National Park Service
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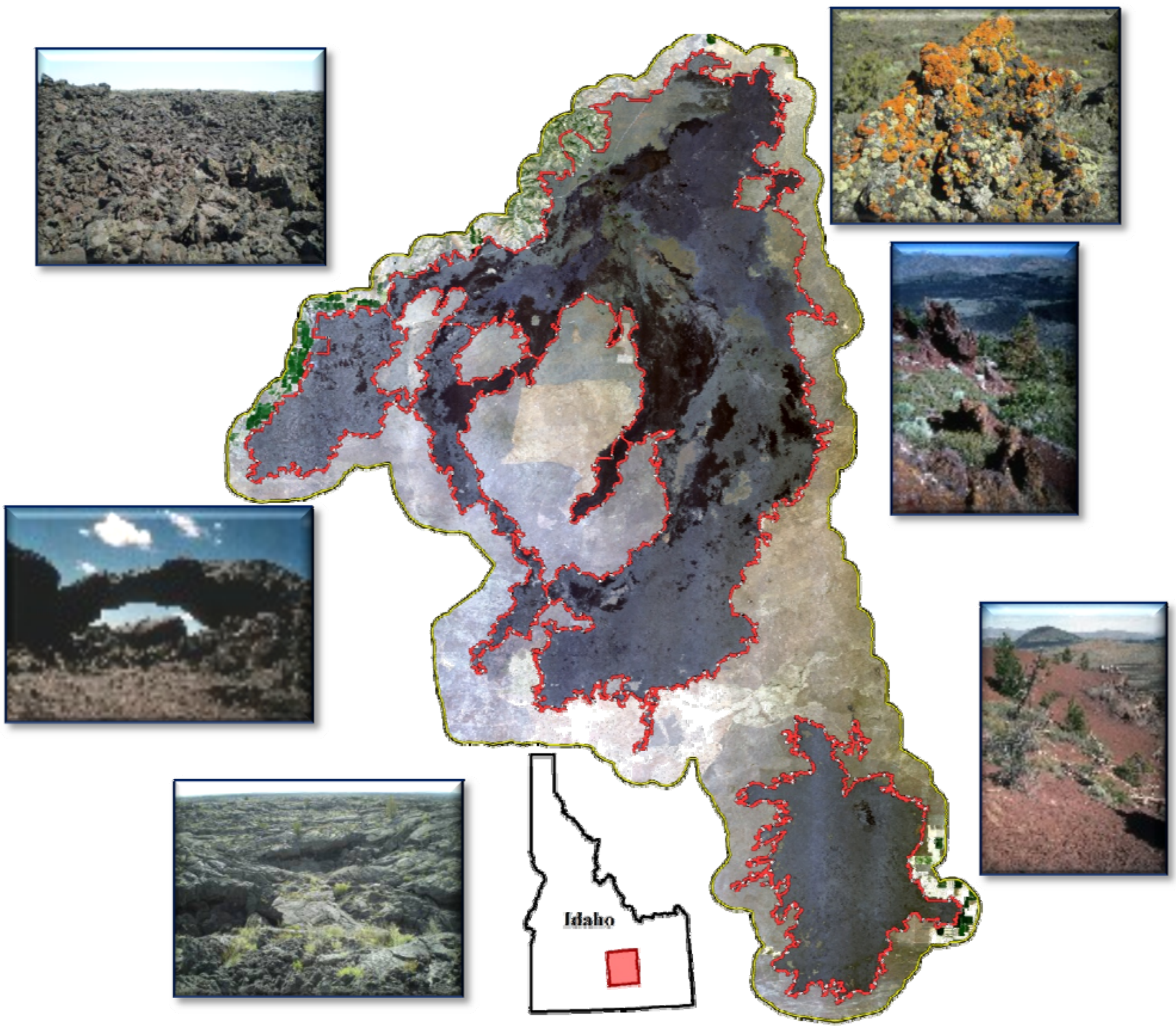
Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Craters of the Moon National Monument and Preserve

Natural Resource Report NPS/UCBN/NRR—2012/602



ON THE COVER
Map and Photographs of Craters of the Moon National Monument and Preserve located in south-central Idaho with insets of pictures acquired from the website at: www.nps.gov/crmo/index.htm and from Northwest Management, Inc.

Natural Resource Condition Assessment

Craters of the Moon National Monument and Preserve

Natural Resource Report NPS/UCBN/NRR—2012/602

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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 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 Web site (http://science.nature.nps.gov/im/units/ucbn/) and the Natural Resource Publications Management Web site (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. viii) for more information.*

Executive Summary

This Natural Resource Condition Assessment (NRCA) is designed to provide the staff of Craters of the Moon National Monument and Preserve (CRMO) a moment-in-time assessment using existing data representing the natural resources of the park and surrounding lands. Described herein are the natural resources of CRMO, a determination of the state of knowledge of their condition using existing data, identification of information gaps, statements of conclusions or hypotheses on the condition of selected natural resources (unknown, degraded, unimpaired), identification of resource threats or potential issues affecting ecosystem health, and recommendations for future focused research. This report maintains consistency under the national NRCA guidelines and standards for study design and reporting products.

Generally, this NRCA seeks to interpret and translate existing scientific information into a form that CRMO managers find useful for supporting natural resource decision-making, action plans, and cultural resource planning. This report and set of geographic information system (GIS) maps with associated data layers serve to: (1) describe CRMO resources in a regional context (setting, significance, issues), (2) provide an interdisciplinary (holistic) snapshot of current resource conditions by management area, (3) document high-priority data gaps and resource condition threats and stressors and (4) identify and describe "high value" and "high vulnerability" (at risk) CRMO resources and management areas. Information, data, and recommendations developed under this project will assist CRMO managers to: (1) develop near-term management strategies and priorities for the resource management program, (2) engage in watershed or landscape scale partnership and education efforts, (3) assist with mid- to longer-term planning (e.g. General Management Plans, Resource Stewardship Strategies, Implementation Plans) and (4) meet performance reporting requirements on 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.).

