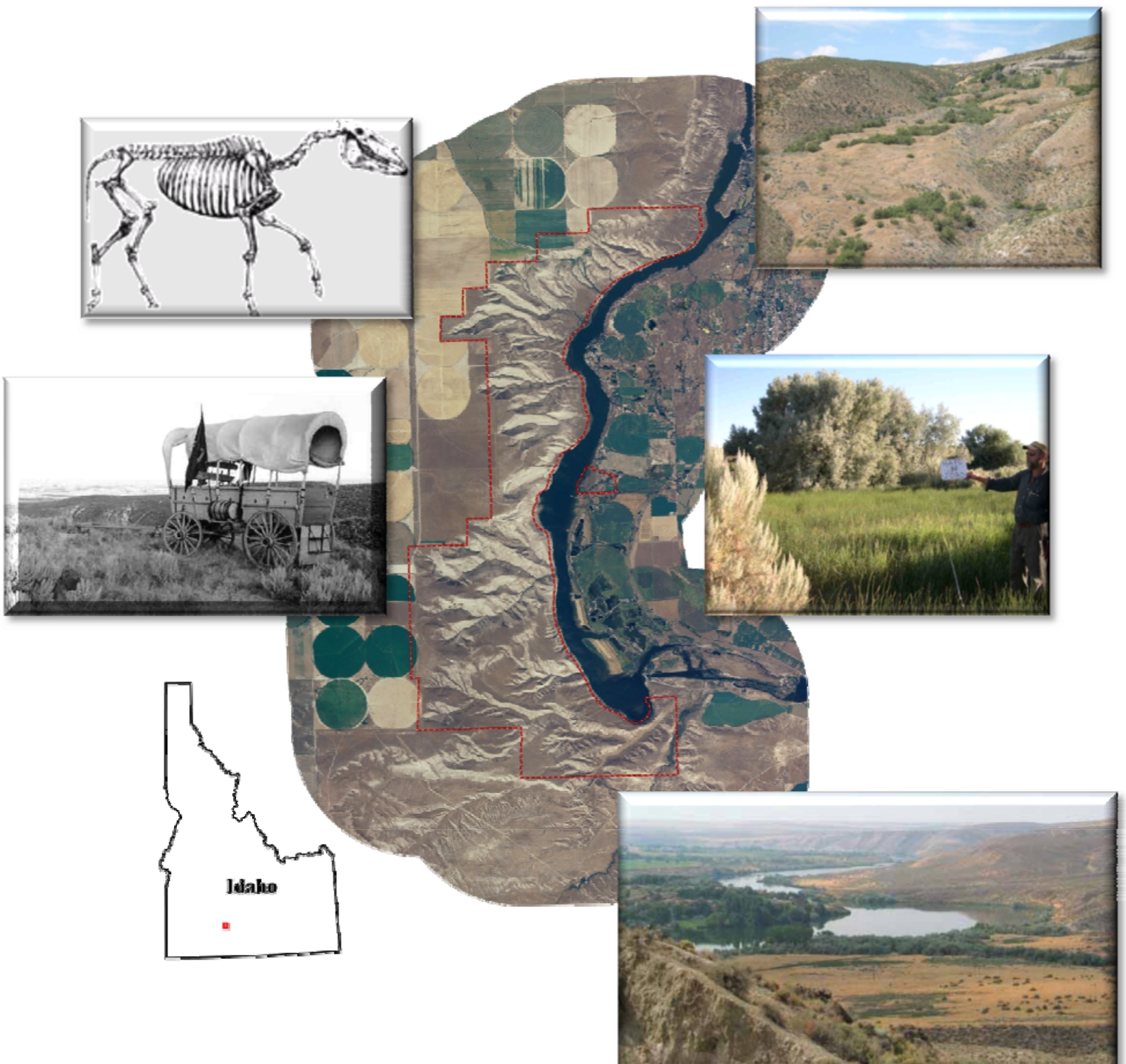
National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Hagerman Fossil Beds National Monument

Natural Resource Report NPS/UCBN/NRR—2012/599



ON THE COVER

Map of Hagerman Fossil Beds National Monument located in south-central Idaho with insets of pictures from the Hagerman Fossil Beds National Monument website and Northwest Management, Inc.

Natural Resource Condition Assessment

Hagerman Fossil Beds National Monument

Natural Resource Report NPS/UCBN/NRR—2012/599

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

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.

This report is available from the Upper Columbia Basin Network website (http://science.nature.nps.gov/im/units/ucbn/) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

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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. 15) for more information.

Executive Summary

Hagerman Fossil Beds National Monument (HAFO), established in 1988, encompasses approximately 4,350 acres in the Snake River canyon in south central Idaho (HAFO 1999, Erixson and Cogan 2009). The Monument is located approximately 35 miles west of Twin Falls, Idaho and 100 miles east of Boise, Idaho. The Bureau of Land Management (BLM) originally managed the area through the Jarbidge Resource Area (Farmer and Riedel 2003). In 1988, the management of approximately 3,974 acres was transferred to the National Park Service (NPS) through the Arizona-Idaho Conservation Act along with 420 acres of State of Idaho Lands (Farmer and Riedel 2003). Most recently, approximately 54 acres were purchased on the east side of the Snake River as the future site of the visitor center and research facilities.

The history of the Monument has been well defined from emigrants traveling the Oregon Trail, early farmers and ranchers, and by the Monument's international reputation as one of only six exceptional Pliocene fossil quarries in the world. Since the discovery of these fossil beds in the 1930's, nearly 100 species of vertebrate fossils including the largest, most well-preserved specimens of the "Hagerman Horse" have been recovered (HAFO 1998). HAFO Pliocene era fossils date three to four million years old and are distributed vertically through 152 m (500 feet) of the Glenns Ferry Formation along the banks of the Snake River. There is a continuous undisturbed stratigraphic representation of 500,000 years that includes wetlands, riparian, and grassland savanna organisms making it one of the most biologically diverse representations of historic conditions.

The current conditions of the Monument are much different than those experienced by the Hagerman Horse, and even by early fossil hunters of the 19th century. Historically, the HAFO area was comprised of a complex mosaic of different plant communities that supported a biologically diverse group of wildlife and plant species. However, intensive agricultural development and modification of the Snake River and riparian zone has radically altered the natural environment. These land use changes present extremely difficult challenges to the resource management team in the park. Additionally, natural disturbance, anthropogenic influences, and adjacent land management practices have enabled the establishment of invasive noxious weed populations (HAFO 1999, Rodhouse 2009, 2010). The recent catastrophic Long Butte Fire that burned 75% of the monument, including most of the upland vegetation, in August 2010, has exacerbated the situation, accelerating the conversion of the park toward a largely weed-dominated environment.

Management of invasive and noxious weeds requires the development of strategic plans. These plans must incorporate prevention, education, and control options that are economically sustainable (Whitson 1998, DiTomaso 2000). There are five commonly suggested controls for invasive species; however, the foundation of noxious weed management requires natural resource stewardship as well as private and public cooperation. With the high cost of weed control and the biological alterations as invasive species spread throughout the Nation's fields and ecosystems, the importance of prevention and management of desired resources becomes more and more critical.

Natural disturbances disrupt local vegetation and can aid the spread of noxious weeds and the evolution of ecosystems. Fire is one example of natural disturbance that plays an integral role in the fecundity and progression of a landscape through disturbance and nutrient cycling. HAFO is predominantly a middle to lower-elevation ecosystem composed of sagebrush and grasslands. The occurrence of the Long Butte Fire in August 2010 has dramatically altered much of the natural vegetation within HAFO. More than 75% of the Monument was burned (Lonneker 2010), which increases the potential for erosion, landslides (Farmer 1999), water quality issues from runoff and a permanent shift in sagebrush ecosystems to less desirable species (HAFO 2001).

Additional concerns facing the Monument stem from a tightening of Federal air quality regulations for ozone. The proposed human health standard for ozone by the EPA would, as of the date of this publication, list between 126 – 193 NPS units as non-compliant. The level of ozone at these sites is currently in excess of the newly proposed values said to be established between 60 and 70 parts-per-billion. The installation of an ozone monitoring station will gather data necessary for the compliance of HAFO under these developing regulatory levels. This data could also provide for a comparison of air quality data with vegetation data for the identification of indicator species, as some plant species have known sensitivities to ozone (UCBN 2001). Ozone and air quality have also been linked to climate change (Hopkin 2007) and recent findings suggest all continents and most oceans are being affected by climate changes and most specifically temperature increases (Parry et al. 2007). Recent data representing the UCBN suggests the area will experience warmer, wetter winters, an increase of approximately 3.1° F by 2030 and a five percent increase in precipitation (Mote et al. 2008). This would mean a reduction in winter snow accumulation and an increase in precipitation as rain. This can lead to increased flooding in spring due to rain-on-snow events hastening spring snowmelt as well as less available water later in the summer as snowpack storage would have already been lost. Changes of this nature over extensive areas, much larger than HAFO, have the potential to affect water availability in rivers as large as the Snake River thereby exhibiting far-reaching impacts. Vulnerabilities to climate change are said to rely heavily on chosen management pathways, ecosystem stability and species diversity.

Balancing management of the Monument’s natural resources and recreation coupled with growing concerns of climate change and air quality degradation will present exceptional challenges for managers and require continuously relevant data. The 2010 species list published by the NPS details the number of species known to exist in the park as well as a number of species considered to be “possibly present”. Wildlife at HAFO is dominated by a variety of birds and small rodents with aquatic species existing near the Snake River and springs scattered throughout the area. Some aquatic species could be studied as potential water quality indicators relating to sediment loading (Welsh and Ollivier 1998); thereby providing alternative options to managers for administration of the Monument’s water resources.

It is recognized that the water levels in the Lower Salmon Falls Reservoir and the amount of groundwater recharge after agricultural irrigation is outside the control of NPS managers. However, understanding the impacts from the lack of sufficient riparian hydrology in a static system with controlled water levels is critical to adequately managing the aquatic resources within HAFO. As a result of land use activities, springs represent a significant supply of nonpoint-source additions to the Snake River. Water use alternatives that reduce chemical loading to the Snake River by reducing the quantity of discharge may be undesirable, since other land uses and ecosystems are dependent on the consistency of these springs. Ultimately, regulations or a reduction in anthropogenic practices that increase constituent concentrations in the Snake River Plain aquifer will be required to decrease sedimentation, maintain the quantity of spring discharge, and improve water quality (Clark and Ott 1996).

This Natural Resource Condition Assessment (NRCA) report and accompanying geodatabase is designed to give HAFO resource managers a better understanding of current natural resource conditions within and adjacent to the Monument. Assessments were accomplished through literature review, evaluating existing data, and collection of new data for areas where sufficient, reliable data was not available. Information gained from this assessment will help form the basis for development of actions to mitigate degradation of HAFO's natural resources and assist in the development of desired future conditions through Park management processes. Additionally, an overall description of HAFO natural resources and their history, condition, threats, and stressors are presented throughout this document followed by a summary and management recommendations. All management practices structured toward attaining Proper Functioning Conditions within natural ecosystems will aid NPS resource managers in accomplishing their goals of conservation for future generations.

Acknowledgements

This project was completed through the effort and dedication of numerous individuals and organizations. We are very thankful for all the support and help from Lisa Garrett, Program Manager for the NPS Upper Columbia Basin Network and all the staff at Hagerman Fossil Beds National Monument who went out of their way to assist field crews in every manner possible. They were very professional and extremely helpful throughout the process. Finally, we owe a great deal of appreciation to Vaiden Bloch from Northwest Management, Inc. who was invaluable in preparing the Geodatabase and map project files.

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.

Acronyms and Abbreviations

BLM	U.S. Bureau of Land Management
CAA	Clean Air Act of 1970, as amended
DOI	U.S. Department of the Interior
HAFO	Hagerman Fossil Beds National Monument
GIS	Geographic Information System
IDFG	Idaho Department of Fish and Game
I&M Program	Inventory and Monitoring Program
IMPROVE	Interagency Monitoring of Protected Visual Environments
ISDA	Idaho State Department of Agriculture
km	Kilometers
km^2	Square kilometers
mi	Miles
mi^2	Square miles
Monument	Hagerman Fossil Beds National Monument
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NASS	National Agricultural Statistics Service
NMI	Northwest Management, Incorporated
NPS	National Park Service
NRCA	Natural Resource Condition Assessment
NRR	Natural Resource Report
NVC	National Vegetation Classification
NVIP	National Vegetation Inventory Program
PSD	Prevent Significant Deterioration
UCBN	Upper Columbia Basin Network
U.S.	United States of America
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WCA Program	Watershed Condition Assessment Program
WRCC	Western Region Climate Center

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. 15) for more information.

Introduction

Purpose and Scope

The mission of the National Park Service (NPS) 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, City of Rocks National Reserve, Craters of the Moon National Monument and Preserve, Hagerman Fossil Beds National Monument, John Day Fossil Beds National Monument, Lake Roosevelt National Recreation Area, Minidoka Internment National Monument, Nez Perce National Historical Park, and Whitman Mission National Historic Site.

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 oversite and technical support for this effort is provided by the division's Natural Resource Condition Assessment (NRCA) Program. The NRCA Program partnered with the Pacific West Region to fund and oversee an assessment at each park in the Upper Columbia Basin Network. This report documents the results of the Natural Resource Condition Assessment completed for Hagerman Fossil Beds National Monument (HAFO).

Generally, this NRCA seeks to interpret and translate existing scientific information into a form that HAFO managers find useful for supporting natural resource decision-making, action plans, and cultural resource planning. NPS guidelines for creating NRCAs specifies the use of existing data, but field-based rapid assessment techniques can be used if sufficient upland data is lacking for a site (NPS 2009). For the UCBN parks, and HAFO in particular, prior authorization was given to collect new field data via rapid field assessments based on BLM rangeland health methodologies (Pellant et al. 2005).

The assessment of both the existing information and the new rapid assessment data for HAFO is summarized in this NRCA project report. The HAFO NRCA report and set of Geographic Information System (GIS) maps with associated data layers will serve to:

- Describe HAFO resources in a regional context (setting, significance, issues);
- Provide an interdisciplinary (holistic) snapshot of current resource conditions by management area;
- Document high-priority data gaps and resource condition threats and stressors; and
- Identify and describe "high value" and "high vulnerability" (at risk) HAFO resources and management areas.

It is important to note that this preliminary assessment of natural resources at HAFO is of a general level and will focus on providing broad ecological information. Information, data, and recommendations developed under this project will assist HAFO managers to:

- Develop near-term management strategies and priorities for the HAFO resource management program;
- Engage in watershed or landscape scale partnership and education efforts;
- Assist with mid- to longer-term planning (e.g. General Management Plans, Resource Stewardship Strategies, Implementation Plans)
- Meet performance reporting requirements on HAFO resource condition status (Department of Interior "land health" goals, Office of Management and Budget "natural resource condition" scorecard, NPS state of the parks reports, etc.)

NRCA Background

Natural Resource Condition Assessments (NRCAs) are broad-scope ecological assessments intended to develop synthesis "information products" readily usable by park managers for resource stewardship planning. NRCAs are needed for reporting on various performance measures, including the Department of the Interior (DOI) Strategic Plan "*land health*" goals. NRCAs evaluate current conditions for a subset of natural resource indicators in national park units that inform/identify: 1) overall trends (when possible), 2) critical data gaps, and 3) provide general levels of confidence. The resources and indicators emphasized in NRCAs are driven by the park resource setting, status of current resource stewardship planning, and established scientific principles. By evaluating criterion one through three, high-priority indicators are identified and the availability of data and expertise to assess the indicators and resources are addressed. Additional NRCA Program information may be accessed online at: http://www.nature.nps.gov/water/nrca/index.cfm

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement, not replace, traditional issue- and threat-based resource assessments. Three key elements make NRCAs valuable for both planning and performance reporting. They include:

1. Building on multi-disciplinary data, information, and knowledge already assembled through efforts of the NPS Inventory and Monitoring (I&M) Program, other NPS science support programs, and from partner collaborators working in and near parks;
2. Emphasizing a strong geospatial component for how the assessment is conducted and in the resulting information products; and
3. Providing narrative and/or semi-quantitative descriptions of science-based reference conditions for resources that will assist park managers to define Desired Future Conditions through park planning processes (reference conditions will become more refined and quantitative over time).

Information gained from this NRCA report will form the basis for developing actions to reduce and prevent impairment of park resources through both park and partnership efforts. The stated goals of the NRCA are to:

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

The ensuing report is designed to give park staff a moment-in-time or snapshot assessment using a combination of existing data and new rapid assessment point information for various upland sites in HAFO. The goal of this report is to adequately describe the natural resources of HAFO and their current condition while maintaining the consistency set forth under the national NRCA guidelines and standards for study design and reporting products. The overall objective of this project is to determine the state of knowledge of park condition using both existing and new rapid assessment data, identify information gaps, state conclusions or hypotheses on the condition of selected natural resources (unknown, degraded, unimpaired), identify resource threats or potential issues affecting ecosystem health, and recommend further studies.

Study Area

Monument Setting

Hagerman Fossil Beds National Monument (HAFO), established in 1988, encompasses approximately 4,350 acres in the Snake River canyon in south central Idaho (HAFO 1999, Erixson and Cogan 2009). The Monument is located approximately 35 miles west of Twin Falls, Idaho and 100 miles east of Boise, Idaho. The Bureau of Land Management (BLM) originally managed the area through the Jarbidge Resource Area (Farmer and Riedel 2003). In 1988, the management of approximately 3,974 acres was transferred to the National Park Service through the Arizona-Idaho Conservation Act. An additional 420 acres of State of Idaho Lands was transferred as well adding to the total area of the Monument (Farmer and Riedel 2003). More recently approximately 54 acres were purchased for the Monument on the east side of the Snake River. The Snake River is present through the length of the HAFO Monument and is a major tributary of the Columbia River system that travels through the physiographic region of Idaho known as the Snake River Plain (

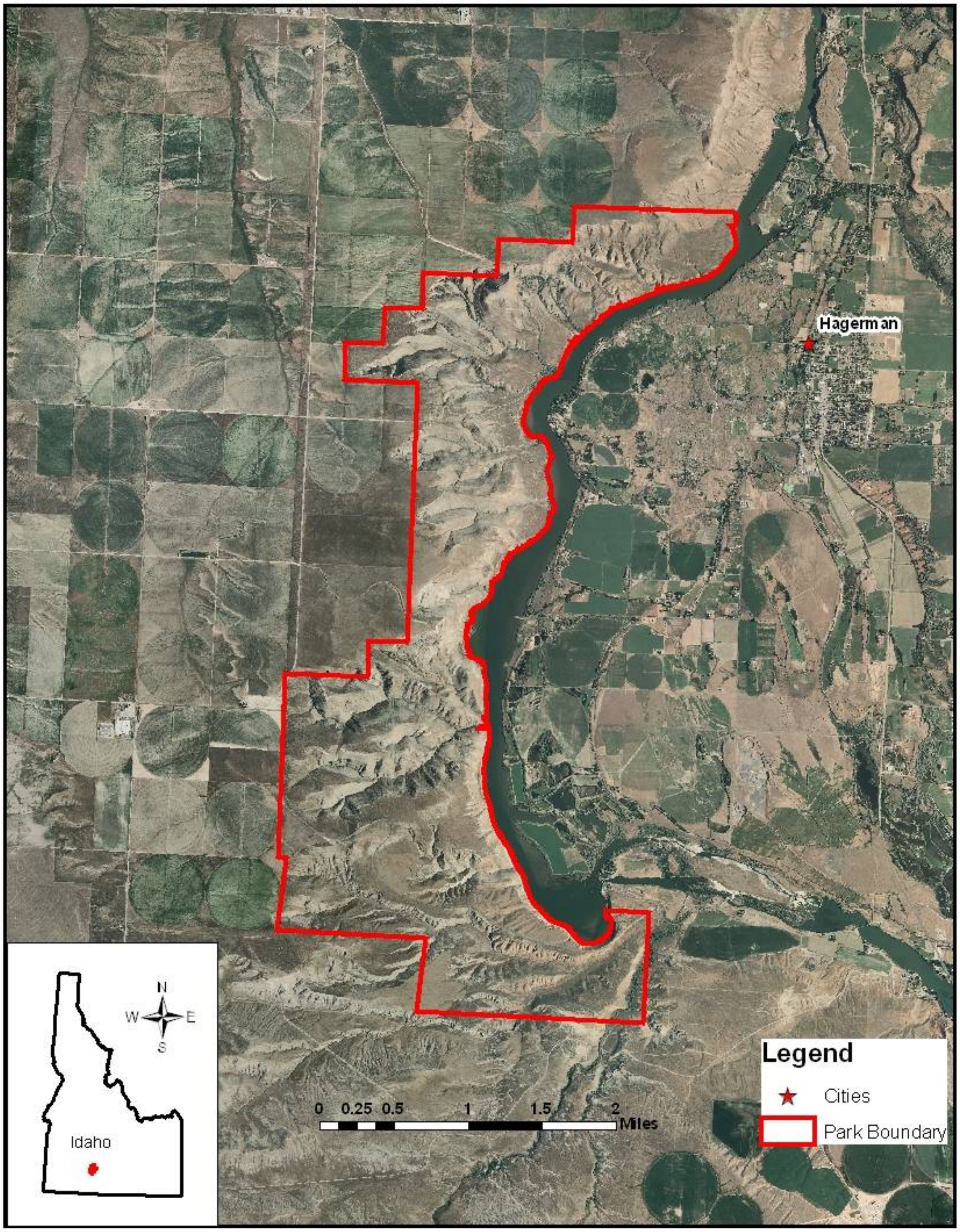

Figure **1**).

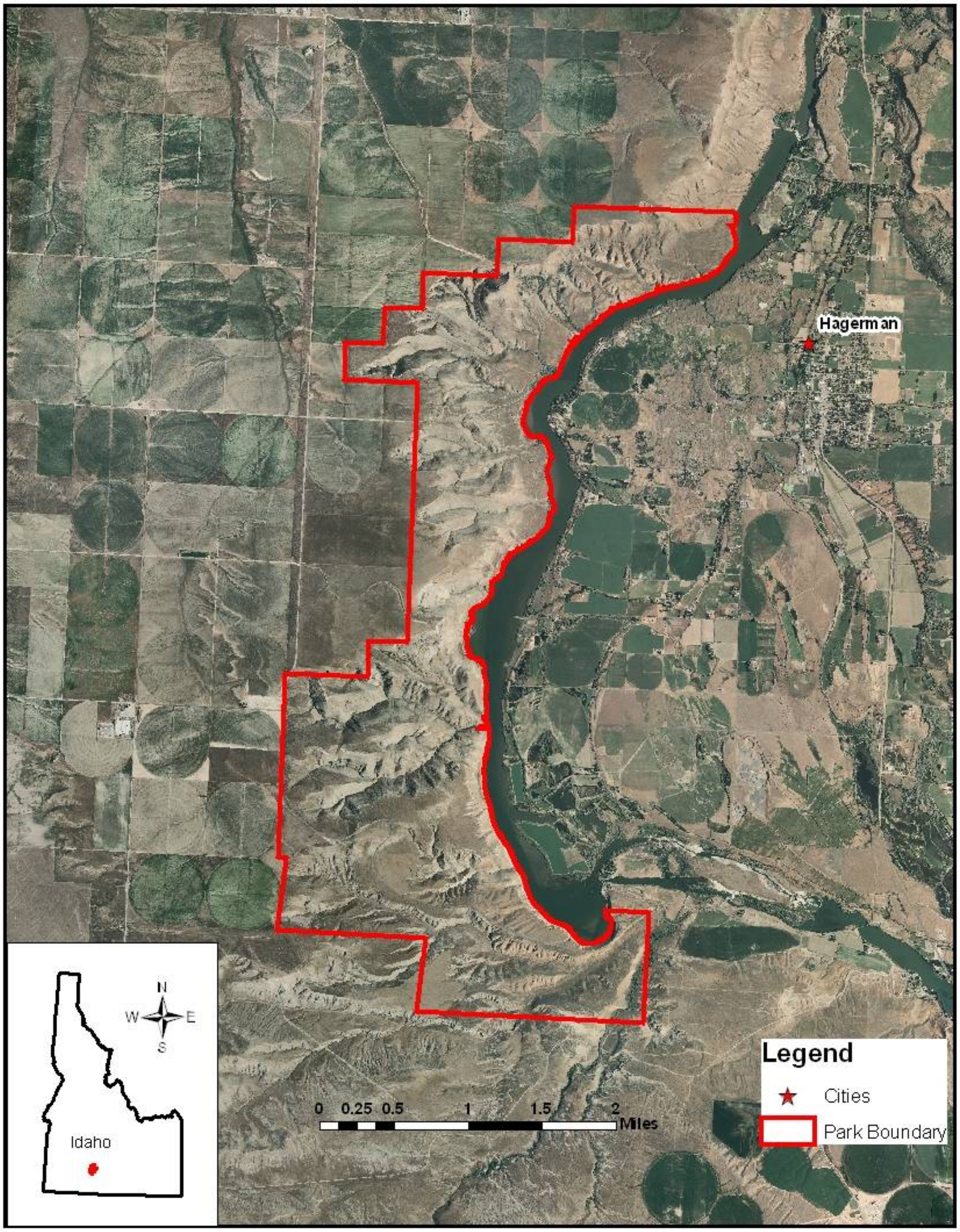

Figure 1. Map of HAFO in southern Idaho.

The Snake River Plain is a topographic depression that cuts across Basin and Mountain structures paralleling the North American plate and is underlain entirely by basalt erupted from the large shield volcanoes found in the area. Beneath these basalts are rhyolite lavas and ignimbrites that erupted as the lithosphere passed over the Yellowstone hotspot. Thick sections of interbedded lacustrine (lake) and fluvial (stream) sediments are found in the area of the Hagerman Valley. These sediments comprising the surrounding stratigraphic Glenns Ferry Formation have a complex hydrologic system and are prone to landslides (HAFO 1998).

These landslides often expose fossils explaining why HAFO is one of the most important archeological locations known. The predominantly Pliocene era fossils are distributed vertically through 152 m (500 feet) of the Glenns Ferry Formation along the banks of the Snake River in southern Idaho. Since the 1930's, scientists have found fossils in this area above the Snake River with the most notable find being the largest known deposits of "Hagerman Horse" fossils in North America (HAFO 1998, HAFO 1999). Hagerman Horse fossils (a zebra like horse) and others including cats, fish, turtles, beavers, camels, peccaries and mastodon are found at HAFO. These fossils are from the late Pliocene epoch dating nearly 3.5 million years old and are preserved in the sediments beneath the Monument. Much of the terrain in HAFO is steep and is characterized by ridges, canyons, landslide scarps, and some flatlands near the rim of the Hagerman Valley. The Hagerman Valley is thought to have been formed during the Bonneville Flood approximately 15,000 years ago. During the formation of the valley the Bonneville Flood and consequently the Snake River have cut through the Snake River Plain exposing areas where the Snake River Plains Aquifer has developed seeps in the valley walls (HAFO 1999). The Snake River Plains Aquifer, which is one of the largest underground aquifers in the world, supports an abundance of springs fed on the exposed steep canyon walls. Due to the numerous viable springs found in the Hagerman Valley, the Snake River canyon near HAFO is known as the "Thousand Springs" area (Farmer and Riedel 2003).

Management goals have evolved through time as the administration and management objectives have developed within HAFO. An overview of the historical management objectives and goals are provided below.

The purpose and site significance of HAFO was established in November of 1988 through legislation Title III of Public Law 100-696. A combination of statements was developed to define the significance of the HAFO Monument and why the Monument was established. These purpose statements were recorded as:

- Preserve for the benefit and enjoyment of present and future generations the outstanding paleontological sites known as the Hagerman Valley fossil sites.
- Provide a center for continuing paleontological research.
- Provide for the display and interpretation of the scientific specimens uncovered at such sites.
- Provide for the orderly and regulated use of and research in the Monument by qualified scientists, scientific groups, and students under the jurisdiction of such qualified individuals and groups.

The initial management goals of the HAFO Monument were presented in the NPS Long-Range Interpretive Plan 1998 (HAFO 1998). These guidelines outlined the focal points of management for the Monument and established some guidelines for future areas of management focus. These focal points are written as:

- Preserve and protect the paleontological resources of the Hagerman Valley fossil sites, including both specimens and their context.
- Provide a center for continuing paleontological research, education and interpretation.
- Encourage and support scientific research and related activities associated with Monument resources and the science of paleontology.
- Achieve appropriate accreditation for Monument facilities and programs.
- Provide a range of opportunities for visitors to experience and understand the present and past environmental interrelationships, resources and values of the Monument.
- Preserve, protect and interpret the natural and cultural resources associated with the Monument.
- Provide for the health and welfare of the Monument visitors, researchers and staff.
- Cooperate with the operation, maintenance, repair, upgrade, and modification of existing electrical and irrigation facilities within the boundaries of the Monument as legislatively required, while minimizing any adverse impacts of these activities on Monument resources, values, research, or visitors.
- Consistent with the above, strive to be a "good neighbor" and an asset to the long-term welfare of the Hagerman Valley region. Maintain effective relations with the local communities, state and federal agencies and tribal governments.

The Resources Management Plan was revised in 1999 from a 1995 publication developed in accordance with the NPS Resource Management Plan Guidelines published March 1989, under the directives of NPS Management Policies ruling of Public Law 100-696 in 1988 (HAFO 1999) lists three main goals for the HAFO Monument. Likewise, the Wildland Fire Management Plan for HAFO published in 2001 also lists three similar goals for resource management within the Monument (HAFO 2001). These goals mirror the areas of significance discussed in the HAFO Long-Range Interpretive Plan printed in 1998. The three areas of focus are listed below:

- Preserve and protect the paleontological resources of the Hagerman Valley fossil sites, including both specimens and their context.
- Preserve, protect, and interpret the natural and cultural resources associated with the Monument.
- Provide for the health and welfare of Monument visitors, researchers and staff.

The 1999 HAFO Resources Management Plan defines the goals for natural resources along with strategies for each area of consideration. The goals defined throughout the 1999 Management Plan are listed here by section.

Goals: Paleontological Resources

- Identify and document paleontological resources, sites, and their geological setting, and protect from unnaturally accelerated erosion and other unnatural disturbance.

- Encourage, facilitate, and manage paleontological research.
- Provide for public appreciation and understanding of the science of paleontology and enjoyment of fossil resources in such a way that they are protected for research use.

Goals: Non-paleontological Natural Resources

- Re-establish native plant communities and associated ecological processes, such as disturbance regimes and soil processes.
- Perpetuate natural diversity, abundance, and behavior of native wildlife species.
- Identify and mitigate impacts to Monument resources by external activities.
- Control the spread of non-native species and, where feasible, remove them from areas where they are already established.

Goals: Cultural Resource

- Identify, evaluate, nominate and manage cultural resources within the boundaries of HAFO in accordance with federal and state laws and regulations and NPS policies.
- Identify potential impacts on cultural resources.
- Continue to develop a working consultative relationship with Native American groups whose heritage and contemporary interests include resources within HAFO.
- Work with partners within the NPS and the local and regional communities to develop coordinated approaches to interpreting the area's cultural heritage and protecting cultural properties.

Goals: Archeological Resources

- Identify and document archaeological resources, sites, and their setting, and protect them from unnaturally accelerated erosion and other disturbances.
- Encourage, facilitate, and manage archaeological research.
- Properly document and manage archeological collections to ensure long-term conservation and research use.

Goals: Historical Resources

- Identify and document historical resources, sites, and their setting and protect them from unnaturally accelerated erosion and other disturbances.
- Establish a Park Archives to preserve the administrative record of HAFO; prepare an Administrative History of HAFO.

Goals: Integrated resources

- Properly document and manage paleontological collections to ensure long-term conservation and research use.
- Provide a center for paleontological research, resource management, and public enjoyment.

- Manage all Monument uses and design access, facilities and other developments to minimize impacts on resources and ecological processes.

Historical Setting

Environmental changes caused the migration of people to the Hagerman area that led to new cultural developments and innovations. This area of southwestern Idaho has been inhabited by humans continuously from as early as 15,000 B.C to present time (Farmer and Riedel 2003). Remains from these early settlements include stone tools, campsites, food remains, and structures. The first people to inhabit this area are believed to have lived here in the Paleo-Indian period (15,000 B.C.- 8000 B.C.) and projectile points, believed to have been used to hunt large mammals that are now extinct (HAFO 1998), have been found in the region. During the Archaic period (8000 B.C-1500 B.C), it is believed that small groups of people lived off of plants and animals in the area. Evidence exists of these small groups living in what is now the Hagerman Fossil Beds National Monument during the late Archaic period.

Fishing was the main means of subsistence along the Snake River with salmon and trout runs through the sheltered Hagerman Valley, making this area a desirable place to inhabit (Farmer and Riedel 2003). Evidence exists from the Paleo-Indian period, Archaic period, to the Proto-Historic period that people used the Snake River for a means of subsistence. Campsites in the Monument were generally in areas that had rock shelters or caves. These areas were also popular fishing spots for local Indians who traded with the Euro-American emigrants who passed along the Oregon Trail (HAFO 1998).

The first European contact the natives had in the Hagerman Valley was with an explorer and trapper named Wilson Price Hunt in November of 1811. Many fur trappers later followed on the Oregon Trail starting in 1841. The Hagerman Valley was directly affected by settlements in the area and people passing through. Farming and mining also began in the late 1870’s and an increase in settlements occurred when the Union Pacific Railroad reached the area in 1882 (Farmer and Riedel 2003). In 1910 a dam was built on the Snake River at Lower Salmon Falls by the Great Shoshone and Twin Falls Land and Water Power Company to provide power to local communities and settlements. Idaho Power Company acquired the dam in 1919 and constructed the Upper Salmon Falls Dam in 1937 thereby altering water levels in the Snake River channel at HAFO and providing improved access to water for irrigation and ranching. Ranching started in the late 1870’s and peaked in the 1910’s-1920’s. Hagerman got its name through a pharmacist from Ohio named Stanly Hageman who originally opened a drug store in the valley in 1891 and was also interested in ranching. In 1892 Mr. Hageman was tasked with establishing a post office for the growing population of the area and through a misspelling of his last name the post office was registered as Hagerman and was never changed (Master Plan 2006).

The Hagerman site was found by a local rancher Elmer Cook during the 1920’s after he showed some fossils he had found to government geologist Dr. Harold Sterns. Sterns then presented the fossils to Dr. Gidley of the Smithsonian Institution who identified the fossils as remains of an extinct horse (*Equus simplicidens*), which subsequently led to initial expeditions to the area in 1929 and 1930 (HAFO 1999) and two additional expeditions in 1931 and 1934. During the 1950’s and 1960’s various institutions gained interest in the area and digging expeditions continued until 1999. In addition to the Hagerman Horse, fossils of over 180 animal and 35 plant types have been found. The HAFO fossil beds are known as the world's largest concentration of Upper Pliocene age terrestrial fossils and thereby are considered "internationally" important (HAFO 1999).

Natural Resources

Geology

HAFO is in the central portion of the Great Rift and is located on the extensive Snake River Plain, a major Cenozoic tectonic volcanic feature in the Basin and Range geologic region of Idaho. Explosive rhyolitic volcanism associated with the Yellowstone-Snake River Plain hotspot deposited the Idahvada Volcanics from between 14 and nine million years ago (Bonnichsen and Breckenridge. 1982). As the thermal uplift associated with the hotspot subsided due to northeast/southwest extension of the rift, eruptions continued through much of the Miocene epoch which filled the western Snake River Plain with welded and vitric tuffs as well as silicic lavas (Malde 1991).

Eleven million years ago sediment depositions of Idahvada Volcanics named the "Idaho Group" by Cope (1983) were deposited on floodplains and in lakes and streams across the Snake River Plain Area. Malde and Powers (1962) divided the "Idaho Group" into seven formations ranging in age from 11 million to 700,000 years old and described their location in more detail. The Monument is situated on the arid slopes of the Snake River Plain and its boundary generally follows the top edge of the bluffs to the west, and the mid channel of the Snake River to the east. As the Snake River flows through the Hagerman Valley it bisects nearly horizontal sedimentary deposits known geologically as the Glenns Ferry Formation, a part of the Idaho Group; basalt bedrock, part of the Snake River Group is also common. The Hagerman Valley lies along the eastern edge of the Glenns Ferry Formation and is an extensive network of floodplains and stream deposits associated with ancient "Lake Idaho". The floodplains are intermixed with localized, discontinuous lava flows which extend over an extensive portion of the western part of the Snake River Plain.

The age of the Glenns Ferry Formation can be described as fully existing within the Pliocene to early Pleistocene time periods, or roughly 5 to 1.5 million years ago (Malde 1991). Deltaic, fluvial and flood plain features are the primary components comprising this formation and are exposed by the bluffs on the west side of the Monument. The HAFO fossil beds are characterized by poorly consolidated sediments, minor lava flows of basalt or volcanic ash intermixed with sediments comprising of abrupt facie changes in expansive layers of silt, thick layers of sand, some sandstone and thinly bedded clay. These sediment deposits are commonly characterized by monotonous fine grained, graded, calcareous, pale-olive silt beds from one to three feet thick and capped with a dark, carbonaceous clay from one to several inches thick (Malde 1965).

The fossils are buried within these sediments which are overlain by permeable gravel and inter-bedded with sand and silt. These gravel dominated features are known as "Tuana Gravel" and they rest on the Glenns Ferry Formation. Within the Tuana Gravel exists a continuous caliche layer several feet below the surface. The caliche forms a cap on top of the bluffs and is a barrier to ground water infiltration where it remains unbroken. This layer appears to have formed during an interglacial drying cycle during the Pleistocene era (Bjork 1968). Younger sedimentary formations and alluvial deposits are also notable along the bluffs catering to the geologic interest of this area.

Geology at HAFO is not static and is subject to periodic physical and chemical processes. Common physical processes altering the geology at HAFO are erosion and slope movements. Slope movements occur at HAFO as landslide events, where sections of the cliffbanks break free of the underlying material and are deposited further down slope close to, or in the Snake River. Landslides are likely caused by a combination of natural poor soil consolidation, steep slopes, and the flow of groundwater. Of these, groundwater manipulation for agricultural irrigation purposes may have caused up to seven various landslides at HAFO over the last 25 years and their frequency and size may be increasing (Covington 2004).

Air Quality

Air pollution associated with industrialization and urbanization is believed to adversely affect sensitive natural resources and therefore has the potential to degrade resources in our country's National Parks. Human-caused air pollutants are known to cause injury to various species of plants, acidify water bodies, and leach nutrients from soils (NPS 2004). A workshop hosted by the NPS in 2003 published a list of ozone sensitive plant species and species known to be bioindicators, (plants that respond quickly to specific constituents due to sensitivities and can be used as "early indicators" of exposure); to aid Monument managers in identifying ozone degradation impacts (UCBN 2001). This list of species is published in (NPS 2003) through an evaluation of ozone sensitive species on NPS and U.S. Fish and Wildlife lands.

Vegetation

This area's unique terrain supports nearly 380 species of vascular plants including a mix of common native plants, non-native species, and some native plant communities indigenous to this area (Erixson and Cogan 2009). The native elements mainly include shrub species found throughout the Monument. The non-native species tended toward invasive trees, primarily Russian olive (*Elaeagnus angustifolia*) and invasive grasses including cheatgrass (*Bromus tectorum*). Natural plant communities in the area are not well represented and appear to be located in isolated patches found on benches and steeper slopes. HAFO is predominately bounded on the south and west by sagebrush plateaus and on the east by the Hagerman Valley.

Shadscale (*Atriplex confertifolia*) and Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) shrublands dominate the uplands and footslopes in most areas within the Monument. The uplands are typically loosely associated with east-facing slopes supporting Wyoming big sagebrush. The footslopes are commonly associated with shadscale although both species can be found in other areas. Much of the vegetation on the level ground along the rim is associated with semi-natural vegetation as these areas were grazed and in some cases utilized for agricultural prior to the establishment of the Monument in 1984. Areas with available soil moisture near springs, the Snake River and irrigation ditches support woodland vegetation primarily on the east side of the Monument. The common woodland tree species found along the river include Russian olive, Narrowleaf cottonwood (*Populus angustifolia*), and Black cottonwood (*Populus balsamifera*). American elm (*Ulmus americana*) was present primarily outside of the Monument's boundaries.

Relatively recent human disturbance to the natural landscape has introduced many non-native species to the area, which are replacing the native grasses and riparian vegetation. This includes crested wheatgrass (*Agropyron cristatum*) and cheatgrass which are both common grasses throughout the Monument. Another non-native invasive observed at HAFO is Russian olive which has proliferated along irrigation ditches and waterways throughout southern Idaho. Predominantly the land cover adjacent to the HAFO project area is agricultural use which exists throughout the Snake River Valley.

The HAFO area, a middle-to-lower elevation ecosystem, historically relied on wildfire (Morris 2006) from Native Americans to maintain a composition of sagebrush and grasslands. During August of 2010 the vegetation throughout HAFO and the surrounding area experienced drastic and extreme changes to its ecosystems and vegetative compositions when the Long Butte Fire burned more than 75% of the Monument (Lonneker 2010). This fire has accelerated the conversion of the HAFO landscape to one dominated by non-native weedy species.

Upland Habitats/Species

The area in and around HAFO comprises interactions between different ecosystems supporting a biologically diverse set of wildlife and vegetative species. Sagebrush and grasslands meet with agricultural fields creating fringe habitats at the edge of the Monument. Disturbance and anthropogenic influences have supported the establishment of other commonly occurring species such as rabbitbrush (*Chrysothamnus nauseosus*) as well as introduced grasses and weeds (HAFO 1999). Rodhouse (2009) stated sagebrush steppe is prevalent in southern and central Idaho and is considered one of many vital signs for ecosystem health that can be used by resource managers. Past and present park development (Chambers et al. 2008) and recreation have fragmented areas dominated by sagebrush steppe causing a shift in species composition of some areas within HAFO. These composition modifications occur when soils are disturbed and/or when noxious and invasive species such as cheatgrass and Russian olive are established (HAFO 1999, Rodhouse 2009).

The composition of varied habitat combinations often supports many diverse species as well as provides areas to observe accelerated ecological change. For example: throughout the 1800's and into the early 1900's wild horses still roamed the Hagerman Valley (Master Plan 2006) where they are no longer present today. Through these observed changes multifaceted plans and goals for conservation can be developed to help manage evolving ecosystems and their diverse species. The NPS published a species list for HAFO in 2008 which identified 200 bird, 35 mammal, 17 reptile, eight amphibian and one fish species that were either present or possibly present within the bounds of the Monument (NPS 2008). As of August 2010 and the occurrence of the Long Butte Fire, natural vegetation existing within the HAFO Monument has been drastically altered. More than 75% of the Monument was burned thereby damaging much of the natural sagebrush within HAFO, placing further pressure on natural resource managers for preservation and restoration of the historical conditions.

Aquatic Habitats/Species

Ephemeral streams are found throughout portions of HAFO supplied through seeps and springs amplified by irrigation runoff water mixing with the Snake River Aquifer. Most aquatic ecosystems in the Great Basin are isolated due to the arid nature of the climate and relative scarcity of water (Chambers et al. 2008). Drainage areas in the Great Basin are typically in steep and somewhat rocky terrain and within HAFO they are comprised of many ravines and gully-type features leading toward the Snake River. Riparian areas within the Great Basin comprise only about 1% of the total area and are supported almost entirely by surface waters. Some are seasonal however, seasonal or perennial, riparian areas support the majority of biodiversity within these arid ecosystems (Chambers et al. 2008).

HAFO consists of two areas, one large area west of the Snake River and a small 54 acre parcel on the east side of the River. The additional area was purchased in 1998 and is where the Visitor's Center and headgate for the Bell Ditch irrigation system are located (Farmer and Riedel 2003). The terrain on the majority of the Monument is predominately steeply sloping bluffs and ridges bordering the Snake River. This area is generally oriented east facing and encompasses ten seasonal streams, some springs and numerous seeps within the park boundary. Three of the more well known seasonal streams are Peters Creek, Fossil Gulch and Yahoo Creek. Yahoo Creek is on the farthest southeastern end of the Monument and Fossil Gulch is near the northwestern end of the Monument (NRCS 2010) where landslides occasionally occur (Raytheon 1995)

There are six fish species and four sensitive plant species thought to be present in the vicinity of the Monument and boundary waterways although the current status of each specifically is not known (Cole 1995, HAFO 1999, NPS 2008). The Bald eagle (*Haliaeetus leucocephalus*) is the only species on the federally threatened or endangered species list known to be transitory within the park boundaries on a seasonal frequency (NPS 2008).

Presently, the Organic Act of 1916 obligates the NPS to protect and conserve the areas it manages for the enjoyment and use of future generations. Furthermore, the NPS guided by the Clean Air Act is charged with the protection of our Nation's parks and the encompassed resources from air pollution through the use of all national and regional means (NPS 2004). At the time of this publication no assessment of ozone at HAFO has been performed through the use of off-site data, direct measurement, or kriging (a statistical interpolation process that uses data from remotely sensed locations) (UCBN 2001). The NPS starting in 2011 is gathering data for compliance with the proposed EPA standards at ozone monitoring stations in south central Idaho (NPS 2010a, Nelson 2010).

