Empididae					1	1
	Hemerodromia			2			1

	Stream	Bridge Creek	Rock Creek	Rock Creek	John Day River	John Day River	John Day River
	Site	R11	R08	R15	R14A	R14B	R14C
	Date	8/26/2008	8/27/2008	8/27/2008	8/28/2008	8/28/2008	8/28/2008
	Habitat	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide
	Percent Subsampled	100.00	100.00	100.00	100.00	100.00	100.00
	ABR Sample ID	08-610-04	08-610-05	08-610-06	08-610-07	08-610-08	08-610-09
	Neoplasta	1					
	Prosimulium				1		
	Simulium	3			8	5	12
	Antocha			2			
	Hexatoma		1	1			
Ephemeroptera	*Acentrella turbida*				29	12	4
	Baetis flavistriga		1	6			
	Baetis tricaudatus	13	5	20	128	80	100
	Baetis damaged		5				
	Diphetor hageni		1			2	
	Fallceon quilleri	1		3	7		
	Baetidae damaged	4		29	48	18	23
	Pseudocloeon dardanum				6		1
	Drunella grandis	5					
	Ephemerella excrucians						
	Ephemerella imm						1
	Cinygmula						
	Ecdyonorus criddlei			1			
	Epeorus			11	5	4	6
	Rhithrogena	14	3	137	18	71	32
	Heptageniidae damaged				2		2
	Paraleptophlebia bicornuta					1	
	Leptophlebiidae damaged			1	1	2	
	Asioplax				1	4	3
	Tricorythodes	68	27	2	15	16	8
Lepidoptera	*Petrophila*	2	18		15	4	8
Odonata	*Ophiogomphus*	11					
	Argia		2				1
Plecoptera	*Zapada columbiana Gr.*	1					
	Malenka						

	Stream	Bridge Creek	Rock Creek	Rock Creek	John Day River	John Day River	John Day River
	Site	R11	R08	R15	R14A	R14B	R14C
	Date	8/26/2008	8/27/2008	8/27/2008	8/28/2008	8/28/2008	8/28/2008
	Habitat	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide	Reach-Wide
	Percent Subsampled	100.00	100.00	100.00	100.00	100.00	100.00
	ABR Sample ID	08-610-04	08-610-05	08-610-06	08-610-07	08-610-08	08-610-09
	Isogenoides				1	1	
	Skwala	23	5	13	4	9	4
	Calineuria californica			1			
	Doroneuria					3	6
	Hesperoperla pacifica	1		2		1	2
	Pteronarcys		1				
	Pteronarcidae damaged						1
Trichoptera	*Amiocentrus aspilus*						
	Brachycentrus	53	92		1	1	19
	Glossosoma						3
	Glossosomatidae pupae			1			
	Helicopsyche borealis		1				
	Hydropsyche	159	171	22	95	101	114
	Cheumatopsyche		8	3	18	36	22
	Hydroptila	1					
1	*Leucotrichia*					1	
	Ochrotrichia	1	1	2			
	Lepidostoma						
	Nectopsyche						
	Dicosmoecus						
	Onocosmoecus unicolor	1					
	Chimarra		2	1	14	4	13
Gastropoda	*Ferrissia*	2		2			1
	Lymnaeidae		2				
	Gyraulus parvus		20				
	Physella	1	1				
Pelecypoda	Pisidiidae						
TURBELLARIA	Turbellaria						
NEMATA	Nemata			1		6	3
	Total	489	515	521	510	542	513

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NPS 177/100904, January 2010

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