The entire study area addressed herein totals approximately 928,780 acres (375,864 hectares**).** The study area is defined as the 6th level hydrologic unit code watersheds and the resulting physical and biological settings of CRMO are described using this geographic area. Preliminary scoping meetings were held in October 15, 2009 and included representatives from CRMO and other agencies and interested participants. The purpose of the CRMO NRCA is to evaluate and report on current conditions, critical data and knowledge gaps, and select existing and emerging resource condition influences of concern to the CRMO managers. Certain constraints were placed on this NRCA, including: (1) condition assessments are conducted using existing data and information, (2) identification of data needs and gaps is driven by the project framework categories, (3) the analysis of natural resource conditions includes a strong geospatial component and (4) resource focus and priorities are primarily driven by CRMO resource management.

NRCA results are presented for the natural resource categories of wildlife, American pika, pygmy rabbit, pronghorn, bats, Greater Sage-grouse, Clark's nutcracker, sagebrush-obligate birds, water resources, geology/soils, air quality, land use, and climate. Inventory data are good to excellent for several resources including:

Geology/Soils (classified, described, and mapped between 2005 to 2010),

- Land Use (detailed CRMO specific vegetation and land use classification and mapping completed from 2007 to 2009),
- Wildlife (surveys conducted between 2000 to 2005),
- Individual Wildlife Species (monitoring and habitat analysis is on-going), and
- Air Quality (monitoring in-place and ongoing),
- Water Resources (monitoring in-place and ongoing), and
- Climate (monitoring in-place and ongoing).

The literature review process conducted in this project revealed a few areas of general need or data gaps. Of primary concern was the lack of condition and synthesis information for the ecosystems of CRMO. Also the assessment and condition studies that build upon basic inventories to assess and inform the nature, extent, and/or condition of resources are lacking at CRMO.

Several types of information were not available or were too dated to inform this NRCA. Summarized herein are the important data that would improve natural resource management by CRMO staff. We did not estimate cost or indicate agency responsibility due to the extensive nature of the data. This summary should provide guidance to staff for future research/data collection efforts within and outside CRMO:

- Additional research is needed for several wildlife species of concern identified as sagebrush-obligate. Due to the natural history of these species and habitat requirements, continued monitoring of the sagebrush-steppe is desirable. An extensive survey of the pronghorn migration routes and the species habits would be informative. Additionally, little is known beyond annual monitoring data for sagebrush-obligate birds. Inventory and monitoring efforts should focus on these species.

- The need for an assessment of vernal pools, seeps and springs, wetlands, and riparian areas within CRMO has been identified from an analysis of the available literature. There have not been focused studies identifying the location, providing a description, and determining the quality of these mesic/aquatic resources or of their importance to CRMO plant communities, wildlife and habitat, or surface and groundwater quality.

- Drinking water pumped from the two shallow wells located near the headwaters of Little Cottonwood Creek should be monitored for water quality in order to protect the health and safety of park staff and visitors. Monitoring drinking water quality will also provide insight into the degree of treatment and maintenance for the water supply infrastructure and treatment systems needed to comply with human consumption standards.

- Accurate and standardized land cover/use mapping for the project area (especially for the areas surrounding CRMO) that meets National Map Accuracy Standards (±40 ft = ±12.2 m) and is repeatable over time. This information is very important for watershed modeling using water quality attributes, wildfire risk assessment, wildlife habitat structure, soils, and other resource values. A long term monitoring program incorporating annual to five-year updates should be employed at CRMO to provide managers with this vital information. Public outreach programs focused on the unique resources of CRMO and responsible ownership actions adjacent to the CRMO border would be invaluable to help preserve the natural resources.

- Studies focused on bat species were lacking for CRMO beyond the OMSI paper (Ave et al. 2004); many bat species within Idaho are species of concern and further research on population distribution and occurrence would aid efforts to provide species conservation and possibly provide insight into climate variations based on bat behavioral patterns.

Recommended management actions based on the literature, GIS databases, monitoring research data, interviews of CRMO natural resource staff, and field observations conducted for this NRCA include but are not limited to:

(1) Acquire subsurface mineral rights for the Monument area of CRMO;
(2) Acquire water rights for all waters of the State of Idaho put to beneficial use;
(3) Account for visitor access by updating all trails to meet Americans with Disability Act standards;
(4) Determine the potential for oil and gas developments;
(5) Determine control methods for invasive and noxious plant species in accordance with neighboring land managers;
(6) Monitor plant communities and wildlife species to determine climate change and wildfire effects within the CRMO area;
(7) Regularly update the vegetation inventory and land use geodatabase to provide current habitat support information for all research applications particularly modeling studies;
(8) Continue collecting climate data to add to the long-term CRMO and regional databases, and model for developing short- and long-term trends;
(9) Complete an assessment of current water resources including vernal pool locations and attributes to determine benefits to CRMO resources; and
(10) Complete an assessment and status report of all kipukas (i.e. islands of vegetation in the lava flows) to determine proper functioning condition and the possibility of use in wildfire and climate change monitoring.

Based on these suggested recommendations, similar management practices, and additional resources, CRMO should be able to attain proper functioning ecosystem conditions and accomplish the NPS goals and objectives of conservation for future generations.