Climate

The four seasons are distinct at Hagerman Fossil Beds National Monument. Spring is early, often beginning in March and winter is late, often beginning in late October. Conditions within the Monument change significantly between seasons; summers are moderately long with hot days and warm nights. Winters are relatively cold, with minimum temperatures occasionally dipping below 0 °F in January. The annual average precipitation is approximately 11.4 inches (28.9 cm) and is predominately deposited in winter as snowfall reaching a depth of approximately 29 inches (73.6 cm). A warming or cooling of the region due to changes in climate could alter these cycles and thereby affect many aspects of the Monument's unique ecosystems and biodiversity.

Water Resources

Throughout the Great Basin water resources are an important factor for maintaining ecosystems, biodiversity and anthropogenic habits. As populations continue to grow in the Great Basin and HAFO area some water use is being converted from agricultural applications to urban and human consumption (Chambers et al. 2008). On the east side of the Snake River is the Hagerman Bench which encompasses the 54 acres containing the HAFO Visitor's Center. The Hagerman Bench has two notable spring-fed streams near HAFO, Riley Creek and Billingsley Creek, (HAFO 1999) as well as the Bell Ditch. Irrigation ditches intercept the majority of runoff water from this area that is flowing toward the River making them the predominate sources of surface water available for aquatic vegetation. On the western side of the Snake River, where the majority of the Monument exists, development of agricultural fields and roadways bordering this area has altered land features and changed flow patterns concentrating flow in some areas and draining others. Excess flow from these landscape alterations is thought to have contributed to landslides on the western edge of the Monument (Farmer and Riedel 2003, HAFO 1999).

The numerous natural springs throughout the Hagerman Valley and Snake River region referred to as the "Thousand Springs" area have been a source of water and food since the first trapper-explorer Wilson Price Hunt passed through the Hagerman Valley in 1811 (HAFO 1999). The Thousand Springs area is located south of the Hagerman Bench and is where an area of the very large Snake River Aquifer has been exposed by the development of the canyon. The groundwater produced in this area is a constant 58 °F and good quality due to the nature of the substrate it passes through (Farmer and Riedel 2003). The excellent water quality from this source has supported commercial trout fisheries and State hatcheries in this area of Idaho since the first established farm in 1928 (Master Plan 2006). No natural springs are thought to occur in HAFO but in recent years a series of springs and seeps that discharge water from perched aquifers have occurred in the cliffsides at HAFO. The exact number of discharge points is unknown but they likely did not exist prior to the construction of a system of unlined canals and irrigated fields on the western plateau above HAFO (Farmer and Riedel 2003). For more information on recent springs, perched aquifers and landslides at HAFO please reference Water Resources Management Report online at: http://www.nps.gov/archive/hafo/landslides/slidedoc.htm.

The Snake River and three known aquifers in the HAFO area (Moffat and Jones 1984, Young 1984) support the area's ecosystems, recreation and hydroelectric power. Seep of ground water from these aquifers is partially responsible for landslides in the Monument while other water is a source of drinking water for area residents (HAFO 1999, Farmer and Riedel 2003). In 1910 the Great Shoshone and Twin Falls Land and Water Power Company built a dam across the Snake River at Lower Salmon Falls (HAFO 1999, Shallat et al. 2000) as the first project near Hagerman for the generation hydroelectric power. In 1919 Idaho Power Corporation (IDP) acquired this facility with the addition of an additional turbine, and then constructed the upper Salmon Falls dam in 1937 (Idaho Power 2010).

Methods

This NRCA is a collaborative project between the NPS, UCBN, HAFO (the stakeholders for this study), and Northwest Management, Inc (NMI) (the principal investigator). A scoping meeting was held at the onset of the study and a contract established to meet the goals of the NRCA program for HAFO. This section of the assessment summarizes results from scoping meetings and constraints, objectives, and project expectations, and presents the approach to acquisition of new rapid assessment information and the selection of existing data that included electronic datasets, reports and research inventories, and vital signs monitoring data.

NRCA Project Scoping

A series of preliminary meetings and follow-up communications were held in 2009 and included staff representation from UCBN, HAFO and NMI. The purpose of the NRCA was discussed and the goals of this project were to evaluate and report on current conditions, assess critical data and knowledge gaps, and select existing and emerging resource condition influences of concern to HAFO managers. During the planning sessions, the NRCA standards and protocols were reviewed (NPS 2009) and the project scope was outlined with following guidelines: (1) use existing data and information whenever possible; (2) collect new rapid assessment information when no data exists for important resources; (3) identify data needs and gaps within the project framework categories; (4) analyze the natural resource conditions and include a strong geospatial component; and (5) focus and prioritize on resources important to HAFO resource management.

Specific project expectations and outcomes resulting from the initial scoping meeting included: (1) for key natural resource components, consolidate available HAFO data, reports, and spatial information; (2) define an appropriate description of reference condition for each of the key natural resource components and indicators so that statements of current condition can be developed for the NRCA report; (3) develop a reporting format that reflects the spatial delineation of reserve-specific human and ecological focus areas; (4) the resource assessment should clearly identify "management critical" data; (5) where applicable, develop GIS products that provide spatial representation of resource data, ecological processes, resource stressors, trends, or other valuable information that can be better interpreted visually; (6) conduct analysis using existing datasets for geology, vegetation mapping, and invasive plant species to develop descriptive statistics about key natural resource indicators; (7) discuss the issue of key natural resource indicators that are not contained within HAFO or controlled directly by Monument management activities; (8) describe the relationship between selected human uses and key natural resources; and (9) use "gray literature" and reports from third party research to the extent practical.

Expectations for HAFO staff participation were detailed in the initial scoping meeting. HAFO staff participated in project development and planning, reviewed interim and final products, and participated in ecological/resource assessments. Involvement of HAFO staff in this project ensured that the true needs of HAFO were being met through the efforts of NMI. In addition to HAFO resource staff, UCBN staff was also involved in the development of this NRCA. The NPS Agreement Technical Representative, John Apel, coordinated the efforts of the Principal Investigator, the project work group, HAFO personnel, and the UCBN. The NPS was responsible for informing the NMI Principal Investigator of the specific activities required to comply with the "NPS Interim Guidance Document Governing Code of Conduct, Peer Review, and

Information Quality Correction for NPS Cultural and Natural Resource Disciplines" or any subsequent guidance issued by the NPS Director.

Project findings presented in this report will hopefully aid HAFO resource managers with the following objectives: (1) develop near-term management priorities; (2) engage in watershed or landscape scale partnership and education efforts; (3) conduct park planning (e.g., general management plan, compliance, Resource Stewardship Strategy); and (4) report program performance (e.g., Department of Interior Strategic Plan's "land health" goals).

The HAFO NRCA provides a "snapshot-in-time" summary for all of the HAFO natural resources based a review and summary of existing data. The summaries were then used to help evaluate the condition of a select set of natural resources that were identified and agreed upon by the project team. If a natural resource was found lacking for existing data, new rapid assessment points were collected at specific sites. In contrast, if the resource had sufficient existing data, the data was synthesized and no new data was collected. Table 1 contains a list the natural resource that were preliminarily summarized, those that were field assessed, and those that were synthesized based on existing data.

Table 1. List of Summarized, Site Specific Field Assessed, and Synthesized Natural Resources for HAFO.

Summarized Resources	Site Specific Field Assessed Resources	Synthesized Assessed Resources
Geology	Upland Resources	Land Use
Air Quality	Aquatic and Water Resources	Geology
Vegetation		Paleontological & Archeological Resources
Upland Habitats/Species		Noxious Weeds
Aquatic Habitats/Species		Wildfire
Land-Use		Air Resources
Climate		Wildlife
Water Resources		Climate

GIS and Geodatabases

A large part of the information identified in this report is in the form of points, lines, polygons, and raster data and was evaluated using a Geographical Information System (GIS). GIS software provides spatial analysis capabilities such as overlay, buffer, extraction, and modeling. Results can then be displayed in map and tabular form. ArcGIS Version 9.3.1 software was used for geo-processing, editing and graphics display.

An ArcMap project file (.mxd) was developed for HAFO to manage, control and store layer annotation using ArcGIS software. Many types of geographic Datasets can be accessed and managed within a map project file, including feature classes, attribute tables, and raster Datasets. Data layers were stored in an Environmental Systems Research Institute (ESRI) File Geodatabase providing a compact, easily utilized database structure for storage and distribution. The NPS ArcMap 8.5 x 11 inch layout template was used in the HAFO map project file to create figures of mapped data for display in this publication (Figure 2).

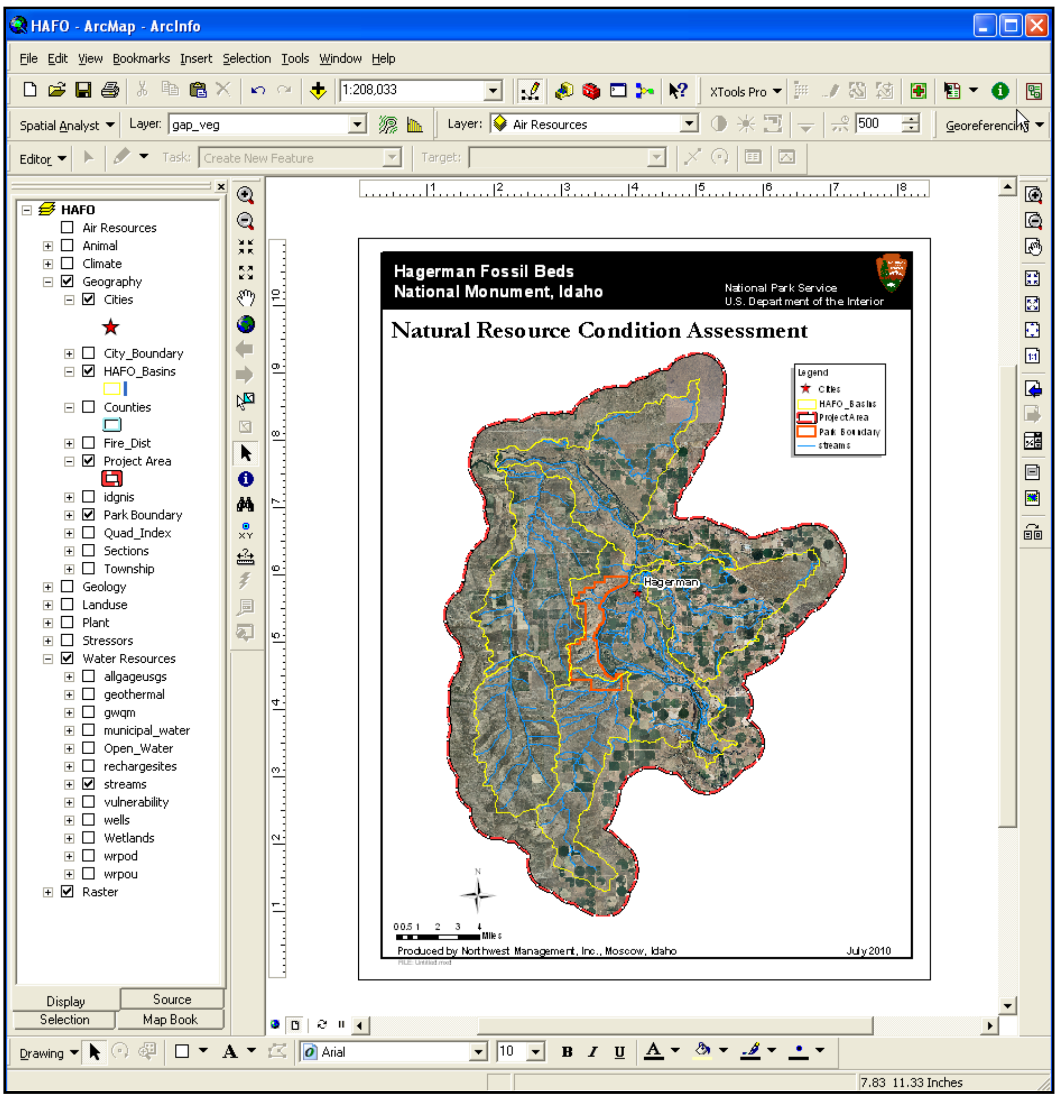

Figure 2. Screenshot of ArcGIS HAFO Map Project

A geographically defined project area was created for HAFO by selecting the 6th level Hydrologic Unit Code (HUC) watershed basins surrounding HAFO administrative boundary and adding a two kilometer buffer. General base map layers and aerial photography were developed to the full project area extent. All other layers were clipped to the Hydrologic Basins extent for analysis and summarization of attributes.

The map project file was 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), Universal Transverse Mercator (UTM) zone 12 projection. Metadata for each layer was extracted from the original file, or generated based on known information if available. Some layers were acquired without metadata so an attempt was made to provide general information about the file whenever possible. The metadata for each layer is included within the geodatabase for each file 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 and Digital Raster Graphics were processed and clipped to the project area using LizardTech GeoExpress 7 software and converted into a MG3 (MrSid Generation 3) file format. Attribute information for all data layers clipped to the hydro basins extent were summarized in an Excel spreadsheet based on the various attribute parts, lengths, acreage etc. of the various data layers in the map project and associated geodatabase file.

All GIS data layers were imported into an ArcGIS File Geodatabase using ArcCatalog ver. 9.3.1. Feature Datasets were created based on theme type. A geodatabase is an ArcMap file structure that stores geometry, spatial reference system, attributes Datasets, network Datasets, topologies, and many others features. Feature Datasets house the various layers or Feature Classes in organized categories. This GIS format provides a uniform method for storing and accessing GIS data and provides the flexibility to add new information as it becomes available.

Feature classes (layers) were organized into categories or Feature Datasets (directories) based on general theme type. Although data was not available for each Feature Dataset, the empty Feature Dataset is included in the geodatabase for data that may become available in the future. The general Feature Datasets developed for this project include:

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

Aerial photography was not included in the geodatabase due to file size and limitation of processing MG3 file formats. Aerials are included in a separate directory outside the geodatabase. All GIS data, project files and summary tables 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 that cover three states; 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. HAFO is in the Upper Columbia Basin Network established under the NPS Inventory and Monitoring Program (NPS 1999). Table 2 is the status of inventories of the species taxa groups for HAFO. Available data from completed inventories were utilized where needed in the report otherwise the data is directly available at 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, are in progress while no inventories are available for invertebrates and invasive plant species.

Table 2. Status of inventories of species taxa for HAFO maintained by UCBN.

Species Taxa	Complete	Year Completed	In Progress	Not Complete
Mammals	√	2005		
Birds	√	2005		
Amphibians	√	2005		
Reptiles	√	2005		
Fish	√	2005		
Invertebrates				√
Vascular Plants	√	2005		
Rare Plants	√	1995		
Invasive Plants				√

Additional non-biological Datasets have been identified by the UCBN as important for park management (Table 3). 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). Four Datasets have not been completed by the UCBN, however, some park sites may have data available from other sources.

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 five 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. HAFO has 11 vital signs established for monitoring: water chemistry, aquatic macroinvertebrates, invasive/exotic plants, riparian vegetation, sagebrush-steppe vegetation, aspen, limber pine, Sage grouse, bats, and land cover and use (Garrett et al. 2007).

Table 3. Status of inventories of non-biological data maintained by UCBN.

Non-Biologic Datasets	Complete	In Progress	Not Complete
Air Quality/Emissions	√		
Ozone Risk	√		
Water Quality	√		
Landcover			√
Paleo Resources		√	
Geology	√		
Soils	√		
Cultural Landscapes			√

Site Specific Assessment

Site specific assessments were completed at HAFO as a component of this study. These on-the-ground assessments were conducted using standard methodologies allowing for a quick evaluation of the current condition of upland and water environments.

Upland Resource Assessment

Four upland sites were evaluated using the 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" by Pellant et al. (2005). Eight sample points within the four sites; the Horse Quarry (5), Ag. Field south of the Horse Quarry (1), Yahoo Creek (1) and the Research Center (1) were assessed using the BLM rapid assessment for rangeland health methodology.

The rangeland health rapid assessment methodology was designed to provide a preliminary evaluation of three 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 et al. 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 five categories of departure recognized, which include “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 one (none to slight) to five (extreme) was assigned to each category. For allotments with more than one sample per ecological site, an average was calculated for each indicator and then summed for each landscape attribute. There are ten indicators for soil site stability they include: (1) rills, (2) water flow patterns, (3) pedestals and/or terracettes, (4) bare ground, (5) gullies, (6) wild scoured, blowouts, and/or deposition areas, (7) litter movement, (8) soil surface resistance to erosion, (9) soil surface loss or degradation, and (10) compaction layer. In addition to the 10 previous indicators, there are also 10 indicators for hydrologic function that include all of the previous indicators except that wild scoured, blowouts, and/or deposition areas and litter movement plant composition are replaced with (11) plant community composition and distribution relative to infiltration and runoff, and (12) litter amount. Finally the indicators for biotic integrity include indicators 8, 9, and 10 above along with (13) functional/structural groups, (14) plant mortality/decadence, (15) annual aboveground production, (16) invasive plants, and (17) reproduction capability of perennial plants.

The score for each landscape attribute was the sum of the indicators minus the reference conditions; determined to be ten for soil site stability and hydrologic function and nine for biotic integrity, based on a score of one 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; and expressed as a percentage. 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 (<21%), slight to moderate (21-40%), moderate (41-60%), moderate to extreme (61-79%), 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 one to 20 acres in size as noted in the database. Maps were generated for each allotment depicting evaluation-sites and other land features. The point data was also placed in the geodatabase for future reference.

Water Resource Assessment

On-site evaluation of water resources at the Monument included an assessment of the riparian resource condition of the Bell Ditch and the Snake River shoreline (Figure 3). A total of five observation sites included assessment of one lentic and four lotic areas. An example of the assessment worksheets are displayed in Appendix B and C. The primary objective in evaluating riparian habitat was to provide the NPS with a moment-in-time status point for managing land use within their control. The three main objectives were to:

1. Identify existing riparian condition.

2. Identify the specific threats and stressors impacting riparian functions and values (e.g., wildlife habitat, water quality improvement, aquatic species protection, etc.).

3. Recommend solutions to minimize or eliminate threats and stressors to riparian and associated aquatic resources.

Riparian areas were selected for assessment since the condition of riparian areas often control and dictate 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, containing 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 surface water throughout the year.

The following description outlines the PFC methodology applied at each site to evaluate riparian/shoreline conditions. Sites selected for evaluation were assessed using the “proper functioning condition” (PFC) riparian assessment methodology developed by the BLM for lotic (i.e., flowing water) sites (Prichard et al. 1998) and lentic (i.e., standing water) sites (Prichard et al. 2003).

Lotic Riparian PFC Assessment: The lotic PFC method evaluates 17 hydrology, vegetation, and stream geomorphology indicators of riparian condition or “health” and subsequently assigns a functionality rating to each site. The “proper functioning condition” of a lotic riparian area refers to the stability of the physical system, which in turn is dictated by the interaction of geology, soil, water, and vegetation. A properly functioning lotic riparian area is in dynamic equilibrium with its streamflow forces and channel processes. The channel adjusts in slope and form to handle larger runoff events with limited perturbation of channel characteristics and associated riparian plant communities.

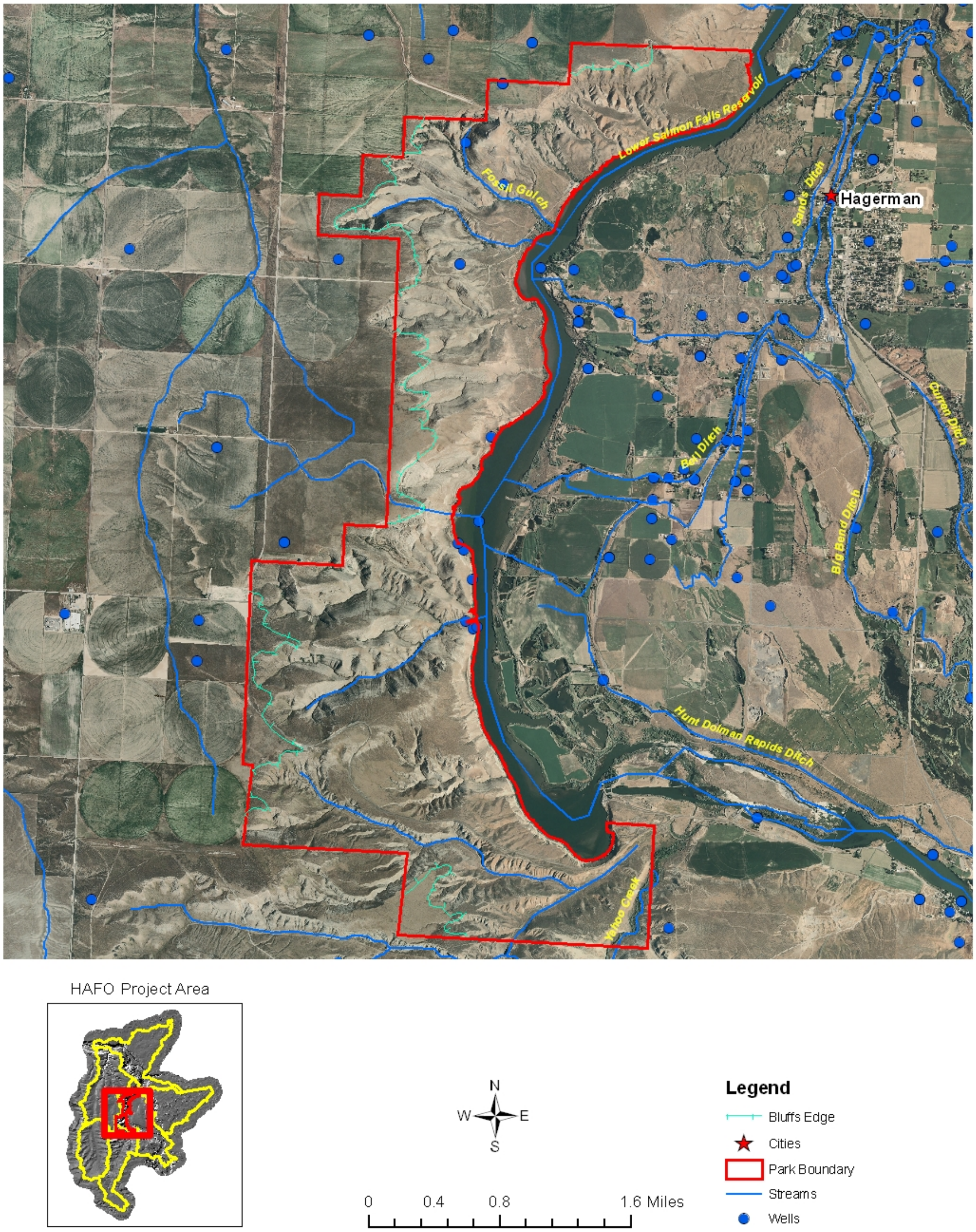

Figure 3. This figure displays the boundaries and water sources within the HAFO Monument.

Because of this stability, properly functioning lotic riparian areas can maintain fish and wildlife habitat, water quality enhancement, and other important ecosystem functions even after larger storms. In contrast, nonfunctional systems subjected to the same storm events might exhibit excessive erosion and sediment loading, loss of fish habitat, loss of associated wetland habitat, and so on.

Based on assessments of the hydrologic, vegetative, and geomorphology elements of the lotic riparian area, one of the following three functionality ratings was assigned to each site: (1) Proper Functioning Condition, (2) Functional-At Risk, or (3) Nonfunctional.

Proper Functioning Condition (PFC): Streams and associated riparian areas are functioning properly when adequate vegetation, landform, or large woody debris is present to:

- dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload, and aid floodplain development;
- improve floodwater retention and groundwater recharge;
- develop root masses that stabilize stream banks against cutting action;
- develop diverse ponding and channel characteristics to provide habitat and the water depths, durations, temperature regimes, and substrates necessary for fish production, waterfowl breeding, and other uses; and
- support greater biodiversity.

Functional-At Risk: These riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. For example, a stream reach may exhibit attributes of a properly functioning riparian system, but it may be poised to suffer severe erosion during a large storm in the future due to likely migration of a headcut or increased runoff associated with recent urbanization in the watershed. When this rating is assigned to a stream reach, then its “trend” toward or away from PFC is assessed.

Nonfunctional: Those are riparian areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, sustaining desirable channel and riparian habitat characteristics, and so on as described in the PFC definition. The absence of certain physical attributes such as a floodplain where one should exist is an indicator of nonfunctioning conditions.

During this site visit, the team assessed lotic riparian functional condition of four sites along the western (i.e., left bank) shoreline of the Snake River within the Hagerman Fossil Beds park unit. The lotic assessment results are discussed individually in the Results section below and each assessment is supported by a detailed PFC assessment checklist. The assessment checklists for the Snake River 1 and Bell Ditch sites are shown in Appendix B and C.

Lentic Riparian PFC Assessment: The lentic PFC method evaluates 20 hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of lentic riparian wetland areas. For these areas PFC is a state of resiliency that will allow a lentic riparian-wetland area to hold together during wind and wave action events or overland flow events with a high degree of reliability (Prichard et al. 2003). This resiliency provides opportunities to achieve desired values over time, such as waterfowl and amphibian habitat, shoreline protection, or wildlife forage.
Based on assessments of the hydrologic, vegetative, and erosional/depositional elements of the riparian-wetland area, one of the following three functionality ratings is assigned to each site:

Proper Functioning Condition: Lentic riparian-wetland areas are functioning properly when adequate vegetation, landform, or debris is present to:

1. dissipate energies associated with wind action, wave action, and overland flow from adjacent sites, thereby reducing erosion and improving water quality;

2. filter sediment and aid floodplain development;

3. improve flood-water retention and groundwater recharge;

4. develop root masses that stabilize islands and shoreline features against cutting action;

5. restrict water percolation;

6. develop diverse ponding characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterbird breeding, and other uses; and

7. support greater biodiversity.

Functional – At Risk: Riparian-wetland areas that are in functional condition, but that have an existing soil, water, or vegetation attribute that makes them susceptible to degradation.

Nonfunctional: Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or woody debris/rocky structure to dissipate energies associated with wind action, wave action, and overland flow from adjacent sites, and thus are not reducing erosion and improving water quality.

During the site visit, the team assessed the riparian-wetland functional condition of one lentic site near Bell Ditch on the eastern shoreline (i.e., right bank) of the Snake River within the Hagerman Fossil Beds park unit. This lentic assessment is discussed in more detail in the Results section below. A detailed lentic PFC assessment checklist in is presented in Appendix C.

Noxious Weeds

Idaho has 64 species of weeds designated as noxious by state law and are divided into three groups dependant on the level of concern for each species. The groups listed as; Early Detection Rapid Respond (EDRR), Control or Contain have been titled based on applicable control requirements. A state wide noxious weed list can be found in NPS (2008). Noxious weeds of importance to HAFO were identified in several documents (HAFO 1999, Farmer and Riedel 2003, EPMT 2008, Erixson and Cogan 2009, Rodhouse 2009, Rodhouse 2010). Additionally, GIS data on noxious weeds was acquired from past investigations and placed in the HAFO geodatabase under stressors. State and county level databases were searched for noxious weed locations and local county weed superintendents were contacted for unpublished data. Available data have been summarized on maps and recommendations made by species.

Wildfire

Multiple wildland fire related data layers are included in the HAFO GeoDatabase under Stressors, and as separate model derived raster layers. These Datasets are compiled by federal agencies and are available in the public domain at http://www.landfire.gov/index.php. The currently available files provide information relating to fire behavior fuel models, condition, potential and behavior, as well as historic fire locations and fire extents. The data was clipped to the HAFO basins area and summarized within the project summary Excel spreadsheet on the DVD disk.

The Fire Regime Condition Class (FRCC) Departure Index data was used to evaluate the condition of vegetation within the HAFO project area. The Departure Index is not directly related to the risk of wildfire but is one indicator of vegetation departure from presumed historical conditions. The index uses a range from 0 to 100% to describe the amount that current vegetation has departed from simulated historical vegetation reference conditions (Hann et al. 2004, Holsinger et al. 2006). The departure results from changes to species composition, structural stage, and canopy closure. Tables with calculated area and percent of total project area for Fire Regime Condition Class as well as Historic Fire Regime are included in the results section of this report.

Results

GIS and Geodatabase

Raster

Raster data is a geospatial image formed by a matrix of cells (pixels) organized into a grid where each pixel contains a value representing information. Resolution of raster data increases as pixel size decreases giving a high resolution data layer more precise geographic location accuracy. Raster data can be discrete, representing features or continuous, showing gradations such as temperature or elevation. Many raster Feature Datasets are included in the HAFO geodatabase. Several of these raster files are from the LANDFIRE program which is a multi-agency, vegetation, fire and fuel characteristics mapping project. LANDFIRE layers are derived from modeling and high level classification. Table 4 lists the raster data files included in the HAFO geodatabase.

Table 4. Raster Datasets for HAFO. (Source See Appendix A.).

Themes	Geodatabase File Name	Number Parts
Raster Data		
Vegetation (GAP)	gap_veg	17 types
Digital Elevation Model	hafo_dem	807m-177m
Hillshade Terrain Model	hafo_hlsd	
Digital Raster Graphic	HAFO_DRG	
Aerial Mosaic	hafo_naip.sid	
Land use	landuse	28 Types
13 Fire Behavior Fuel Model	lf_13fbfm	9 Models
Existing Vegetation (Landfire)	lf_evt	24 Types
Fire Regime Condition Class	lf_frcc	8
Fire Regime Group	lf_frg	7
Mean Fire Return Interval	lf_mfri	14
Succession Class (Landfire)	lf_scls	12

Considering the raster themes listed in Table 4, two pertain to cover vegetation, one to agricultural land use, and six are modeled layers from the LANDFIRE program. The other raster data layers are base maps which include; a hillshade terrain model derived from the digital elevation model (DEM), clipped USGS 7.5 minute quadrangle digital raster graphic (DRG) (HAFO_DRG) and aerial photo mosaics of the project area from 2006 NAIP imagery (hafo_naip.sid). A summary of the information contained in each raster Dataset is presented under the applicable GIS / Geodatabase heading in this section.

Land Use

The Land Use Feature Dataset in the HAFO geodatabase contains feature classes pertaining to human development, ownership, land classification and infrastructure. Several layers in the set are specifically associated with infrastructure in and around the Monument boundary. Major road and utility features were gathered from public and private organizations with some overlap in coverage. Table 5 below lists the various features within the HAFO Land Use Feature Dataset.

Table 5. Land Use Feature Dataset for HAFO. (Source See Appendix A.)

Themes	Geodatabase File Name	Number Parts	Length Miles
Landuse			
Antenna towers	ASR_Towers_sgca	1	
Cell towers	cell_towers_sgca	1	
Highways	Highways	133	151.1
Landowners	Landowners	6	
Pipelines	pipeline	21	34.3
Powerlines	Powerlines	502	82.5
Railroads	Railroads	40	16.6
Roads	Roads	1171	463.7
State Highways	State_Highways	32	41.5
Agriculture Land Use	strata_a_id	5	
Trails	trails	5	6.04
Weather Stations	weather_stations	1	

The Agricultural Land Use feature class (strata_a_id) listed above, gives a general overview classification of the homogeneous land use areas of the region and shows the limitations of certain Datasets. This classification, produced by the USDA National Agricultural Statistics Service (NASS), is developed from visual interpretation of satellite imagery. Small scale classified layers such as this are intended for display and analysis at the state level, and are limited in their use at the landscape level. As can be seen in Figure 4, the majority of area within the HAFO project area, clearly identifiable on aerial photography as rangeland or woodland is classified as "Snake River Extensive Cultivated", including the Hagerman Fossil Beds National Monument. Table 6 below identifies the various classified land units within the Agricultural Land Use feature class along with tabulated acres and percent of total area within the HAFO project area.

Table 6. General Agricultural land use within the HAFO project area. (Source See Appendix A.).

Agricultural Land Use USDA-NASS (strata_a_id)	Acres	% Total
Agri-Urban: > 20 Homes per Sq. Mi.	418.9	0.34%
Lightly Cultivated (SPEC 40: S-Cen	12,454.5	10.04%
Lightly Cultivated (SPEC 40: South)	23,223.6	18.73%
Snake River, Extensive Cultivated	37,383.8	30.14%
Snake River, Intensive Cultivated	50,535.0	40.75%

The following map (Figure 4) displays Agricultural Land Use and other feature classes in the Land Use Feature Dataset.

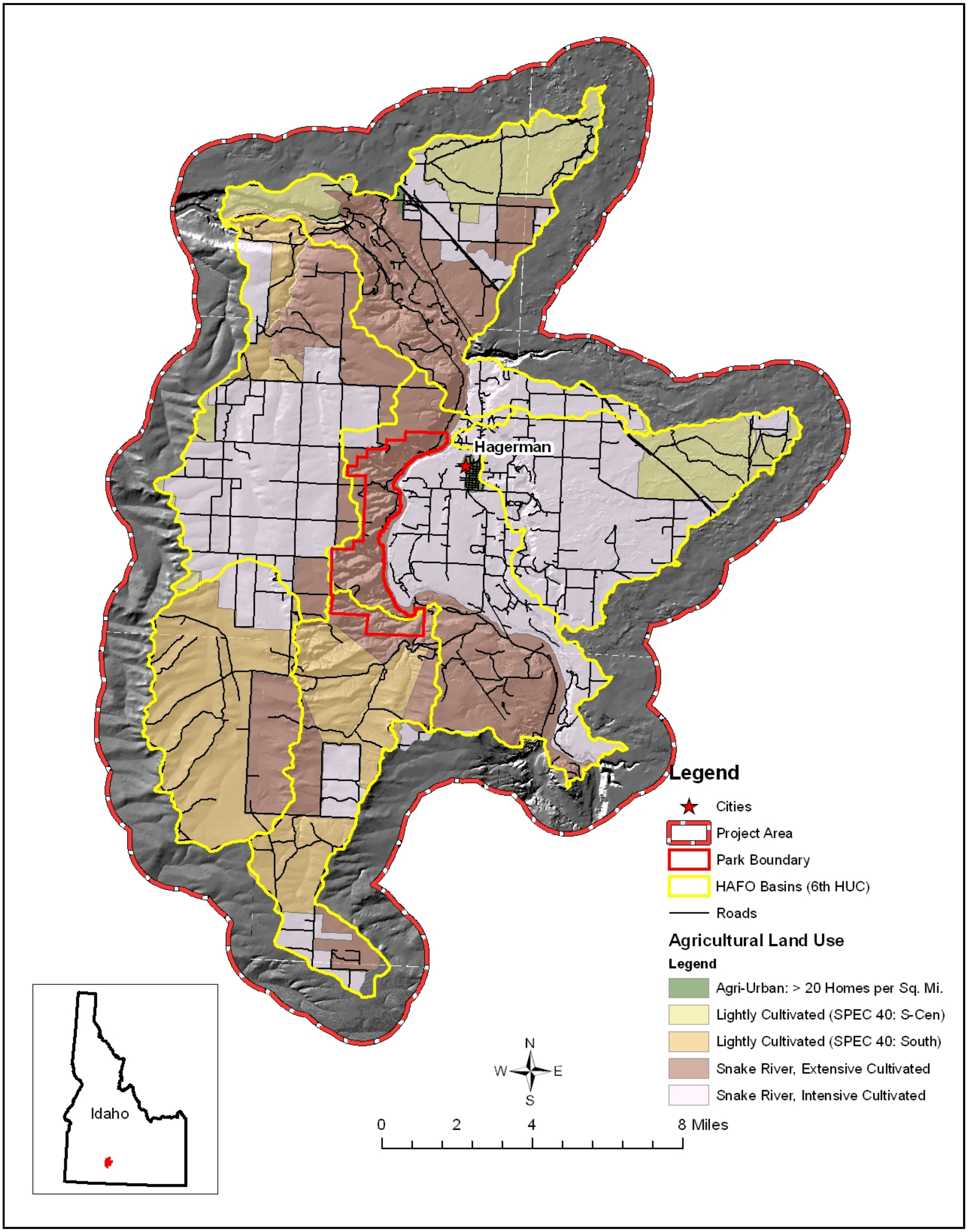

Figure 4. Agricultural Land Use Feature Class.

Land Ownership: Another feature class included in the Land Use Feature Dataset is Land Ownership. This layer, produced by the BLM, is the land ownership status of the area around HAFO current to 2009, showing Federal, State and Private lands in Idaho. The Federal ownership depicted in this layer is the managing agency of the land. Table 7 below lists the various ownerships within the HAFO project area, the acres owned and percent of total area within the HAFO project area.

Table 7. Ownership within HAFO project area. (Source See Appendix A.)

Owner	Acres	% Total
Bureau of Land Management (BLM)	43,854.7	35.36%
National Park Service (NPS)	4,309.8	3.48%
Private	69,526.9	56.06%
State	5,097.2	4.11%
State Fish & Game	1,009.3	0.81%
State Parks	217.9	0.18%

The following map (Figure 5) displays Land Ownership and other feature classes in the Land Use Feature Dataset.

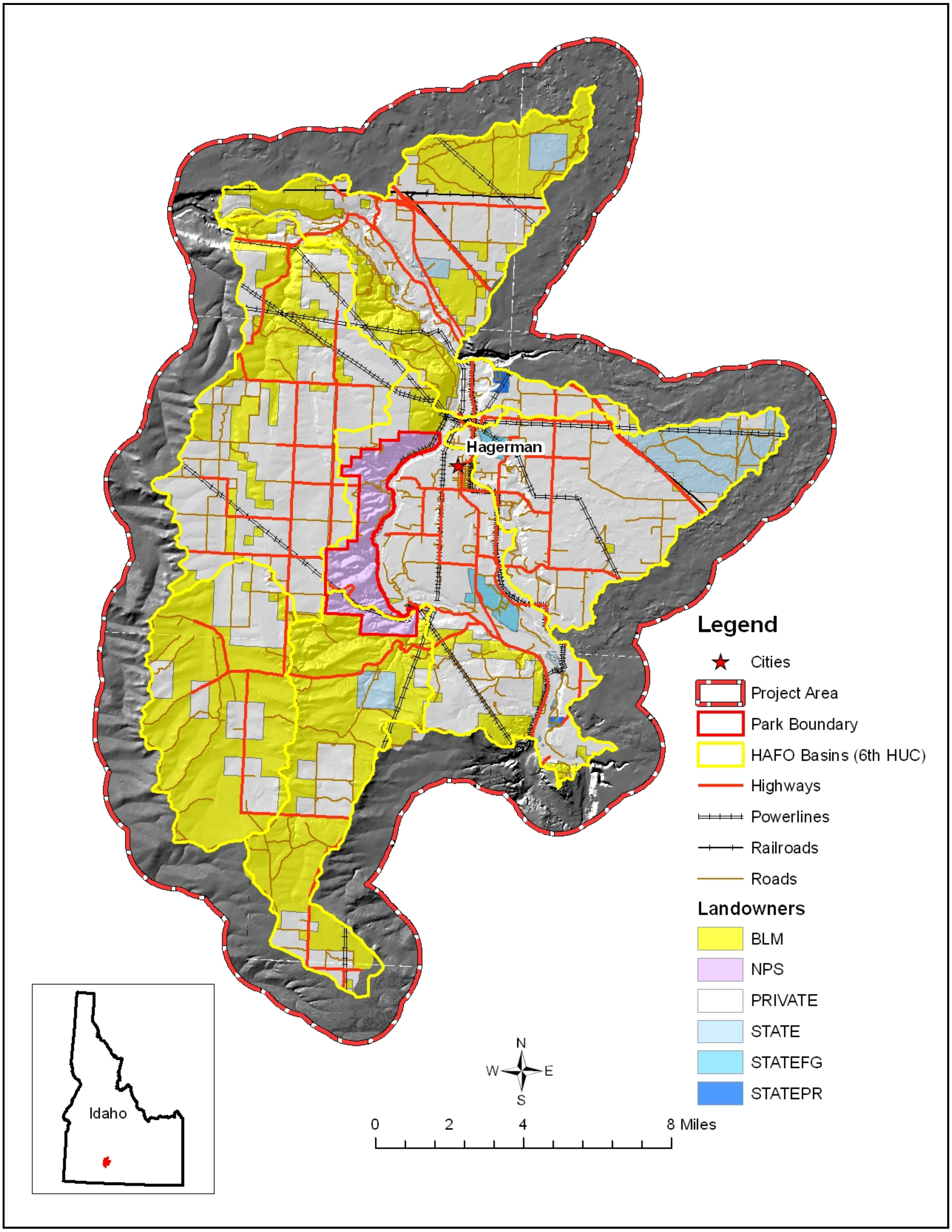

Figure 5. Land ownership within HAFO project area.

Vegetation Data: The HAFO geodatabase includes two vegetation raster Datasets covering the HAFO project area. These are public domain layers developed by different agencies based on classification of satellite imagery. Table 8 lists the general vegetation cover types depicted in each raster Dataset as well as total acres and percent of total area covered by each vegetation type identified in the attribute table of the file.

Table 8. GAP vegetation for the HAFO Monument. (Source See Appendix A.)

Attribute (Class_Name)	GIS Acres	% Total Area
gap_veg		
Low Intensity Urban	247.5	0.200%
Agricultural Land	59,684.6	48.127%
Foothills Grassland	32.9	0.027%
Wet Meadow	21.3	0.017%
Shrub Steppe Annual Grass Forb	8,439.5	6.805%
Perennial Grassland	23,284.8	18.776%
Perennial Grass Slope	105.2	0.085%
Basin and Wyoming Big Sagebrush	21,073.9	16.993%
Saltdesert Scrub	2,892.1	2.332%
Rabbitbrush	4,931.8	3.977%
Low Sagebrush	731.9	0.590%
Water	1,852.5	1.494%
Broadleaf Dominated Riparian	192.4	0.155%
Shrub Dominated Riparian	476.8	0.384%
Deep Marsh	5.3	0.004%
Shallow Marsh	20.0	0.016%
Mixed Barren Land	23.4	0.019%

Figure 6 depicts the various vegetation classification attributes identified by the GAP Vegetation raster layer within the HAFO geodatabase

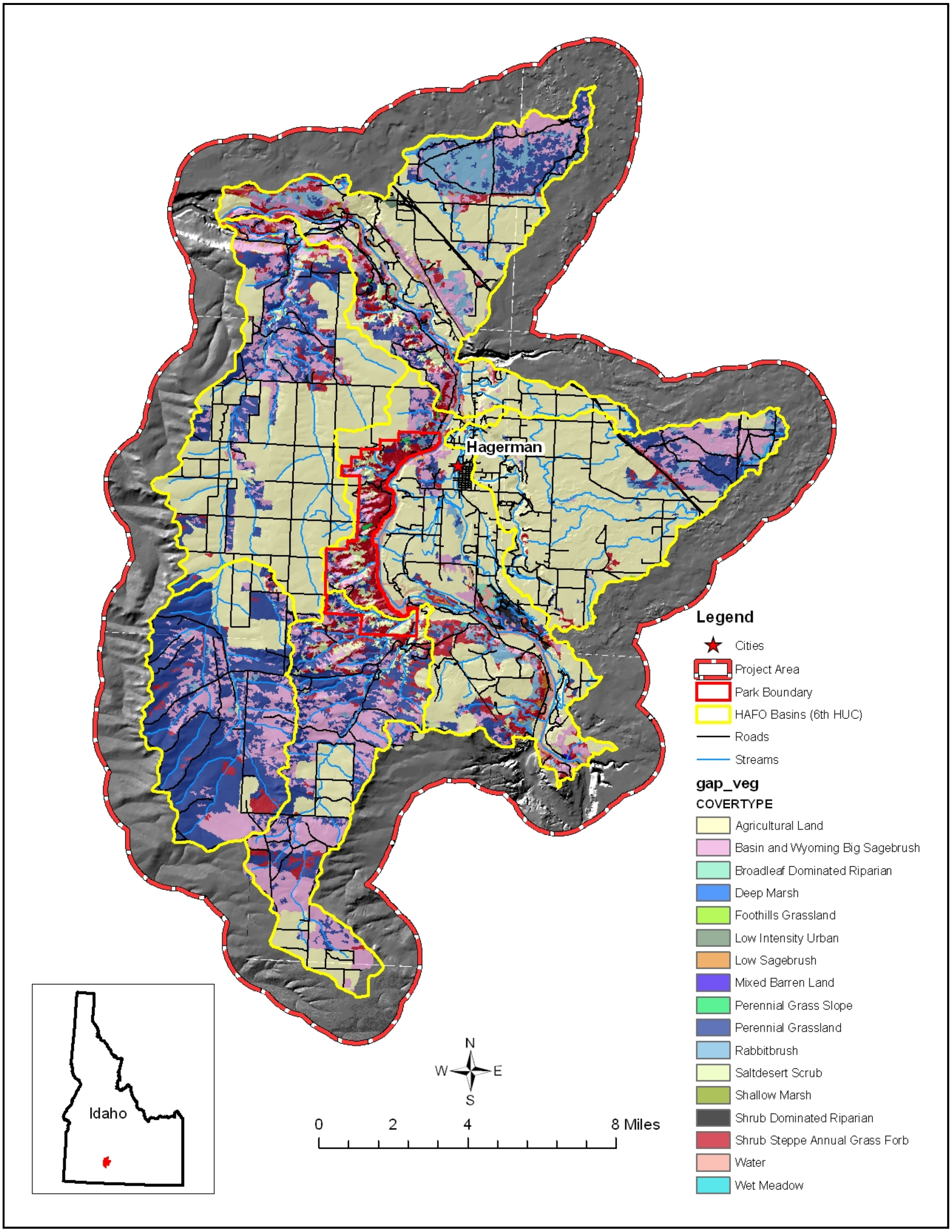

Figure 6. GAP Vegetation classification map for HAFO.

LANDFIRE Existing Vegetation Type (lf_evt): Existing Vegetation Type is a LANDFIRE predictive model representing the percent of average canopy cover of existing vegetation for a 30-m grid cell. The lf_evt layer's attribute table contains multiple vegetation classifications including name, order, class and subclass. This provides opportunity to display the data in a variety of ways from general cover classes to specific predominant species types. Table 9 lists the various cover types, acres of each and percent of total area depicted using the nvcsclass column in the files attribute table. A more specific classification of vegetation types can be found in the Project Summary Excel spreadsheet located on the DVD data disk.

Table 9. Landfire Existing Vegetation Type summary for HAFO. (Source See Appendix A.)

Attribute (nvcsclass)	GIS Acres	% Total Area
lf_evt		
Herbaceous - grassland	59,694.3	48.13%
Herbaceous - shrub-steppe	9,687.0	7.81%
No Dominant Lifeform	4,467.0	3.60%
Non-vegetated	2,053.6	1.66%
Open tree canopy	5,614.7	4.53%
Shrubland	42,302.5	34.11%
Sparsely vegetated	196.8	0.16%

Figure 7 depicts the NVCS vegetation classification attributes identified by the LANDFIRE Existing Vegetation Type raster layer within the HAFO geodatabase. More specific vegetation classification can be shown for the HAFO project area by formatting one of the other attribute fields in the files attribute table.

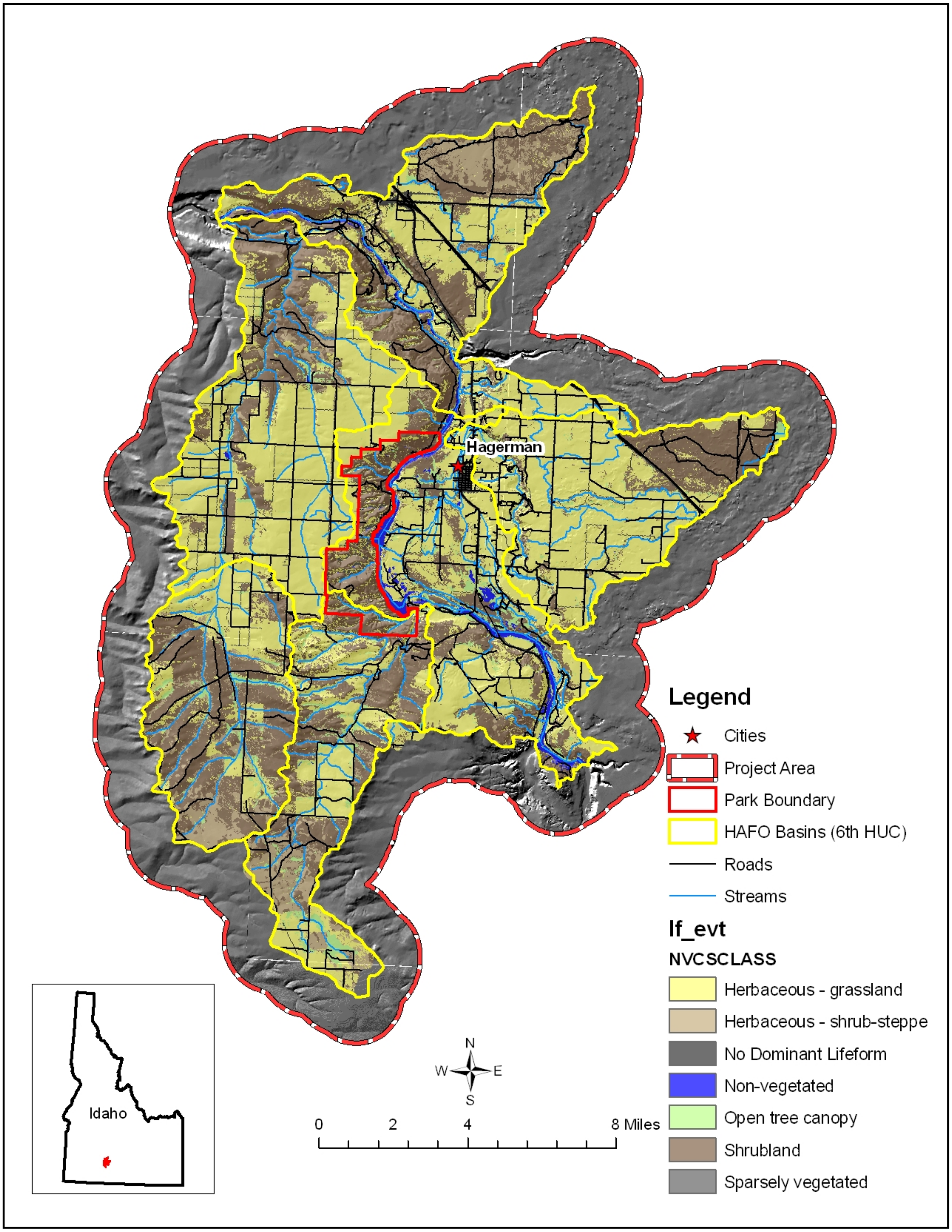

Figure 7. Landfire Existing Vegetation Type, classification attributes (NVCS) for HAFO.

Agricultural Land Use (Landuse_1): The USDA, National Agricultural Statistics Service (NASS) produces a raster Dataset from classified satellite imagery depicting strata of land use areas. The strata are defined based on percent cultivated and non-agricultural lands and water. Table 10 and Figure 8 identify and quantify the various strata defined in this raster layer.

Table 10. Agricultural Land Use raster Dataset for HAFO. (Source See Appendix A.)

Attribute (Class_Name)	GIS Acres	% Total Area
Landuse_1		
Corn	9,765.98	7.875%
Sorghum	7.75	0.006%
Sweet Corn	316.18	0.255%
Barley	664.14	0.536%
Spring Wheat	20.15	0.016%
Winter Wheat	3,162.59	2.550%
Other Small Grains	51.15	0.041%
Rye	5.42	0.004%
Oats	206.14	0.166%
Safflower	4.65	0.004%
Alfalfa	11,414.31	9.204%
Sugar Beets	521.54	0.421%
Dry Beans	687.38	0.554%
Potatoes	925.30	0.746%
Peas	59.67	0.048%
Fallow/Idle Cropland	214.66	0.173%
Grass/Pasture/Non-Ag	13,221.50	10.661%
NLCD - Open Water	2,248.14	1.813%
NLCD - Developed/Open Space	7,076.11	5.706%
NLCD - Developed/Low Intensity	1,183.36	0.954%
NLCD - Developed/Medium Intensity	354.15	0.286%
NLCD - Developed/High Intensity	18.60	0.015%
NLCD - Barren	2.32	0.002%
NLCD - Evergreen Forest	35.65	0.029%
NLCD - Shrubland	30,599.09	24.673%
NLCD - Grassland Herbaceous	40,900.56	32.980%
NLCD - Woody Wetlands	342.53	0.276%
NLCD - Herbaceous Wetlands	6.97	0.006%

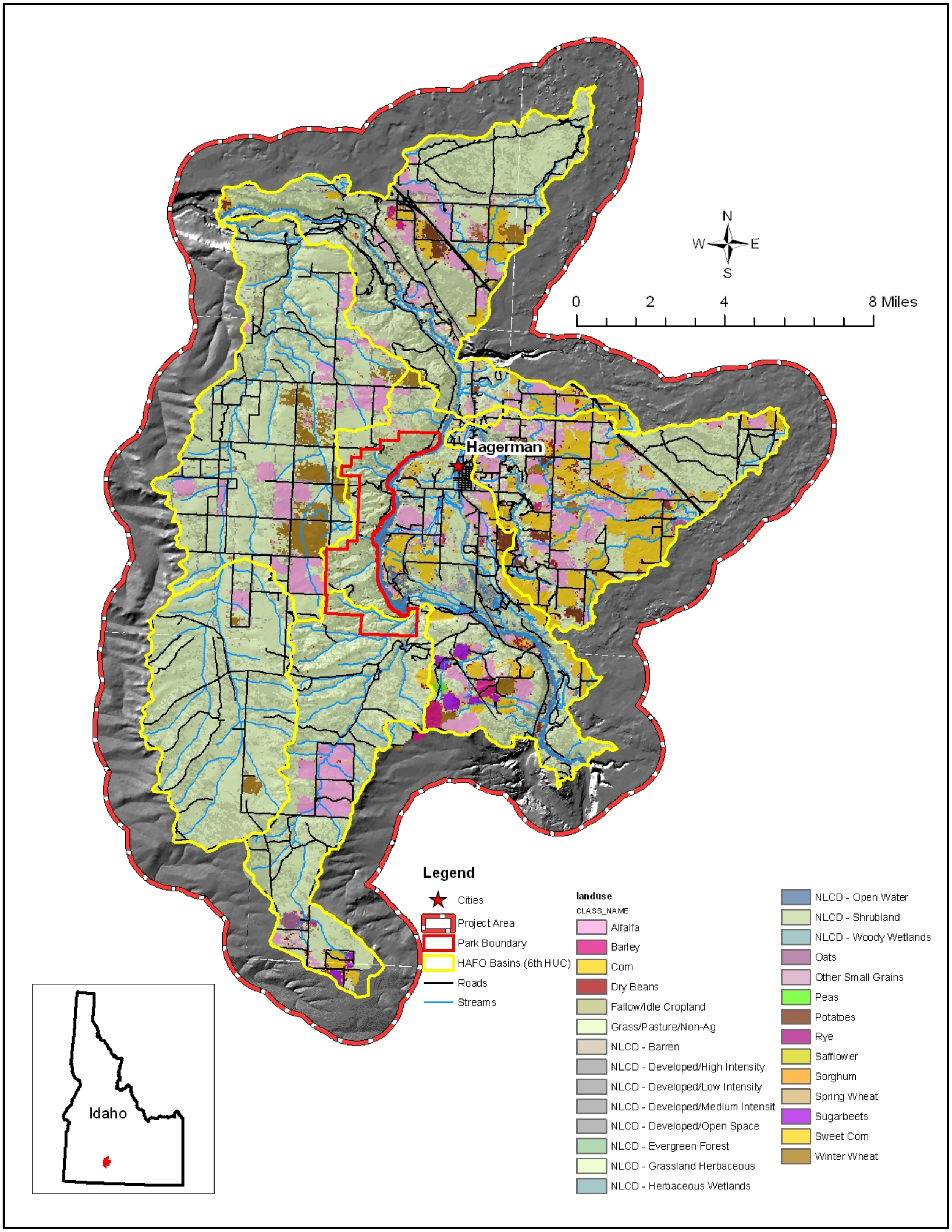

Figure 8. Land use raster data map for HAFO.

Plant: The Plant Feature Dataset in the HAFO geodatabase contains a feature class pertaining to plot locations collected with GPS for the 2007 vegetation study. The data was collected within the park boundary specifically for Natural Resource Technical Report NPS/UCBN/NRTR-2009/212. Figure 9 shows the plot locations within the HAFO park boundary.

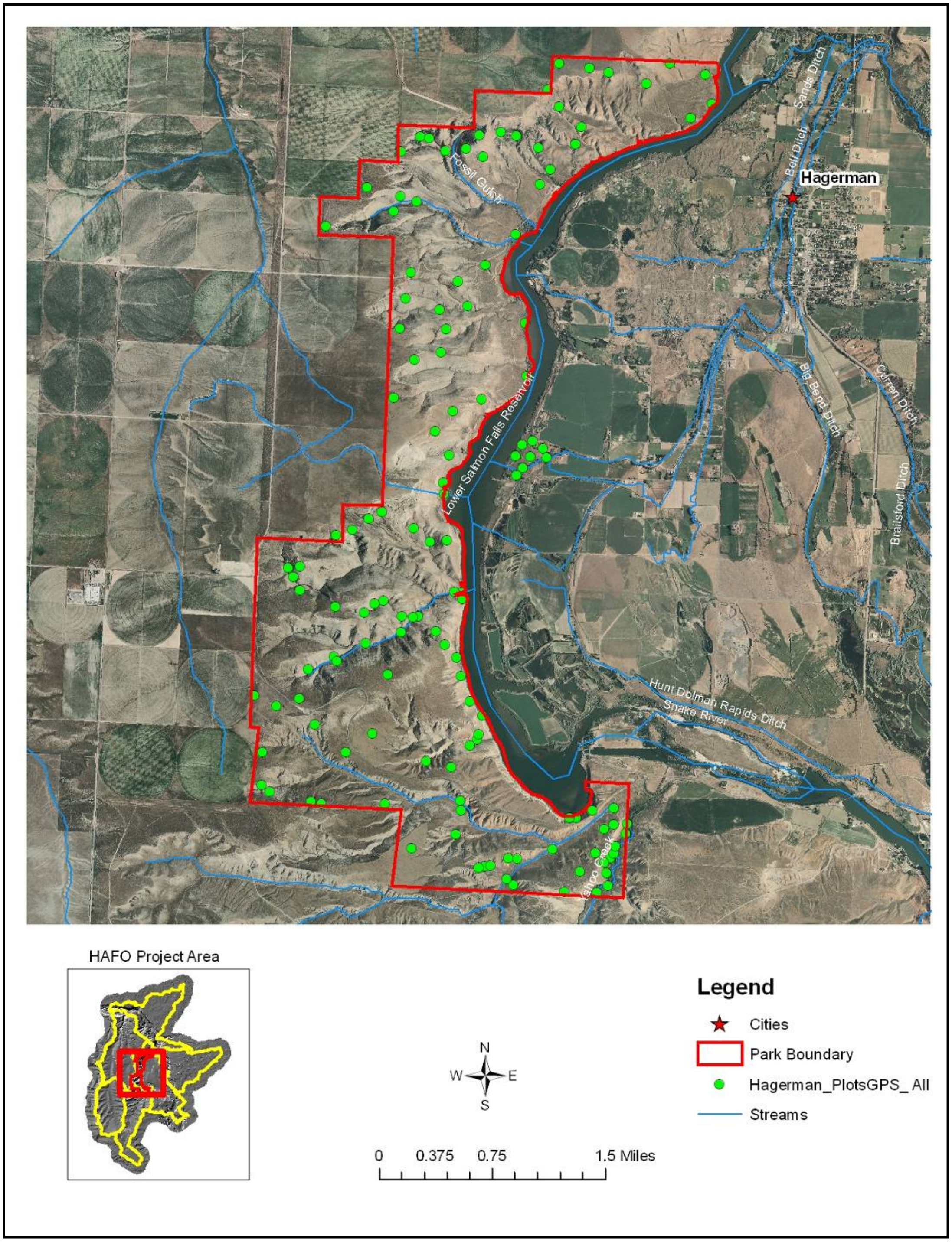

Figure 9. HAFO 2007 vegetation study plot locations collected with GPS.

Succession Class: Succession class is a LANDFIRE data layer that categorizes current vegetation composition and structure into five successional states representing 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 et al. 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 shown below (Hann et al. 2004) (Table 11) and Figure 10 displays the areal extent of each succession class.

- 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

Table 11. Succession Class Attributes within HAFO study area. (Source See Appendix A.)

Attribute (Label)	GIS Acres	% Total Area
lf_scls		
Succession Class A	570.2	0.460%
Succession Class B	15,032.7	12.122%
Succession Class C	5,294.7	4.269%
Succession Class D	302.4	0.244%
Succession Class E	813.4	0.656%
Uncharacteristic Native Vegetation Cover / Structure / Composition	2,543.1	2.051%
Uncharacteristic Exotic Vegetation	41,181.3	33.206%
Water	2,019.4	1.628%
Urban	4,467.0	3.602%
Barren	34.2	0.028%
Sparsely Vegetated	11.3	0.009%
Agriculture	51,746.3	41.725%

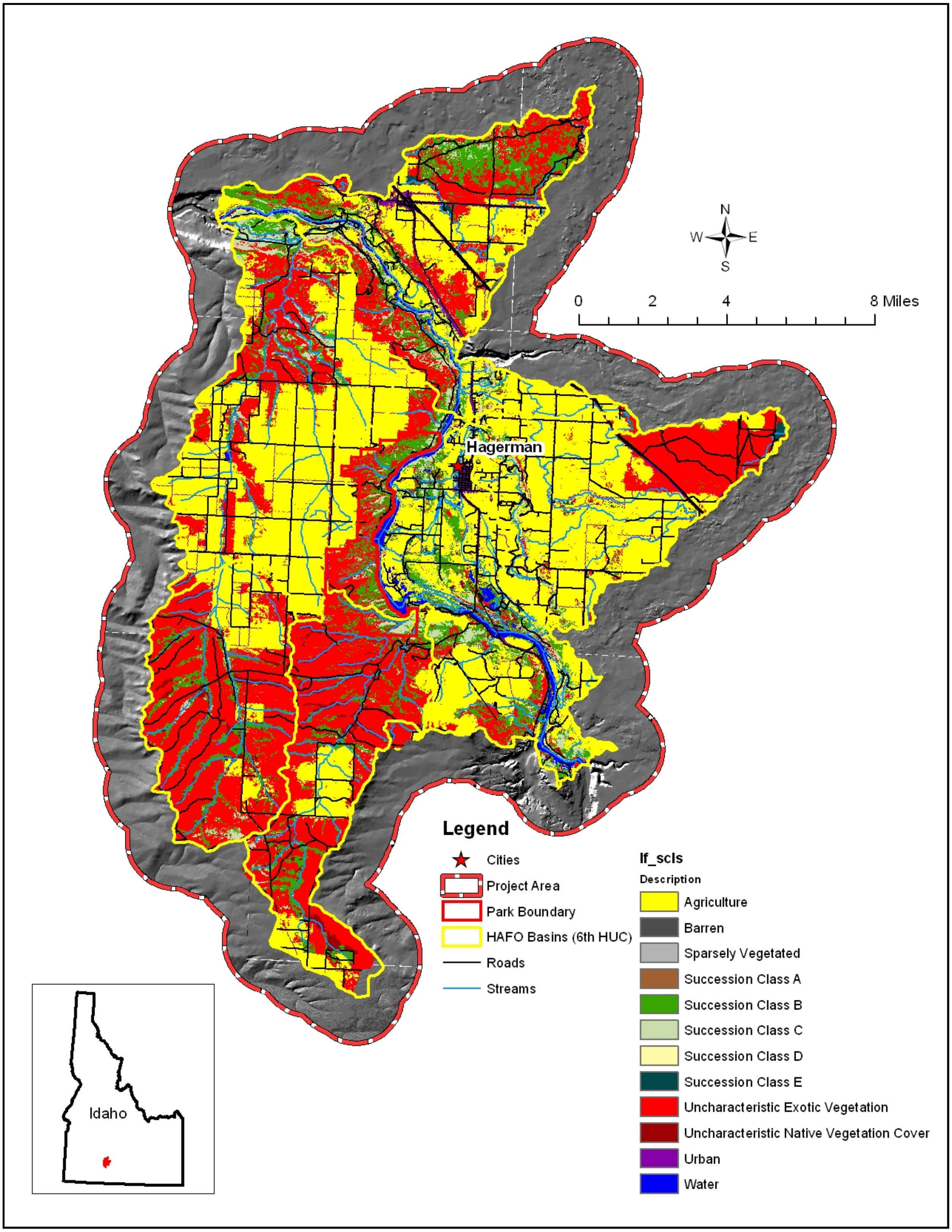

Figure 10. Successional Classes within the HAFO study area.

Wildfire

Stressors are disturbance events that result in significant ecological effects within a system to cause change. GIS stressor data found within the HAFO project area includes features on fire occurrence from various agencies. The information contained in these files is dated and somewhat limited in extent depending on the jurisdictional boundaries of the reporting agency. More wildfire data are needed to augment the current information. Table 12 lists the fire related Feature Classes within the HAFO Stressors Feature Dataset.

Table 12. HAFO Stressor Feature Dataset. (Source See Appendix A.)

Themes	Geodatabase File Name	Number Parts
Stressors		
Fires BLM 72-08	BLM -Fiires_pts_72-08	94
Fed Fire Occurrence NPS	fedfireoccurrence_1980-2004_nps	2
Historical Fires	FIG_Historical _Fires	54
Wldfires BLM polygons	wilfire_id_blm	98

The Stressor Feature Dataset provides historic information on fire occurrence. This information is overlapping in time and spatial position. Fire data is often recorded by multiple agencies and a single fire incident can be present in more than one data file with varying characteristics. Wildfire was a threat to resources at HAFO from fire ignitions on or adjacent to Monument lands prior to the Long Butte Fire of 2010. Wildfire data from the BLM, NPS and multi agency data from the Fire Analysis Program, is included in the HAFO geodatabase. Collectively, these files list fire occurrence for the period 1957 through 2008. The data records fires that have occurred in the project area and are representative of ignition sources and the type of fires common to the Monument. According to the BLM_Fire_Pts_72-08 Dataset, approximately 13,786 acres burned as a result of wildfire ignitions during the period 1980- 2008. Table 13 lists the BLM recorded fires within the project area from 1980-2008. Table 14 lists the number of fires by source from the BLM records.

Table 13. BLM recorded burned acres by year and cause for the project area. 1980-2008

BLM Fire Pts 72-08 FIRE YEAR/ Cause>	Human (Ac)	Natural (Ac)	Unknown (Ac)	Grand Total (Ac)
1980	721			721
1981	117			117
1982	35	25		60
1983	3183			3183
1984	60			60
1985	0			0
1986	338			338
1987	26			26
1989		565	20	585
1990	312			312
1991	20			20
1992	141			141
1994	10			10
1995	718.5			718.5
1996	917			917

BLM Fire Pts 72-08 FIRE YEAR/ Cause>	Human (Ac)	Natural (Ac)	Unknown (Ac)	Grand Total (Ac)
1997	146	3434		3580
1999	43.6			43.6
2000	822.7			822.7
2001	615.1			615.1
2002	5	225		230
2003	3.1	11		14.1
2005	163.6			163.6
2006	16.3	103.6		119.9
2007	948.1	14		962.1
2008	25	1.2		26.2
Grand Total	9387	4378.8	20	13785.8

Table 14. This table displays the BLM Recorded fires by year and cause for the HAFO project area. 1980-2008.

BLM Fire Pts 72-08 FIRE YEAR/ Cause>	Human	Natural	Grand Total
1980	2		2
1981	2		2
1982	1	1	2
1983	5		5
1984	2		2
1985	1		1
1986	4		4
1987	2		2
1989		2	2
1990	2		2
1991	1		1
1992	5		5
1994	1		1
1995	2		2
1996	4		4
1997	1	5	6
1999	3		3
2000	10		10
2001	7		7
2002	1	1	2
2003	3	2	5
2005	6		6
2006	4	2	6
2007	7	1	8
2008	2	1	3
Grand Total	78	15	93

Figure 11 depicts the data layers in the stressors feature Dataset within the HAFO project area.

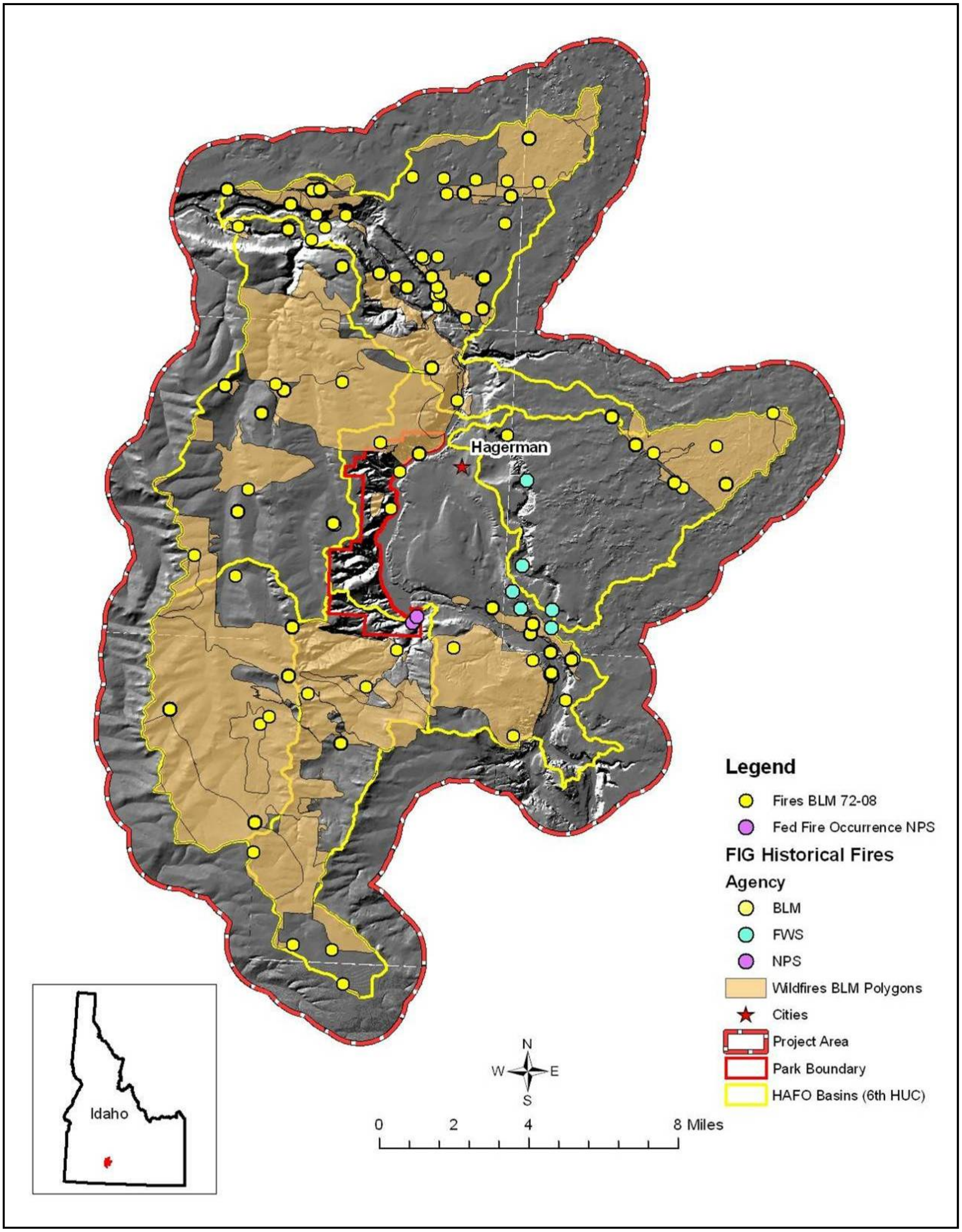

Figure 11. Historic fire locations and wildfire polygons reported by agency within the HAFO project area.

LANDFIRE Raster Data: LANDFIRE is an interagency mapping project shared by the Department of Interior, USFS and Wildland Fire Leadership Council. The program produces a suite of comprehensive and consistent data layers covering the United States. The purpose of the program is to develop maps needed to help land managers prioritize areas of hazardous fuel reduction and ecological conservation. LANDFIRE data products are developed from relational data bases, field plots, remote sensing, modeling and peer-reviewed science to create spatial data layers to be used by managers for decision making. LANDFIRE products are developed from the most current data available and are continuously updated. Several LANDFIRE raster Datasets were acquired for HAFO to document past, current and potential future conditions. Following is the general characteristics of each LANDFIRE raster Dataset acquired for HAFO followed by a map depicting the extent of the various attributes associated with that specific layer (LANDFIRE 2007).

Andersons 13 Fire Behavior Fuel Models (HAFO13fbfm)
Andersons 13 Fire Behavior Fuel Models is a LANDFIRE data layer representing the distinct distribution of fuel loading found among surface fuels following methodology developed by H. E. Anderson (Anderson 1982). It describes the composition and characteristics of both surface fuel and canopy fuel. The Dataset is used for fire behavior related modeling. Table 15 and Figure 12 identify the various fuel models and area of each within the HAFO basin areas.

Table 15. Andersons 13 Fire Behavior Fuel Model for HAFO. (Source See Appendix A.)

Attribute (fbfm13)	GIS Acres	% Total Area
lf_13fbfm		
FBFM1	35,441.4	28.578%
FBFM2	22,793.0	18.379%
FBFM3	738.7	0.596%
FBFM5	6,363.0	5.131%
FBFM8	40.7	0.033%
Urban	4,465.5	3.601%
Agriculture	51,462.9	41.497%
Water	2,676.0	2.158%
Barren	34.7	0.028%

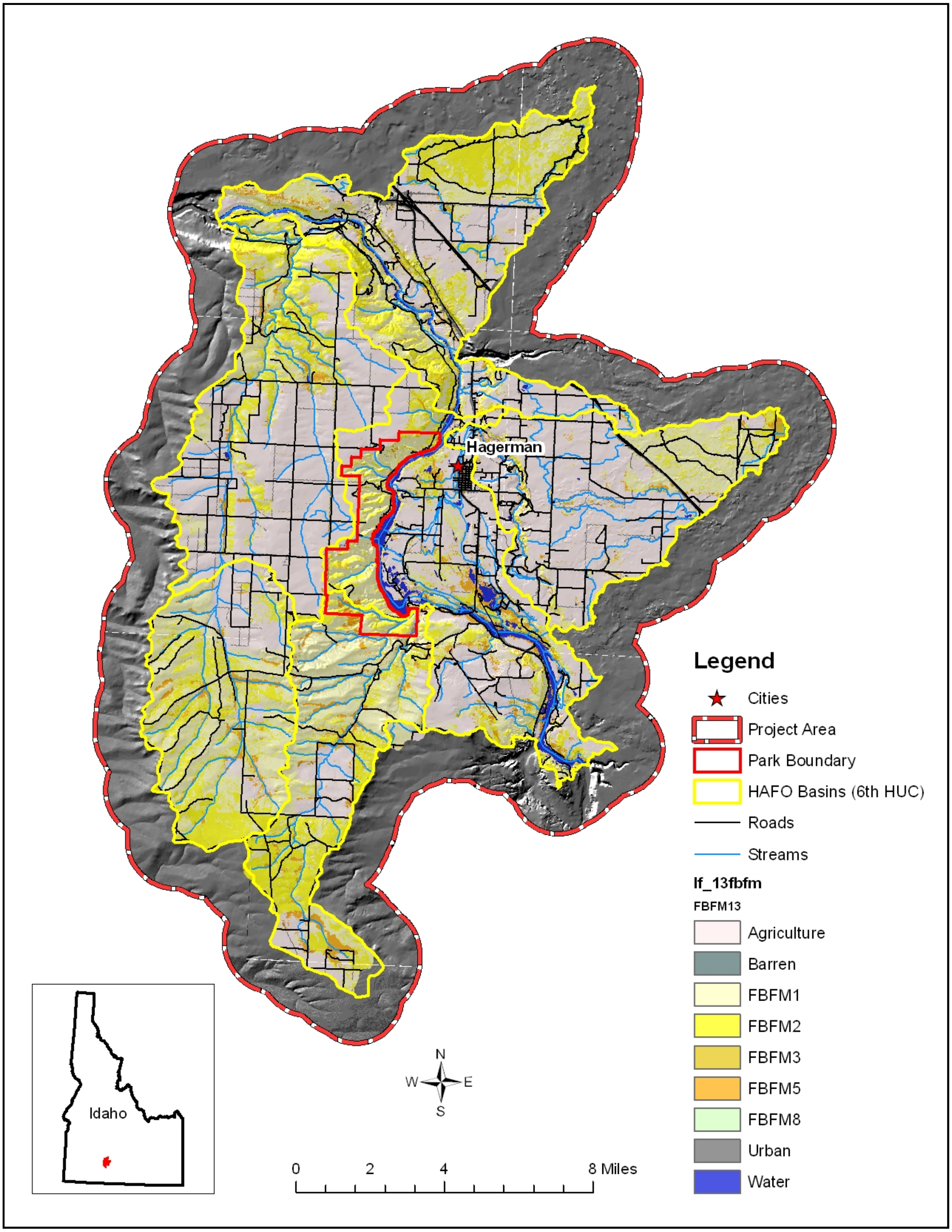

Figure 12. Andersons 13 Fire behavior model map for HAFO.

Fire Regime Group: Fire Regime Group (FRG) or Historic Fire Regime 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. Historic 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 five 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

Table 16 and Figure 13 identify the extent and area of each Fire Regime Group within the HAFO basin areas.

Table 16. Fire Regime Group breakdown by area for HAFO. (Source See Appendix A.)

Attribute (Description)	GIS Acres	% Total Area
lf_frg		
<= 35 Year Fire Return Interval, Low and Mixed Severity (Fire Regime I)	803.9	0.648%
<= 35 Year Fire Return Interval, Replacement Severity (Fire Regime II)	101,872.7	82.145%
> 200 Year Fire Return Interval, Any Severity (Fire Regime V)	9,792.7	7.896%
Water	2,019.4	1.628%
Barren	34.2	0.028%
Sparsely Vegetated	11.3	0.009%
Indeterminate Fire Regime Characteristics	9,481.8	7.646%

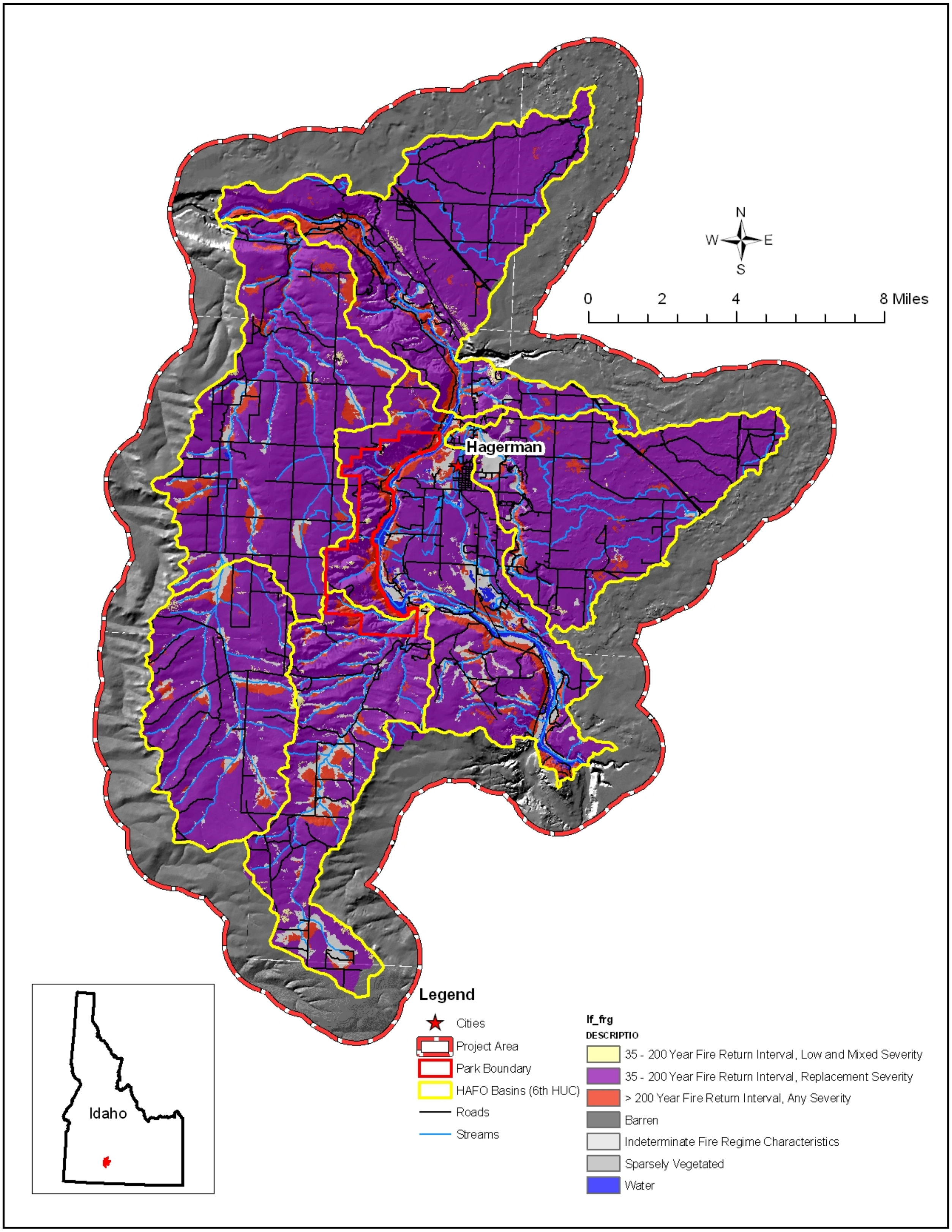

Figure 13. Map of Fire Regime Group for HAFO.

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. Table 17 and Figure 14 summarize FRCC within the HAFO basin areas.

Table 17. HAFO Fire Regime Condition Class. (Source See Appendix A.)

Attribute (Label)	GIS Acres	% Total Area
lf_frcc		
Fire Regime Condition Class I	62.7	0.051%
Fire Regime Condition Class II	9,542.5	7.695%
Fire Regime Condition Class III	56,132.6	45.262%
Water	2,019.4	1.628%
Urban	4,467.0	3.602%
Barren	34.2	0.028%
Sparsely Vegetated	11.3	0.009%
Agriculture	51,746.3	41.725%

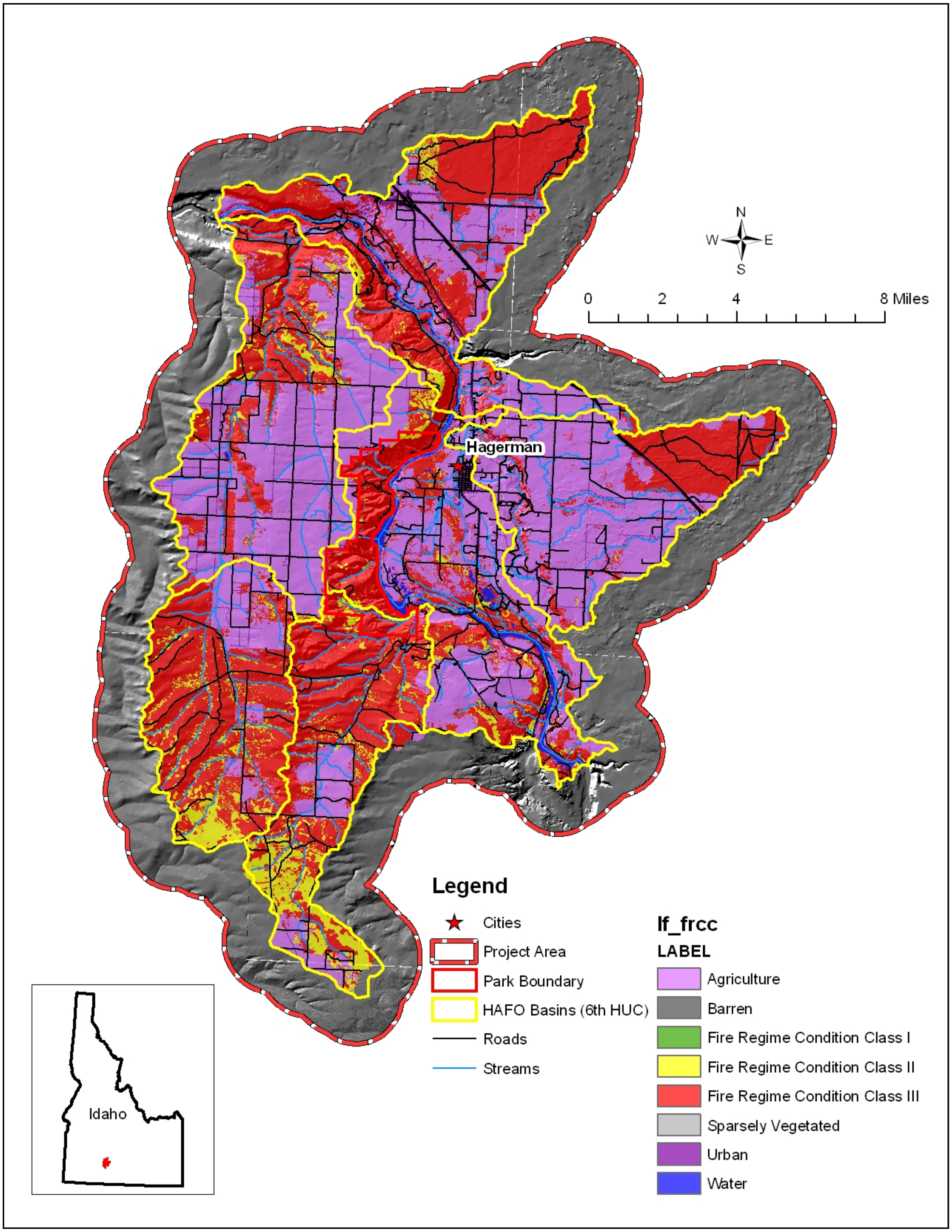

Figure 14. Map of HAFO Fire Regime Condition Class.

Fire Regime Condition Class Departure: An estimate of Fire Regime Condition Class Departure from historic conditions was estimated by the LANDFIRE Group 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 four general classes; 0-25%, 26-50%, 51-75% and 76-100%. The following, Table 18 and Figure 15, summarizes the generalized FRCC Departure for HAFO.

Table 18. Fire Regime Condition Class Departure by Acres and Percent. (Source See Appendix A.)

Attribute (Label)	GIS Acres	% Total Area
lf_frcc_dep		
0-50% Departure	549.7	0.44%
50-75% Departure	44,124.4	35.95%
75-100% Departure	21,063.6	16.98%
Water	2,019.4	1.63%
Urban	4,467.0	3.60%
Barren	34.2	0.03%
Sparsely Veg	11.3	0.01%
Agriculture	51,746.3	41.73%

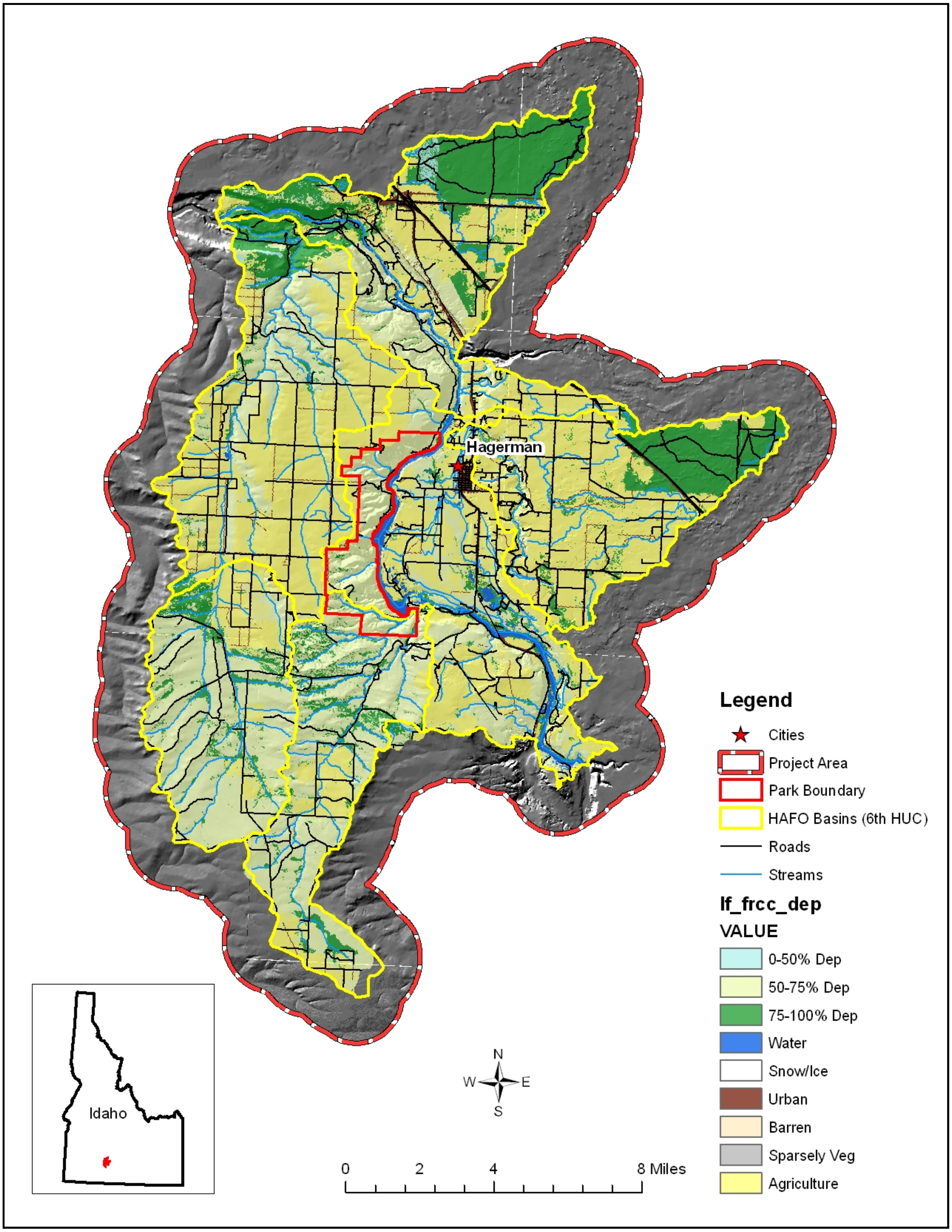

Figure 15. Fire Regime Condition Class Departure for the HAFO Study Area.