Acknowledgements

This assessment and final report was completed through the effort and dedication of numerous individuals and organizations. We are very thankful for all the support and assistance from Lisa Garrett, NPS Upper Columbia Basin Network (UCBN) and John Apel, Craters of the Moon National Monument and Preserve (CRMO). Lisa and John possess the vision to develop and implement this assessment, the natural resource knowledge of CRMO, and the professionalism and dedication to guide it to completion. We owe a great deal of appreciation to our dedicated staff, including Vaiden Bloch, Geographic Information System (GIS) Specialist, from Northwest Management, Incorporated (NMI).

The management and natural resource staff of CRMO, John Apel and Doug Owen, made us welcome when we arrived; Doug provided an excellent overview of CRMO, John provided a wealth of information which was very helpful for this project, and Steven Bekedam assisted researchers by providing helpful advice and information on the different resource and management areas within CRMO. For these and other contributors to the success of this assessment and final report, we are grateful.

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

AQRV	Air Quality Related Values
BLM	U.S. Bureau of Land Management
CAA	Clean Air Act of 1970, as amended
COMLF	Craters of the Moon Lava Field
CRMO	Craters of the Moon National Monument and Preserve
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
HUC	Hydrologic Unit Code
I&M Program	Inventory and Monitoring Program
IMPROVE	Interagency Monitoring of Protected Visual Environments
ISDA	Idaho State Department of Agriculture
IWCC	Idaho Weather Climate Center
KBLF	King's Bowl Lava Field
km	Kilometers
km^2	Square kilometers
mi	Miles
mi^2	Square miles
MS	MicroSoft
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NASS	National Agricultural Statistics Service
NMI	Northwest Management, Incorporated
NM&P	National Monument and Preserve
NPS	National Park Service
NRCA	Natural Resource Condition Assessment
NRCS	Natural Resources Conservation Service
NRR	Natural Resource Report
NVC	National Vegetation Classification
PSD	Prevent Significant Deterioration
SRP	Snake River Plain
UCBN	Upper Columbia Basin Network
U.S.	United States of America
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCA Program	Watershed Condition Assessment Program
WLF	Wapi Lava Field
WRCC	Western Region Climate Center
WRD	Water Resources Division
YELL	Yellowstone National Park

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. viii) 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*" (NPS 1999). To uphold the NPS mission, the Director approved the Natural Resource Challenge to encourage national park managers to focus on the preservation of the U.S. natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the challenge, 270 park units in the national park system were organized into 32 inventory and monitoring (I&M) networks, including the UCBN.

The UCBN consists of nine widely separated NPS units located in western Montana, Idaho, eastern Washington, and central Oregon. Park units within the UCBN 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 (WRD) received an increase in funding to assess natural resource conditions within selected national park units including CRMO. Management oversight and technical support for this effort is provided by the WRD, Natural Resource Condition Assessment (NRCA) Program. The NRCA Program partnered with the NPS Pacific West Region to fund and oversee an assessment for each park unit in the UCBN. This report documents the results of the Natural Resource Condition Assessment (NRCA) completed for CRMO. It is anticipated that the CRMO NRCA will ultimately provide important information for the state of the parks reports that are currently in conceptual planning stages (Garrett, pers. comm. 2011).

Generally, the CRMO NRCA seeks to interpret and translate existing scientific information into a form that CRMO managers find useful for supporting natural resource decision-making, action plans, and cultural resource planning. This report and set of geographic information system (GIS) maps with associated data layers serve to:

- Describe CRMO 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) CRMO resources and management areas.

The analyses and assessment data presented in this NRCA is of a general nature that provides broad ecological information. Information, data, and recommendations developed under this project will assist CRMO managers to:

- Develop near-term management strategies and priorities for the CRMO 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 CRMO resource condition status as need for the Department of Interior "land health" goals, Office of Management and Budget "natural resource condition" scorecard, NPS state of the parks reports, etc.

The ensuing report is designed to provide park staff a moment-in-time assessment of the natural resources of CRMO and the surrounding area based on existing data. This report describes the natural resources of CRMO, determines the state of knowledge of their condition using existing data, identifies information gaps, states conclusions or hypotheses on the condition of selected natural resources (unknown, degraded, unimpaired), identifies resource threats or potential issues affecting ecosystem health, and recommends further studies. This report maintains consistency under the national NRCA guidelines and standards for study design and reporting products.

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 U.S. Department of the Interior (USDI) 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 the NRCAs are driven by the park resource setting, status of current resource stewardship planning, and established scientific principles. By evaluating these three criteria, 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/NRCondition_Assessment_Program/Index.cfm.

NRCAs represent a relatively new approach to assessing and reporting park resources and 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 as they work 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:

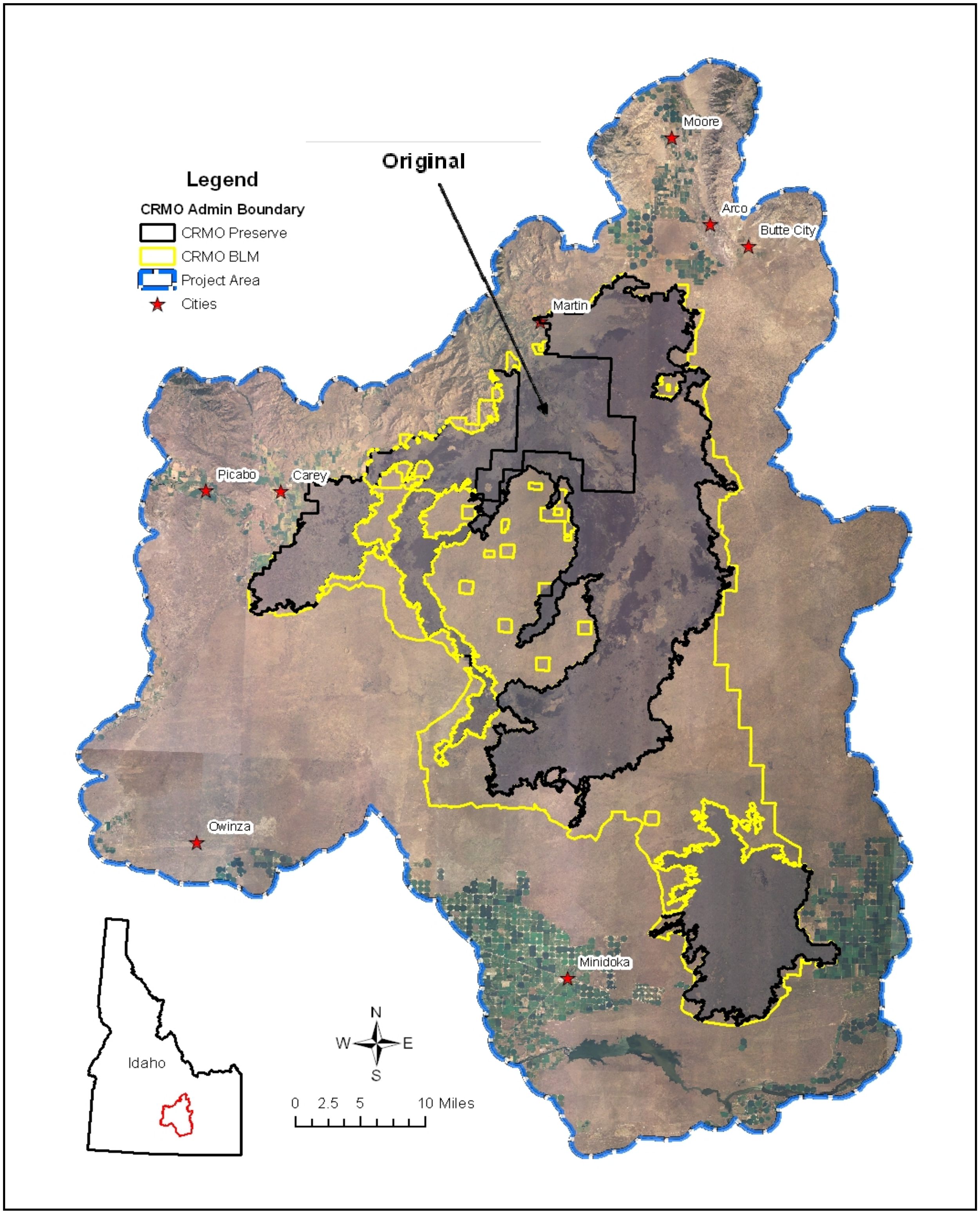
- Determine the state of knowledge concerning overall natural resource condition,
- Identify information gaps and resource threats,
- Assess overall ecosystem health, and
- Set the stage to establish the context for management actions and collaboration.

Study Area

In 1924, the original (approximately 53,495-acre (21,649-hectare) Craters of the Moon National Monument was established by proclamation of President Calvin Coolidge (NPS 2009). In 2000, Craters of the Moon National Monument was expanded by President William J. Clinton (Proclamation 7373) to encompass a total land area of just over 750,000 acres (302,420 hectares) with some areas managed by the NPS (National Monument and National Preserve) and some by the U.S. Bureau of Land Management (BLM) (National Monument). CRMO was originally established to preserve an unique geologic area of volcanic cones, craters, lava flows, and lava tube caves and now includes almost the entire Great Rift (the best-developed example of a volcanic rift zone in the contiguous U.S.) (Kuntz 1982).

CRMO is located at the base of the Pioneer Mountain Range foothills to the north along a gentle sloping plain that descends onto a portion of the Eastern SRP. This area of central Idaho occurs within the Intermountain Plateau physiographic division, Snake River Basin - High Desert and Basin and Range physiographic provinces (Omernik 1986) of the United States. The entire SRP is large, extending across the entire length of southern Idaho from the Yellowstone Plateau and Teton Mountains in northwestern Wyoming to the Idaho/Oregon border, approximately 10,000 mi^2 (25,900 km^2) long (CRMO 2005). The SRP is also approximately 60 miles (96.5 km) wide and contains lava deposits over 10,000 ft (305 m) deep (based on borehole data). At the eastern end of the SRP are located the most recent volcanic eruptions on the SRIP (approximately 2,100 years ago) occurring along the Great Rift and centered at CRMO (NPS-CRMO 2009).

CRMO volcanic features stem from three young (Late Pleistocene-Holocene) lava fields. These include (from north to south): the Craters of the Moon, Kings Bowl, and Wapi lava fields (Figure 1). Most of the landscape comprising the largest lava field (Craters of the Moon) formed during a series of eight major eruptive periods that occurred over the past 15,000 years (Owen 2008). Together the three lava fields cover about 400 square miles (1,036 square kilometers). The remaining lands in and around the lava fields are primarily classified as sagebrush-steppe grasslands covering an area of approximately 717 square miles (1857 kilometers), yielding a combined total area for CRMO of 1,117 square miles (2,893 square kilometers).