Mean Fire Return Interval: Mean Fire Return Interval is a LANDFIRE data layer that quantifies the number of years between fires under the presumed Historic Fire Regime. The data is derived from simulation models using vegetation, topography, historic weather, and disturbance dynamics. Table 19 summarizes the area of simulated five-year return intervals within the HAFO basin areas and Figure 16 showing the extent of each area. All these data were collected and summarized prior to the Long Butte Fire of 2010 and therefore are intended to be representative pre-fire information.

Table 19. Mean Fire Return Interval for HAFO. (Source See Appendix A.)

Attribute (Label)	GIS Acres	% Total Area
lf_mfri		
71-80 Years	6.9	0.006%
81-90 Years	113.6	0.092%
91-100 Years	959.5	0.774%
101-125 Years	18,558.2	14.964%
126-150 Years	43,921.8	35.416%
151-200 Years	39,116.6	31.542%
201-300 Years	7,474.6	6.027%
301-500 Years	1,922.0	1.550%
501-1000 Years	282.0	0.227%
>1000 Years	114.1	0.092%
Water	2,019.4	1.628%
Barren	34.2	0.028%
Sparsely Vegetated	11.3	0.009%
Indeterminate Fire Regime Characteristics	9,481.8	7.646%

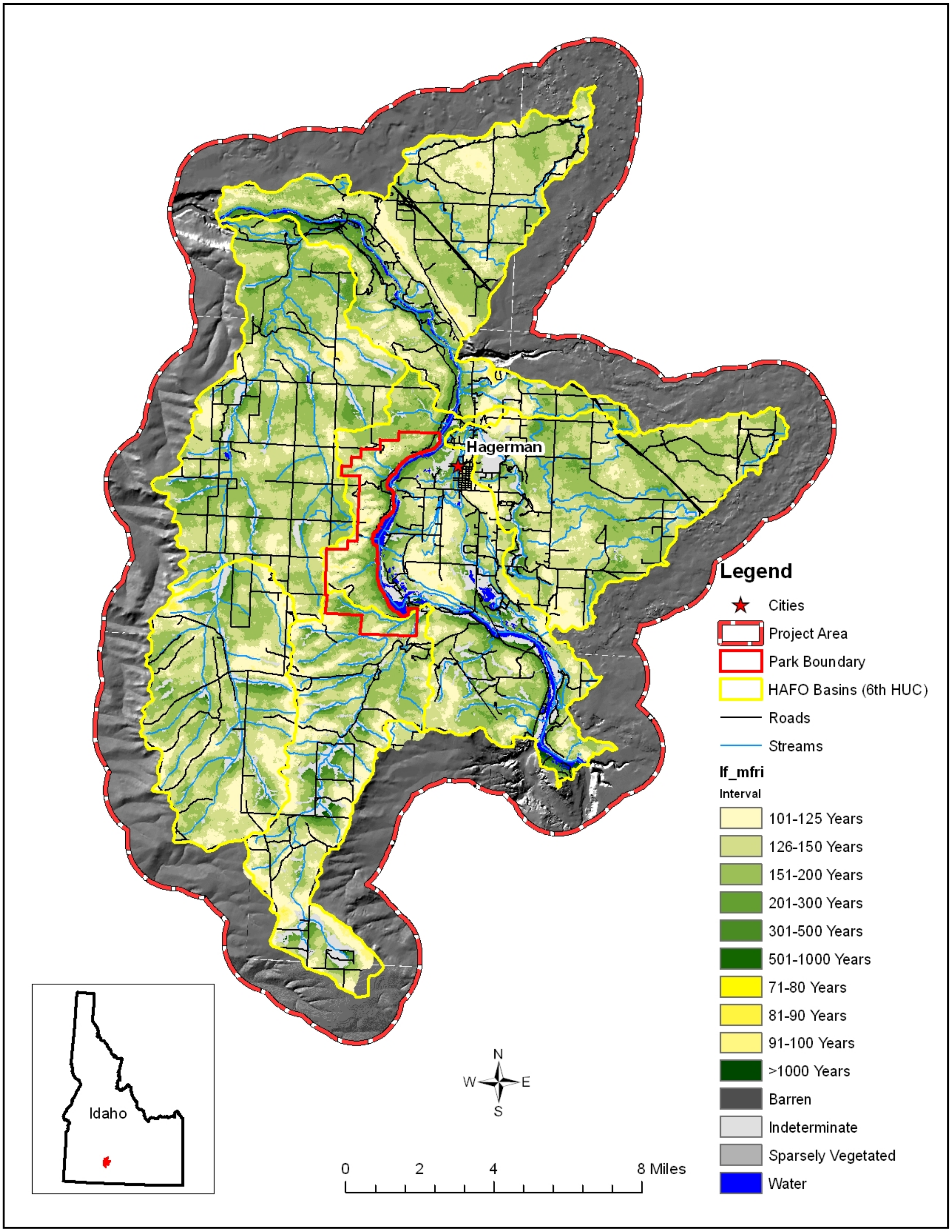

Figure 16. Map of fire return intervals for HAFO.

Air Resources

There was no specific geographical data related to air resources found for the HAFO project area at the time this data was compiled.

Animal

Geographical data pertaining to animals is somewhat limited for the HAFO project area. Animal feature data included in the HAFO geodatabase pertain to grazing allotments and pastures as well as the Idaho Fish and Game (IDFG), Game Management Units (GMU). Allotment and pasture layers were acquired from the BLM. They depict the boundaries of the livestock grazing areas under their jurisdiction within the HAFO basins area as of 2008. IDFG Game Management Units layer describes the generalized location of hunting unit boundaries within HAFO as described in the published regulations. Table 20 lists the general characteristics of the Animal features.

Table 20. Characteristics of the Animal Feature Dataset. (Source See Appendix A.)

Themes	Geodatabase File Name	Number Parts
Animal		
Range Allotments	rngAllotment_id_blm	20
Grazinig Pastures	rngPasture_id_blm	56
Game Management Units	GMU	3

The following tables (Tables 21 -23) list the specific information contained in each of the applicable themes, GIS attribute tables.

Table 21. Grazing Allotment GIS attributes.

ALLOT_NO	ALLOT_NAME	GIS_ACRES
01142	Thousand Springs	3,748.0
01143	Yahoo	14,080.6
01145	Twin Butte	4,086.4
01147	Kubic	6,456.1
01150	Hagerman Group	9,868.6
91001	Hull	160.8
91002	Malad	1,338.5
90403	W Bliss	272.6
90405	'101'	1,135.0
90415	Indian	1,156.7
90416	Clover Creek	800.6
90417	Davis Mtn	1,513.8
90418	Black Can	1,063.2
90901	Shoestring Sp	1,452.3
90902	Shoestring Ct	2,221.1
90903	Junction	23.1

Table 22. Grazing Pastures attributes.

ALLOT_NO	ALLOT_NAME	PAST_NO	PAST_NAME	GIS_ACRES
01142	Thousand Springs	00	Thousand Springs	3,748.0
01143	Yahoo	00	Yahoo	14,080.6
01145	Twin Butte	00	Twin Butte	4,086.4
01147	Kubic	00	Kubic	6,456.0
01150	Hagerman Group	00	Hagerman Group	9,868.6
90403	W Bliss	0	Relay Tower	32.2
90403	W Bliss	0	Southeast	173.8
90403	W Bliss	0	Southwest	66.6
90405	101	0	River	473.6
90405	101	0	L River	661.5
90415	Indian	0	Canal	1,156.7
90416	Clover Ck	01	Canal	800.6
90417	Davis Mtn	0	Canal	1,513.8
90418	Black Can	0	Open Crossing	1,063.2
90901	Shoestring Sp	0	West	1,158.5
90901	Shoestring Sp	0	Center	293.8
90902	Shoestring Ct	0	East	834.3
90902	Shoestring Ct	0	West	1,386.7
90903	Junction	01	Junction	23.1
91001	Hull	0	Hull	160.8
91002	Malad	0	Malad	1,338.5
N/A	N/A	0	N/A	4,915.4

Table 23. IDFG Game Management Unit attributes.

UNIT	ZONEID	AREAID	RANK	ACRES	ZONE_NAME	REGIONID
45	4	229	208	10,802.0	Bennett Hills	4
46	17	230	213	75,309.1	Owyhee-South Hills	4
53	26	238	245	37,904.8	Snake River	4

Figure 17 depicts the Grazing Pastures, Range Allotments and Game Management Units layers, clipped to the HAFO watershed basin areas located in the Animal Feature Dataset of the HAFO Geodatabase.

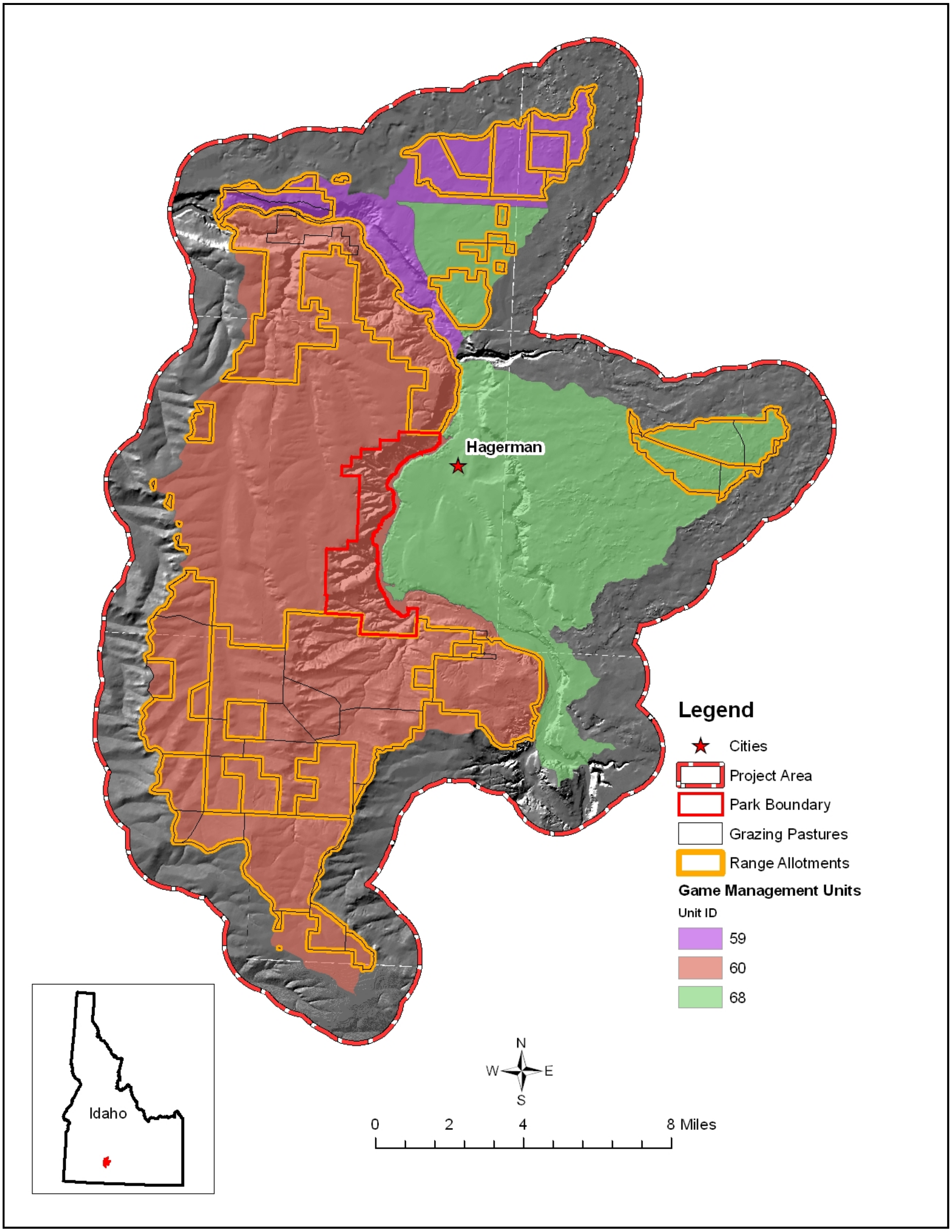

Figure 17. HAFO Animal Feature Dataset.

Climate
Climate features included in the HAFO Geodatabase include data layers showing the average precipitation and temperature within the project area. Precipitation averages range from 8-12 inches annually, and temperature averages ranges from 49-51 °F annually. The data layers show the average temperature and precipitation gradient across the project area.

Figure 18 and Figure 19 illustrate the information in the precipitation and temperature layers.

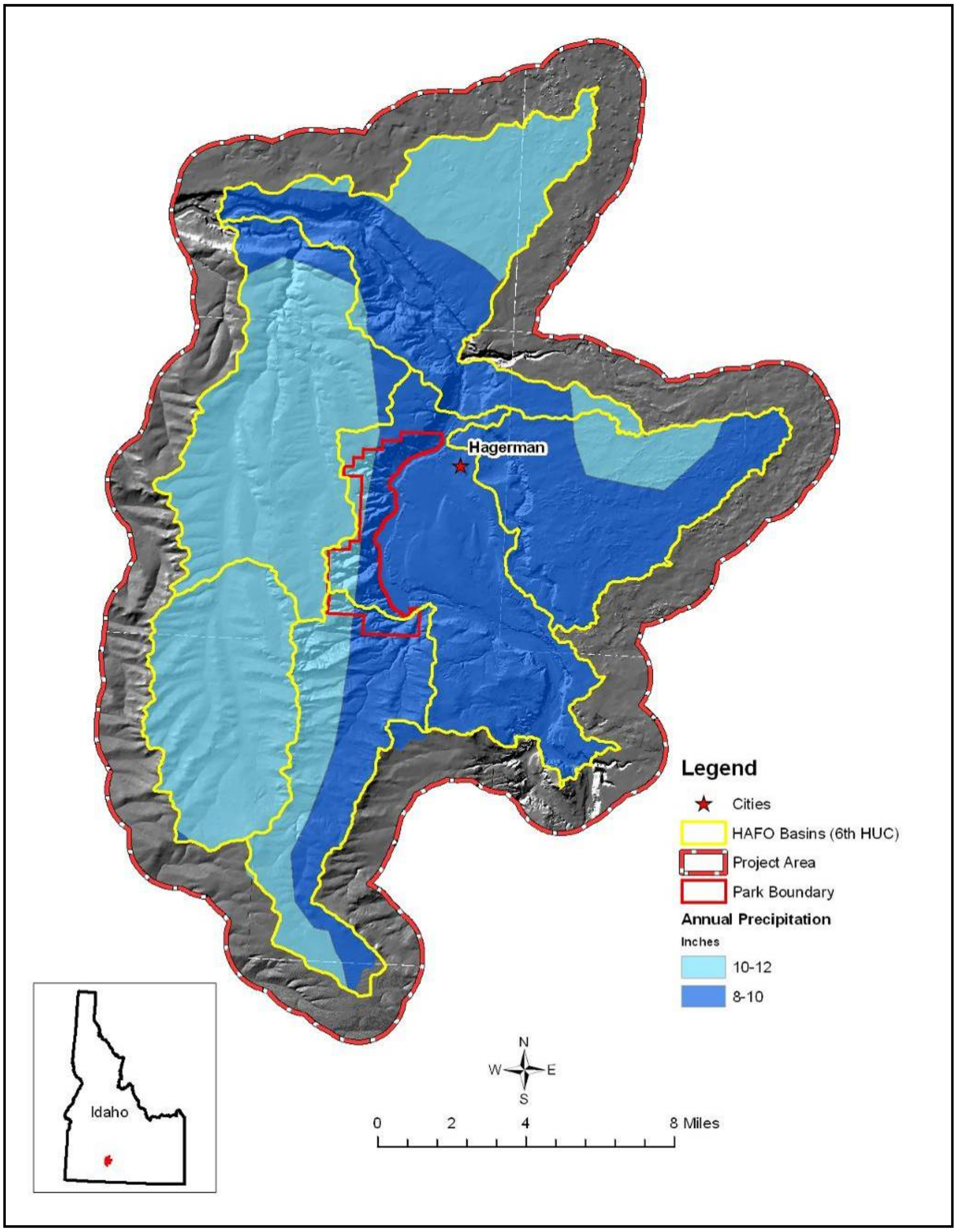

Figure 18. Precipitation zones within the HAFO project area.

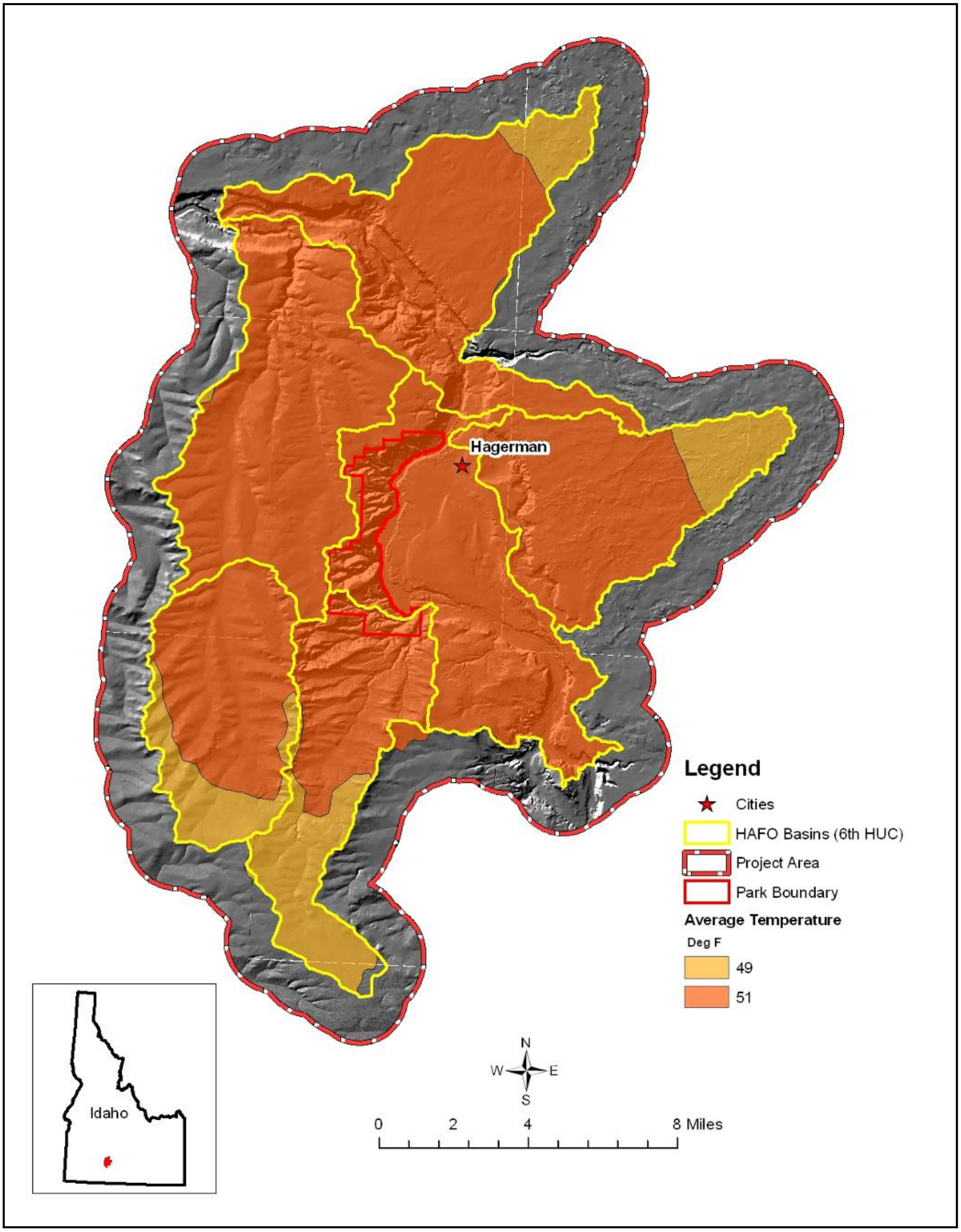

Figure 19. Temperature zones within the HAFO project area.

Geography

The Geography Feature Dataset within the HAFO geodatabase contains feature classes associated with specific delineated locations or boundaries. This includes features such as administrative boundaries, districts, public land survey lines, watershed basins and ecologic units. Table 24 is a list of the various feature classes included in the Geography feature Dataset of the HAFO geodatabase.

Table 24. Geography Dataset for HAFO. (Source See Appendix A.)

Themes	Geodatabase File Name	GIS Acres	Number Parts
Geography			
Cities	cities		1
City Boundaries	City_Boundary		2
Counties	Counties		5
Fire Districts	fire_dist		8
Watershed Basins	HAFO Basins	124,015.8	6
Basins Buffer	HAFO_Basins_Buffer	196,840.8	1
Geographic Names	ignis		72
Park Boundary	parkbndy	4,264.4	1
7.5 ' Quadrangle Index	Quad_Index		11
Sections	Sections		255
Townships	Township		14

The following map (Figure 20) displays a few of the features included in the Geography Feature Dataset visible at this small scale.

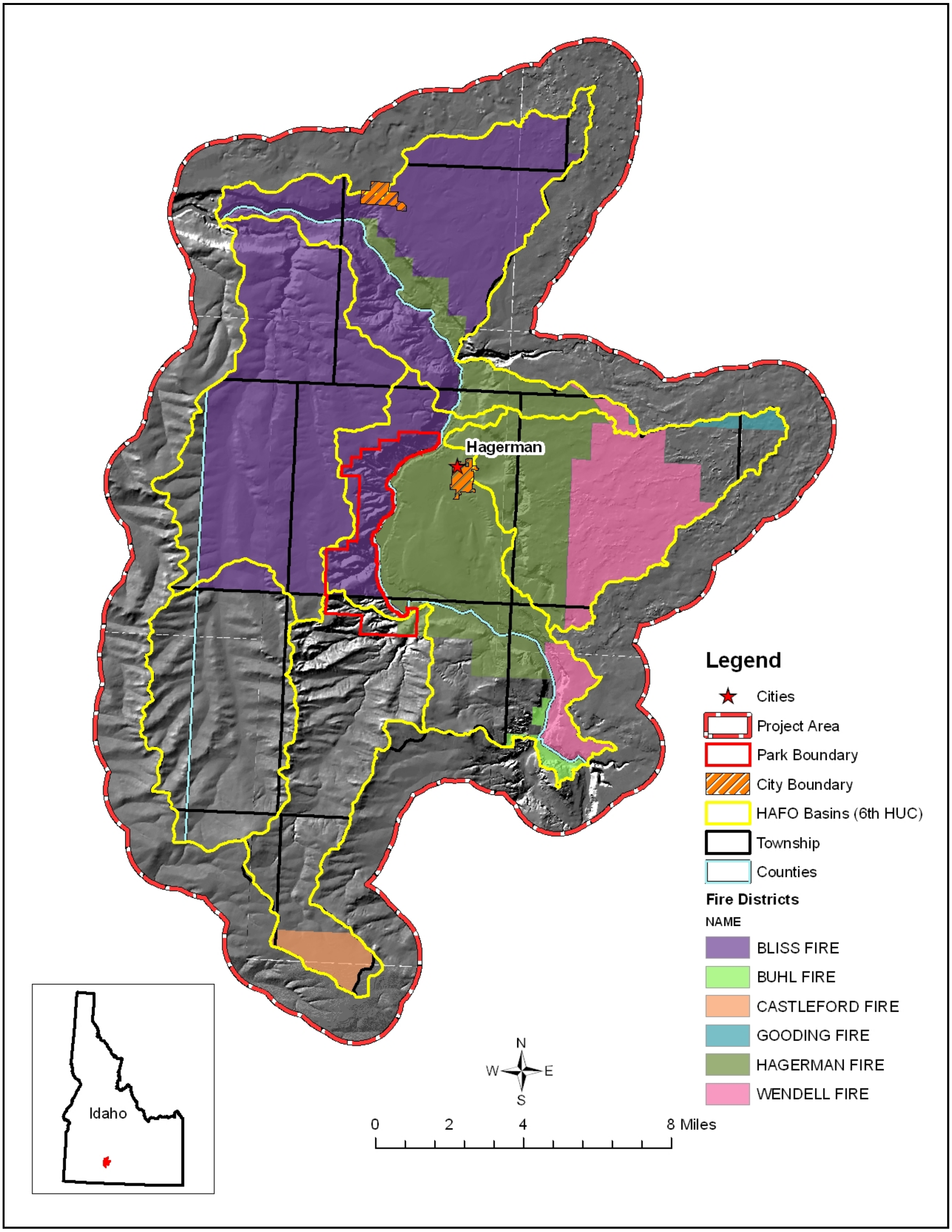

Figure 20. Example layers from the HAFO Geography Feature Dataset.

Geology

The Geology Feature Dataset includes detailed soils (SSURGO), fault lines, geology polygons, ground water lithology and seismic hazard rating feature classes. The following table (Table 25) lists the various layers found in this Feature Dataset along with acres and number of parts (number of feature parts) where appropriate. For the geology polygon and general soils feature, attribute name, acres and percent of total area encompassed by that feature's defining attributes are listed.

Table 25. Geology geodatabase file for HAFO. (Source See Appendix A.)

Themes	Geodatabase File Name	Number Parts
Geology		
Aquifer	aquifer	4
Faults	Faults	3
Geology	Geology	13 Types
Ground Water	gw_flow	
Soils	hafo_soils	1041
Lithology	lithology	3

Figure 21 shows the geology polygon layer along with other features found in the Geology Feature Dataset within the HAFO geodatabase.

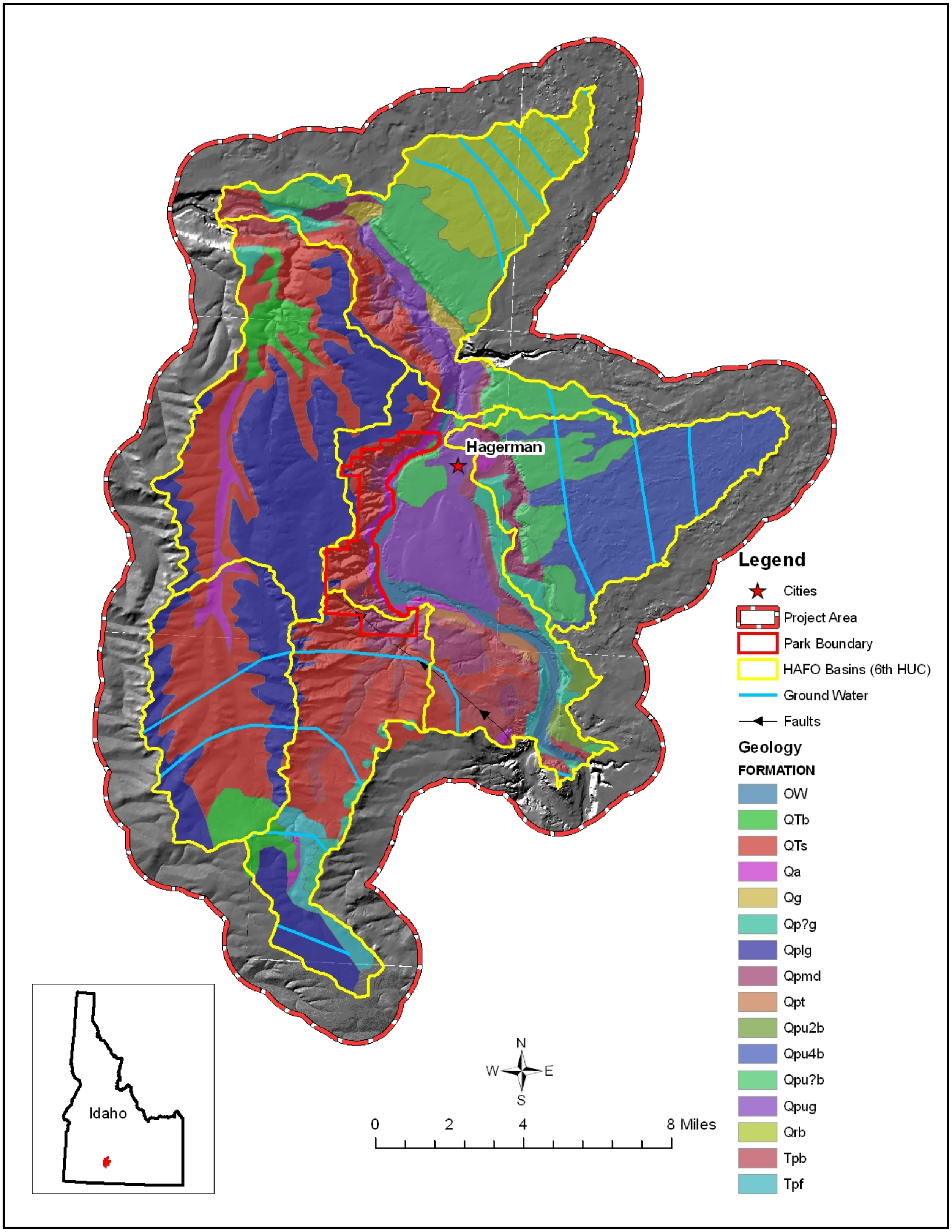

Figure 21. Example layers from the HAFO Geology Feature Dataset.

Water Resources

Water Resources Feature Datasets within the HAFO geodatabase include features pertaining to natural and developed water sources, water rights, geothermal locations, water quality monitoring sites and generalized areas sensitive to ground water contamination. Table 26 lists the various feature classes and their general characteristics included in the Water Resources Feature Dataset. The occurrence of seeps and springs in HAFO due to recent irrigation activities were not included since they have not been thoroughly documented and no existing spatial information is available.

Table 26. Water Resource Feature Dataset for HAFO. (Source See Appendix A.)

Themes	Geodatabase File Name	Number Parts	Length Ft
Water Resources			
USGS Gaging Stations	allgageusgs	29	
Geothermal sources	geothermal	22	
Ground water monitor sites	gwgm	11	
Municipal water	municipal_water	11	
Open Water	Open_Water	7	
Ground water concern areas	rechargesites	3	
Streams	streams	324	1,535,700.0
Ground water vulnerability areas	vulnerability	4	
Wells	wells	681	
Wetlands	Wetlands	4	
Water Rights point of diversion	wrpod	1900	
Water Rights point of use	wrpou	2361	

The following map (Figure 22) depicts several of the Water Resources Feature Classes within the HAFO geodatabase.

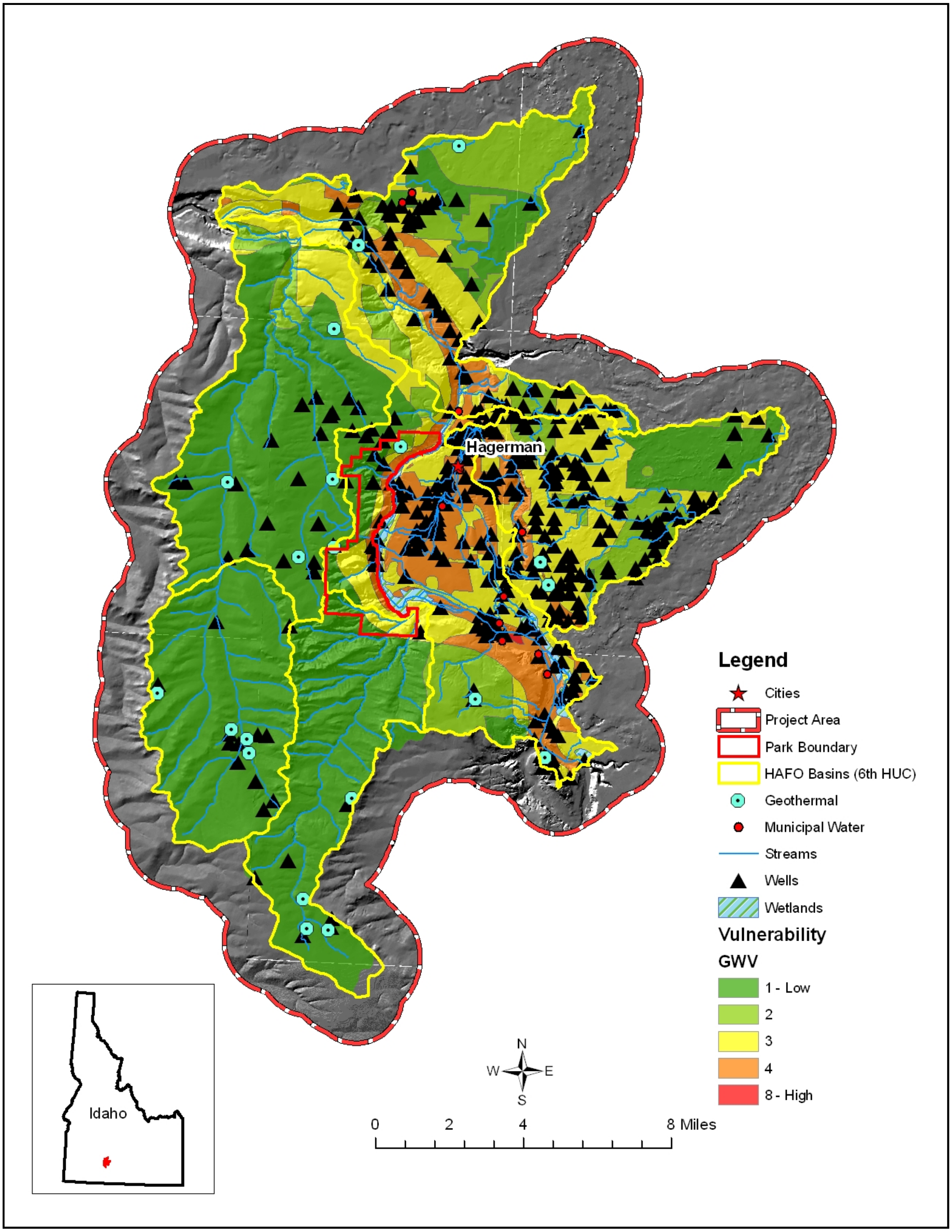

Figure 22. Selected Feature Classes from the HAFO Water Resource Feature Dataset.

River and stream drainages are uniquely identified by HUCs using a nationwide system developed in the mid-1970s by the USGS under the sponsorship of the Water Resources council. The underlying concept of the HUC system is a topographically defined set of drainage areas organized in a nested hierarchy based on surface feature size (WBD Users Guide 2010). A Hydrologic Unit code is a multi-digit number that identifies watersheds for the purpose of water resources planning and data management. This system divides the nation into 21 regions (Level 1, 2-digit), 221 subregions (Level 2, 4-digit), 378 Basins (Level 3, 6-digit), 2,236 Sub-Basins (Level 4, 8-digit). Additional mapping has been completed subdividing subbasins into watersheds, 5^{th} level (10 digit), and subwatersheds, 6^{th} level (12 digit). A hierarchical HUC consisting of two digits for each level in the hydrologic unit system is used to identify any hydrologic area. The code identifies each of the four levels of hydrologic classification within four two-digit fields. The Pacific Northwest is number 17 of the 21 regions (HUC1) in the United States. The HAFO project area is located in the Yahoo (1704021211) and Tuana Gulch (1704021213) Watersheds within the Snake River subregion. There are six - 6^{th} level HUC basins in the HAFO project area that cover 123,909 acres (Figure 23).

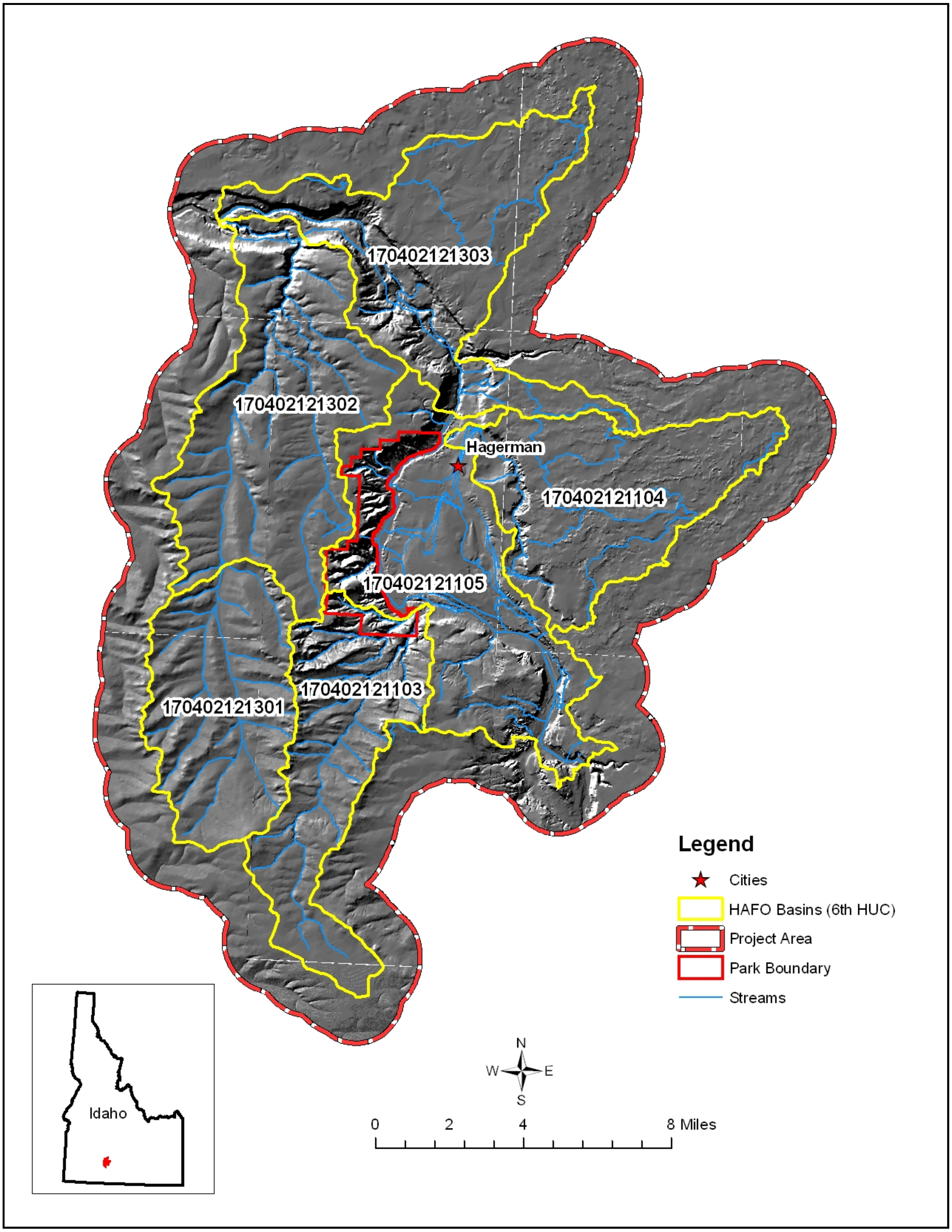

Figure 23. Map of HAFO 6th HUC Boundaries.

The numeric Hydrologic Unit Code is the primary, unique identifier for each hydrologic unit; however, the numeric identifier alone makes it difficult to relate a hydrologic unit to a geographic area. Hydrologic units are usually named after significant or prominent hydrographic features in an area. The following Table 27 lists the six hydrologic units and their associated prominent feature name encompassing HAFO.

Table 27. HAFO Hydrologic Units.

HUC_12	Acres	HU_12_NAME
170402121103	16,497.7	Yahoo Creek
170402121301	16,261.3	Upper Tuana Gulch
170402121104	18,803.6	Billingsley Creek
170402121105	24,050.1	Peters Gulch-Snake River
170402121302	24,917.2	Lower Tuana Gulch
170402121303	23,379.0	Birch Creek-Snake River

Other

Elevation and Hillshade: A ten meter pixel resolution digital elevation model (DEM) mosaic was developed for the HAFO project area. The DEM mosaic was created from individual USGS 10-m DEM quadrangle tiles, and clipped to the HAFO project area. Every pixel in the DEM mosaic is registered with an elevation value in meters. From this Dataset a hillshade terrain model was developed using the ESRI ArcGIS Spatial Analyst extension. The hillshade terrain model is used as a base map for several maps in this document providing the background three dimensional perspective of the ground surface. With the DEM, it is also possible to create contour lines, analyze slope and aspect, and perform view shed analysis. The elevation within the HAFO project area ranges from 807-1177 meters (2,647-3,860 feet) above mean sea level. The following map (Figure 24) depicts the digital elevation model over the hillshade terrain model.

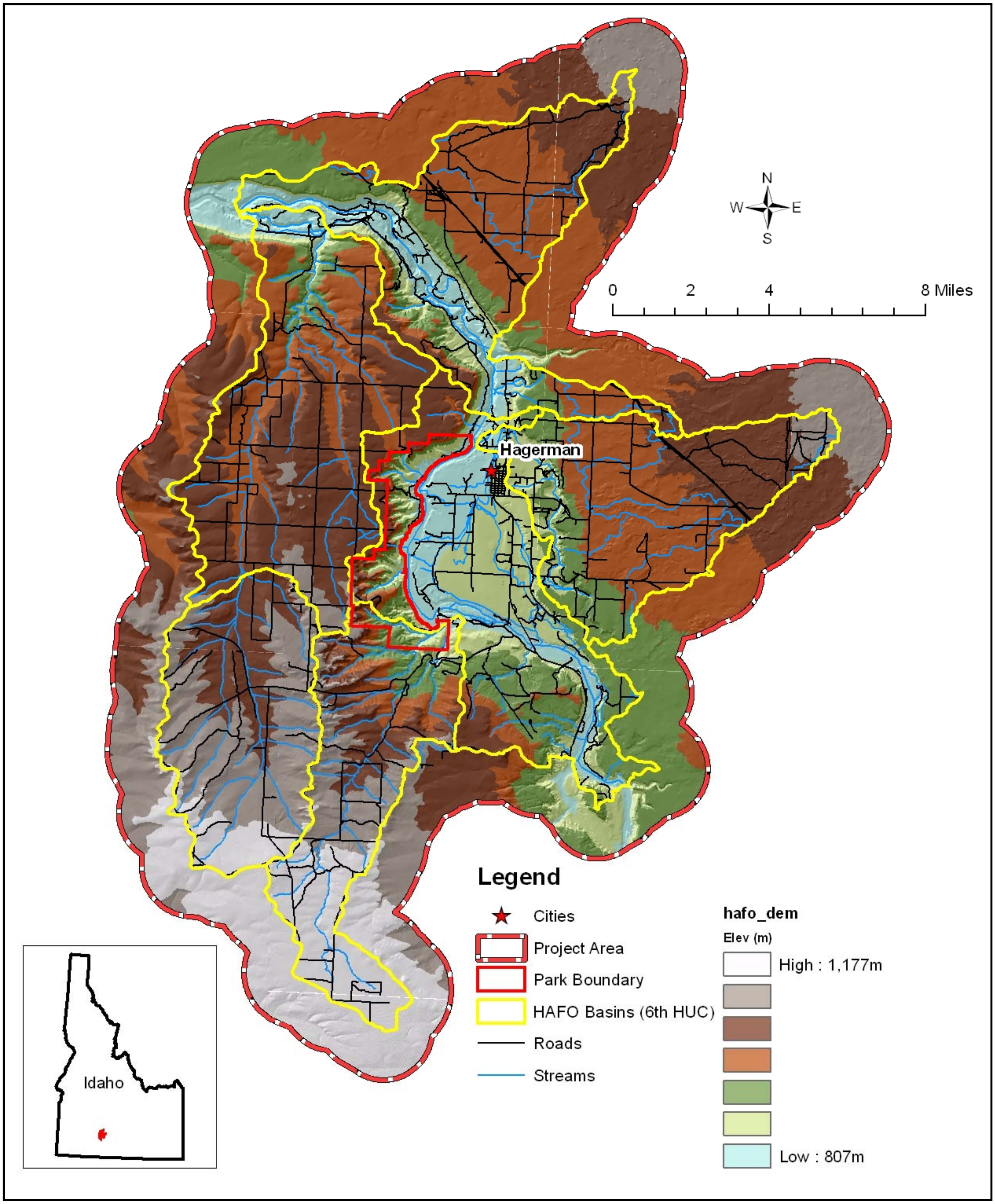

Figure 24. Digital Elevation Model (DEM) and Hillshade base map for HAFO.