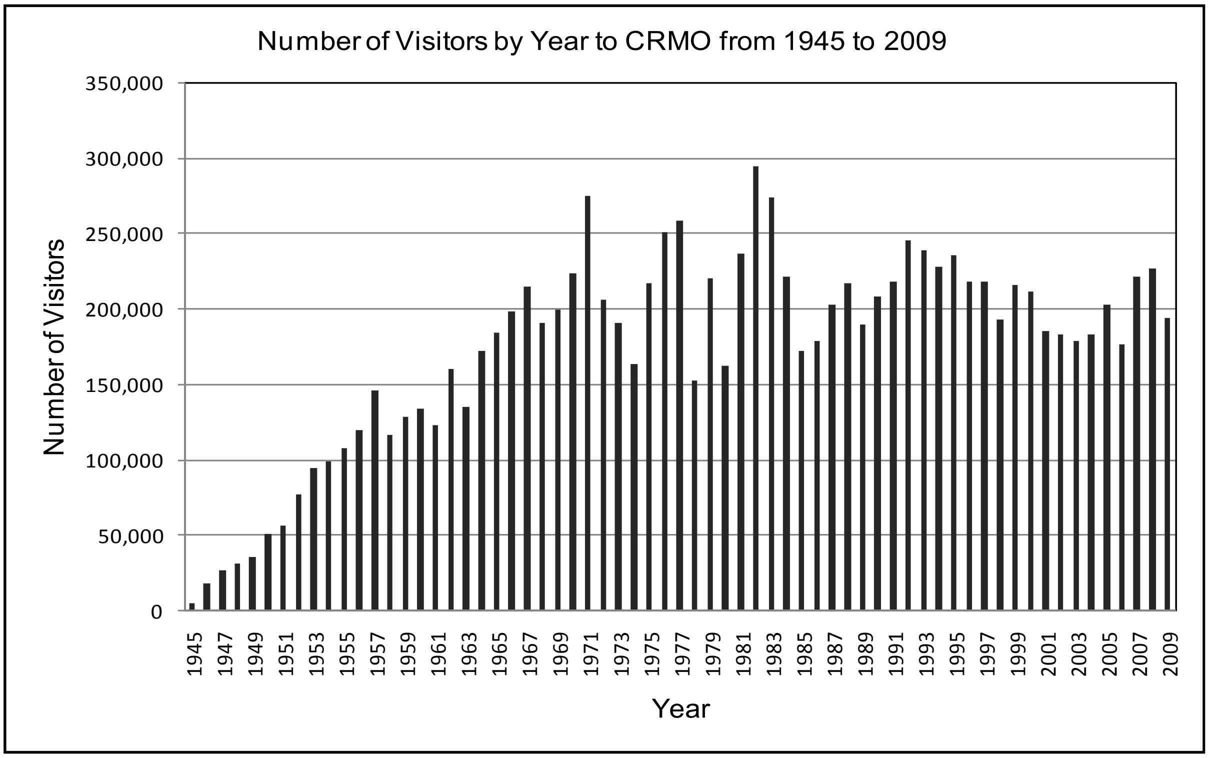
Map note: Yellow lines indicate BLM lands outside of the lava flows (NPS-lands) and include privately-owned in-holdings (small squares).

Figure 1. Map of CRMO in Central Idaho.

The topography at CRMO is rugged with an average elevation of approximately 6,305 ft (1,990 m) ranging from 4,880 ft (1,625 m) on the southeastern boundary to 7,730 ft (2,355 m) in the northern foothills. CRMO is a moonscape of volcanic ridges, slopes, shield volcanoes, cinder (tephra) cones up to 100-700 ft (31-213 m) tall, lava cones, lava flows, cracks and fissures all intertwined with longitudinal sand dunes, sagebrush flats and loess plains. The three striking lava fields expose some of the best examples of open rift cracks on earth, including the deepest at 650 feet (198 m). Also exposed are excellent examples of basaltic lava, including Aa (a'a), block lava, and pahoehoe (shelly, spiny, and slabby pahoehoe). Unique geologic features are common with over one hundred tree molds (cavities and impressions left by lava-incinerated trees), hundreds of lava tubes (caves), and numerous other volcanic features including tumuli, pressure plateaus, pit craters, spatter cones, and hornitos. Some areas of pre-eruption "old" soils and vegetation exist within the older lava flows that were surrounded by, but not covered with the new or younger lava flows. These sites are known as kipukas and occur throughout the project area as both small pockets and large plains. Other areas within CRMO also support relatively undisturbed examples of native shrub-steppe habitats but are not considered to be kipukas.

The towns nearest the CRMO headquarters include Carey (24 mi (39 km) to the northwest), Arco (18 mi (29 km) to the northeast), and Minidoka (15 mi (24 km) to the south). The nearest largest cities are Twin Falls (90 mi (145 km) to the southwest), Pocatello (100 mi (161 km) to the southeast), and Idaho Falls (84 mi (135 km) to the east). The five Idaho counties with portions of CRMO are predominantly rural and consist of Blaine, Butte, Lincoln, Minidoka, and Power counties containing population totals (density/1 mi2 or 2.6 km2) of: 21,166 (7/mi2); 2,808 (1/mi2); 4,545 (3/mi2); 19,014 (27/mi2); and 7,753 (5/mi2), respectively. State Highway 93/26/20 crosses CRMO on the north and is the only paved highway touching the Monument. CRMO is bordered on all sides primarily by public lands managed by the BLM through the Upper Snake River, Shoshone, and Burley Field Offices. Large areas of private agricultural lands border CRMO near Arco, Carey, and along the eastside of the Wapi Lava Field.