Aerial Photography: Aerial photography of the HAFO project area was acquired for 2006 from the National Agricultural Imagery Program (NAIP). County wide mosaics (CCM) for Elmore, Gooding, Twin Falls and Owyhee Counties, Idaho were used to develop the project area aerial mosaics for HAFO. This imagery has a two meter pixel resolution. The HAFO_NAIP.sid mosaic was created from the original CCMs using Lizard Tech Geoexpress Software, ver. 7. The final mosaic was clipped to the HAFO watershed areas. Color was blended between adjoining images where possible to reduce contrast between tiles. Figure 25 shows the 2006 HAFO mosaics created for this project.

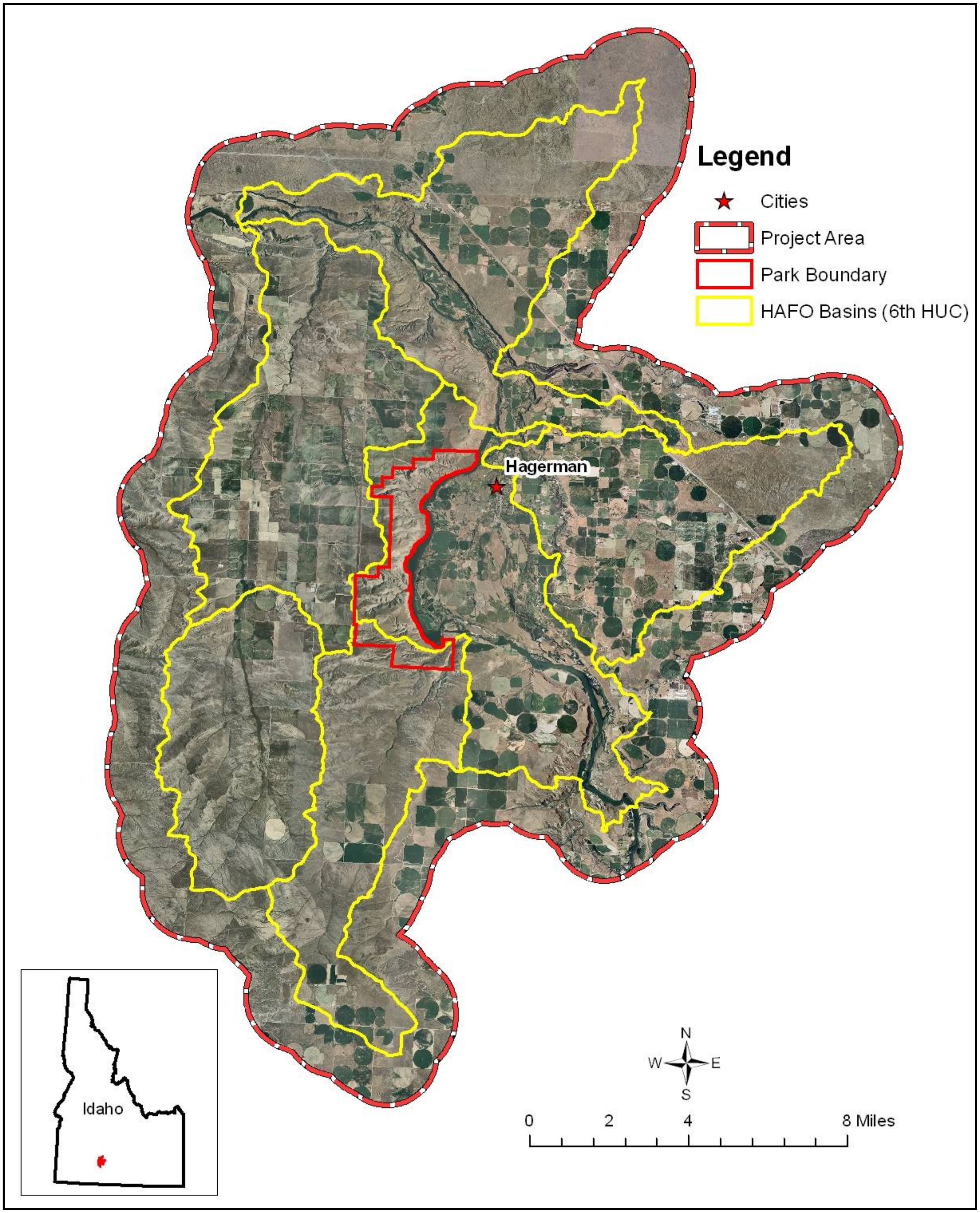

Figure 25. 2006 NAIP aerial photography mosaic of the HAFO project area.

USGS 7.5' Topographic Imagery: A digital raster graphic (DRG) basemap of the HAFO Project area was created using Lizard Tech Geoexpress Software, ver. 7. The original files used to develop this area were the scanned county wide topographic mosaics produced by the USGS, and georeferenced to the earth surface in the Universal Transverse Mercator projection. The file is a clip of the DRG of Elmore, Gooding, Twin Falls and Owyhee Counties, Idaho to the HAFO project area. Figure 26 shows the HAFO DRG mosaic produced from this process.

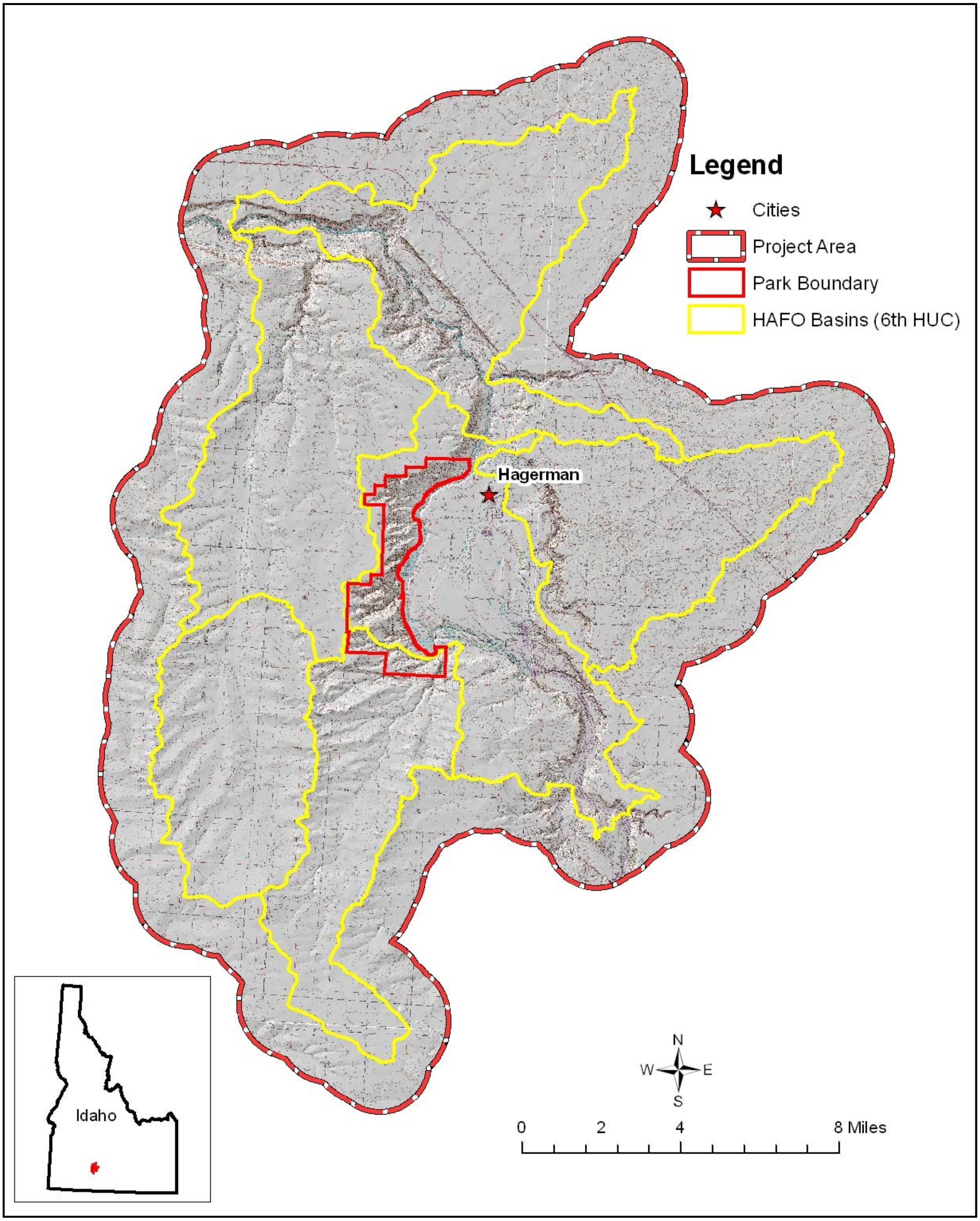

Figure 26. Digital Raster Graphic, Topographic map for HAFO.

Upland Site Specific Assessments

Unit specific assessments were made on the four upland sites identified in the methods section, including ecological assessments for eight sample points across these sites. The following is an evaluation of each of the eight ecological sites with maps of sample points and soils, which are the basis for the ratings of the three landscape attributes. All data collected at the eight 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 HAFO Geodatabases under the Geography category called nrca_plots.shp. Conclusions and recommendations that apply to all the sites sampled are discussed in the Summary and Recommendations section of this report.

Horse Quarry

Loamy 8-12 ARTRW8/PSSPS-ACTH7 Ecological Site: Two soils map units were sampled within this ecological site; Badland-Kudlac association found in the upper reaches of this site and the Kudlac silty-clay soils, found down slope and nearer to the river. Sample points 2, 3, 4 and 6 are in the Badland-Kudlac map unit and sample point 5 is in Kudlac silty-clay map unit as displayed in Figure 27 below (NRCS 2010).

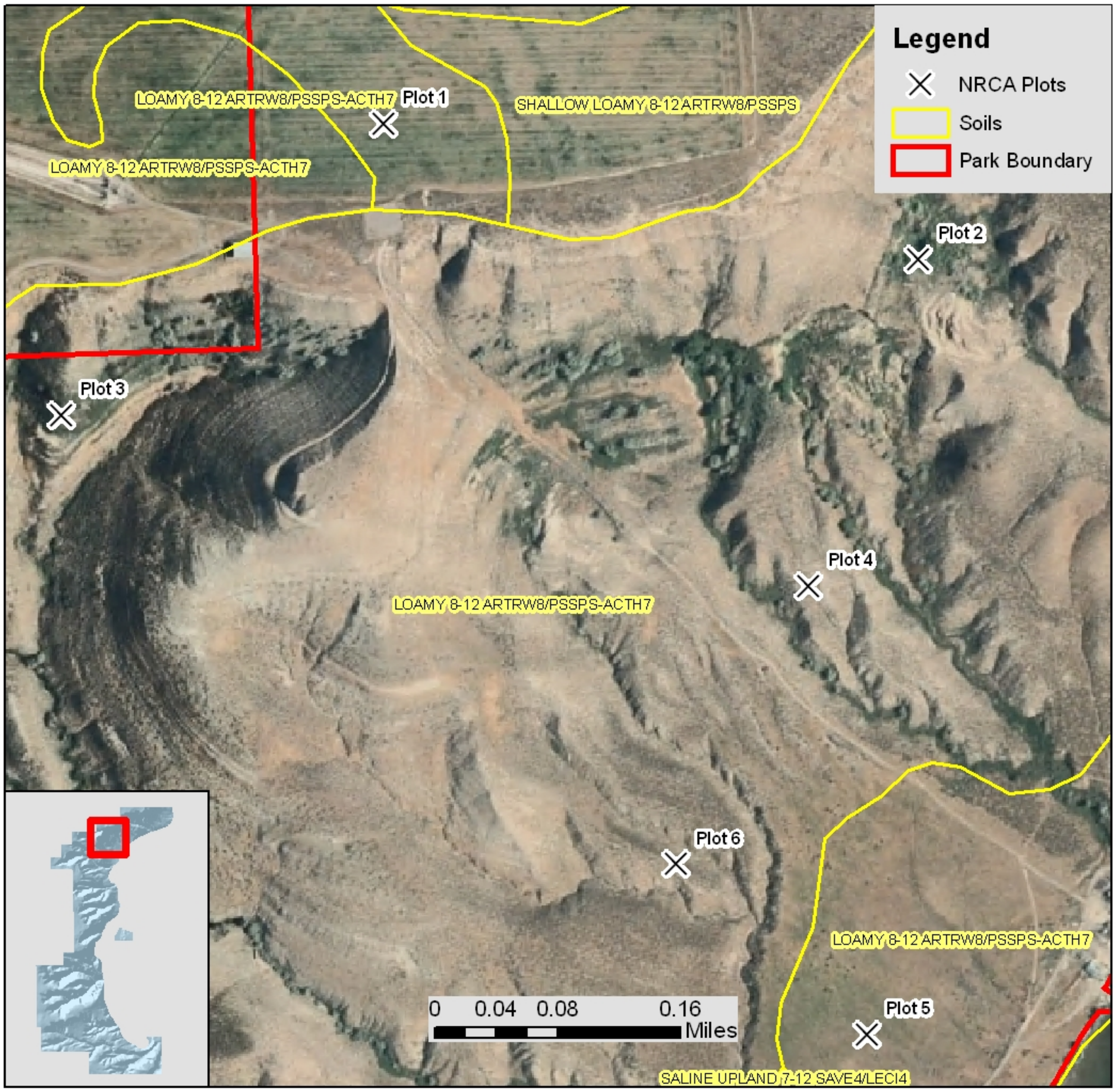

Figure 27. Map of the ecological site sample plots 2, 3, 4, 5 and 6 in the Horse Quarry area, HAFO.

The Badland-Kudlac soils are silty clay over a silty clay loam and developed from lacustrine deposits. The depth to a root restrictive layer is greater than 60 inches and the soil is well drained. These soils are found on 30% to 90% slopes. The Kudlac silty-clay soil also developed from lacustrine deposits but has a more developed soil profile. The soil is well drained and has a depth of 60 inches. This soil occurs on 4% to 30% slopes.

All five plots sampled in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site (R011XY001ID) were in the Horse Quarry upland area. The historic climax plant community is Wyoming big sagebrush (*Artemisia tridentata* ssp. w*yomingensis*)/bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata*)-Thurber's needlegrass (*Achnatherum thurberianum*).

Four of the five plots (2, 4, 5, 6) are on gentle to moderate slopes (2-12%) at an elevation ranging between 2,800 to 3,200 feet. Plot 3 is on a relatively steep backslope (56%) at an elevation of approximately 3,200 feet. Three of the five plots (2, 3, and 4) exhibit similar biotic integrity landscape attribute departure values (22.9%, 37.1%, and 31.4%, respectively) (Figure 28, Figure 29, Figure 30). The current vegetation growing on plot 2, a relatively moist site, is the tree species peachleaf willow (*Salix amygdaloides*) and the introduced smallflower tamarisk (*Tamarix parviflora*). The tall shrub component is composed of narrowleaf willow (*Salix exigua*) and Mackenzies's willow (*Salix rigida mackenzieana*). Basin wildrye (*Elymus cinereus*), hardstem bulrush (*Schoenoplectus acutus*) and the invasive cheatgrass (*Bromus tectorum*) are the predominant grass species. The noxious weeds Canada thistle (*Cirsium arvense*) and bull thistle (Cirsium vulgare) dominate the forb composition. Plots 3 and 4 shrub layer was dominated by Wyoming big sagebrush with a sparse component of native bunchgrasses. Invasive plants on these sites include cheatgrass, Canada thistle and smallflower tamarisk.

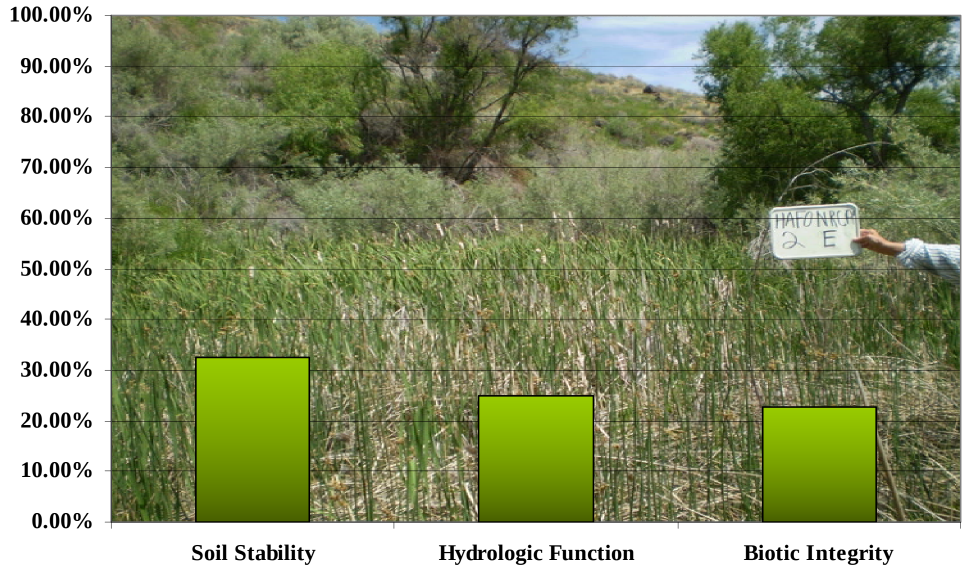

Figure 28. Plot 2 – Percent departure from the reference condition of the three landscape attributes in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site, Horse Quarry, HAFO.

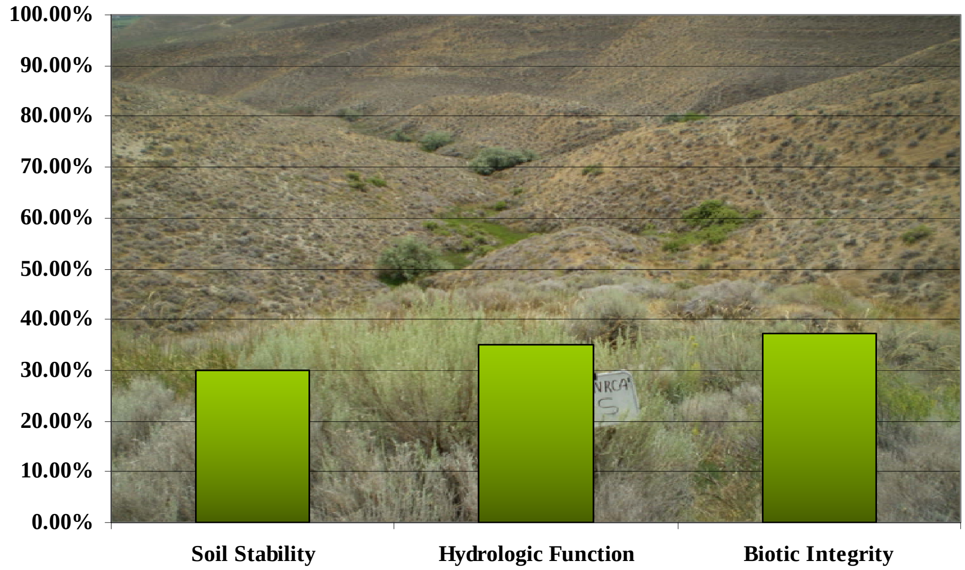

Figure 29. Plot 3 – Percent departure from the reference condition of the three landscape attributes in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site, Horse Quarry, HAFO.

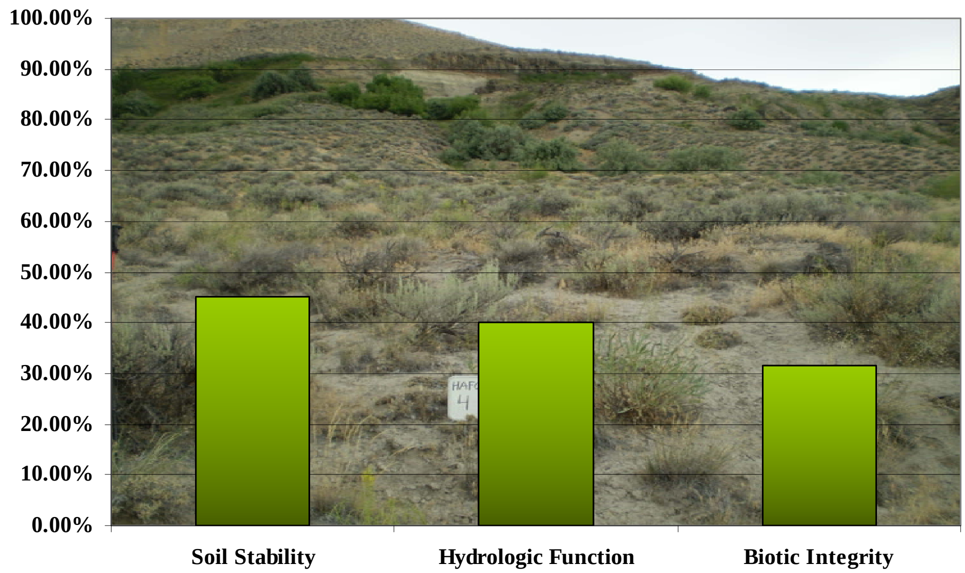

Figure 30. Plot 4 – Percent departure from the reference condition of the three landscape attributes in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site, Horse Quarry, HAFO.

Plots 5 and 6 (Figure 31 and Figure 32) have the same biotic integrity landscape attribute values (60%). Both sites have been heavily invaded by introduced invasive grasses, cheatgrass and tall tumblemustard (*Sisymbrium altissimum)* with a conspicuous lack or near lack of native perennial bunchgrasses. Wyoming big sagebrush and rubber rabbitbrush (*Chrysothamnus nauseosus*) occur only in sporadic patches over these sites.

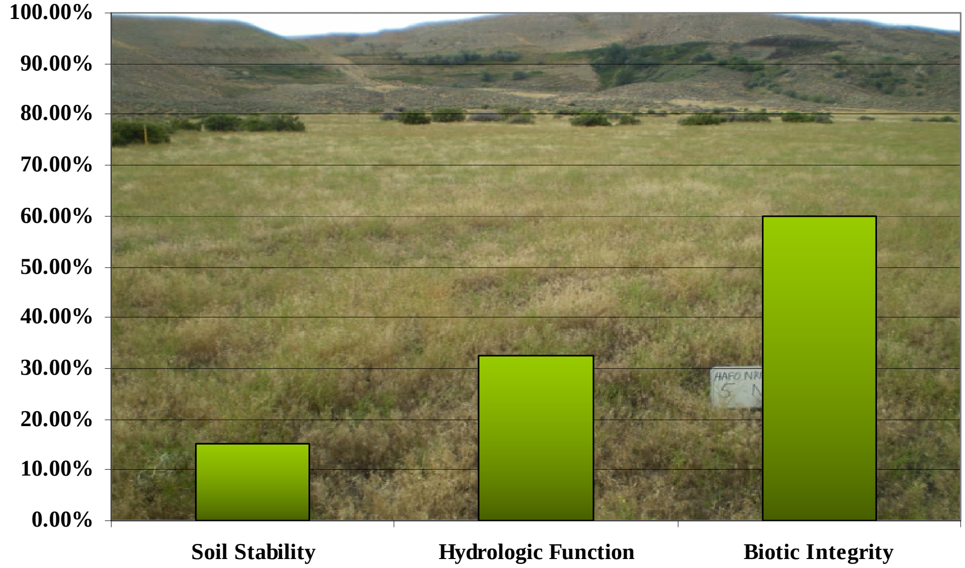

Figure 31. Plot 5 – Percent departure from the reference condition of the three landscape attributes in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site, Horse Quarry, HAFO.

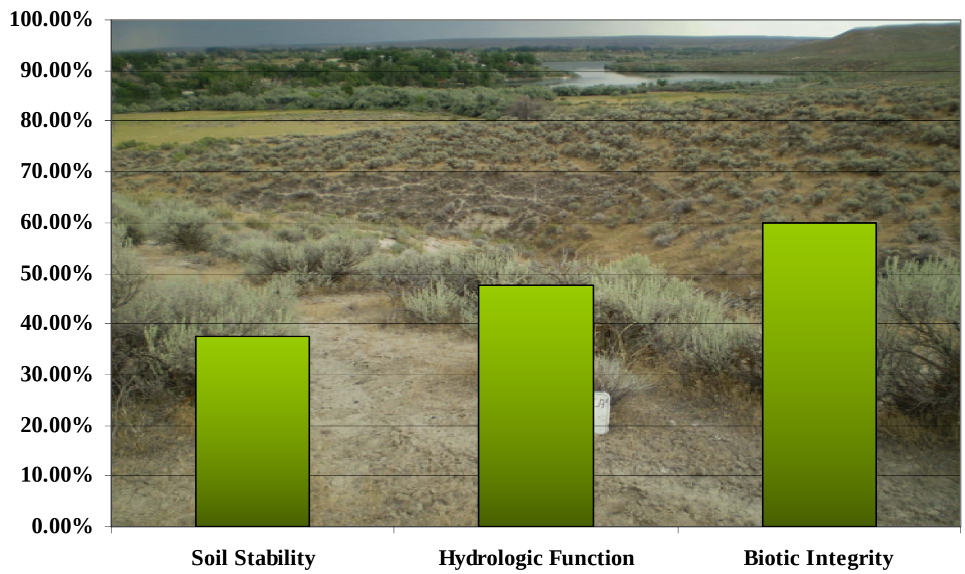

Figure 32. Plot 6 – Percent departure from the reference condition of the three landscape attributes in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site, Horse Quarry, HAFO.

The relatively poor biotic integrity rating on plots 5 and 6 is due to past management practices such as grazing and cultivation. Although these sites have relatively gentle slopes, the inaccessibility of these areas may limit the vegetation management options to those that can be implemented by hand, such as pulling or spraying.

The plots are located on the hillside above the river in the northern portion of the park. The average soil stability attributes of the five plots were rated as slight to moderate departure, (32.0%) with three of the plots receiving the same rating and plot 5 exhibiting a none to slight rating (15%) and plot 4 with a moderate rating (45%). The average hydrologic function attribute for all five plots also rated as slight to moderate departure (36%) with four of the plots receiving a similar rating and only plot 6 exhibiting a moderate rating (47.5%) (Figure 33).

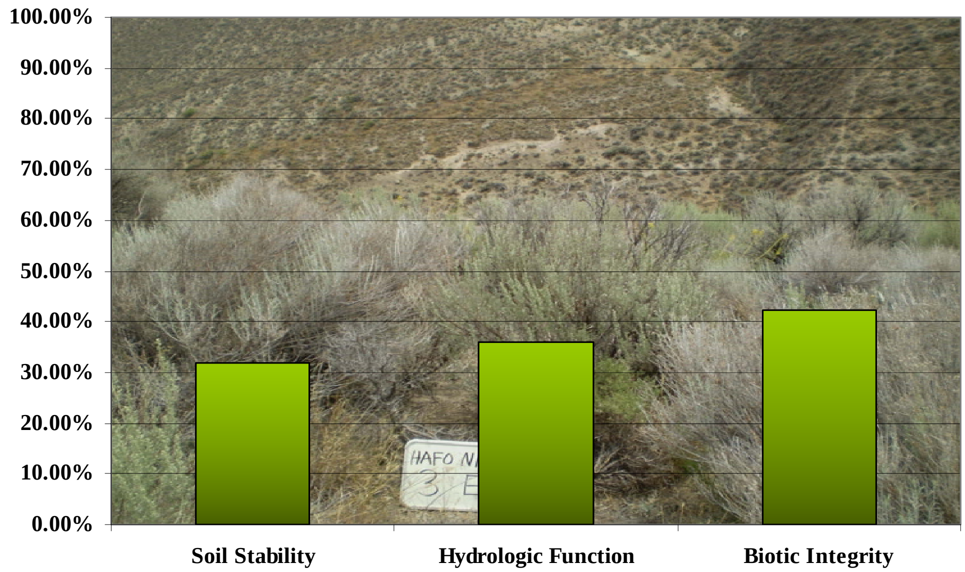

Figure 33. Average percent departure values (all five plots) from the reference condition of the three landscape attributes in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site, Horse Quarry, HAFO. (Plot 3 in background).

Old Agricultural Field above Horse Quarry

Loamy 8-12 ARTRW8/PSSPS-ACTH7 Ecological Site: The soil map unit sampled on this ecological site was Purdam silt loam, a soil with parent materials consisting of mixed alluvium and/or lacustrine deposits and loess. The soils are silt loams and silty clay loams over the top cemented material, which has formed at a depth of 33 to 70 inches. The depth to a root restrictive layer is 20 to 40 inches and the soil is naturally well drained. One plot was sampled in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site within this area. Plot 1 is located near the northern boundary of the park on the large flat above the Horse Quarry site (Figure 34). The site has a slope of less than 5% and is at an elevation of 3,390 feet.

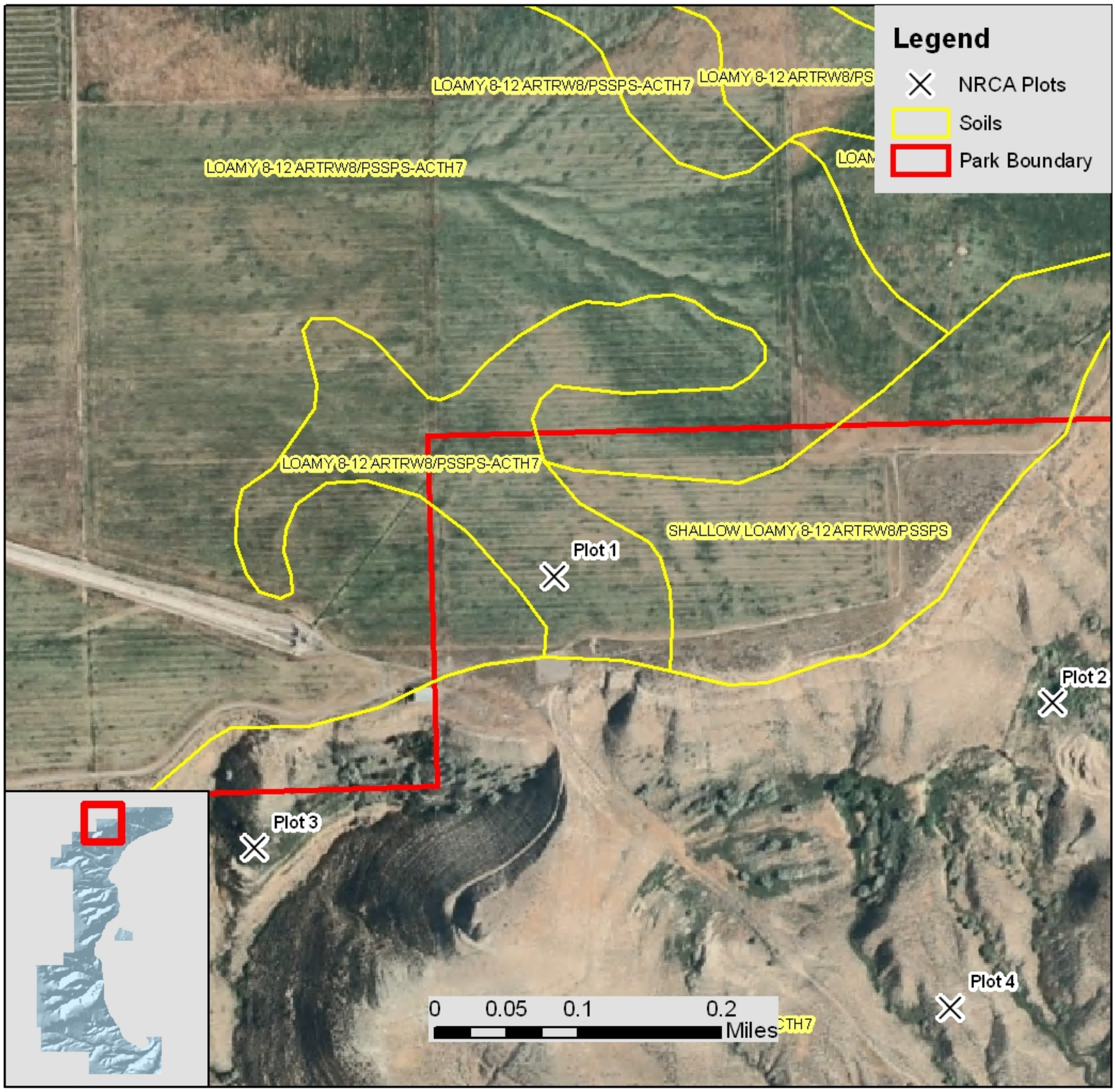

Figure 34. Map of ecological site sample plot 1 in the Old Agricultural Field, HAFO.

The soil stability and hydrologic function attributes were rated as slight to moderate departure, 35% and 40%, respectively due to the amount of bare soil between the plants, the lack of plant litter and the evidence of wind erosion on the site. The biotic integrity attribute was rated at moderate to extreme (68.6%) due to the near complete absence of native shrubs and bunch grasses (Figure 35).

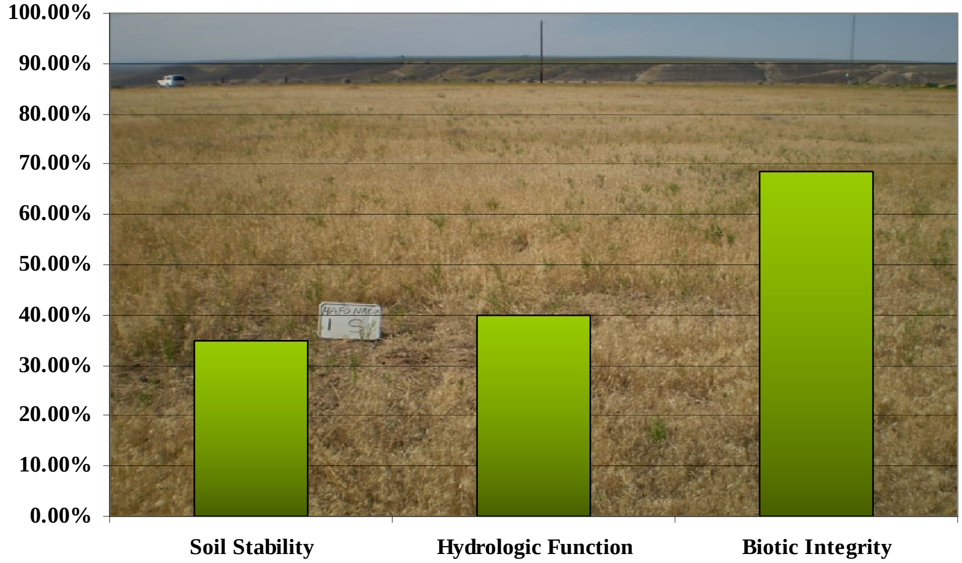

Figure 35. Plot 1 – Percent departure from reference condition of the three landscape attributes in the Loamy 8-12 ARTRW8/PSSPS-ACTH7 ecological site, Old Agricultural Field, HAFO.

Plot 1 is in Purdam silt loam with parent materials consisting of mixed alluvium and/or lacustrine deposits and loess. The potential climax plant community is dominated by the Wyoming big sagebrush in the shrub component and Thurber needlegrass in the grass component. The current vegetation is dominated completely by introduced and invasive plants with no native grass or native shrubs present. On this plot there were no shrubs present and the grass component is composed of crested wheatgrass (*Agropyron cristatum*), cheatgrass and common wheat (*Triticum aestivum*). The forb layer is dominated by tall tumblemustard *(Sisymbrium altissimum)*, Russian thistle (*Salsola iberica*) and burning bush (*Kochia scoparia*).

Yahoo Creek

Sandy 8-14 ARTRT/HECOC8-ACHY Ecological Site: The Yahoo Creek site is composed of one ecological site. The soil is Quincy loam derived from mixed eolian sands and/or alluvium parent materials. The soils are loamy fine sand over a stratified loam fine sand to silt loam. The depth to a root restrictive layer is greater than 60 inches and the soil is excessively drained. One plot was sampled in the Sandy 8-14 ARTRT/HECOC8-ACHY ecological site in the Yahoo Creek area. Plot 7 is within the southeastern portion of the park on a toeslope just above Yahoo Creek (Figure 36).

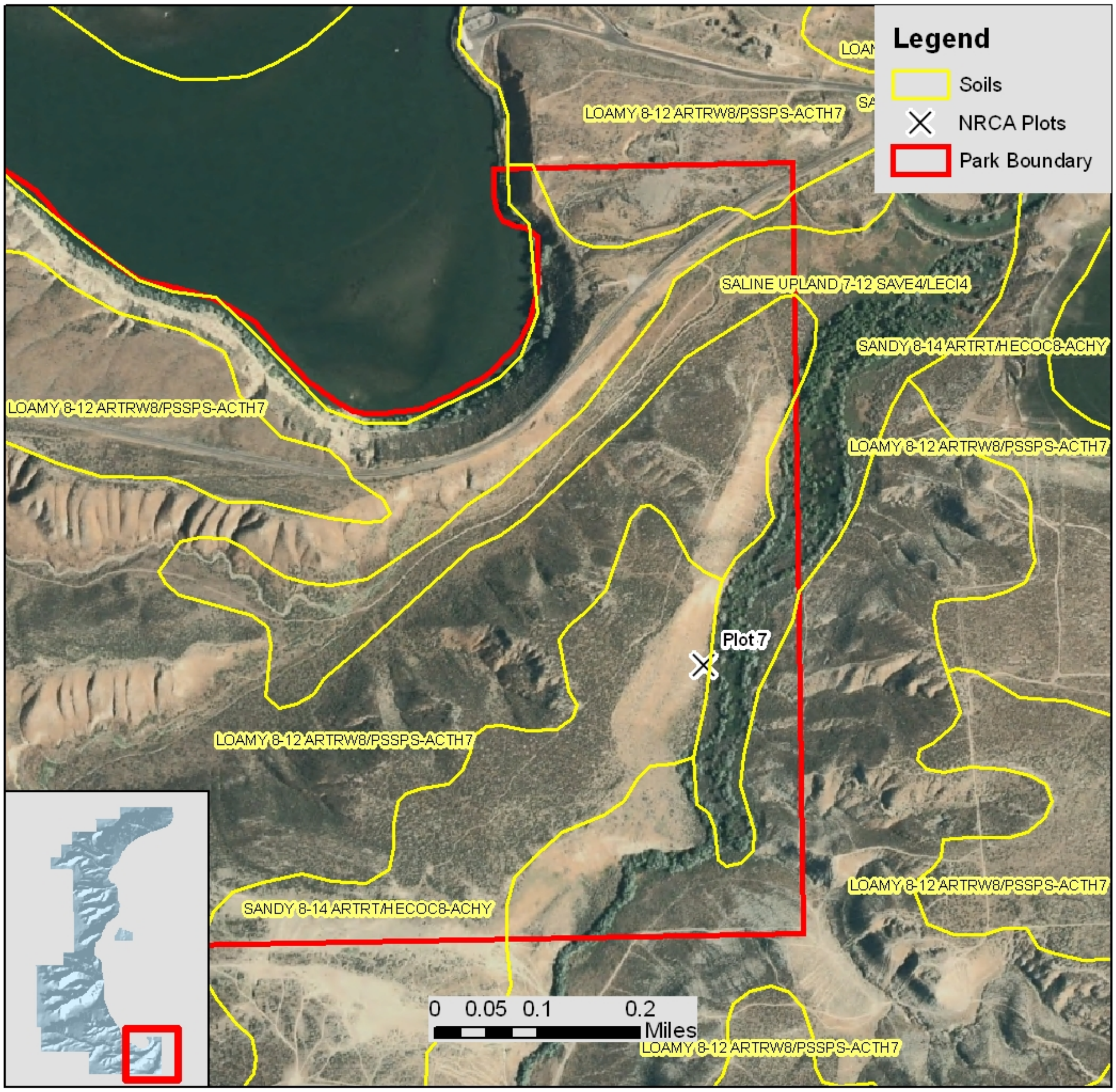

Figure 36. Map of ecological site Sandy 8-14 ARTRT/HECOC8-ACHY, plot 7 in Yahoo Creek area, HAFO.

The soil stability and hydrologic function attributes were rated as moderate departure, 50.0% and 52.5%, respectively due to quantity of bare soil and evidence of some sheet erosion and areas of soil scouring and deposition. The biotic integrity attribute was rated at moderate departure (51.4%) due to the presence of non-native vegetation and past use as cropland (Figure 37).

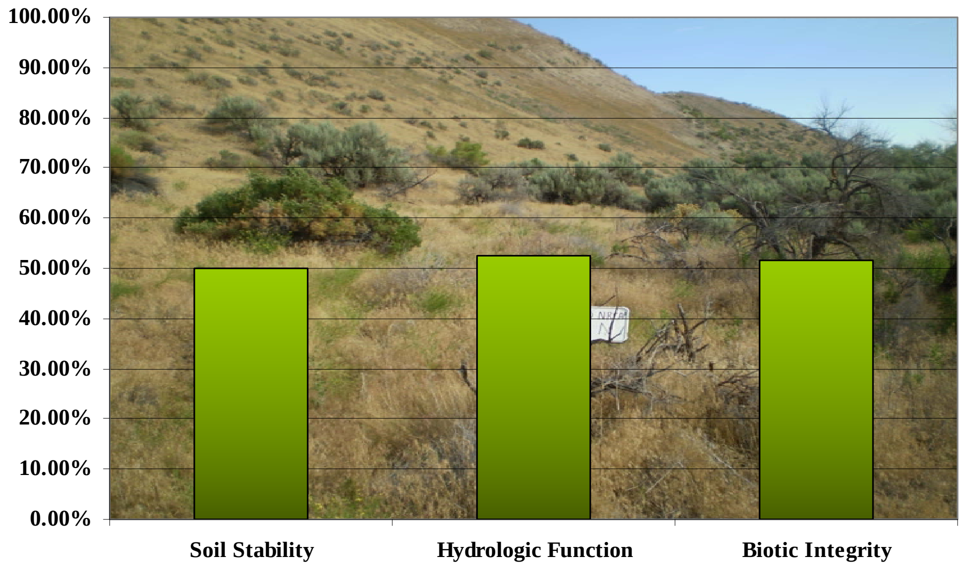

Figure 37. Plot 7 – Percent departure from reference condition of the three landscape attributes in the Sandy 8-14 ARTRT/HECOCO8-ACHY ecological site, Yahoo Creek, HAFO.

Plot 7 is in Quincy loamy fine sand soil which is loamy fine sand over a stratified loam fine sand to silt loam. The potential climax plant community is dominated by the grasses needle and thread (*Hesperostipa comata*) and Indian ricegrass and the shrubs big sagebrush (*Artemisia tridentata*) and antelope bitterbrush (*Purshia tridentata*).

The current shrub vegetation is composed of greasewood (*Sarcobatus vermiculatus*), basin big sagebrush (*Artemisia tridentata tridentata*), shadscale saltbrush (*Atriplex confertifolia*), and rubber rabbitbrush (*Chrysothamnus nauseosus*) in the shrub layer. The grass component is composed entirely of non-native annual grasses, cheatgrass and annual wheatgrass (*Agropyron triticeum*) with no perennial bunchgrasses present. Canada thistle, Russian thistle and tall tumblemustard dominates the forb layer.

Loamy 13-16 ARTRV/PSSPS-FEID Ecological Site: This ecological site is an overlay of soils derived from mixed alluvium and/or colluvium parent materials. The soils are loamy over gravelly loam/extremely gravelly clay with clay in the subsoil. Rooting depth is greater than 60 inches and the soil is well drained.

One plot was sampled in the Loamy 13-16 ARTRV/PSSPS-FEID ecological site in HAFO. Plot 8 is located on the east side of the Snake River on the Research Center on a gently sloping toeslope at an elevation of approximately 2,800 feet (Figure 38). The soil stability and hydrologic function attributes were rated as slight to moderate departure, 22.5% and 35.0%, respectively. The biotic integrity attribute was rated as moderate departure (51.4%) due to the presence of non-native plants and lack of native plants (Figure 39).

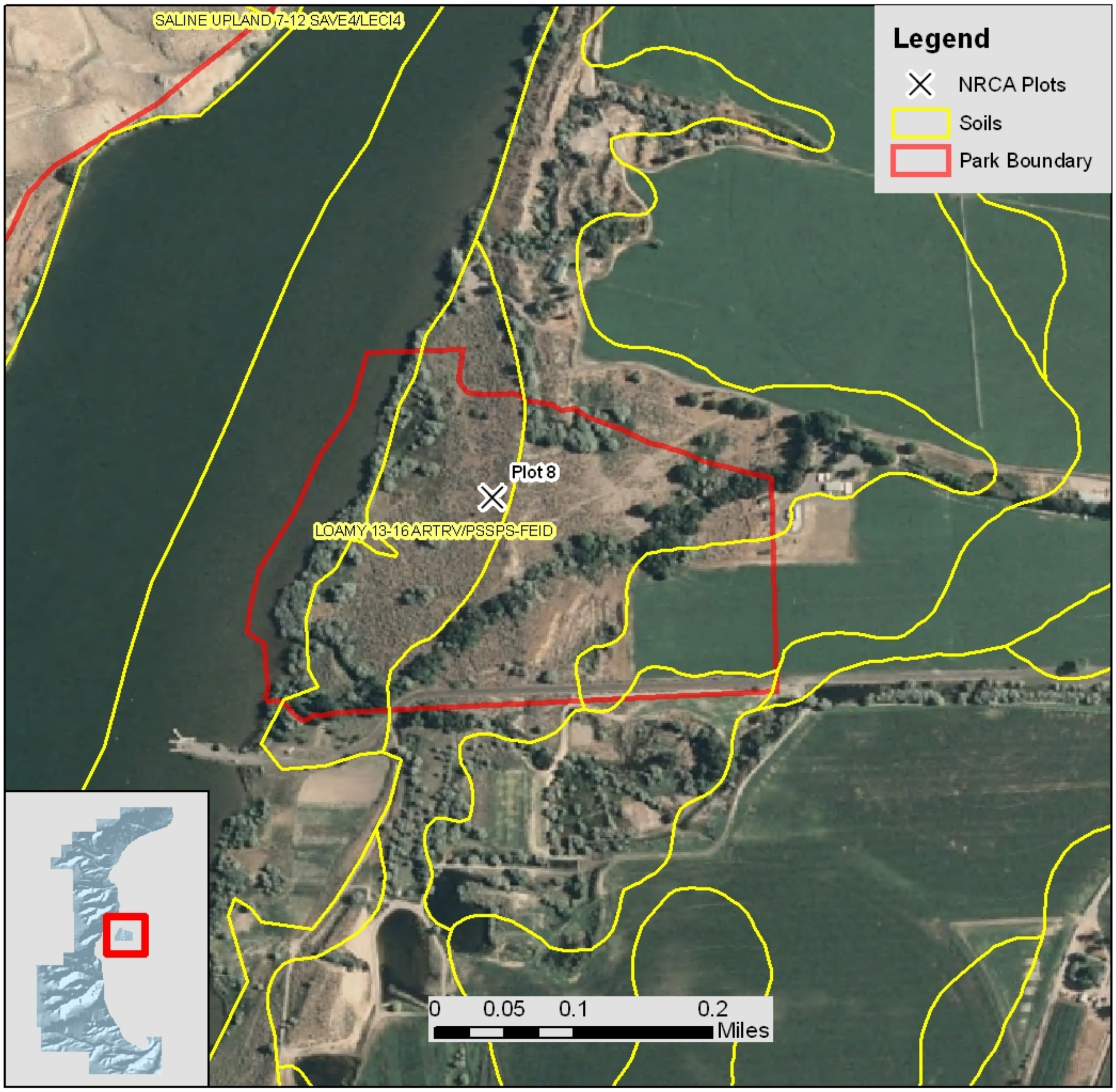

Figure 38. Map of ecological site Loamy 13-16 ARTRV/PSSPS-FEID, plot 8 in Research Center area, HAFO.

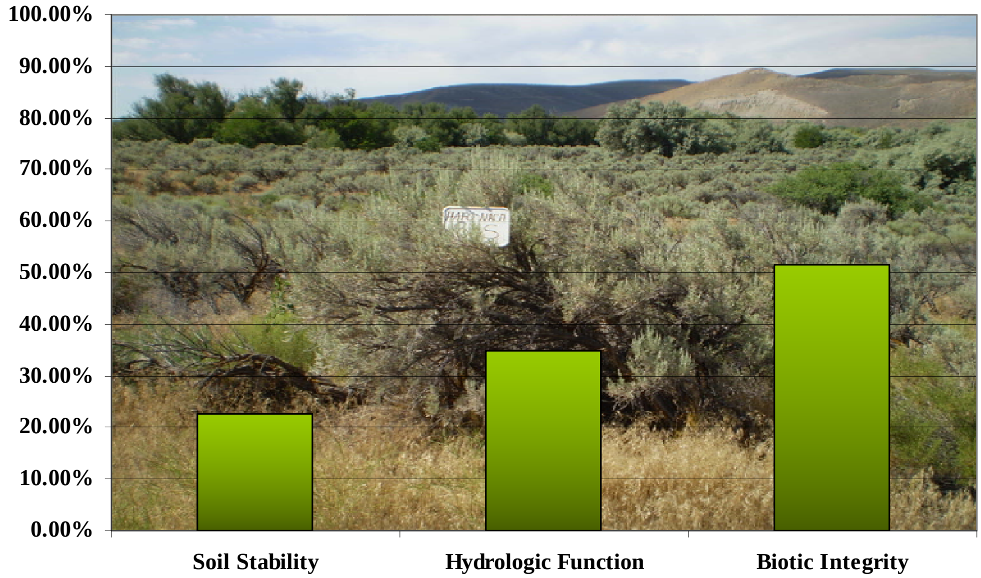

Figure 39. Percent departure from reference condition of the three landscape attributes in the Loamy 13-16 ARTRV/PSSPS-FEID ecological site, Research Center, HAFO (background is plot 8).

Plot 8 is in Isknat loam mixed alluvium and/or colluvium parent materials. The potential vegetation is composed mainly of Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata*) and mountain big sagebrush (*Artemisia tridentata vaseyana*). The current vegetation is composed of a mix of shrub species and primarily annual grasses. The shrub component consists primarily of basin big sagebrush (*Artemisia tridentata tridentata*), fragrant sumac (*Rhus aromatica*), greasewood (Sarcobatus vermiculatus) and rabbitbrush (*Chrysothamnus* spp.). Non-native annual grasses, cheatgrass and seaside barley (*Hordeum marinum*), dominate this component with only a small quantity of native bunchgrass present, spike dropseed (*Sporobolus cryptandrus*). Tall tumblemustard and field bindweed dominate the forb component and are both non-native plants.

Upland Sites

Table 28 is a summary of the departure values by plot for each landscape attribute along with site physiographic information such as slope, aspect, and elevation. Of the eight total plots, five had a soil stability attribute rating of slight to moderate departure from reference condition, one had a none to slight rating and the remaining two had a moderate rating. The hydrologic function attribute rated six out of eight plots in the slight to moderate departure ratings and the remaining two exhibiting a moderate rating. The soil integrity attribute assessment indicated the Monument lands are in good condition, functioning properly and not contributing significantly to soil erosion in their respective watersheds. Based on the current soil stability and hydrologic function ratings, future Monument management should stabilize and improve water quality.

The biotic integrity attribute ratings indicated many areas are not in good condition. No plots were rated in the none to slight departure category (<21%), three fell into the slight to moderate category (21%-40%), four in the moderate category (41%-60%) and one in the moderate to extreme category (61%-80%). Portions of the park have been cultivated in the past and there is history of livestock grazing on-site. The poor biotic integrity attribute ratings indicate three units are in poor condition, but with a change in process to a plan with active vegetation management and species control these ratings should improve.

Table 28. Summary of departure ratings for the three landscape attributes and physiographic attributes for HAFO upland sample plots.

Park Unit	Plot No	Soil Stability % Departure	Hydrologic Function % Departure	Biotic Integrity % Departure	Slope (%)	Aspect (degrees)	Elevation (ft)	Topographic Position
Old Ag Field	1	35.0%	40.0%	68.6%	1	250	3,392	Terrace
Horse Quarry	2	32.5%	25.0%	22.9%	0	0	3,127	Backslope
Horse Quarry	3	30.0%	35.0%	37.1%	56	184	3,200	Backslope
Horse Quarry	4	45.0%	40.0%	31.4%	5	172	2,962	Toeslope
Horse Quarry	5	15.0%	32.5%	60.0%	3	128	2,849	Valley Bottom
Horse Quarry	6	37.5%	47.5%	60.0%	12	122	2,907	Toeslope
Yahoo Creek	7	50.0%	52.5%	51.4%	18	112	2,915	Toeslope
Research Center	8	22.5%	35.0%	51.4%	8	284	2,855	Toeslope

Paleontological and Archeological Resources

Hagerman Fossil Beds National Monument established in 1988, encompasses approximately 4,350 acres in the Snake River canyon in south central Idaho (HAFO 1999, Erixson and Cogan 2009). The Snake River is present through the length of the HAFO Monument and is a major tributary of the Columbia River system that travels through the physiographic region of Idaho known as the Snake River Plain. The Snake River Plain is an extensive land feature present in south central Idaho and is comprised of sediments, lava flows, flood rifts and terraces from the Bonneville Flood, and an abundance of Pliocene fossils found throughout the HAFO Monument area. Where the Snake River Plain meets the Snake River at HAFO, bluffs are created, some extending approximately 500 feet above the River (HAFO 1999, Farmer and Riedel 2003). These bluffs have a complex hydrogeologic system (Farmer 1999) and are prone to landslides which are known to expose fossils (HAFO 1998). These landslides have been cause for concern among Monument managers regarding the safety of visitors, scientists, and excavation workers as well as for the potential loss of valuable fossil resources when slope failures displace large amounts of material toward or into the Snake River (Raytheon 1995, Farmer 1999, HAFO 1999).

Fossils found at the HAFO Monument are predominately Pliocene era dating three to four million years old and are distributed vertically through 152 m (500 feet) of the Glenns Ferry Formation along the banks of the Snake River (Erixson and Cogan 2009). Since the discovery of these fossils by rancher Elmer Cook in the 1920's the most notable find has been the largest most well preserved specimens of "Hagerman Horse" fossils (HAFO 1998). However, there have also been nearly 100 species of other vertebrate fossils found including; 50 mammals, 27 birds, 18 fish, nine reptiles, four amphibians as well as several freshwater snails and clams (HAFO 1999). The Hagerman Fossil Beds General Management plan published in 1996 identified several specific points of "international historic significance" in support of HAFO establishment, resource management and use. The four specific points relating to fossils within HAFO are:

- The Monument contains world-class paleontological resources that include the world's best quality, quantity, and diversity of fossils from the Pliocene time period. This record includes a representation of species present before the last ice age as well as one of the earliest representations of modern flora and fauna globally.

- The paleontological record at HAFO contains a continuous undisturbed stratigraphic representation for at least 500,000 years that includes wetlands, riparian, and grassland savanna organisms. This diversity coupled with Management's dedication to maintain a center for paleontological research has allowed scientists to integrate diverse technologies from alternative fields of science to develop innovative approaches in the science of paleontology.

- "The presence of the Hagerman Horse Quarry is a defining point of HAFO and is recognized as one of the six most complete sites in the world regarding the history on, and specimens of this creature" (MacFadden 1992). There are individuals exhibiting both sexes as well as complete skeletons revealing information representative of the ecology and population structure of these creatures.

- The history of the research at HAFO has provided paleontologists the opportunity for education and interpretation regarding development of the science of paleontology as well as a deeper understanding of the resources itself.

In addition to fossils the HAFO area is rich in archeological remains of human adaptation and inhabitance dating back 15,000 years before the present (B.P.) (HAFO 1999). Researchers have found archeological remains from paleo-people that suggest the use of the HAFO area as subsistence campsites and possibly permanent dwellings. Some of the human related artifacts include spear and hunting projective points as well as evidence that the people of the area hunted large, now extinct mammals, on the Snake River Plain (HAFO 1999). The evidence of these people supports the transition into the Historic period when indigenous people are understood to have established subsistence fishing practices for anadromous fish that came up the Snake River from the Pacific Ocean to the Upper Salmon Falls as described in the HAFO Resources Management Plan (1999). The entire River corridor has been surface surveyed as of 1993 as well as the areas proposed for development of the new visitors center and research laboratory on the east side of the River, surveyed as of 1999 (HAFO 1999).

The Monument is also recognized as one of three units in the national park system to have parts of the Oregon Historic National Trail (HAFO 1996). Shallat et al. (2000) observed that areas of the trail require additional surveys and management as they are being degraded by a handicap access road that leads to a boater recreation ramp near the Visitor's Center. The historic Oregon Trail is recognized as an important part of Idaho State history representing the first euro-American emigrants to the HAFO area (HAFO 1996, HAFO 1998, HAFO 1999).

Noxious Weeds

There are 11 known Idaho State designated noxious weeds present in Hagerman Fossil Beds National Monument. No known weeds from the Early Detection Rapid Response (EDRR) List for Idaho were identified however one is listed for "control" and ten weeds are listed for "containment" (ISDA 2010) as shown in Tables 29 – 30.

Table 29. Known Species on HAFO from the Statewide Noxious Weed Control List.

Common Name	Scientific Name
Perennial Sowthistle	*Sonchus arvensis*

Table 30. Known HAFO species on the Idaho Statewide Noxious Weed Containment List.

Common Name	Scientific Name
Canada Thistle	*Cirsium arvense*
Diffuse Knapweed	*Centaurea diffusa*
Field Bindweed	*Convolvulus arvensis*
Houndstongue	*Cynoglossum officinale*
Puncturevine	*Tribulus terrestris*
Purple Loosestrife	*Lythrum salicaria*
Rush Skeletonweed	*Chondrilla juncea*
Saltcedar	*Tamarix ramosissima*
Scotch Thistle	*Onopordum acanthium*

Common Name	Scientific Name
Spotted Knapweed	*Centaurea maculosa*

Table 31 displays all weeds observed in the HAFO Monument since 1999. The Exotic Plant Management Team (EPMT) publishes an annual report each year encompassing many of the NPS properties. HAFO commonly relies on data provided by the EPMT (EPMT 2007) as there was not an active weed management team on staff as of 2008 (EPMT 2008) and weed management is presently a task assigned to all Park Service staff in addition to their current duties. The spread of invasive and noxious weeds in HAFO to this point is contributed to vehicle use and recreation of Monument visitors; however, as of August 2010 more than 75% of HAFO was burned during the Long Butte Fire placing pressure on natural resource managers for restoration efforts. With the expansive areas of HAFO soil exposed by the fire, restoration and re-vegetation will be crucial in minimizing the further spread or establishment of weeds.

Table 31. This table displays the noxious and invasive weeds of concern identified by multiple resources within HAFO (HAFO 1999, Farmer and Riedel 2003, EPMT 2008, Erixson and Cogan 2009, Rodhouse 2010, ISDA 2010).

Common Name	Scientific Name
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
Cheatgrass	*Bromus tectorum*
Common Mullein	*Verbacum thapsus*
Common reed	*Phargmites australis*
Common teasel	*Dipsacus asper*
Diffuse knapweed	*Centaurea diffusa*
Field bindweed	*Convolvulus arvensis*
Houndstongue	*Cynoglossum officinale*
Medusahead	*Taeniatherum caput-medusae*
Perennial sowthistle	*Sonchus arvensis*
Prickly sowthistle	*Sonchus asper*
Puncturevine	*Tribulus terrestris*
Purple loosestrife	*Lythrum salicaria*
Reed canary grass	*Phalaris arundinacea*
Rush skeletonweed	*Chondrilla juncea*
Russian olive	*Eleagnus angustifolia*
Russian thistle	*Salsola tragus/S. australis*
Saltcedar	*Tamarix* spp.
Scotch thistle	*Onopordum acanthium*
Spotted knapweed	*Centaurea stoebe*
Tumbling mustard	*Sisymbrium altissimum*

Wildfire

Human-caused fires have burned the HAFO area for the past ten thousand years of documented human occupation (HAFO 2001) as Native Americans used fire to manipulate vegetative cover as well as improve feed and habitat for important game species. In a more recent period from 1980 to 2008 there have been seven fires in the vicinity of the HAFO Monument that have exceeded 500 acres in size (FAMWEB 2010). Five of these fires were human caused. The total number of burned acres within the HAFO area from 1980 to 2008 has been approximated at 13,786. Fire suppression and land management activities have the ability to affect plant composition and fire occurrences within HAFO (Morris 2006, Chambers et al. 2008). Over time land uses and alterations to fire regimes can facilitate progressive conversion of ecosystems to more late seral species or a more homogeneous species composition. Predominately invasive grasses establish these more homogenous ecosystems which can further alter fire regimes (Brooks and Pyke 2001) and often support the propagation of invasive species. The integral role of fire in the progression of a landscape through disturbance and nutrient cycling is something natural resource managers are continually considering.

The areas with a plant composition dominated by sagebrush have an average fire-free interval of 20-70 years relevant to topography, fuel load and occurrence of natural ignitions (McArthur et al. 1990). Fire-adapted grasses, such as cheatgrass, which increase fine fuels, the rate of fire spread and thrive in fire dominated ecosystems, can decrease the return interval of fire (Pellant 1996, Link et al. 2006, Kitchen and McArthur 2008) in ecosystems that historically supported fire regimes of 60 to 110 years to as little as three to five years (Whisenant 1990). Within the HAFO reserve, the Hagerman Fire Management Plan (2001) states the establishment of cheatgrass is suspected to alter fire regimes from a historic reoccurrence interval average of 20 to 50 years to as short as nine to ten years. The vegetation found within HAFO prior to the Long Butte Fire suggested fire exclusion had been successfully limited in much of the Monument for years (HAFO 2001) primarily as a result of safety practices for recreational users as well as science and research personnel.

The HAFO area is a middle to lower elevation ecosystem that historically relied on wildfire (Morris 2006) from Native Americans to maintain a composition of sagebrush and grasslands. An increased fire frequency, extent and severity, has the potential to accelerate soil erosion, increasing suspended solids and the turbidity of water sources as well as degrading overall area surface water quality (Neary et al. 2005). During August of 2010 severe alterations to the HAFO area experienced these accelerated changes to its ecosystems as the Long Butte Fire burned more than 75% of the Monument (Lonneker 2010).

The Long Butte Fire was one of the largest fires ever recorded in the HAFO area and is the largest fire on record to occur within the Monument boundaries. The Long Butte Fire varied in intensity and severity across HAFO. Some areas experienced total vegetation loss and the wildfire baked the ground creating hydrophobic soils. Other areas were burned to a lesser degree resulting in the beneficial removal of biomass and enrichment of mineral soils through nutrient cycling.

HAFO Burned Area Emergency Response (BAER) and Burned Area Rehabilitation (BAR) Plans were established in September of 2010 following the Long Butte Fire which burned 3,004 acres

(75%) of HAFO (Janssen 2010). Both of these plans predominately focus on resource conditions published in the General Management Plan of 1996, Resource Management Plan of 1999, Fire Management Plan of 2001 and Water Resources Management Plan of 2003 published by the National Park service, as well as observed post-fire conditions gathered during the 2010 site inspections. The BAER plan identifies six attributes to evaluate within the burned area (Table 32) and provide an introduction of the attribute and a background of the locality as well as the basis for attribute selection. The report also establishes new and updated reclamation objectives for each resource based on an overview of immediate issues and post-fire findings. Additionally, each attribute description also addresses the effects of fire and fire management on the resource of concern and makes specific and non-specific recommendations for action opportunities (Janssen 2010). Included in the Janssen (2010) report are individual specification sheets presenting the calculated costs associated with emergency stabilization and rehabilitation actions detailed to occur within HAFO. These projects total $323,184 with an additional cost of $165,062 for staffing increases and planning.

Table 32. BAER plan attribute identification for significant resources to focus rehabilitation efforts.

Attribute	Number of Specifications Addressing the Attribute	Financial Disbursement
Paleontological Resources	1*	$25,298
Cultural Resources	1	$32,795
Vegetation Resources	4**	$130,596
Soil and Hydrologic Resources	4**	$130,596
Safety and Resource Protection	1*	$25,298
Minor Infrastructure	1	$3,900

"1*" - Total funds for both projects are presented as one project and shown in the "Financial Disbursement" column for the first attribute.

"4" -** There are four projects presented and the funding is shared between the attributes shown.

Following the Long Butte Fire, pre- and post-fire photographs were complied in burned areas across HAFO where vegetation information had been collected (Table 33). The map in Figure 40 shows the mosaic of burn severity and displays the location of vegetation plots within HAFO. These specific locations are presented in further detail in
Figure **41** through Figure 50 which follow the map. These images represent pre- and post-fire pictures taken during the vegetation inventory assessments completed by Northwest Management, Inc. in 2009 and during the NPS post-fire assessments following the fire. The post-fire photographs were chosen with respect to the initial vegetation plots in order to display an accurate representation of the pre-fire vegetation.

Table 33. The data on dominant vegetation for the five plots (2003, 2507, 007, 2013, and 2035) analyzed to compare pre- and post-fire conditions within the Monument.

Scientific Name	Plot No.	Percent Coverage on Plot
Artemisia tridentata tridentata	2003	25 - 35%
Atriplex confertifolia	2003	2 - 4.9%
Sisymbrium altissimum	2003	< 1%
Stanleya pinnata	2003	< 1%
Bromus tectorum	2003	35 - 49.9%
Stanleya pinnata	2507	1 - 1.9%
Bromus tectorum	2507	10 - 14.9%
Bromus tectorum	2507	10 - 14.9%
Artemisia tridentata wyomingensis	2507	10 - 14.9%
Atriplex confertifolia	7	<0.5%
Agropyron cristatum, sensu amplo	7	25 35%
Bromus tectorum	7	1 - 1.9%
Poa secunda, sensu stricto	7	<0.5%
Chorispora tenella	7	2 - 4.9%
Camelina microcarpa	7	<0.5%
Lactuca serriola	7	<0.5%
Descurainia sophia	7	<1%
Sisymbrium altissimum	7	<0.5%
Artemisia tridentata wyomingensis	2013	10 - 14.9%
Chrysothamnus viscidiflorus viscidiflorus	2013	2 - 4.9%
Balsamorhiza sagittata	2013	<1%
Chrysothamnus nauseosus	2013	<1%
Astragalus whitneyi confusus	2013	<1%
Leptodactylon pungens pungens	2013	1 - 1.9%
Lupinus leucophyllus	2013	1 - 1.9%
Lactuca serriola	2013	<1%
Eriogonum ovalifolium	2013	<1%
Crepis acuminata	2013	<1%
Elymus smithii	2013	<1%
Poa secunda, sensu stricto	2013	1 - 1.9%
Elymus cinereus	2013	<1%
Elymus elymoides	2013	1 - 1.9%
Stipa hymenoides	2013	<1%
Stipa thurberiana	2013	<1%
Bromus tectorum	2013	<1%
Artemisia tridentata wyomingensis	2035	25 - 35%
Sarcobatus vermiculatus	2035	2 - 4.9%
Atriplex confertifolia	2035	<1%
Lactuca serriola	2035	<1%
Descurainia sophia	2035	<1%
Bromus tectorum	2035	10 - 14.9%

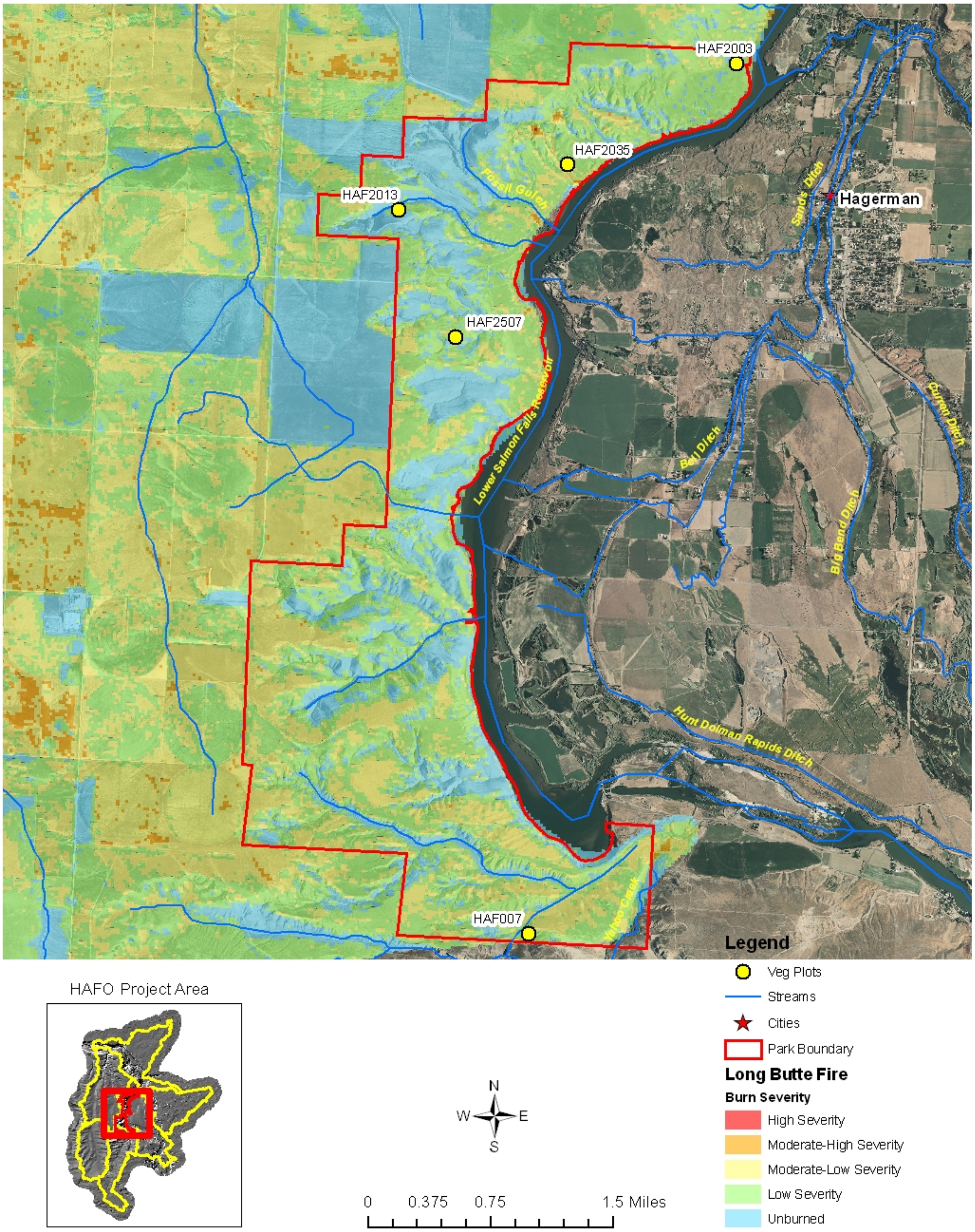

Figure 40. This map of Hagerman Fossil Beds National Monument displays burned severity following the Long Butte Fire of 2010 as well as the locations of vegetation plots with pre- and post-fire assessment images (Lonneker 2010).

Figure 41. Plot No. 2003 located in the Northern most reaches of the Monument was comprised of Artemisia tridentata tridentata/Bromus tectorum plant community type prior to the Long Butte Fire. The dominant vegetation within the observation plot no. 2003 was composed of cheatgrass (Bromus tectorum) 35 to 49.9% and Wyoming big sagebrush (Artemisia tridentata var. wyomingensis) 25 to 35%.

Figure 42. Plot No. 2003 located in the Northern most reaches of the Monument after the Long Butte Fire in 2010, indicated as low burn severity on the Burn Severity map.

Figure 43. Plot No. 2507 located near the middle portion of the Monument traveling from north to south. This plot was an observation plot where only the dominant species present where recorded. This plot was comprised of Artemisia tridentata wyomingensis plant community type prior to the Long Butte Fire. The dominant vegetation within the observation plot no. 2507 was composed of cheatgrass (Bromus tectorum) 10 to 14.9% and Wyoming big sagebrush (Artemisia tridentata var. wyomingensis) 10 to 14.9%.

Figure 44. Plot No. 2507 located near the middle portion of the Monument traveling from north to south after the Long Butte Fire in 2010, indicated as low burn severity on the Burn Severity map.

Figure 45. Plot No. 007 located near the Southern reaches of the Monument was comprised of Agropyron cristatum - Herbaceous vegetation plant community type prior to the Long Butte Fire. The dominant vegetation within plot no. 007 was desert wheatgrass (Agropyron cristatum, sensu amplo) at 25 to 35%.

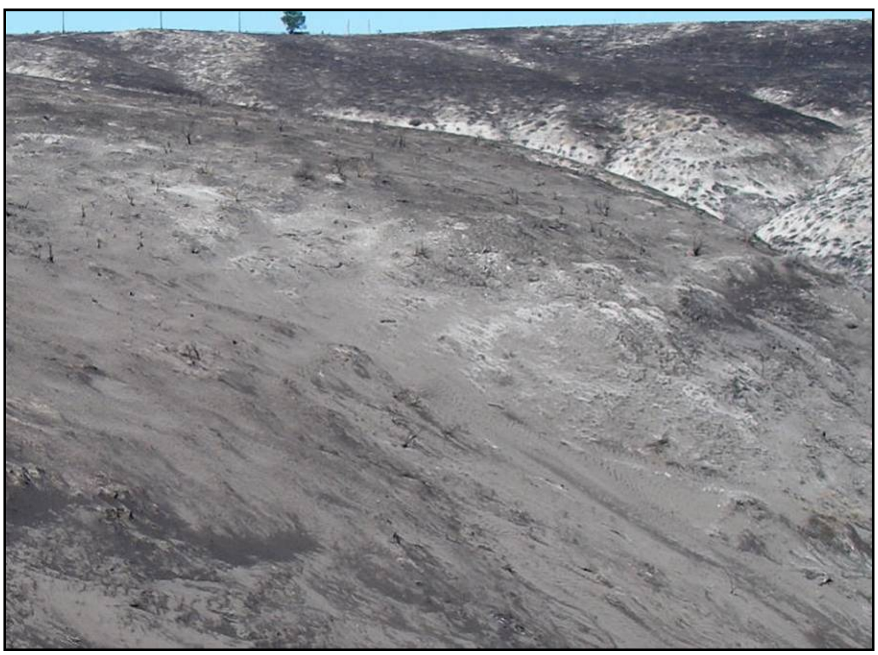

Figure 46. Plot No. 007 located near the Southern reaches of the Monument after the Long Butte Fire in 2010, indicated as low burn severity on the Burn Severity map.

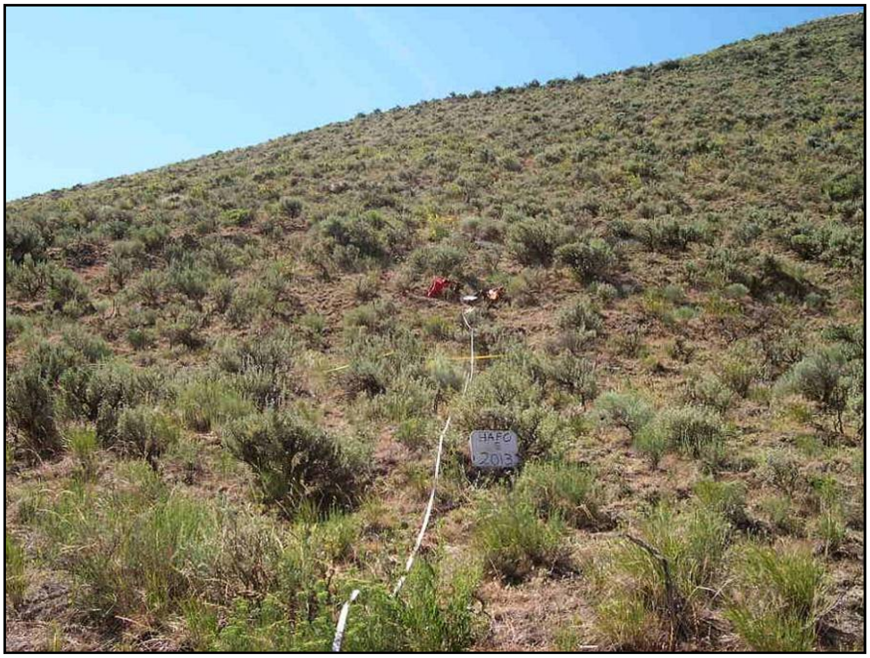

Figure 47. Plot No. 2013 located on the Northern half of the Monument on the higher elevation slopes above the Snake River. This area was comprised of an Artemisia tridentata tridentata/Bromus tectorum plant community type prior to the Long Butte Fire. The dominant vegetation within plot number 2013 was Wyoming big sagebrush (Artemisia tridentata wyomingensis) at 10 to 14.9%.

Figure 48. Plot No. 2013 located on the Northern half of the Monument on the higher elevation slopes above the Snake River after the Long Butte Fire in 2010, indicated as low to moderate-low burn severity on the Burn Severity map.

Figure 49. Plot No. 2035 located on the Northern half of the Monument on the lowland areas near the Snake River. This area was comprised of an Artemisia tridentata wyomingensis /Bromus tectorum plant community type prior to the Long Butte Fire. The dominant vegetation in plot number 2035 was Wyoming big sagebrush (Artemisia tridentata wyomingensis) 25 to 35% and cheatgrass (Bromus tectorum) 10 to 14.9%.

Figure 50. Plot No. 2035 located on the Northern half of the Monument on the lowland areas near the Snake River, after the Long Butte Fire in 2010, indicated as low to moderate-low burn severity on the Burn Severity map.

Areas dominated by sagebrush and mixed grass species can have an average fire-free interval of 20-70 years depending on topography, fuel load, and the occurrence of natural ignitions. However, fire-adapted grasses such as cheatgrass, which increase fine fuels, the rate of fire spread and thrive in fire-dominated ecosystems can decrease the return interval of fire (Link et al. 2006, Kitchen and McArthur 2008, Reid et al. 2008) in ecosystems that historically supported fire regimes of 60 to 110 years to as little as three to five years (Whisenant 1990). An increased fire frequency, extent, and severity has the potential to accelerate soil erosion which increases suspended solids and the turbidity of water sources across the Monument as well as within the Snake River degrading overall water quality (Neary et al. 2005).

Air Resources

The ambient air quality in Hagerman is said to be very good. The airshed around Hagerman is considered a Class II area under the 1977 Clean Air Act Amendments and the only exception to nearly perfect air quality, results from strong winds blowing over tilled agricultural fields and periodic field burning (HAFO 2001). Since the 1970's the NPS has operated on a system of "vital sign" monitoring as part of their comprehensive air quality monitoring program (NPS 2004) This program was established to collect air quality, ozone, atmospheric wet and dry deposition and assess visibility. In 2001 an assessment of ozone at a nearby NPS unit (City of Rocks National Reserve) known as CIRO, was performed through the use of kriging data collected from 1995 to 1999 (UCBN 2001).

The UCBN (2001) assessment identified three species sensitive to ozone and listed the potential for degradation of vegetation at CIRO as "moderate" due to the existence of threshold levels of ozone within a 90-day period. The sensitive species identified at the Reserve were considered bioindicator species potentially capable of assisting managers with the identification of degradation effects from ozone. These species do not exist at HAFO, however, the method for evaluating ozone levels from off-site data could assist the Monument's natural resource managers as both NPS units are located in southern central Idaho and exhibit similar climate and vegetative attributes. Additionally, available ozone data is collected throughout the Treasure Valley north of HAFO and has the potential to be more relevant to the Monument using the same method of kriging used at the CIRO Reserve.

The Idaho Department of Environmental Quality has three ozone sensors in the Treasure Valley, one in Kootenai County on the Rathdrum Prairie near Coeur d'Alene and plans for a fourth one in the Treasure Valley pending funding (IDEQ 2009). There are three styles of ozone monitoring commonly recognized by the National Park Service; continuous, portable continuous, and integrated passive. Continuous ozone monitoring is accomplished through the use of permanent site equipment designed to collect hourly data per Code of Federal Regulations (CFR) 40 part 50 and is common when regulatory compliance is desired. These sites are required to have a temperature controlled shelter, AC electrical power, a telephone and are expected to need four to six hours of onsite service per week and biannual calibrations (NPS 2004). Portable continuous monitoring is intended for short-term seasonal use when regulatory compliance is not desired. The equipment is usually battery or solar powered and complies with the EPA regulations for hourly data collection. Portable sites are expected to need one to two hours of onsite service per week after being calibrated during setup (NPS 2004). Integrated passive ozone monitoring requires fixed sampling instruments designed for weekly average measurements through analysis in an off-site laboratory. These stations do not meet EPA regulations and are commonly used to evaluate the need for continuous monitoring station establishment because they are the least expensive system of the three described (NPS 2004).

Wildlife

The HAFO Monument consists of one large area west of the Snake River where the terrain is comprised of steeply sloping bluffs and ridges and a second smaller area to the east of the River that slopes slightly to the west and transitions to nearly flat. The west majority of the Monument is generally oriented east to west with exposed slopes facing east. There are ten seasonal streams, some springs and numerous seeps located within the park boundary including three of the more well known seasonal streams being; Peters Creek, Fossil Gulch and Yahoo Creek (Farmer and Riedel 2003, NRCS 2010). The drainages of these streams are typically in steeper terrain or bluffs surrounding the Monument and provide one of the only sources of water for wildlife and vegetation. The composition of these varying habitats isolated by the availability of water often supports many diverse species affording managers the opportunity to observe local ecological processes. These observations can assist managers in the development of multifaceted plans and goals aimed at conservation objectives.

It should be noted that after the field research and data collection in this area a majority of the Monument was burned by a large fire. The Long Butte Fire occurred in August 2010 and dramatically altered most of the natural vegetation throughout the HAFO Monument (Lonneker 2010). More than 75% of the Monument was burned degrading large areas of habitat affecting the resident species. Changes of this magnitude place pressure on natural resource managers to preserve and restore historic conditions, vegetation, and ecosystems in order to maintain the biodiversity of HAFO.

The NPS published a species list for HAFO in 2010 which identified 200 bird, 35 mammal, 17 reptile, eight amphibian and one fish species that were either present or possibly present within the bounds of the Monument (NPS 2010). The aquatic species listed for HAFO are; Steelhead (*Oncorhynchus mykiss*), small-mouth bass (*Micropterus dolomieui*), chub (*Couesius plumbeus*), suckers (*Catostomus* spp.), non-native carp (*Cyprinus carpio*), and sturgeon (*Acipenser transmontanus*) (Cole 1995, HAFO 1999, NPS 2008), along with five known sensitive plants; the wollypod milkvetch (*Astragalus purshii ophiogenes*), stream orchid (*Epipactis gigantea*), Shockley's buckwheat (*Eriogomun shockleyi shockleyi*), Torrey's blazingstar (*Mentzelia torreyi acerosa*), and Antelope Valley Beardtongue (*Penstemon janishiae*) (Cole 1995). There is one known federally listed threatened or endangered species the bald eagle (*Haliaeetus leucocephalus*) which is a delisted species suggested to be monitored and is known to be transitory within the Monument's boundary primarily during the fall and winter months (NPS 2008).

The HAFO species list also inventoried four amphibian species present in the park which include the western toad (*Bufo boreas*), Great Basin spadefoot (*Spea intermontana*), American bullfrog (*Rana catesbeiana*) and pacific chorus frog (*Pseudacris regilla*) and refers to four other species probably present in the park but not confirmed. Additionally, ten reptile species were documented, four more are probably present and include; the Nightsnake (*Hypsiglena torquata*), valley garter snake (*Thamnophis sirtalis fitchi*), long-nosed leopard lizard (*Gambelia wislizenii*), and the western skink (*Eumeces skiltonianus*) as well as three other unconfirmed species including the rubber boa (*Charina bottae*), long-nosed snake (*Rhinocheilus lecontei*), and the western ground snake (*Sonora semiannulata*) (NPS 2010). Lastly, of the 35 mammal species identified 26 were confirmed to be present on HAFO, nine mammal species probably present and one species, the short-tailed weasel (*Mustela erminea*) is unconfirmed at this time. A list of all species and their occurrence in HAFO can be found on the National Park Service website (NPS 2010b).

There are no species of bats listed on the NPS 2010 species list for HAFO; however a study by Ave et al. (2004) confirmed there were eight species of bats present in and around the HAFO area using passive and active sonar. During this study the team also potentially identified the presence of one other species; the Hoary bat (*Lasiurus cinereus*) not thought to reside in HAFO. A list of the bat species assumed to occur at the HAFO Monument and the surrounding area is presented in Table 34. Two other species, the California myotis (*Myotis californicus*) and the silver-haired bat (*Lasionycteris noctivagans*) were not confirmed during data collection however are presumed to be present in the area (Ave et al. 2004). Due to the importance of bats in Idaho and the number of bat species listed as state or federal species of concern, future monitoring efforts should target these unique vertebrates at the HAFO Monument.

Table 34. Bat species detected and thought to be present through various acoustic recordings at HAFO (Ave et al. 2004).

Common Name	Scientific Name	Detection Type
Big brown bat	*Eptesicus fuscus*	Active Anabat
Hoary bat	*Lasiurus cinereus*	Passive Anabat (?)
Little brown myotis	*Myotis lucifugus*	Active Anabat
Long-eared myotis	*Myotis evotis*	Active Anabat
Pallid bat	*Antrozous pallidus*	Active Anabat
Townsend's big-eared bat	*Corynorhinus townsendii*	Active Anabat
Western pipistrelle	*Pipistrellus hesperus*	Sonobat
Western small-footed bat	*Myotis ciliolabrum*	Passive Anabat
Yuma myotis	*Myotis yumanensis*	Passive Anabat

Climate

The Intergovernmental Panel on Climate Change (IPCC), a scientific intergovernmental body set up by the World Meteorological Organization and by the United Nations Environment Program, focuses on climate change impacts, adaptation, and vulnerability. Generally, climates in this region become warmer and drier when assessed in a southerly direction from the Northern Rockies and the Upper Columbia Basin toward Arizona and New Mexico. Climate change and the effects of variations in precipitation, biodiversity, and temperature are a focus in natural resource management and more specifically throughout the western United States over the past three decades (Ashton 2009). Managers in the west are being asked to evaluate natural resource prescriptions based on ecological responses to climate trends in regard to geopolitical and climatic boundaries to better identify system vulnerabilities and determine resource conservation targets (Ashton 2009).

The majority of precipitation derived for this region transpires from polar air masses colliding with air from the Gulf of Mexico (McWethy et al. [In Press]) as well as influential prevailing winds from the Pacific Ocean (Kittel et al. 2002). Trends in precipitation have been less identifiable for the Rocky Mountain regions (McWethy et al. [In Press]) and speculation points to the influences of drought conditions over the regions recent history (Ray et al. 2008). However, fluctuations in precipitation for the northwestern United States have been documented by Mote *et al.* (2005) for the past century. Data showing increases in steam hydrograph fluctuations related to spring runoff (Winkler et al. 2005), as well as lower April 1st snow water equivalent (SWE) values and shallower snowpack depths (Palmer 1988, Kattelmann and Elder 1993) demonstrate some of the critical influences climate change can have at a watershed scale (McWethy et al. [In Press]).

At HAFO the four seasons are distinct, however, spring is early, often beginning in March and winter is late, often beginning in late October. HAFO is characterized by a plateau/continental interior climate, averaging 11.4 inches (28.9 cm) of precipitation annually (Figure 51) with prevailing winds from the west at an average wind speed in the Monument vicinity of approximately 11.2 mph (18.2 km/h). Precipitation is weighted toward the winter and spring months. Snowfall averages approximately 29 inches (73.6 cm) annually with December and January having the heaviest accumulations.

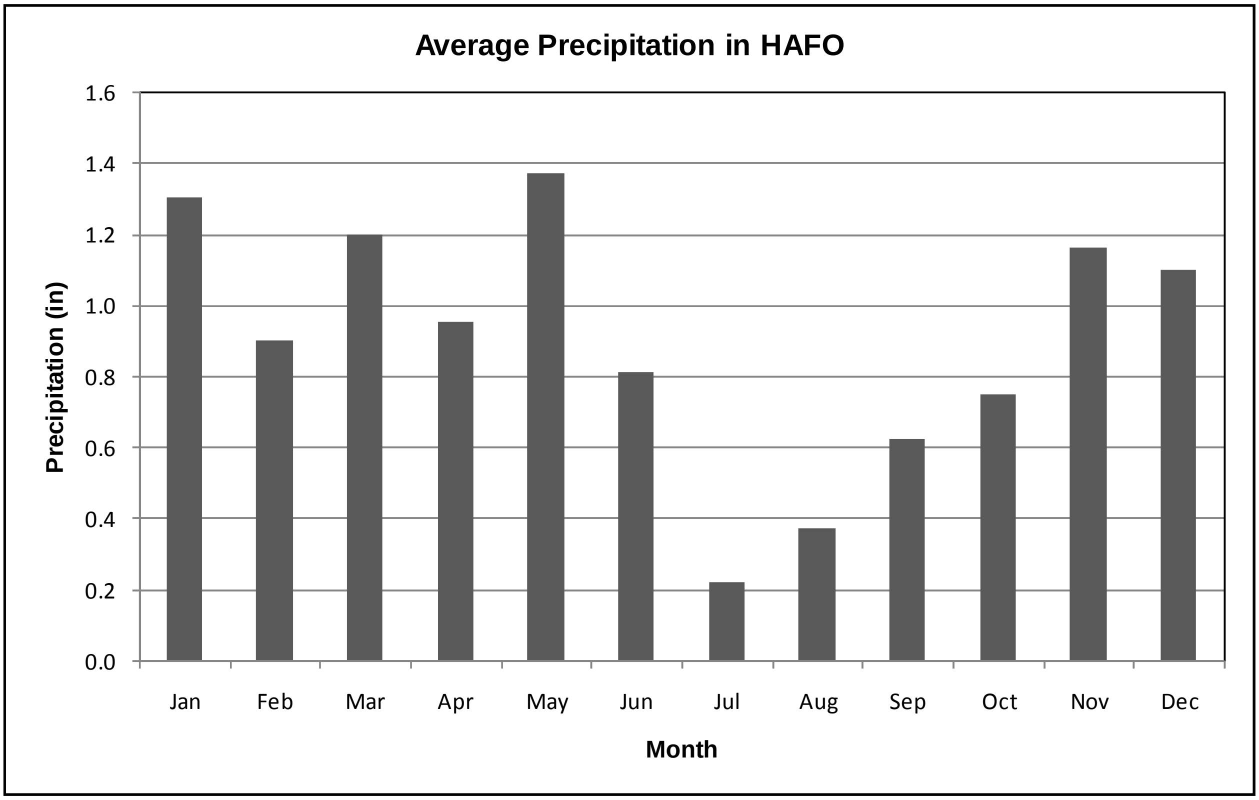

Figure 51. Average precipitation at HAFO.