Annual visitation to CRMO ranges from approximately 200,000 to 250,000 (NPS 2010b). Of this total, approximately 12,000 represent overnight stays, approximately 10,000 represent local visitors from the surrounding communities, and approximately 86,000 visitors use lodging or camping facilities within 50 miles of CRMO. Visitation increased steadily from approximately 51,000 in 1950 until reaching a high of nearly 295,000 visitors in 1982. Recent visitation rates for the last five year were on average over 227,000 (Figure 2). Recreation, including wildlife viewing, photography, camping, hiking, backpacking, picnicking, cross-country skiing, snowshoeing, and experiencing the volcanic formations and landscapes, is primarily the chief reason for visiting CRMO. CRMO also provides many educational opportunities for visitors including unique geologic and environmental studies for students and professionals.



(Source: NPS 2010b)

Figure 2. Number of visitors to CRMO between 1945 to 2009 .

Historical Setting

CRMO is located on a recent volcanically active portion of the Snake River Plain (SRP) south of the Pioneer Mountains. There is evidence that Paleo-Indians occupied lands in and around the SRP including the CRMO-area as early as 9,600 years ago. Historically, the Northern Shoshone created trails through the Craters of the Moon Lava Field during summer migration from the Snake River to the Camas Prairie, west of the lava field (NPS 1991). Both the Shoshone-Bannock and the Shoshone-Paiute Tribes have a history of using the lands associated with CRMO for hunting and gathering but no evidence exists for permanent habitation by any Native American group (NPS 1991). It is thought that the most recent volcanic eruptions, ending about 2,100 years ago, were likely witnessed by the Northern Shoshone people. For example, legends identify a serpent on a mountain that when angered by lightning, coiled around and squeezed the mountain until liquid rock flowed, fire shot from cracks, and the mountain exploded.

The first permanent Euro-American settlements were occupied during the late 1800s and early 1900s. The CRMO area was used by homesteaders primarily as rangeland to graze sheep and cattle. In the Pioneer Mountains gold, silver, and lead mining were common pursuits in the late 19th and early 20th century. Historically, Native Americans used fire to manipulate the vegetation and wildlife in the area (Williams et al. 2001) and since the mid-1800s, sheepherders used fire on lands within CRMO to reduce shrub cover and encourage herbaceous vegetation growth.

Natural Resources

Air Quality

As of 1977, the CRMO area is designated a mandatory Class I airshed under the Federal Clean Air Act of 1970, as amended (CAA). Sections 160-169 of the CAA establish a program to Prevent Significant Deterioration (PSD) of air quality in clean air areas (i.e., attainment areas), which include Class I areas. Among the purposes of the PSD program are "*to preserve, protect and enhance air quality in national parks, monuments, national seashores, and other areas of special national or regional natural, recreational, scenic or historic value*". Congress provided additional protection for Class I areas in Section 169A of the CAA, which specifies a national goal of "*remedying any existing and preventing any future manmade visibility impairment*" in Class I areas.

The NPS works to preserve, protect, enhance, and understand air quality and resources sensitive to air quality in the national park system (NPS 2010). This focus is important for park units because air pollution affects ecological health, scenic views, human health, and visitor enjoyment even at relatively low levels. Since the 1970s the NPS has operated a comprehensive air quality monitoring program (NPS 2004). The monitoring program was established to collect data for air quality parameters including, ozone, atmospheric wet and dry deposition of nitrogen, sulphur, ozone, and to assess visibility.

Air pollution associated with industrialization and urbanization is known to adversely affect sensitive natural resources and therefore has the potential to degrade resources in U.S. national parks. Human-caused air pollutants are known to cause injury to humans and various species of plants, acidify water bodies, and leach nutrients from soils (NPS 2004). The federal government has granted responsibility and authority to enforce air quality standards and regulations in most states, including Idaho. All NPS units are required to comply with the National Ambient Air Quality Standards (NAAQS) both inside and outside unit boundaries, and protect visibility in congressionally-mandated Class I unit areas.

An inventory of air emissions was performed (NPS 2001, IDEQ 2010) using data from two air quality monitoring stations at CRMO and air quality trend data were analyzed for selected parameters through 2009 (NPS 2010). The U.S. Department of Energy (DOE) operates a station adjacent to the headquarters building and the NPS operates a station with Interagency Monitoring of Protected Visual Environments (IMPROVE) and National Atmospheric Deposition Program (NADP) monitors. These are located approximately one-half mile (0.8 km) south of the headquarters building. The IMPROVE program monitors visibility conditions in national parks and wilderness areas. Their monitoring stations use modular aerosol samplers to measure fine and total aerosol mass by pulling air through specialized filters that are routinely collected and analyzed. In 2010, the NPS Air Resources Division included CRMO data (presented herein) in their annual air quality performance and progress report.

A national regional haze rule has been adopted that requires states to improve visibility over the next 60 years in 156 national parks and wilderness areas across the country. A regional haze State Implementation Plan (SIP) has been prepared by the Idaho Department of Environmental Quality (IDEQ 2010) to meet the requirements of the federal Regional Haze Rule (40 CFR, Part 51, Section 308). The SIP contains strategies and elements related to each requirement of this rule and it also addresses the transport/movement of haze across state boundaries in coordination with other states. Two of the primary SIP requirements are to address industrial source Best Available Retrofit Technology (BART) requirements and demonstrate reasonable progress in improving visibility by 2018 for each Class I area, including CRMO.

Climate

Records of climatic conditions and precipitation have been maintained continuously at the Visitor Center weather station (102260) from 1958 to 2010 (WRCC 2011). CRMO is predominantly characterized by a plateau/continental interior climate that is semi-arid with hot, dry summers and cold, dry winters. Significant precipitation (approximately 45% of the annual total) is deposited during the winter as snow totaling approximately 90 inches (229 centimeters) annually and contributes to the overall annual precipitation average of 15.5 inches (39 centimeters) (Idaho State Climate Service 2003, WRCC 2011). Temperatures within CRMO define four seasons and vary significantly between the moderately long summer and winter seasons. Average monthly minimum and maximum temperatures range from 11^{o}F to 29^{o}F (-11.7^{o}C to -1.7^{o}C) in January, the coldest month and 53^{o}F to 85^{o}F (11.7^{o}C to 29.4^{o}C) in July, the warmest month (WRCC 2011).

Geology and Soils

CRMO contains the Great Rift, one of the most significant geological areas in Idaho, that encompasses about 400 square miles (1,036 square kilometers) and represents over 60 different volcanic eruptions (NPS 2005). Three geologically young lava deposits provide examples of some of the deepest lava flows with many unique features including pahoehoe and aa lava flows, lava tubes, and volcanic cinder cones (NPS 2011b). Approximately 450,000 acres (182,109 hectares) of CRMO are covered by a young mantle of lava with the remaining 300,000 acres (121,406 hectares) covered with older lava flows with developed soils supporting sagebrush-steppe plant communities (NPS 2005, Kuntz et al. 2007).

The three youngest flows at CRMO include Craters of the Moon flow in the north and the Kings Bowl and the Wapi flows in the south (NPS 2011b) (Figure 3). Each of these flows is between 2,000-2,500 years old compared to over 10,000 years old for the older flows (Kuntz et al. 1992). The areas between the young lava flows consist of Pleistocene-age lava (Kuntz et al. 1992).

Soils within CRMO include older deposits formed prior to, and protected from lava flow and younger deposits blown in or developed from more recent volcanic exposures. Protected older areas within the younger lava flows are called kipukas and have deep soils with “islands” of vegetation. The older volcanic rocks are typically mantled with windblown loess (silt) or eolian sand deposits. Thirteen general soils mapping units were described by the USDA-SCS (Johnson 1991) for this region and include: (1) well drained and somewhat excessively drained soils on fan terraces and stream terraces (three units), (2) well drained soils on basalt plains (five units) and (3) well drained soils on mountainsides and foothills (five units).

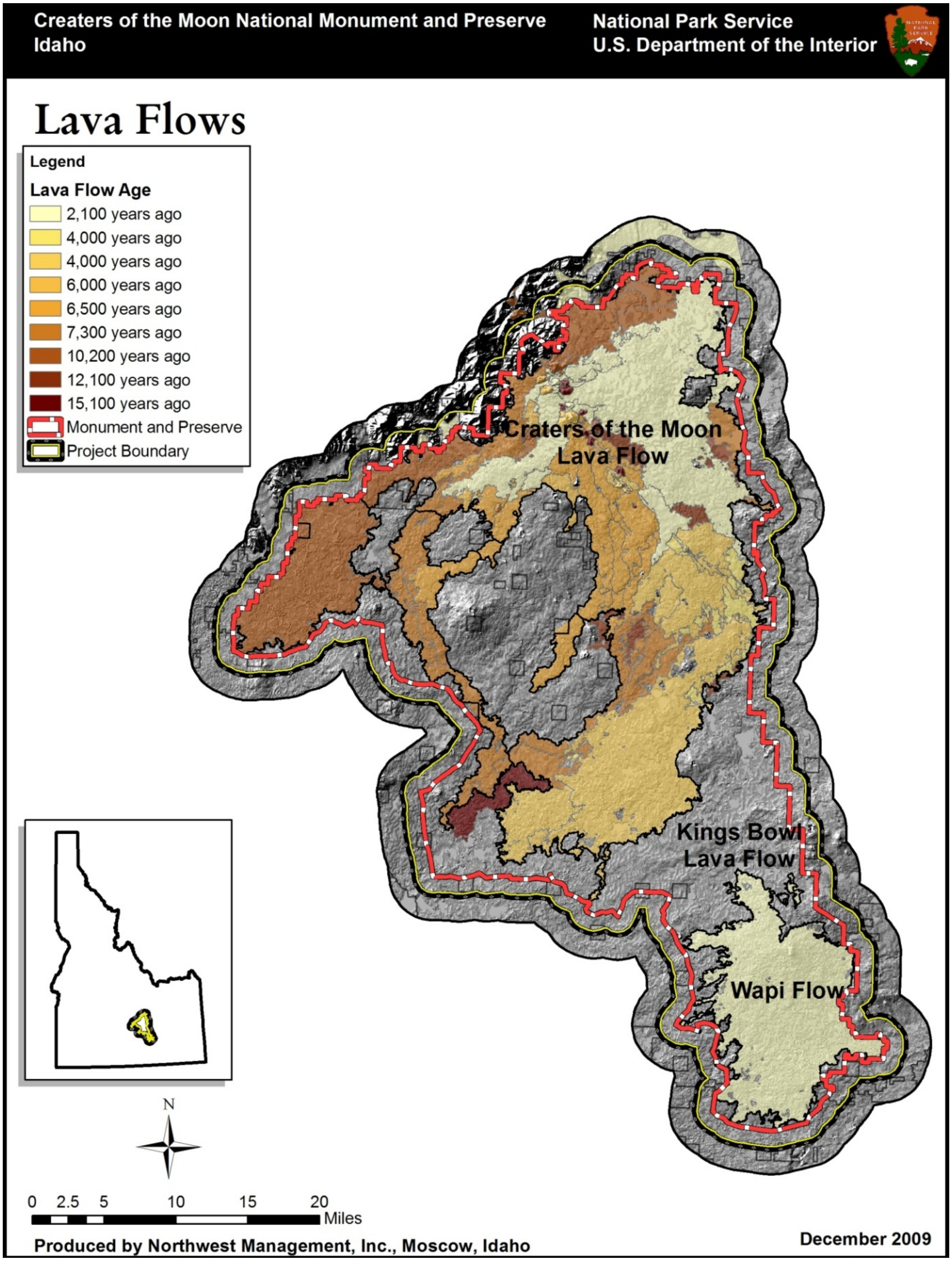


Figure 3. Lava flows within CRMO.