Due to the presence of four seasons the conditions within the Monument change significantly throughout the year; summers are moderately long with hot days averaging 81.6 °F (27.6 °C) and warm nights averaging 52.4 °F (11.3 °C) in July (Figure 52). The hottest days typically approach or exceed 100 °F (38 °C) and temperatures of the exposed soil can reach 120 ^{o}F (48.9 ^{o}C) (HAFO 2001). Winters are relatively cold with an average maximum temperature of 37.9 °F (3.3 °C) and an average minimum temperature of 20.6 °F (-6.3 °C) usually occurring in January. These climatic variations combine at HAFO to create a relatively short growing season of approximately 135 days (NRCS 2009).

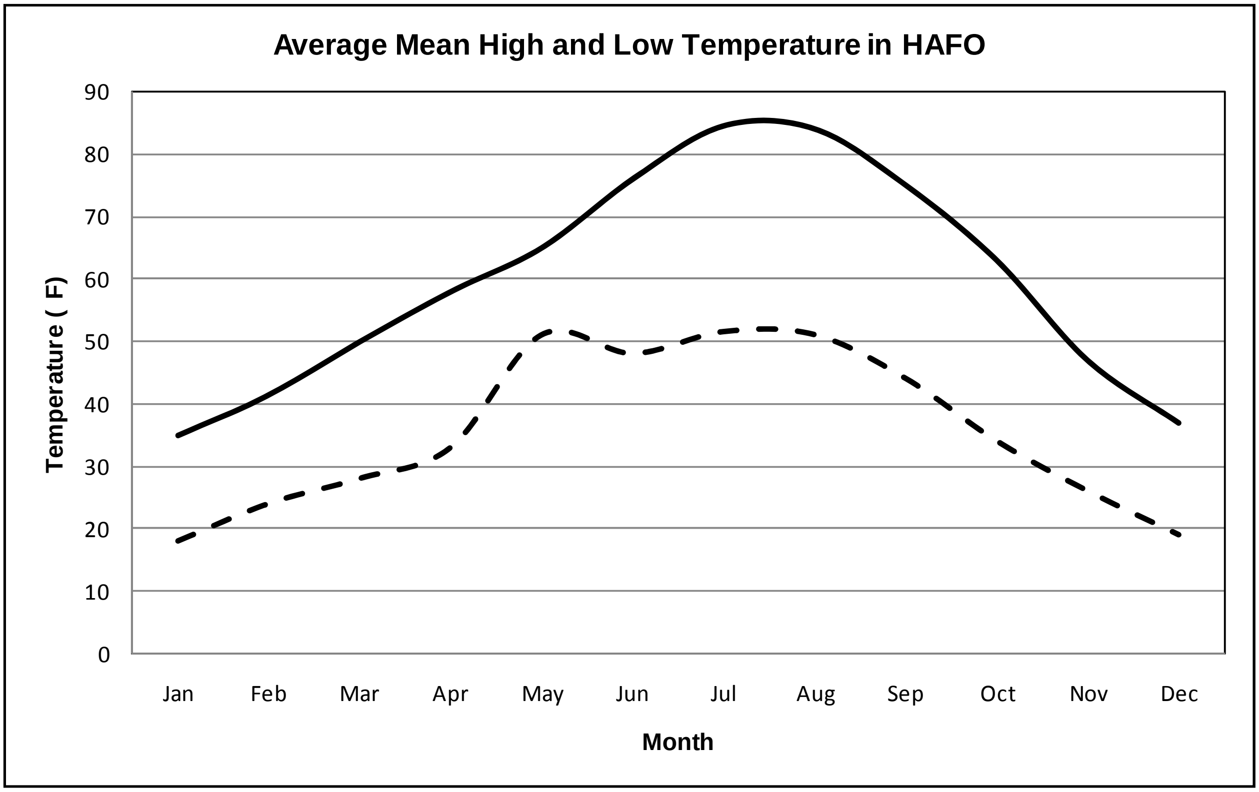

Figure 52. Average mean high/low temperature at HAFO.

Winter snowpack depth may be the most crucial climatic attribute for general management of watersheds and the accounting of water availability in the United States. Winter snow fall throughout the western United States accounts for more than 60% of renewable annual water supply in the form of spring runoff and sustained seasonal streamflow (Changnon et al. 1991, Serreze et al. 1999, Fassnacht 2004). As data is gathered on the response of ecosystems to variations in climate, winter precipitation and temperature change have become pivotal issues for natural resource management plans and future research (McWethy et al. [In Press]).

Water Resources

Riparian Area Assessments

This section and Table 35 provide a summary of PFC assessment results and a detailed description of conditions encountered at each site. The lentic site (Bell Ditch Wetland) received a functional rating of PFC while the four lotic sites all received a functional rating of “Functional-At Risk,” with either a “downward” (i.e., moving away from functional) or “not apparent” trend.

Sites were assessed using the “proper functioning condition” (PFC) riparian assessment methodology developed by the Bureau of Land Management for lotic-flowing water habitats and lentic-pond and lake habitats (Prichard et al. 1998, Prichard et al. 2003). The Bell Ditch wetland area received a “Proper Functioning Rating” as the wetland area was observed to be adequately functioning for a lentic aquatic area. This wetland should continue to provide beneficial hydrologic functions due to the maintenance and protection of irrigation by NPS personnel. All four lotic sites along the Snake River were rated “Functional - At Risk” with sites 1 and 3 having a downward trend and sites 2 and 4 having no apparent trend. “Functional – At Risk” riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. Part of this downward trend can be attributed to the controlled water levels from the Lower Salmon Falls dam as well as diking for agricultural production which also contributes to the reduced riparian hydrology for these sites. The factors resulting in “Functional - At Risk” ratings are beyond the control of HAFO park managers.

Table 35. Summary of results of HAFO PFC Assessment.

Site	Functional Rating	Trend for Functional - At Risk
Lentic Site		
Bell Ditch Wetland	Properly Functioning	n/a
Lotic Sites		
Snake River 1	Functional - At Risk	Downward
Snake River 2	Functional - At Risk	Not Apparent
Snake River 3	Functional - At Risk	Downward
Snake River 4	Functional - At Risk	Not Apparent

Lentic Evaluation

The Bell Ditch Wetland was selected by field personnel based on the desire of NPS personnel to assess its functionality. The site was assessed using the lentic PFC methodology (Prichard et al 2003).

<u>*Bell Ditch Wetland*</u>: Bell Ditch, assessed in August 2009 (Figure 53), is a spring-fed ditch that has been channelized and moved to its existing location to maximize agriculture production in the Hagerman valley. The Ditch is used to provide irrigation to crops and also conveys irrigation runoff water to the Snake River (i.e., agriculture drain). The Bell Ditch Wetland assessed within the Monument is a small depressional wetland located within the riparian area of Bell Ditch, approximately one quarter mile from the mainstem of the Snake River.

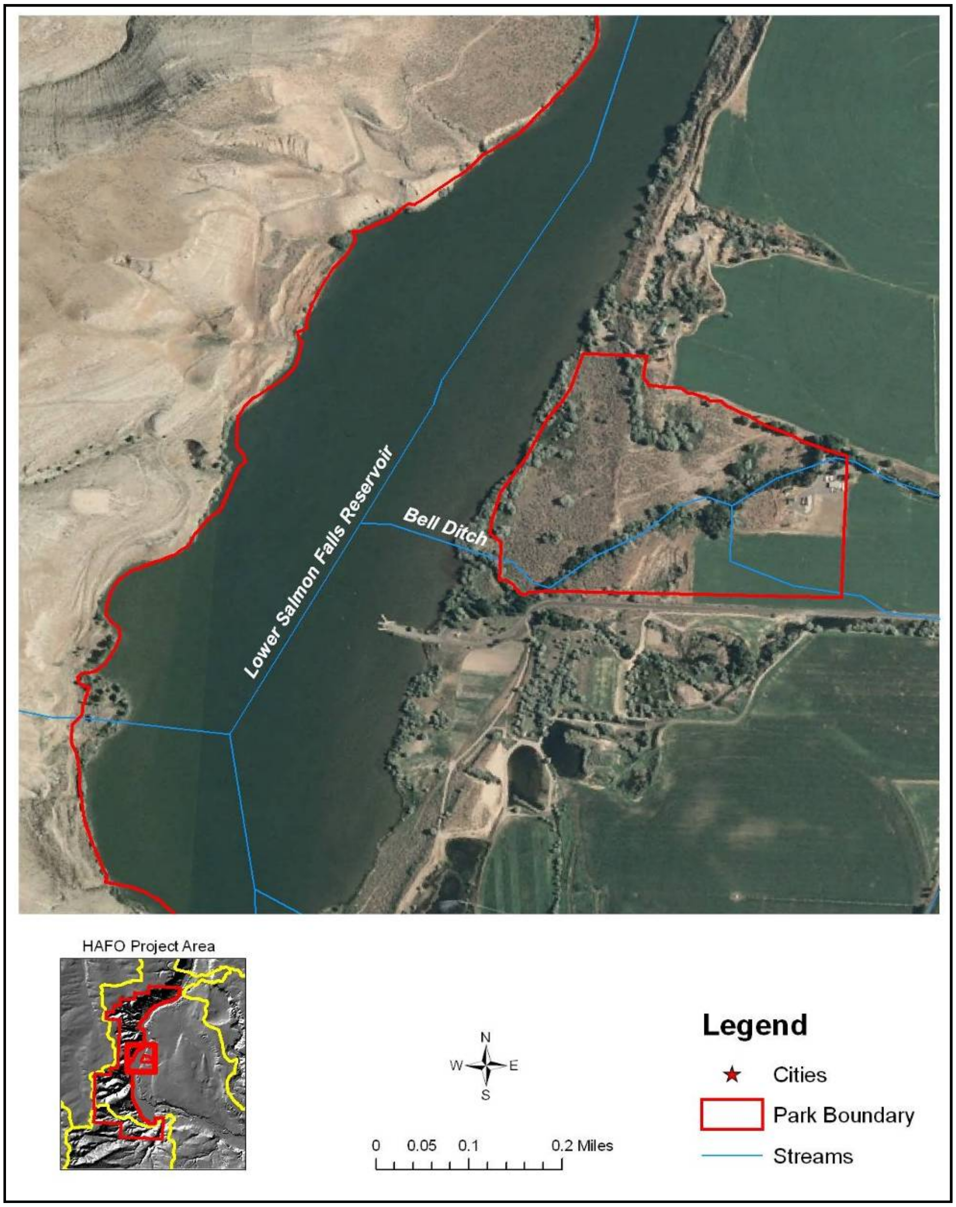

Figure 53. Site map of Bell Ditch Wetland.

The Bell Ditch Wetland receives adequate hydrology to maintain wetland characteristics, both from surface flows and from natural spring water associated with Bell Ditch. The wetland was saturated near the surface during the August site visit and fluctuation of water levels at the site does not appear to be excessive. The presence of obligate wetland species, such as cattails (*Typha* spp.) and other hydrophytic vegetation indicates water quality is sufficient to support riparian-wetland plants (Figure 54). Natural surface and subsurface spring flows have not been altered by disturbance (e.g., hoof action, trails, roads, etc.) to a point where hydrology has been reduced. Although the upland watershed, which is comprised of agriculture and urban land uses, is not in pristine condition, it does not appear to be degrading wetland conditions (e.g., sedimentation, excessive runoff, etc.) at this site.

A majority of the vegetation in the Bell Ditch Wetland, including cattails (*Typha* spp.), sedges (*Carex* spp.), and willows (*Salix* spp.), is classified as hydrophytic and exhibited high vigor during the August 2009 site visit. The presence of hydrophytic vegetation indicates that riparian-wetland soil moisture characteristics are maintained. The wetland contained moderate to high age-class distribution and species diversity, which provides adequate riparian-wetland vegetative cover to protect the soil surface and dissipate energy during overland flows. Favorable microsite conditions are maintained at this depressional wetland because surface water tends to funnel to the site from adjacent uplands. Indicators of abnormal hydrologic heaving due to frost or ice build-up were not observed at the site.

Excessive erosion or deposition was not observed at the Bell Ditch Wetland, indicating that the wetland is in balance with the water and sediment being supplied by the watershed. The high vigor of the plant species observed indicates accumulation of chemicals is not affecting plant productivity or composition. The frequency and duration of hydrologic inputs, and the underlying geologic structure and soil material that is capable of restricting water percolation, allows sufficient composition and maintenance of hydric soils.

The PFC evaluation of the Bell Ditch Wetland resulted in a summary determination of "Proper Functioning Condition" (Appendix C). PFC lentic riparian-wetland areas are functioning properly, which means they are in a state of resiliency that allows the wetland to hold together during wind and wave action events or overland flow with a high degree of reliability, thereby reducing erosion and improving water quality. PFC lentic riparian-wetlands also adequately filter sediment and aid in floodplain development, improve floodwater retention and groundwater recharge, develop root masses that stabilize islands and shoreline features against cutting action, restrict water percolation, provide adequate wildlife habitat, and support greater biodiversity. The Bell Ditch Wetland adequately performs all of these functions and should continue to provide these functions due to the maintenance and protection of conditions by NPS personnel.

Figure 54. Photo of Bell Ditch Wetland.

Lotic Evaluation

NPS personnel indicated a desire to assess the functionality of left-bank Snake River riparian wetlands at Hagerman Fossil Beds. Field personnel analyzed aerial photographs prior to the August site visit and selected four sites within the Snake River riparian area for assessment. The sites were located within the influence of the Lower Salmon Falls Dam and Reservoir and were assessed using the lotic PFC methodology (Prichard et al. 1998) in August 2009.

Snake River 1: The Snake River 1 site was the upstream-most site assessed during August 2009 (Figure 55) and is located approximately one and one-half miles downstream of Upper Salmon Falls Dam. The site is located at the delta of a seasonal drainage flowing to the Snake River from the west. At this location, the channel is not subjected to frequent high flows or seasonal fluctuations in water level due to controlled water levels in the Lower Salmon Falls Reservoir. Evidence of inundation of the floodplain above bankfull width was not observed. The sinuosity, width-depth ratio, and channel gradient are appropriate and in balance with the relatively steep-sided, low-gradient valley floor.

Due to the steep nature of the river banks and presence of dikes along portions of the river's right bank, this system has very little potential for a significant riparian-wetland area and therefore the riparian-wetland area has achieved its potential extent. The upland watershed is comprised of steep, undeveloped bluffs rising in elevation to agricultural land uses on the Snake River plain. The degraded portions of the upland watershed appear to be buffered from the Snake River 1 wetland and do not contribute to riparian-wetland degradation.

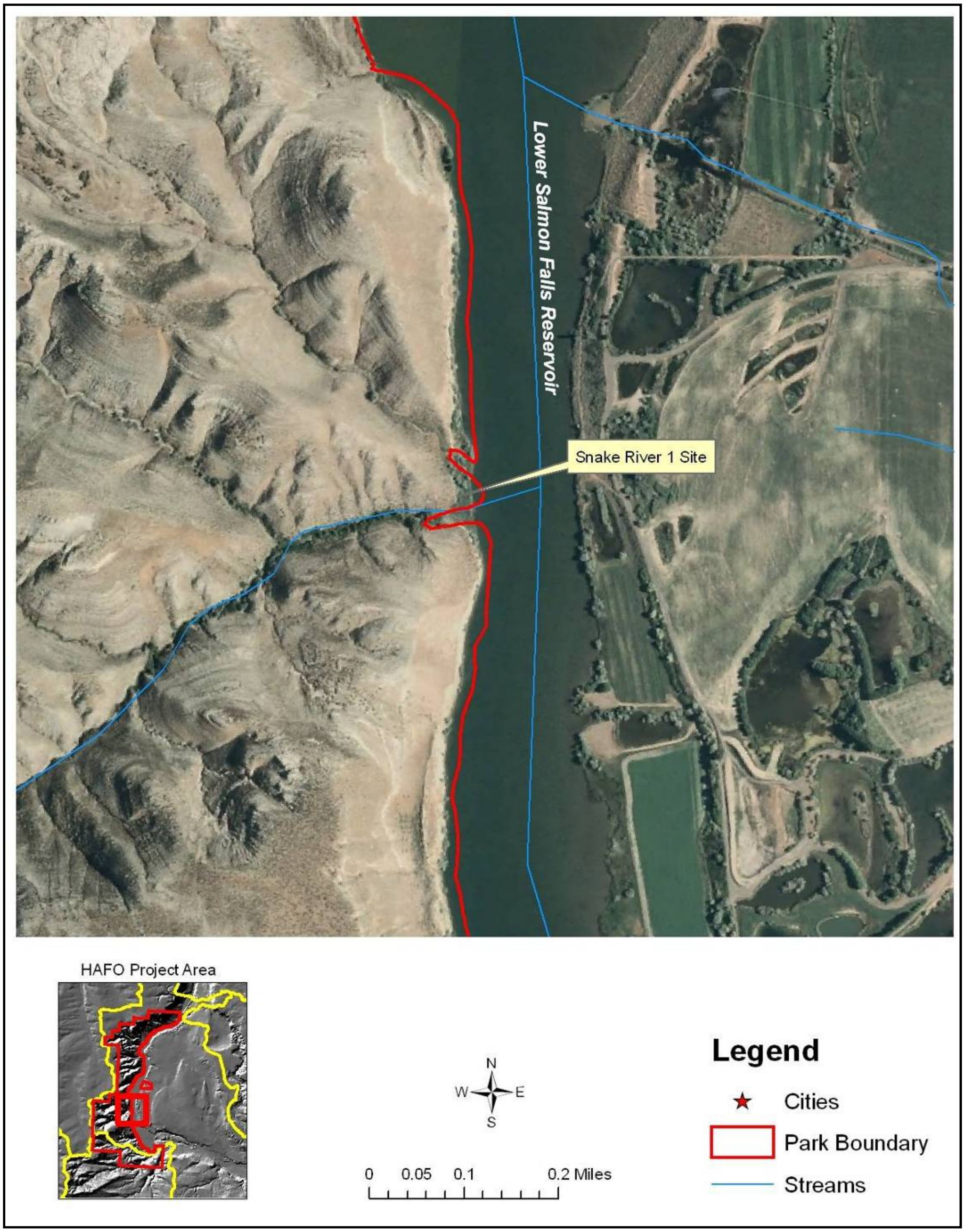

Figure 55. Map of Snake River 1 site.

The plant community at the Snake River 1 lotic assessment site was mostly comprised of riparian wetland vegetation with some upland species also present. Age-class distribution and species diversity of on-site riparian vegetation was moderate to high and was dominated by yellow willow (*Salix lutea*) and sandbar willow (*Salix exigua*), both obligate wetland species (Figure 56).

The presence of native riparian species indicates maintenance of riparian-wetland soil moisture characteristics, and typically provides root masses capable of withstanding high streamflow events, which protects against erosion of the river bank. Invasive species present at the site include Canada thistle, cheatgrass, Russian olive, knapweed (*Centaurea stoebe*), and hounds tongue (*Cynoglossum officinale*). The riparian-wetland plants present exhibit low vigor and appeared stressed due to a lack of sufficient hydrology, which may reduce their ability to withstand high streamflow events. However, given the infrequency of high streamflow events at this site due to controlled water levels in the Lower Salmon Falls Reservoir, the riparian-wetland vegetative cover is adequate to protect banks and dissipate energy during infrequent high flows.

The Snake River 1 lotic assessment site is subject to infrequent high flows because of controlled water levels in the Lower Salmon Falls Reservoir and dikes along portions of the river. Despite the lack of lateral stream movement associated with natural sinuosity, the floodplain and channel characteristics are adequate to dissipate the minimal energy associated with any water fluctuations. The system is vertically stable due to the stable flow structure and low gradient. No excessive erosion or deposition of sediment appeared to be occurring at the site.

The PFC evaluation of the Snake River 1 lotic site resulted in a summary determination of "Functional – At Risk" (Appendix B). "Functional – At Risk" riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. When this rating is assigned to a stream or river reach, then its "trend" toward or away from PFC is assessed. In this case, the Snake River 1 lotic site appears to trend away from PFC because there is insufficient riparian hydrology resulting from controlled water levels in the Lower Salmon Falls Reservoir, diking along the river for agriculture production, and lack of lateral stream movement associated with natural sinuosity, which inhibits floodplain inundation above bankfull width. The lack of sufficient hydrology has stressed riparian vegetation, as indicated by yellow and decadent willow leaves during the site visit. The factors resulting in insufficient riparian hydrology are beyond the control of HAFO park managers, which limits the ability of the Snake River 1 lotic site to reverse the downward trend away from PFC.

Figure 56. Photo of Snake River 1 site.

Snake River 2: The Snake River 2 site was assessed in August 2009 and is located approximately halfway between Upper Salmon Falls Dam and Lower Salmon Falls Dam (Figure 57). The site is located at the delta of a seasonal drainage flowing to the Snake River from the west. At this location, the mainstem Snake River channel is not subjected to frequent high flows or substantial seasonal fluctuations in water level due to controlled water levels in the Lower Salmon Falls Reservoir. Evidence of floodplain inundation above bank full width was not observed during the site visit.

The sinuosity, width-depth ratio, and channel gradient are appropriate and in balance with the relatively steep-sided, low-gradient valley floor. Due to the steep nature of the river banks and presence of dikes along portions of the river, this system has very little potential for a significant riparian-wetland area and therefore the riparian-wetland area has achieved its potential extent. The upland watershed does not appear to be contributing to riparian-wetland degradation.

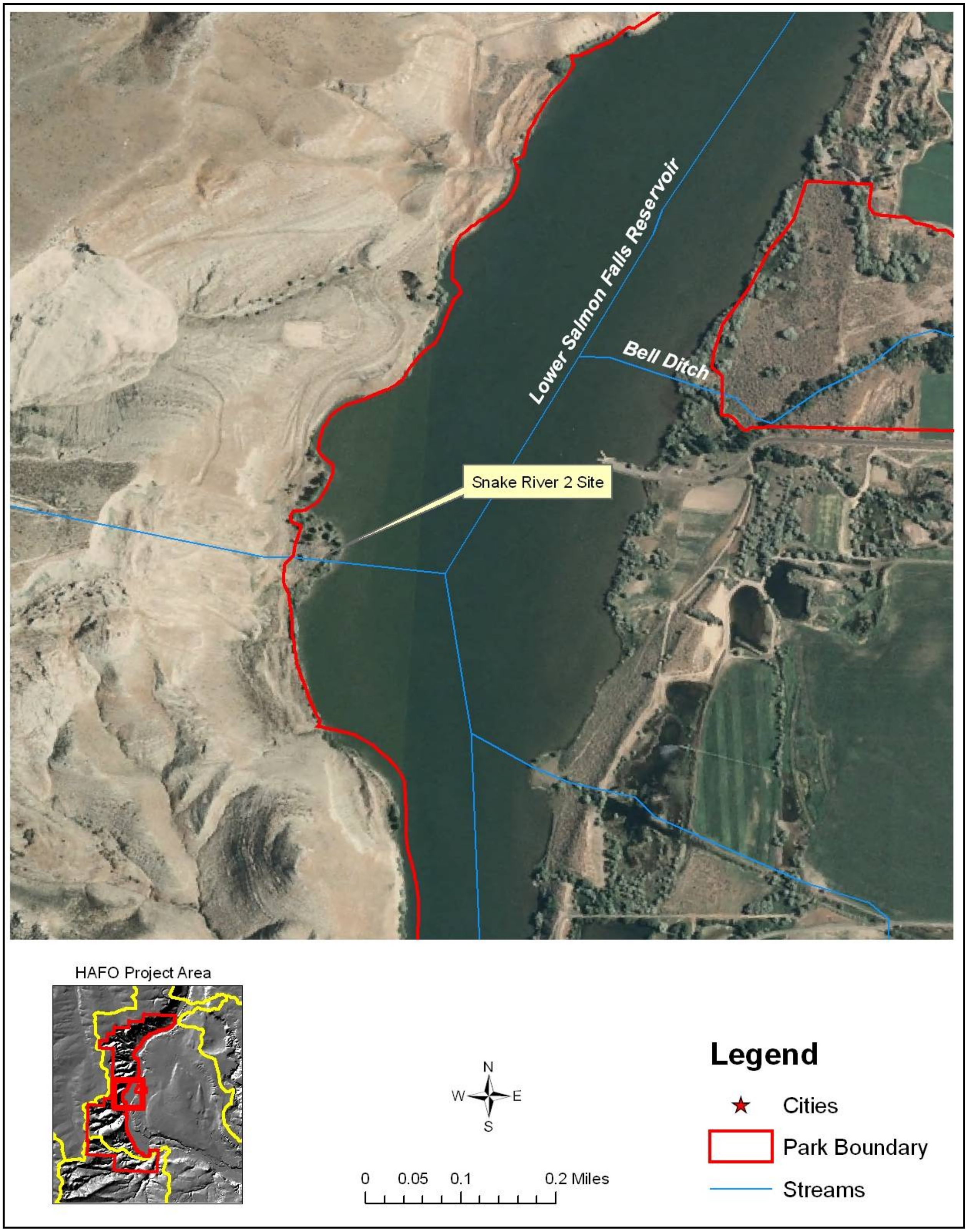

Figure 57. Map of Snake River 2 site.

The plant community at the Snake River 2 assessment site was dominated by emergent hydrophytes, including *Scirpus* spp., sedges (*Carex* spp.), and Baltic rush (*Juncus balticus*) (Figure 58). Other hydrophytic species present included saltgrass (*Distichlis spicata*) and sandbar willow.

Invasive species present at the site includes Russian olive, reed canarygrass (*Phalaris arundinacea*), Canada thistle, and common teasel (*Dipsacus fullonum*). Age-class distribution and species diversity of riparian vegetation was high. The presence of riparian species exhibiting high vigor indicates maintenance of riparian-wetland soil moisture characteristics, and provides root masses capable of withstanding high streamflow events, which protects against erosion of the river bank. Given the infrequency of high streamflow events due to controlled water levels in the Lower Salmon Falls Reservoir, the riparian-wetland vegetative cover is adequate to protect banks and dissipate energy during infrequent high flows.

The Snake River 2 assessment site is subject to infrequent high flows because of controlled water levels in the Lower Salmon Falls Reservoir and dikes along the river. Despite the lack of lateral stream movement associated with natural sinuosity, the floodplain and channel characteristics are adequate to dissipate the minimal energy associated with any water fluctuations. The system is vertically stable due the low gradient and reduced peak streamflows. No excessive erosion or deposition of sediment is occurring at this site.

The PFC evaluation of the Snake River 2 site resulted in a summary determination of "Functional – At Risk". "Functional – At Risk" riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. When this rating is assigned to a stream or river reach, then its "trend" toward or away from PFC is assessed. In this case, the trend was not apparent. The existing riparian area appeared healthy but could be limited in extent due to the unnatural flow regime within the middle Snake River system. The factors resulting in "At Risk" status, including the lack of natural flows that would result in more substantial floodplain connection and riparian hydrology, are beyond the control of HAFO park managers.

Figure 58. Photo of the Snake River 2 site.

Snake River 3: The Snake River 3 site was assessed during August 2009 (Figure 59) and is located approximately two and one-half miles upstream of Lower Salmon Falls Dam. The site is located at the delta of a seasonal, spring-fed drainage flowing to the Snake River from the west. At this location, the mainstem Snake River channel is not subjected to frequent high flows or seasonal fluctuations in water level due to controlled water levels in the Lower Salmon Falls Reservoir. Evidence of inundation of the floodplain above bankfull width was not observed. The sinuosity, width-depth ratio, and channel gradient are appropriate and in balance with the relatively steep-sided, low-gradient valley floor. Due to the steep nature of the river banks and occasional presence of dikes along the river, this system has very little potential for a significant riparian-wetland area and therefore the riparian-wetland area has achieved its potential extent. The upland watershed does not appear to be contributing to riparian-wetland degradation.

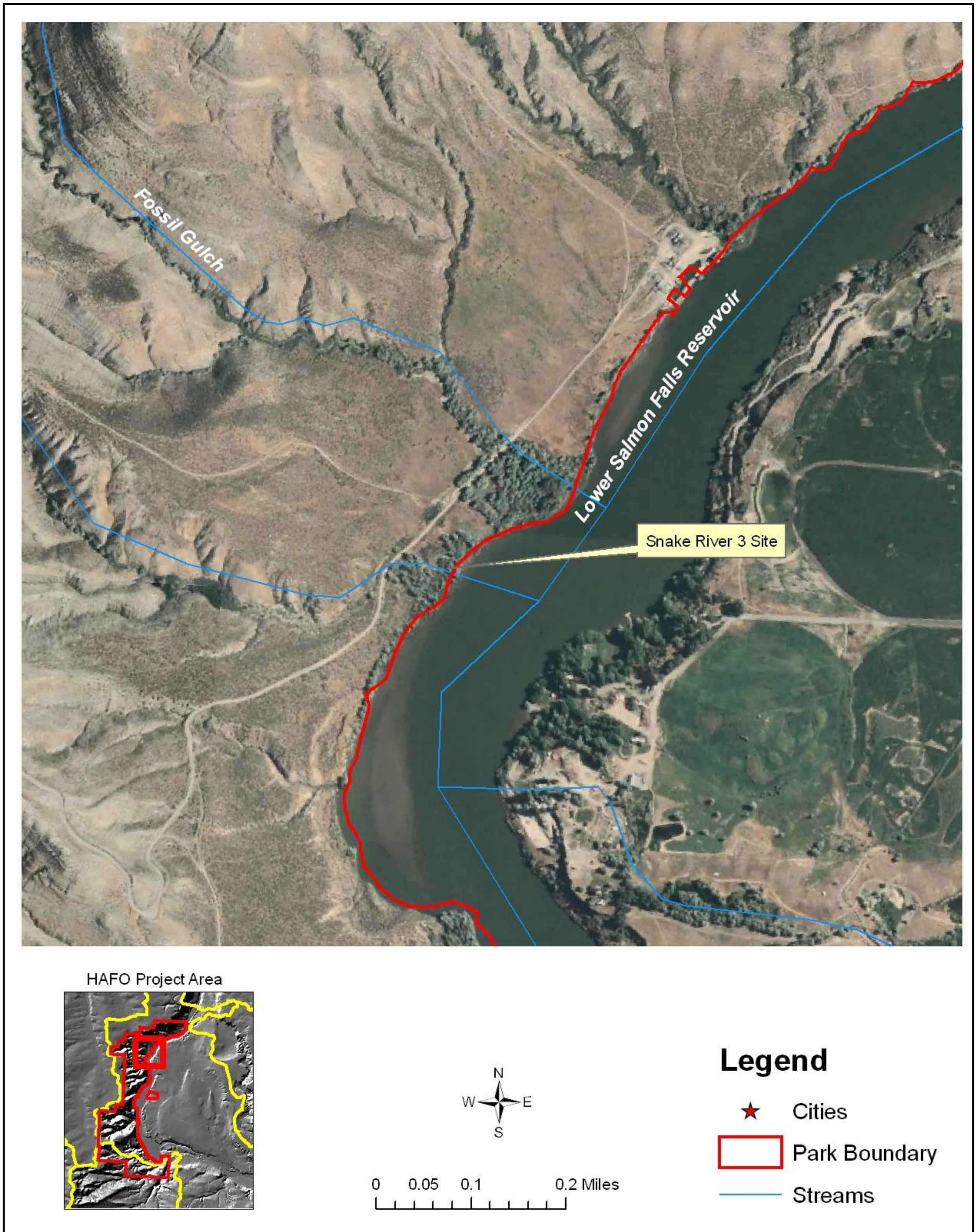

Figure 59. Map of Snake River 3 site.

Snake River 3 riparian vegetation age-class distribution and species diversity was moderate to high and was dominated by black cottonwood (*Populus balsamifera*), sandbar willow, and common reed (*Phragmites australis*) (Figure 60). Black cottonwood and golden currant (*Ribes aureum*) specimens at the site appeared to be stressed (visible yellowing and decadent growth), apparently due to the lack of sufficient riparian hydrology.

Invasive species present include Canada thistle, common teasel, Russian olive, cheatgrass, and reed canarygrass. The presence of riparian species indicates maintenance of riparian-wetland soil moisture characteristics, and typically provides root masses capable of withstanding high streamflow events, which protects against erosion of the river bank. The riparian-wetland plants present on-site exhibit low vigor as they are stressed from lack of sufficient hydrology, which may reduce their ability to withstand high streamflow events. However, given the infrequency of high streamflow events due to controlled water levels in the Lower Salmon Falls Reservoir, the riparian-wetland vegetative cover is adequate to protect banks and dissipate energy during infrequent high flows.

The Snake River 3 lotic assessment site is subject to infrequent high flows because of controlled water levels in the Lower Salmon Falls Reservoir and occasional dikes along the river. Despite the lack of lateral stream movement associated with natural sinuosity, the floodplain and channel characteristics are adequate to dissipate the minimal energy associated with any water fluctuations. The system is vertically stable due to low gradient and reduced peak streamflows. No excessive erosion or deposition of sediment was apparent at this site.

The PFC evaluation of the Snake River 3 site resulted in a summary determination of “Functional – At Risk”. “Functional – At Risk” riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. When this rating is assigned to a stream or river reach, then its “trend” toward or away from PFC is assessed. In this case, the Snake River 3 site appears to trend away from PFC because there is insufficient riparian hydrology resulting from controlled water levels in the Lower Salmon Falls Reservoir, diking along the river for agriculture production, lack of lateral stream movement associated with natural sinuosity, which inhibits floodplain inundation above bankfull width. In addition it appears that springs in the bluffs west of the site could be drying up, which further reduces riparian hydrology at the site. The lack of sufficient hydrology has stressed riparian vegetation at the site. The factors resulting in insufficient riparian hydrology are beyond the control of HAFO park managers, which limits the ability of the Snake River 3 lotic site to reverse the trend away from PFC.

Figure 60. Photo of Snake River 3 site.

Snake River 4: The Snake River 4 site was assessed in August 2009 and is located approximately two miles upstream of Lower Salmon Falls Dam (Figure 61). The site is located at the delta of a seasonal spring-fed drainage flowing to the Snake River from the west. At this location, the mainstem Snake River channel is not subjected to frequent high flows or substantial seasonal fluctuations in water level due to controlled water levels in the Lower Salmon Falls Reservoir. Evidence of floodplain inundation above bankfull width was not observed during the site visit. The sinuosity, width-depth ratio, and channel gradient are appropriate and in balance with the low gradient landscape setting. Due to the presence of dikes along portions of the river and controlled flows, this system has very little potential for a significant riparian-wetland area and therefore the riparian-wetland area has achieved its potential extent. The upland watershed does not appear to be contributing to riparian-wetland degradation.

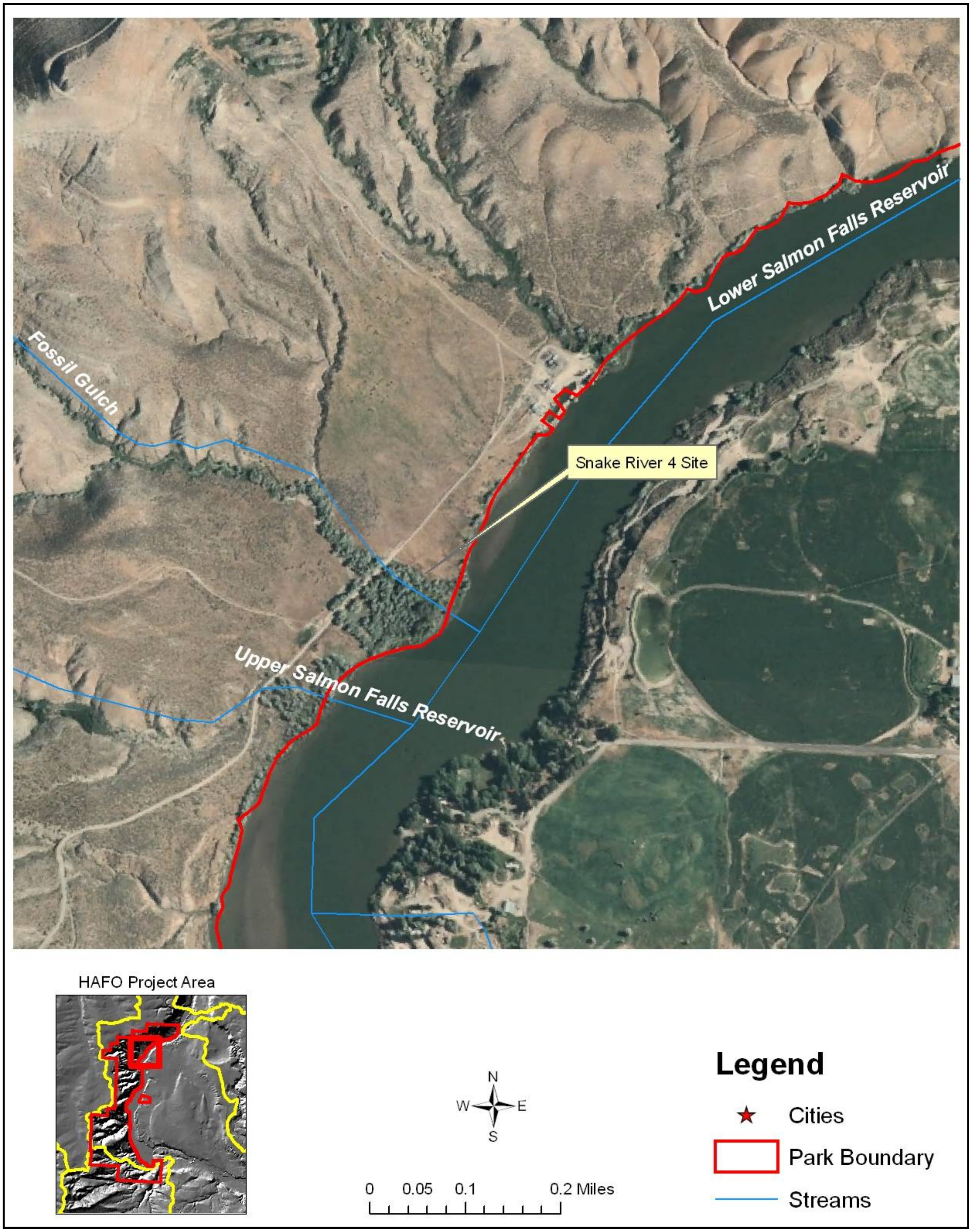

Figure 61. Map of Snake River 4 site.

Snake River 4 riparian vegetation age-class distribution and species diversity was moderate to high and was dominated by Russian olive and sandbar willow (Figure 62). Other plant species present included greasewood, yellow willow, and golden currant (*Ribes aureum*). Invasive species present at the site included saltcedar (*Tamarix* spp.), Canada thistle, common teasel, cheatgrass, and Russian olive. The presence of riparian species exhibiting high vigor indicates maintenance of riparian-wetland soil moisture characteristics, and provides root masses capable of withstanding high streamflow events, which protects against erosion of the river bank. Given the infrequency of high streamflow events due to controlled water levels in the Lower Salmon Falls Reservoir, the riparian-wetland vegetative cover is adequate to protect banks and dissipate energy during infrequent high flows.

The Snake River 4 assessment site is subject to infrequent high flows because of controlled water levels in the Lower Salmon Falls Reservoir and occasional dikes along the river. Despite the lack of significant lateral stream movement associated with natural sinuosity, the floodplain and channel characteristics are adequate to dissipate the minimal energy associated with any water fluctuations. The system is vertically stable due to the low channel gradient. No excessive erosion or deposition of sediment was apparent at this site.

The PFC evaluation of the Snake River 4 lotic site resulted in a summary determination of “Functional – At Risk”. “Functional – At Risk” riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. When this rating is assigned to a stream or river reach, then its “trend” toward or away from PFC is assessed. In this case, the trend was not apparent. The existing riparian area appeared healthy but could be limited in extent due to the unnatural flow regime within the middle Snake River system. The factors resulting in “At Risk” status, including the lack of natural flows that would result in more substantial floodplain connection and riparian hydrology, are beyond the control of HAFO park managers.

Figure 62. Photo of the Snake River 4 site.

Threats and Stressors

Upland Resources

This study examined eight upland sample sites in HAFO using a rapid resource assessment methodology (Pellant et al. 2005). The findings for each site are found in the results section of this report. In summary, the soil integrity and hydrologic function attributes indicated the Monument resources are in good condition, functioning properly and not contributing significantly to soil erosion or hydrologic degradation in their respective waterways. However, there is the potential for management practices outside of the Monument to degrade water quality through soil erosion and intensified recreational use in the area. HAFO lands make up a minority of the Snake River watershed area and surrounding non-NPS lands were not assessed. The potential for these areas to decline is a concern if use of the area increases significantly or there is an increase in irrigation water seep that could amplify landslide potential. Based on current soil stability and hydrologic function ratings, the development of a management plan is recommended to stabilize areas of concern in the future.

The biotic integrity attribute ratings indicated many areas are not in good condition. No plots were rated in the none-slight departure category. Portions of the Monument have been cultivated in the past and there is evidence of livestock grazing throughout the area. The biotic integrity attribute ratings indicate five units are in poor condition, and a change in technique incorporating active vegetation management and species control would improve the biotic integrity of these units. Visual observations indicated areas lower in the valley with less slope and those areas close to fossil digging areas generally had a poorer vegetative condition due to use patterns. Steeper slopes in the area were generally in a somewhat better condition.

Concerns over the external factors affecting NPS units throughout the United States were recognized as early as 1933 (Wright et al. 1933). These external factors are predominately related to management and use of adjacent lands and are considered one of the most difficult challenges facing Monument managers (NPS 1980, Buechner et al. 1992). The management of State Parks is commonly affected by management of adjacent lands as ownership boundaries seldom encompass complete species communities, habitats or watersheds (Myers 1972, Western 1982, Garratt 1984). This emphasizes the importance for HAFO management to understand the current conditions and potential changes to resources throughout the area and work with adjoining land owners to develop further-reaching cooperative management approaches.

Land Use

Population growth surrounding HAFO for the period 2000-2009 has increased for Twin Falls (17.1%), Gooding (1.9%), and Owyhee (5.4%) Counties. During the same time, the population of Elmore County has decreased (-1.1%). Overall, taking all four counties into consideration, the population of the region has increased by 11,553 people or 9.77% in 9 years. For the period 2002-2007, the overall number of farms increased 2.31% and the total number of farm acres increased by 1.64%, indicating a moderate rise in agriculture use or conservation areas. This trend is not substantiated by the number of farms with development, which showed an overall decrease of 10.9% during this period (USDA-NASS. 2007). This information suggests that agricultural land use in and around HAFO is generally stable. The population density has increased in three of the four counties surrounding the Monument with only minor changes in land development suggesting most of the population growth is occurring in the urban areas with little impact on rural development. Nevertheless, outdoor recreation will most likely increase placing more pressure on parks and other designated recreational areas. Table 36 lists recent census data for the counties surrounding HAFO.

Table 36. Population Trends in the Counties surrounding the HAFO study area.

Data Name	Elmore Co	Gooding Co	Owyhee Co	Twin Falls Co	Total
Population 2000	29,130	14,158	10,644	64,284	118,216
Population. 2009 Est.	28,820	14,430	11,223	75,296	129,769
Population Change 2000-2009	-310	272	579	11,012	11,553
Population % Change from 2000	-1.06%	1.92%	5.44%	17.13%	9.77%
Number Farms 2002	364	663	571	1297	2895
Number Farms 2007	381	665	620	1296	2962
Number Farms Change 2002-2007	17	2	49	-1	67
Number Farms % Change 2002-2007	4.67%	0.30%	8.58%	-0.08%	2.31%
Land in Farms 2002 Ac	346,034	194,827	571,051	441,121	1,553,033
Land in Farm 2007 Ac	346,550	223,068	569,305	439,537	1,578,460
Land in Farms Change 2002-2007	516	28,241	-1,746	-1,584	25,427
Land in Farms % Change from 2002-2007	0.15%	14.50%	-0.31%	-0.36%	1.64%
Number Farms in Farmsteads, Buildings, Livestock facilities, ponds, roads, wasteland, etc 2002	214	417	328	835	1794
Number Farms in Farmsteads, Buildings, Livestock facilities, ponds, roads, wasteland, etc 2007	185	362	371	680	1,598
Change	-29	-55	43	-155	-196
% Change	-13.55%	-13.19%	13.11%	-18.56%	-10.93%

Geology

Landslides and erosion associated with the perched ground water systems that are recharged by water seeping from unlined canals and agricultural pose a threat to the fossil bearing slopes at HAFO. Multiple studies have indicated that the irrigation system on the plateau to the east of the Monument is the likely source of water that pools in the perched aquifers and likely causes slope stability problems (Young 1984 and Farmer and Riedel 2003). Mapping, monitoring wells, and computer models have all been recommended and some are being implemented by HAFO staff to help assess and quantify the amount of irrigation water being released, the effect this has on the soils, and calculate the impact to the geological features.

Noxious Weeds

The historic land encompassing southern Idaho and the Intermountain West prior to European colonization was predominately a sagebrush steppe ecosystem (West and Young 2000). Over time the influences of agriculture, ranching, land development, and recreation have made substantial changes to these ecosystems and allowed the introduction of many invasive noxious weeds, some of which have become established in the HAFO Monument (HAFO 1999, Farmer and Riedel 2003, Erixson and Cogan 2009, Rodhouse 2009). Idaho currently lists 64 species of weeds designated as noxious by state law. Eleven noxious Idaho weeds exist in HAFO with an additional 11 invasive species being observed. This Idaho noxious weed list is updated annually and can be found on a number of websites and public information sources.

Management of all species of noxious weeds is important for good stewardship of natural resources. Currently the most defined threat to HAFO is the loss of the Monument's sagebrush dominated natural vegetation as a result of the Long Butte Fire. Cheatgrass is one of the most successful competitors against sagebrush ecosystems (Reid et al. 2008) partly due to its ability to lengthen fire seasons, decrease fire return intervals (McArthur *et al.* 1990, Peters and Bunting 1994, Pellant 1996), and out-compete the seedlings of native perennials (Billings 1994, Young 1994). However, cheatgrass is not the only concern for the HAFO as a combined total of 22 invasive and noxious weed species have been documented within the Monument. The presence of these species coupled with the altered natural vegetation and exposed soils resulting from the Long Butte Fire has raised concerns regarding the establishment of invasive species and loss of native habitats. Therefore, the restoration of the HAFO Monument to restore native vegetation and maintain biodiversity will be a critical objective for area managers.

Wildfire

With the burning of approximately 3,200 acres during the Long Butte Fire in August of 2010, the potential for species composition change, erosion, water quality degradation, and soil stability changes, potentially amplifying the occurrence of landslides, have become forefront concerns for Monument managers. The burned areas will also promote the spread of undesirable weed species in the area such as cheatgrass, knapweed, and thistle. Burned areas will be exposed to the elements until the establishment of vegetation and erosion control practices; thus, the potential for sediment transport throughout the Monument and into the Snake River is a concern. This will not only degrade water quality, but the increase of runoff from a lack of vegetation could potentially increase the loss of soil nutrients through leaching and erosion. Additionally, the loss of larger vegetation, such as sagebrush, to areas of HAFO with inherently unstable soils could increase the frequency of landslides and slumps as root systems decompose. The impacts from the Long Butte Fire are expected to affect management decisions for years to come as resource managers work toward the restoration of HAFO's vegetative communities, while continuing to provide recreational use, research access and reestablish habitat for Monument wildlife species with potentially more than 70% less desirable habitat.

Air Resources

The ambient air quality in the Monument is said to be very good. The airshed encompassing HAFO is considered a Class II area under the 1977 Clean Air Act Amendments. The only exception to nearly perfect air quality is the result of strong winds blowing over tilled agricultural fields and periodic field burning (HAFO 2001). Since the 1970's, the NPS has operated on a system of "vital sign" monitoring as part of their comprehensive air quality monitoring program (NPS 2004). In 2001 an assessment of ozone at HAFO was performed using kriged data collected in 1995 to 1999 (UCBN 2001). The UCBN (2001) assessment identified three species that are sensitive to ozone and listed the potential for degradation of vegetation at HAFO as “moderate”. As of the 2004 NPS publication on ozone measurement protocol, there were 40 park locations across the U.S. actively collecting hourly ozone data. This data coupled with the method used for HAFO could assist in the determination of potential ozone degradation at the HAFO Monument.

Wildlife

The diversity of wildlife at HAFO is dominated by a variety of birds and small rodents. The NPS published a species list for the Monument identifying 200 bird, 35 mammal, 17 reptile, eight amphibian and one fish species that were either present or possibly present within the boundaries of the Monument (NPS 2010). The composition of varying habitats isolated by the availability of water affords managers the opportunity to observe local ecological processes. These observations can assist managers in the development of multifaceted plans and goals aimed at specific conservation objectives.

It should be noted that the Long Butte Fire dramatically altered most of the natural vegetation throughout the HAFO Monument (Lonneker 2010). More than 75% of the Monument was burned which affected large areas of habitat and resident species. The extensive damage experienced by existing vegetation from fire intensity will require restoration and rehabilitation to curtail the establishment of undesirable species that have the ability to alter ecosystems and biodiversity. The potential for an increase in stream-flow as a result of the inability of soils to hold excess water and initially lower water consumption due to spare vegetation has the potential to further degrade ecosystems. Changes to natural resources from fires of this magnitude place pressure on managers to preserve and restore historic conditions, vegetation, and ecosystems in order to maintain the desired levels of biodiversity.

Climate Change

The IPCC is focused on evaluating climate change impacts, adaptation, and vulnerability across the northwestern United States. Climate change and the effects of variations in precipitation, biodiversity, and temperature has been a focus in natural resource management throughout the western United States over the past three decades (Ashton 2009).The majority of the Northwest experiences a varied combination of all four seasons. At HAFO, the four seasons are distinct with spring occurring early, often beginning in March, and winter occurring late, often beginning near the end of October. The climate at HAFO is characterized by a plateau/continental interior climate averaging 11.4 inches (28.9 cm) of precipitation annually. Snowfall averages approximately 29 inches (73.6 cm) annually with December and January experiencing the heaviest accumulations. Conditions within the Monument change significantly between seasons; summers are moderately long and hot, with the hottest days typically near or in excess of 100 °F (38 °C) and temperatures of exposed soil reaching nearly 120 ^{o}F (48.9 ^{o}C). Winters are relatively cold with prevailing winds from the west averaging 11.2 mph (18.2 km/h).

These climatic elements coupled with the area’s perched water tables and springs are what have shaped the ecosystems and biodiversity present within the Monument. Changes in climate have the ability to alter precipitation patterns, temperature extremes, and seasons (Ashton 2009) leading to the need for adaptation of species in order to survive. If climate changes occur rapidly a species or ecosystem may not have the ability to adapt sufficiently to mitigate adverse effects and thereby may be lost or constrained to isolated regions with limited biodiversity.

As data is gathered on the response of ecosystems to variations in climate, precipitation and temperature change have become pivotal issues for natural resource management plans as well as focal points for researchers (McWethy et al. [In Press]). Mawdsley et al. (2009) has stated some of the affects that global climate change can have on species and ecosystems.

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 (any infectious disease that can be passed between non-humans to humans or vice versus).
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.

Conservation practices enveloping relevant data can aid in minimizing the impacts to natural resources by climate change through well developed management plans and public education. The direct and indirect impact of changes in climate on natural resources is undoubtedly a complex issue occurring on a variety of different levels.

Water Resources

Aquatic resource threats at HAFO include insufficient riparian hydrology, invasive riparian species, recreational use, poor water quality, and excessive fine sediments. Each aquatic resource threat is described in more detail below as well as in discussions of potential strategies to address aquatic resource risks.

Insufficient riparian hydrology: Normal maximum surface water elevation of the Lower Salmon Falls Reservoir is 2,798 feet, while minimum surface water elevation is 2,792 feet making periodic fluctuations of two to three feet typical and up to six feet on occasion (Farmer and Riedel 2003). The lack of periodic significant water fluctuations inhibits lateral water movement that would typically provide connection to the floodplain from riparian areas. This would be especially important in this semi-arid environment and may be the only source of hydrology to portions of riparian areas throughout the system.

Discharge from the Snake River Plain Aquifer occurs primarily as springs which are also an important source of hydrology to the Snake River. From 1912 to the early 1950's, annual groundwater discharge to the Snake River increased as a result of rising groundwater levels in areas irrigated with surface water, but has decreased since the 1950’s as a result of a combination of increased groundwater withdrawals, increased efficiency in irrigation practices, and local droughts (Kjelstrom 1992, Rupert 1994). Infiltration of excess irrigation water contributes a large amount of recharge in areas where surface water is diverted to irrigate crops (Clark and Ott 1996). Springs were noted to be the primary hydrologic source for the Bell Ditch Wetland and likely a secondary source for all Snake River lotic sites, indicating they may also be an important source of hydrology for riparian areas within the Monument. With increases in population growth and a trend away from agriculture and toward rural development, natural resource managers need to understand critical water sources throughout HAFO that may be affected by the loss of nearby irrigation systems.

Invasive species: Invasive species were identified at all four lotic sites and include Russian olive, Canada thistle, saltcedar, knapweed, houndstongue, reed canarygrass, common reed, cheatgrass, and common teasel. Changes in the plant community from native species to monotypic stands of exotic species can be expected to result in changes to all the invertebrates and microscopic organisms that are associated with the native species. For example, reed canarygrass is a concern because it forms large, single-species stands with which other native species cannot compete. Preventative measures for controlling each invasive species identified should be investigated and implemented as necessary.

Recreational use: Recreational use of the Snake River and Lower Salmon Falls Reservoir is very common, especially by boaters and other water-users during the summer months. While shoreline use by boaters along the HAFO portion of the River is relatively rare, increases in wave action caused by boats can result in significant shoreline erosion.

Water quality: Lower Salmon Falls Reservoir was listed on the 2002 EPA 303(d) list for dissolved oxygen, flow alteration, and sediment, but is not listed on the 2008 303(d) list (Farmer and Riedel 2003, IDEQ 2008). Several waterways upstream of Lower Salmon Falls Reservoir are listed on the 303(d) list including Yahoo Creek at the southern end of the reservoir, which is listed for sedimentation/siltation and fecal coliform. Biological impacts within the Upper Snake River Basin are derived from activities such as stream alterations, water resource development, irrigated agriculture, aquaculture, grazing, and foreign species introduction. The loss of cold water habitat and aquatic life in the Snake River between Milner Dam and King Hill is of special concern and has been the focus of many agency activities (USGS 2009).

Almost half of the stream segments in the Upper Snake River Basin assessed for water quality conditions by the Idaho Department of Health and Welfare were affected by nonpoint-source activities. The primary nonpoint-source activities cited are irrigated and non-irrigated agriculture, grazing, streamflow regulation from dams and diversions, and recreation. Primary point-source activities include agricultural-related industry, municipal wastewater treatment facilities, mining related industry, and aquaculture. Water quality of lakes and reservoirs in the Upper Snake River Basin is affected primarily by agriculture and aquaculture-related activities (Farmer and Riedel 2003). Groundwater contamination from non-point sources is poorly understood because of inadequate or nonexistent monitoring data. However, sparse data indicate that applied agricultural chemicals have leached into the groundwater system in localized areas (USGS 2009).

Concentrations of nutrients and suspended sediment in the main stem of the Snake River generally increase downstream. The largest concentrations in the main stem were in the middle reach of the Snake River between Milner Dam and the outlet of the upper Snake River Basin at King Hill (Clark 1997). Some of the specific water quality issues in the Upper Snake River Basin include (USGS 2009):

- Elevated concentrations of sediments and nutrients and the occurrence of low dissolved oxygen and elevated water temperature in surface water associated with agriculture, grazing, and aquaculture; the result is degraded water quality and impairment of beneficial uses of water in some tributary basins and along the Snake River.

- Potential groundwater contamination by nutrients and pesticides associated with agricultural activities in intensively irrigated areas; and

- Potential surface and groundwater contamination by nutrients from recreational activities in the upper part of the study unit.

Clark and Ott (1996) indicated that springs are a major source of dissolved solids and nutrients to the Snake River. However, the quality of spring-flow varies depending on the source and location of each spring. The variability in spring-water quality appears to result from differences in the source water for each spring, the direction of groundwater flow, and spatial variations in land and water uses.

A two-year surface water quality inventory project started in 1998 indicated baseline water quality parameters are good within HAFO. However, no long term monitoring has been completed to establish detailed chemical trends to effectively discriminate between different flow systems and their associated recharge areas. Additionally, tailwater from the Upper Salmon Falls Powerplant may affect the southernmost portion of the Monument due to supersaturation of oxygen and nitrogen and its effects on the aquatic system (Farmer and Riedel 2003). In proportion to its discharge (less than one percent), the Twin Falls sewage-treatment plant is a major source of total phosphorus (13 percent) (Clark 1997). It is understood that point and non-point source pollution from surrounding land uses are outside the control of NPS managers. However, understanding the sources and impacts of incoming pollutants is important to adequately manage aquatic resources.

Fine sediments: Arroyo and gully erosion of unconsolidated sediments along the steep, poorly vegetated slopes of the Monument has proceeded at a rapid pace. Down-cutting by streams with flow supplemented by perched aquifers has resulted in slope instability problems in upper reaches of local topography and in rapid deposition of fine-grained sediment in lower reaches. These perched aquifers continue to expand both horizontally and vertically in the northern, Fossil Gulch Area, but appear to be decreasing in the Bell Rapids area. Forty-four shoreline erosion and landslide sites have been identified within the Monument area. Raytheon (1995) and active landslides have displaced approximately 60 acres to date (Farmer and Riedel 2003).

Occasional flushing of irrigation pipes causes surface erosion along the steep face of the bluff in localized areas. In several locations channeled surface water runoff has created deep gullies and arroyos. Down-cutting by these ephemeral streams also triggers small landslides from stream banks. These soil failures and down-cutting destroys small channels, threaten fossil beds, and result in deposition of larger quantities of fine-grained sediment into Lower Salmon Falls Reservoir. Near the north end of the Monument, erosion and deposition have occasionally threatened a pump station access road. Slope stability problems are a function of several factors that include unnatural groundwater, naturally steep slope angles up to 70 degrees, poorly consolidated fine-grained soils, naturally sparse vegetative cover and road construction (Farmer and Riedel 2003).

Increasing sedimentation can decrease plant richness and favor invasive vegetation that tolerate disturbance. Sediments often adsorb nutrients and as a result, nutrient contamination often follows sediment contamination, especially at tributary mouths. Impacts of increased sediment on habitat functions of wetlands have been documented for invertebrates, amphibians, and fish. These groups generally have reduced species richness and abundance when subject to increased sediment deposition. Excessive sediment and nutrients at tributary sites throughout the Upper and Middle Snake River Basin are difficult to manage and will continue to pose challenges to HAFO managers.

Summary and Recommendations

Land Use

The population density has increased in three of the four counties surrounding the Monument with the greatest population density increase in Twin Falls County (17.1%). Outdoor recreation is expected to increase continually over time, placing more pressure on recreational areas and outdoor opportunities. Visitation records from HAFO support this expectation and are presented below (

Figure **63**). Initial visitation records were started in the early 1990's obtaining a peak of approximately 15,000 visitors by 1999 (HAFO 1999). This total was considered "relatively high" as there was no signage directing people to the Monument. Visitation has increased steadily from approximately 12,000 in 1995 to a high in 2009 of over 27,000 visitors with an average of approximately 25,000 recreation visits annually for the past five years.

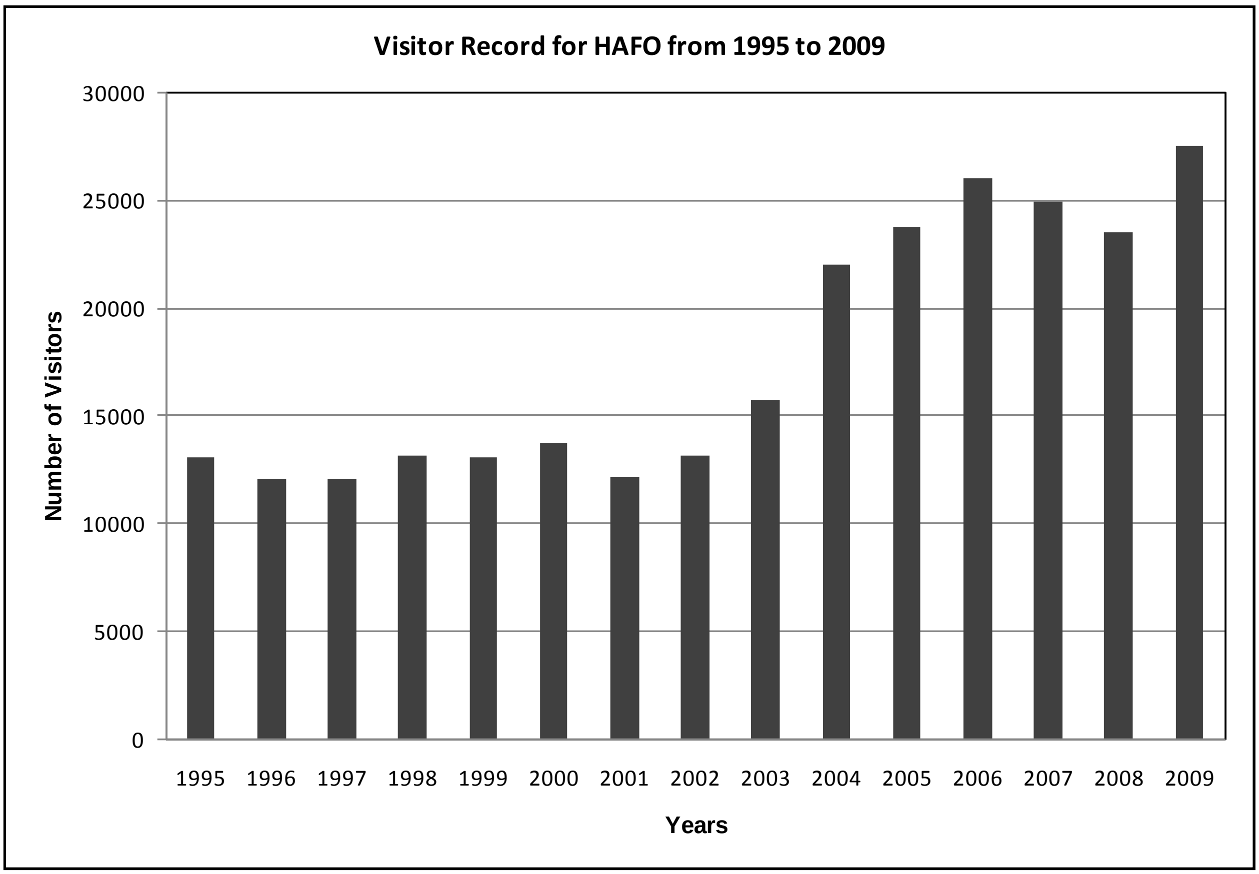

Figure 63. HAFO visitor records by year from 1995 to 2009 (NPS 2010c).

The increases in visitation should be closely monitored to insure that no added pressure is being placed on the natural resources that could possibly lead to degradation of unique areas within the Monument. Monitoring efforts could include more information on what percentage of visitors actually go into the Monument versus those that just go to the visitor center. Visitation to unique areas in and around HAFO is defined by the interaction between different ecosystems supporting a biologically diverse set of wildlife and vegetative species as well as paleontological resources. The significance of species diversity means ecosystems can evolve as individuals compete with each other and cope with the influence of human recreation. Likewise, the paleontological resources are valuable sources of knowledge about the historical biodiversity of the area. An increased presence by human foot traffic may lead to both short-term effects such as soil compaction and long-term ecosystem issues like the permanent removal of vegetation cover.

This report examined several riparian ecosystems, nine grazing allotments, and one historic site within HAFO using a rapid resource assessment methodology (Pellant *et al.* 2005). This methodology was applied to the aspects of HAFO's natural resources identified as: archeological resources, upland resources, noxious weeds, wildfire, air resources, animal, climate, and water resources as detailed in the previous sections. Due to the lack of consistent quantitative information on threats/stressors within the Monument, management recommendations were made under a more qualitative approach. Management practices structured toward attaining proper functioning condition through suggested recommendations and the use of additional resources is expected to accomplish the NPS goals and objectives of preservation for future generations. Management plans developed from detailed information, when implemented, will help reduce ecosystem degradation and encourage preservation and re-establishment of desired ecosystem processes despite potential for increased human activities related to population growth.

Geology

Landslides and perched aquifers created by irrigation activities have, and will likely continue to impact the geology at HAFO. The movement of large sections of land from soil instability caused by the presence of water may expose new geological features or cover existing outcrops. In addition, the soil movement events also directly impacts paleontological, archeological, and vegetation resources in the Monument. The water management plan for HAFO (Farmer and Riedel 2003) has suggested the perched aquifer system at HAFO be mapped, computer modeled, and monitored from wells to: (1) access slope movement and seepage conditions, (2) discern patterns, (3) predict future landslide behavior, (4) help assess non-native vegetation expansion, (5) calculate impact to fossil resources, and help direct (6) fossil salvage operations. Some of these recommendations have already been completed and others are in various states of completion (Farmer and Riedel 2003).

Paleontological and Archeological Resources

Fossils found at the HAFO Monument are predominately Pliocene era dating three to four million years old and are distributed vertically through 152 m (500 feet) of the Glenns Ferry Formation along the banks of the Snake River (Erixson and Cogan 2009). Since the discovery of these fossils in the 1920's nearly 100 species of vertebrate fossils including the largest, most well preserved specimens of the "Hagerman Horse" have been uncovered (HAFO 1998). The Pliocene record of HAFO includes a representation of species present before the last ice age as well as one of the earliest representations of modern flora and fauna globally. There is a continuous undisturbed stratigraphic representation of at least 500,000 years that includes wetlands, riparian, and grassland savanna organisms. The history and research at HAFO has provided paleontologist the opportunity for education and interpretation regarding development of the science of paleontology as well as a deeper understanding of the resource.

It is recommended that managers of paleontological resources at the Monument establish a study on quantifying and qualifying the effects to fossils and loss of resources due to landslide occurrences within the Monument, what impacts on water quality (erosion, sedimentation, constituent transport etc.) could be mitigated for if irrigation were to cease in the area, and the effects on recreation if some fossil sites were opened to supervised public digging where fossils found could be classified as “allowable to own privately”, “research collection”, or “museum specimen” in order to generate revenue for the Monument.

Upland Resources

The area in and around HAFO is comprised of different ecosystems supporting a biologically diverse set of wildlife and vegetative species. Sagebrush and grasslands meet with agricultural fields creating fringe habitats at the edges of the Monument. Disturbance and anthropogenic influences have supported the establishment of other commonly occurring species as well as introduced invasive grasses and weeds (HAFO 1999). These ecosystem modifications commonly occur following the disturbance of soils (HAFO 1999, Rodhouse 2009) providing managers with valuable knowledge for the development of multifaceted plans and goals aimed at conservation of evolving ecosystems and their diverse species. Many of the disturbances affecting HAFO derive from factors located outside of the Monument property.

These external factors are predominately related to management and use of adjacent lands and are considered one of the most difficult challenges facing Park managers (NPS 1980, Buechner et al. 1992). The management of State Parks is commonly affected by adjacent lands because the Park boundaries seldom encompass complete species communities, habitats or watersheds (Myers 1972, Western 1982, Garratt 1984). Future projects, such as vital sign monitoring and post-fire vegetation mapping, can provide data that can be coupled with geographically-based information allowing for more detailed analysis of post-fire vegetation succession and distribution. This will provide researchers with the information necessary to compare physiographic and other landscape attribute relationships to vegetation patterns, restoration efforts and species composition changes. Vegetation management plans developed with this level of detailed information can, when implemented, begin the exclusion process of non-native and noxious plants and increase desired vegetation and the ecosystem processes they support.

Noxious Weeds

Numerous options are available for the control and management of noxious weeds. Multiple herbicides are registered as safe for use around livestock and wildlife and most biological control programs focus on noxious weed control for rangelands affording further protection for foragers (DiTomaso 2000). The successful management of noxious weeds requires the development of strategic plans that incorporate prevention, education and control options that are financially and economically sustainable (Whitson 1998, DiTomaso 2000). On average the U.S. loses $33 billion in crop production to weeds each year and an additional $7 billion is spent on herbicide control alone (USDA 2010). The Pacific Northwest Weed Management Handbook (Peachey et al. 2008) lists the five common options for land managers to control invasive species as biological, cultural or mechanical management, prevention, and the use of herbicides. Furthermore, Whitson (1998) and DiTomaso (2000) summarize a successful management plan for noxious weeds as being a strategic development of goals that incorporate prevention, education and control options that are financially and economically sustainable.

Management of all species of noxious weeds is important for good stewardship of natural resources and cooperation with adjacent landowners, private and public, is one of the most effective methods for control of noxious weeds. With the mounting cost of weed control as noxious species spread throughout the Nation's fields and ecosystems, the importance of prevention and management of desired resources becomes more and more critical. It is recommended that resource managers consider multi-year assessments of weeds to facilitate the identification of species that may be easier to distinguish during seasonal variations in their annual cycles (during flowering or seeding) and to develop a weed management plan to guide decisions through partnerships between the UCBN Inventory and Monitory, the EPMT and the County Weed Management Association of Idaho.

Wildfire

Fire plays an integral role in the fecundity and progression of a landscape through disturbance and nutrient cycling. The HAFO area is predominantly a middle to lower-elevation ecosystem composed of sagebrush and grasslands (Chambers et al. 2008). As of August 2010 and the occurrence of the Long Butte Fire, natural vegetation existing with the Monument has been drastically altered. More than 75% of the Monument was burned; thereby damaging much of the natural sagebrush and placing further pressure on natural resource managers for preservation and restoration of the historical conditions. It is recommended that fire management plans target established ecosystem compositions following the Long Butte Fire with a goal to avoid or mitigate the occurrence of similar extensive fire spread through the Monument in the future should another fire enter HAFO from adjacent lands.

Concerns for Monument managers should also entail increases in erosion from newly disturbed soils, a potential increase in landslide occurrence (Farmer 1999), water quality issues from runoff, and a permanent shift in sagebrush ecosystems to potentially less desirable species (HAFO 2001). The goal of Monument managers to restore historic ecosystems and maintain natural species while catering to continued recreational enjoyment and safety will be a challenge. It is recommended that a monitoring and assessment model be designed to track all attributes of landslides and slope failures in order to develop a hazard/risk rating that encompasses as of the "potential landslide" areas. Additionally, a model that assesses the occurrence of invasive and noxious weed species, spread, and density, and can also identify restoration area boundaries should be established. This model would aid in developing a restoration-based approach to wildland fire management through the creation of inventory-based mapping of current conditions.

Air Resources

The new human health standard proposed by the EPA would, as of the date of this publication, list between 126 – 193 NPS units as non-compliant depending on the ozone value set between 60 and 70 ppb. After the approval of this new standard, the NPS will most likely be granted a timeline in which to bring all units into compliance. The EPA has suggested the NPS apply for funding assistance through the federal Congestion Mitigation and Air Quality (CMAQ)

Improvement Program (NPS 2010a) to aid with the costs associated with construction and development of research sites.

HAFO managers should consider the installation of an ozone monitoring station in order to gather enough data for classification of the Monument under EPA guidelines. Additionally, this data could provide for a comparison of ozone and air quality data to vegetation survey data as some plant species have known sensitivities to ozone (UCBN 2001). Ozone has also been linked to climate change (Hopkin 2007). The method of using kriged off-site data to provide an initial risk rating for HAFO could provide support for the need of a monitoring station on site. Hopkin (2007) further detailed the potential effects of ozone on vegetation and how a plant’s ability to uptake ozone could affect global warming; thereby, increasing the need of natural resource managers to have accurate data as well as understand the complex dynamics of local and regional climate change.

The necessity of accurate, relevant data makes the need to evaluate a number of stations and locations is critical. A single monitoring station may not be representative of the entire Monument if there is significant topography variation or other aspects inhibiting the collection of representative data (NPS 2004). Variations in topography do exist at HAFO that could inhibit adequate coverage of the area with only one monitoring station. Therefore, it is suggested that further research of relevant equipment as well as the collection of initial site-specific air quality data is established to aid managers in the development of a Monument-wide air quality management and monitoring system.

Wildlife

Wildlife at the HAFO is dominated by a variety of birds and small rodent species. The 2010 species list published by the NPS details the number of species known to exist in the Monument as well as a number of species considered to be “possibly present”. One of the species listed as “possibly present” is the greater sage-grouse (*Centrocercus urophasianus*). Although this species has not been observed as of this publication the restoration of HAFO presents a potential to encourage establishment of this species or propagation of existing individuals. Likewise, the balancing management of the Monument’s species and recreational use coupled with growing concerns of climate change and air quality degradation will present exceptional challenges for managers and require continuously relevant data. For example, the presence of many of Idaho’s bat species (Ave et al. 2004) facilitates the prospect of future studies that target this group of unique vertebrates. The spotted bat (*Euderma maculatum*) is thought to be present within the HAFO area due to the presence of habitat and ecosystem conditions, however, at the time of this publication, the spotted bat had not been documented (Ave et al. 2004). This presents an opportunity for future studies that would provide a better understanding of this species and its possible presence in the Monument. Furthermore, monitoring studies targeting these unique species could be used to assess local or regional climatic variations through the use of these mammals’ behavior or hibernation habits as indicators of climatic change (Newson et al. 2009, Jones et al. 2009). Additionally, the potential to use some species of amphibians as water quality indicators relating to sediment-loading (Welsh and Ollivier 1998) may give management more insite into Snake River water quality and new information helpful for maintaining a balance between nature and the influences of humans.

Climate

The IPCC's most recent findings suggest all continents and most oceans are being affected by regional climate changes, particularly temperature increases (Parry et al. 2007). 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. Furthermore, data from JISAO predicts warmer, wetter winters, an increase of 3.1° F by 2030, and a 5% increase in precipitation (Mote et al. 2008). This translates into a reduction in winter snow accumulation and increased precipitation as rain. Through the IPCC, Parry et al. (2007) published a technical summary of observational evidence focusing on climate change impacts, adaptation, and vulnerability showing effects of regional climate changes on natural and human environments are emerging. For example, alterations to flow in the Snake River and ultimately the Columbia River Basin would likely coincide with increased water demand from regional growth impacting urban water supplies within the UCBN and remaining Columbia River Basin area. Currently, the 43 sub-basins within the UCBN and the Columbia River Basin do not have a comprehensive basin-wide plan to address water availability caused by climate change. Therefore, vulnerabilities to climate change are said to rely heavily on chosen management pathways as impacts can be reduced or delayed through applied mitigation practices (Parry et al. 2007, Mote et al. 2008). The impact of climate change on natural resources at HAFO will depend on ecosystem stability and species diversity. Due to the occurrence of the Long Butte Fire and its effects on biodiversity throughout HAFO, managers should incorporate climate change into restoration efforts. Furthermore, the collection of additional data on climate change is necessary to formulate future management objectives as this information coupled with air quality data would support the development of mitigation practices aimed at combating negative climatic impacts to the area.

Water Resources

It is recognized that the water levels in the Lower Salmon Falls Reservoir and amount of groundwater recharge due to adjacent agricultural irrigation is outside the control of NPS managers. However, understanding the impacts of the lack of sufficient riparian hydrology in a static system with controlled water levels and the impact of agricultural irrigation on groundwater recharge and subsequent hydrologic inputs from springs is important to adequately manage aquatic resources within HAFO. Although species present in both the lentic and lotic sites indicate maintenance of riparian-wetland soil moisture characteristics, specimens were observed to be stressed in two of the lotic sites and sources of riparian hydrology appeared to be diminishing in all of the lotic sites. This could be the combined result of reduced flood flows and decreasing natural springs as well as diminishing agriculture return-flows.

As a result of land use activities, the springs both in and around HAFO represent a significant supply of nonpoint-source additions to the Snake River. Unless the inputs of constituents from the springs are reduced, implementation of other practices along the middle Snake River, designed to improve the water quality of the reach, may not be sufficient to reverse eutrophication processes during critical times. Water-use alternatives that reduce chemical loading to the Snake River simply by reducing the quantity of spring discharge may be undesirable because of practices dependent on the consistent discharge springs provide. Ultimately, a reduction in the constituent concentrations in the Snake River Plain aquifer and, consequently, regulated anthropogenic factors will be required to decrease loads, maintain the quantity of spring discharge, and improve water quality throughout the middle Snake River (Clark and Ott 1996).

Stream bank stabilization, riparian area health, and water quality should be the focus of managers at HAFO. A routine monitoring system facilitating the continued collection of water quality parameters, turbidity, and macroinvertebrates should be established in order to track changes with respect to time and aid in assessing Proper Functioning Conditions of stream reaches. Additionally, an assessment evaluating the affects of water-level variation from irrigation diversion on stream banks is recommended to assist in managing stream bank degradation and riparian areas along the banks of the Snake River.

Minimizing human impacts along the shoreline through education of water users is another recommended approach. For example, resource managers can select portions of one or two sites to use as shoreline restoration case studies. These small sections of riparian shoreline could be fenced off from human use and restored through invasive plant removal, native vegetation planting, and large woody debris augmentation. Signs could be placed at the site(s) (visible to water users) describing the importance of shorelines to aquatic species and habitat. Flyers could then be produced and distributed to boaters at nearby marinas and boat launches as a way to encourage wise use of shorelines and riparian areas. This approach helps managers affect use of onsite aquatic resources through educating the public without compromising the overall use of the aquatic habitat.

Data Gaps

The desired depth of information and data were not available for some of the analysis presented in this document. Beneficial data to improve and validate findings for natural resource management by Monument staff is summarized below. A cost analysis and/or responsible agency were not identified due to the extensive nature of additional data. This summary is intended to provide information and guidance to HAFO staff for future data collection efforts within the Monument and the surrounding area.

1. Accurate and standardized land cover/use mapping for the project area that meets National Map Accuracy Standards (± 40 feet) is needed. This information is critically important for watershed modeling of water quality attributes, wildfire risk assessments, and other resource evaluations.

2. A presence/absence study including habitat, food sources and behavior of bats within HAFO is necessary by the NPS for inclusion of these unique vertebrates on the NPS species list.

3. Noxious weed maps in digital format on adjacent private and public lands within the project boundary. Some information is collected by the EPMT and the County Weed Management Association of Idaho as well as other special interest organizations; however a cooperative Dataset including species extents and Monument specific actions is needed. Currently, there are multiple sources of information regarding weeds on HAFO however, there are many inconsistencies, namely number of species present.

4. Data regarding ozone levels and air quality within the HAFO area are needed to assess the Monument’s standing within the newly proposed EPA air quality standards.

5. An updated mapping project on landslides within the Monument including soil attributes, water quality, loss of habitat and risk assessment changes due to the occurrence of the Long Butte Fire and its extent, severity, and overall effects to HAFO resources.

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Appendix A – List of HAFO NRCA Geodatabase Feature Classes

Data Type	File Name	Source
Air Resources	N/A	N/A
Animal		
Game Management Units	GMU	Idaho Dept of Fish and Game
Range Allotments	rngAllotment_id_blm	Bureau of Land Management (BLM)
Grazinig Pastures	rngPasture_id_blm	Bureau of Land Management (BLM)
Climate		
Precipitation Ave	precipitation	US Dept of Agriculture NRCS PRISM
Temperature Ave	Temperature	US Dept of Agriculture NRCS PRISM
Geography		
Cities	cities	Inside Idaho Web Site
City Boundaries	City_Boundary	Inside Idaho Web Site
Counties	Counties	Inside Idaho Web Site
Fire Districts	fire_dist	Idaho State Tax Commission
Watershed Basins	HAFO Basins	Idaho Dept of Water Resources
Basins Buffer	HAFO_Basins_Buffer	Idaho Dept of Water Resources/*NMI*
Geographic Names	ignis	U.S. Geological Survey
Park Boundary	parkbndy	National Park Service
7.5 ' Quadrangle Index	Quad_Index	U.S. Geological Survey
Sections	Sections	Bureau of Land Management (BLM)
Townships	Township	Bureau of Land Management (BLM)
Geology		
Aquifer	aquifer	U.S. Geological Survey
Faults	Faults	U.S. Geological Survey
Geology	Geology	U.S. Geological Survey
Ground Water	gw_flow	Idaho Dept of Water Resources
Soils	hafo_soils	U.S. Dept of Agriculture, NRCS
Lithology	lithology	Idaho Dept of Water Resources

Data Type	File Name	Source
Landuse		
Antenna towers	ASR_Towers_sgca	U.S. Geological Survey
Cel towers	cell_towers_sgca	U.S. Geological Survey
Highways	Highways	Idaho Transportation Department
Landowners	Landowners	Bureau of Land Management (BLM)
Pipelines	pipeline	U.S. Geological Survey
Powerlines	Powerlines	Unknown/NMI
Railroads	Railroads	University of Idaho, Inside Idaho
Roads	Roads	Bureau of Land Management (BLM)
State Highways	State_Highways	Idaho Transportation Department
Agriculture strata	strata_a_id	U.S. Dept of Agriculture
Trails	trails	National Park Service
Weather Stations	weather_stations	Idaho State Climate Service
Plant		
Veg Plots	Hagerman_PlotsGPS__All	UCBN HAFO
Stressors		
Fires BLM 72-08	BLM -Fiires_pts_72-08	FAMWEB NWCG
Fed Fire Occurrence NPS	fedfireoccurrence_1980-2004_nps	Bureau of Land Management (BLM)
Historical Fires	FIG_Historical _Fires	Fire Program Analysis
Wldfires BLM polygons	wilfire_id_blm	Bureau of Land Management (BLM)
Water Resources		
USGS Gaging Stations	allgageusgs	U.S. Geological Survey
Geothermal sources	geothermal	Idaho Dept of Water Resources
Ground water monitor sites	gwgm	Idaho Dept of Water Resources
Municipal water	municipal_water	Idaho Dept of Water Resources
Open Water	Open_Water	University of Idaho, Inside Idaho
Ground water concern areas	rechargesites	Idaho Dept of Water Resources
Streams	streams	Idaho Dept of Water Resources
Ground water vulnerability areas	vulnerability	Idaho Dept of Water Resources
Wells	wells	Idaho Dept of Water Resources
Wetlands	Wetlands	Idaho Cooperative Fish and Wildlife Research Unit

Data Type	File Name	Source
Water Resources		
Water Rights Points of Diversion	wrpod	Idaho Dept of Water Resources
Water Rights Place of Use	wrpou	Idaho Dept of Water Resources
Raster Data		
Vegetation (GAP)	gap_veg	Idaho Cooperative Fish and Wildlife Research Unit
Digital Elevation Model	hafo_dem	U.S. Geological Survey
Hillshade Terrain Model	hafo_hlsd	Derived from DEM
Landuse	landuse	United States Dept. Agriculture USDA
13 Fire Behavior Fuel Model	lf_13fbfm	U.S. Geological Survey Landfire
Existing Vegetation (Landfire)	lf_evt	U.S. Geological Survey Landfire
Fire Regime Condition Class	lf_frcc	U.S. Geological Survey Landfire
Fire Regime Group	lf_frg	U.S. Geological Survey Landfire
Mean Fire Return Interval	lf_mfri	U.S. Geological Survey Landfire
Succession Class (Landfire)	lf_scls	U.S. Geological Survey Landfire
Aerial Mosaic (NAIP)	HAFO_NAIP.sid (not in GDB)	USDA Farm Services Agency

Appendix B – Proper Condition Function Lotic Checklist

Standard Checklist

Name of Riparian-Wetland Area: Snake River 1

Date: 8/11/09 Segment/Reach ID: ____________

Miles: ____________ Acres: ____________

ID Team Observers: D. Hinson K. Eakin

Yes	No	N/A	HYDROLOGY
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present they are active and stable
✓			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
✓			4) Riparian-wetland area is widening or has achieved potential extent
✓			5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
✓			6) There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high-streamflow events
	✓		10) Riparian-wetland plants exhibit high vigor
✓			11) Adequate riparian-wetland vegetative cover is present to protect banks and dissipate energy during high flows
		✓	12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION/DEPOSITION
✓			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) are adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity
✓			16) System is vertically stable
✓			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

(Revised 1998)

Remarks

1) No evidence of inundation due to dams controlling flows
8) Willows dominate although upland species present
10) Yellow & decadent willow leaves
15) Confined river from diking for ag production

Summary Determination

Wildlife

Mule deer

Downy Woodpecker

Functional Rating:

Proper Functioning Condition ____
Functional—At Risk ✓
Nonfunctional ____
Unknown ____

Trend for Functional—At Risk:

Upward ____
Downward ✓
Not Apparent ____

Are factors contributing to unacceptable conditions outside the control of the manager?

Yes ✓
No ____

If yes, what are those factors?

✓ Flow regulations ___ Mining activities ___ Upstream channel conditions
___ Channelization ___ Road encroachment ___ Oil field water discharge
___ Augmented flows ✓ Other (specify) Water source drying up

Veg

Golden Currant
Sandbar Willow
Yellow Willow
Thistle
Fireweed
Cheat Grass
Sage
Russian Olive
Curly Dock
Yellow Mustard
Knapweed
Rabbit Brush
Hounds Tongue
Grease Wood
Goldenrod
Great Basin Wildrye

Appendix C – Proper Condition Function Lentic Checklist

Lentic Standard Checklist

Name of Riparian-Wetland Area: Bell Ditch Wetland

Date: 8/11/09 Area/Segment ID: ______ Acres: ______

ID Team Observers: D. Hinson K. Eakin

Yes	No	N/A	HYDROLOGY
√			1) Riparian-wetland area is saturated at or near the surface or inundated in "relatively frequent" events
√			2) Fluctuation of water levels is not excessive
√			3) Riparian-wetland area is enlarging or has achieved potential extent
√			4) Upland watershed is not contributing to riparian-wetland degradation
√			5) Water quality is sufficient to support riparian-wetland plants
√			6) Natural surface or subsurface flow patterns are not altered by disturbance (i.e., hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)
√			7) Structure accommodates safe passage of flows (e.g., no headcut affecting dam or spillway)

Yes	No	N/A	VEGETATION
√			8) There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
√			9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)
√			10) Species present indicate maintenance of riparian-wetland soil moisture characteristics
√			11) Vegetation is comprised of those plants or plant communities that have root masses capable of withstanding wind events, wave flow events, or overland flows (e.g., storm events, snowmelt)
√			12) Riparian-wetland plants exhibit high vigor
√			13) Adequate riparian-wetland vegetative cover is present to protect shoreline/soil surface and dissipate energy during high wind and wave events or overland flows
√			14) Frost or abnormal hydrologic heaving is not present
√			15) Favorable microsite condition (i.e., woody material, water temperature, etc.) is maintained by adjacent site characteristics

Yes	No	N/A	EROSION/DEPOSITION
√			16) Accumulation of chemicals affecting plant productivity/composition is not apparent
√			17) Saturation of soils (i.e., ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils
√			18) Underlying geologic structure/soil material/permafrost is capable of restricting water percolation
√			19) Riparian-wetland is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)
		√	20) Islands and shoreline characteristics (i.e., rocks, coarse and/or large woody material) are adequate to dissipate wind and wave event energies

(Revised 1999)

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Photos: 1 – Bell Ditch confluence
2 – Bell Ditch wetland looking N/NE
3 – " " " " S

Remarks

Water source: spring source

11) Carex, Cattails, Salix have deep binding root masses

Summary Determination

Wildlife
Dove
Yellow warbler
Deer
Magpie
California Quail
Swallowtail Butterfly
Monarch Butterfly
Chukar

Veg in Wetland
Carex spp.
Salix spp. (Yellow?)
Cattails
Redtop
Epilobium
Equisetum
Hemlock
Nightshade
Stinging nettle

Functional Rating:

Proper Functioning Condition	√
Functional—At Risk	___
Nonfunctional	___
Unknown	___

Trend for Functional—At Risk:

Upward	___
Downward	___
Not Apparent	___

Are factors contributing to unacceptable conditions outside the control of the manager?

Yes ___
No ___

If yes, what are those factors?

___ Dewatering ___ Mining activities ___ Watershed condition
___ Dredging activities ___ Road encroachment ___ Land ownership
___ Other (specify)___

NPS 300/117839, December 2012

National Park Service
U.S. Department of the Interior

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