CRMO soils were recently classified, described, and mapped (NRCS-NPS 2010). The results of this study include the classification of the CRMO soils as generally being developed from wind-blown loess or from alluvium derived from the basaltic lava. Recent soil mapping included 11 general mapping units (Figure 16, page 86), 85 detailed mapping units (including playas and water), and 70 soil series representing 37 ecological sites (a distinctive kind of land, with specific physical characteristics which differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation, and in its response to management). Lava flows comprised 34% of CRMO and Cinderhurst soils (very shallow to bedrock soils, formed over lava beds) comprised 26% (NRCS-NPS 2010).

Soils to the north of CRMO are different than those in the volcanic landscape and Johnson (1991) stated that the Pioneer Mountain foothill soils are generally better developed than those in the rest of CRMO. The foothill soils were classified and mapped using two general units of well drained soils on mountainsides and foothills; the Vitale-Lavacreek-Blackspar and the Elkcreek-Gaib-Winu soil series. In contrast the soils on the lava fields were directly dependent on the deposition of wind-blown loess in cracks and crevices and the erosion of the lava deposits over time. The volcanic exposures within CRMO were classified and mapped (Johnson 1991) under well drained soils on basalt plains using the Lava flows-Cinderhurst type. CRMO soil textures range from fine-to-coarse-textured, with silt loams and sandy loams common outside of the recent lava flows and in kipukas.

Some of the soils with CRMO contain soil crusts (a complex community of cyanobacteria, green algae, lichens, mosses, microfungi, and other true bacteria) and moss cover indicating the lack of recent disturbance. These could be an important factor for determining localized land use patterns and an indicator for the health of local plant communities (Belnap et al. 2001). Moss and lichens are also common on the lava flows where the lichens help break down and dissolve the rock into soil and moss beds help hold this new soil in place (Slaton and Novey 2007).

Vegetation

The vegetation for CRMO and 2-km surrounding the Monument was inventoried, classified and mapped between 2006 and 2009 as part of the NPS National Vegetation Inventory Program (Bell et al. 2009) (Figure 4). Ninety-three plant communities (13 woodland, 63 shrubland, and 17 herbaceous) were identified for CRMO based on classification plot and other site assessment data. Forty-seven of the plant communities sampled at CRMO fit into existing National Vegetation Classification (NVC) association concepts. The remaining plant communities were considered significant enough to create new NVC associations under the classification of Rust and Wolken (2008). Two plant associations were considered endemic to CRMO and another type was classified into a higher order vegetation alliance. A summary of the results of this inventory is provided below and separated by physiognomic group for convenience.

Upland Forests and Woodlands: Woodlands and forests are uncommon within CRMO and are distributed on the Pioneer Mountains footslope, lava flows, and alluvial fans in a range of elevations. Stands typically occupy slightly more mesic habitats and sites protected from the prevailing wind. Canopy density is open and generally controlled by the availability of soil moisture or rooting sites; common trees include Douglas-fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*), Utah juniper (*Juniperus osteosperma*), and Rocky Mountain juniper

(*Juniperus scopulorum*). Commonly associated understory shrubs include mountain snowberry (*Symphoricarpos oreophilus*) and chokecherry (*Prunus virginiana*) on mesic sites with antelope bitterbrush (*Purshia tridentata*), Wyoming big sagebrush (*Artemisia tridentata wyomingensis*), and desert sweet (fern bush) (*Chamaebatiaria millefolium*) on drier sites. Forbs associated with forest and woodland stands include broadleaf bluebell (*Mertensia platyphylla*), sharpleaf valerian (*Valeriana acutiloba*), sticky cinquefoil (*Potentilla glandulosa*), sticky purple geranium (*Geranium viscosissimum*), scarlet painted-cup (*Castilleja coccinea*), and silvery lupine (*Lupinus argenteus*), common grasses include slender wheatgrass (*Elymus trachycaulus*), Nelson's needlegrass (*Achnatherum nelsonii*), and Idaho fescue (*Festuca idahoensis*). Fire is not a major factor in shaping woodland communities within CRMO, however, stands are vulnerable to drought.

Woodland types are represented primarily by Utah juniper trees on the southern Wapi lava field and to a lesser degree in some lower elevation areas of the Craters of the Moon lava field. Limber pine woodlands are most common in the higher elevations of the Craters of the Moon lava field. Some old-growth stands of Utah juniper on lava flows exceed 700 years in age. Many of the communities classified as woodlands might also be called wooded shrublands or wooded herbaceous types due to low tree cover, at or below ten percent cover. Within lava fields characterized by woodlands, understory shrubs typically provide less than 5% of the total stand cover and include fern bush, ocean spray (*Holodiscus* sp.), mock orange or syringa (*Philadelphus lewisii*), dwarf goldenweed (*Haplopappus nanus*), and in favorable microsites, antelope bitterbrush and lava phlox (*Leptodactylon pungens*). Mountain big sagebrush (*Artemisia tridentata vaseyana*) is common in this vegetation type in the southern parts of CRMO. Common understory forbs include scabland penstemon (*Penstemon deustus*) and desert parsley (*Cymopterus terebinthinus*). Indian ricegrass (*Achnatherum hymenoides*), Sandberg bluegrass (*Poa sandbergii*), Thurber needlegrass (*Stipa thurberiana*), and squirreltail (*Elymus elymoides*) are the most common bunchgrasses on these drier sites.

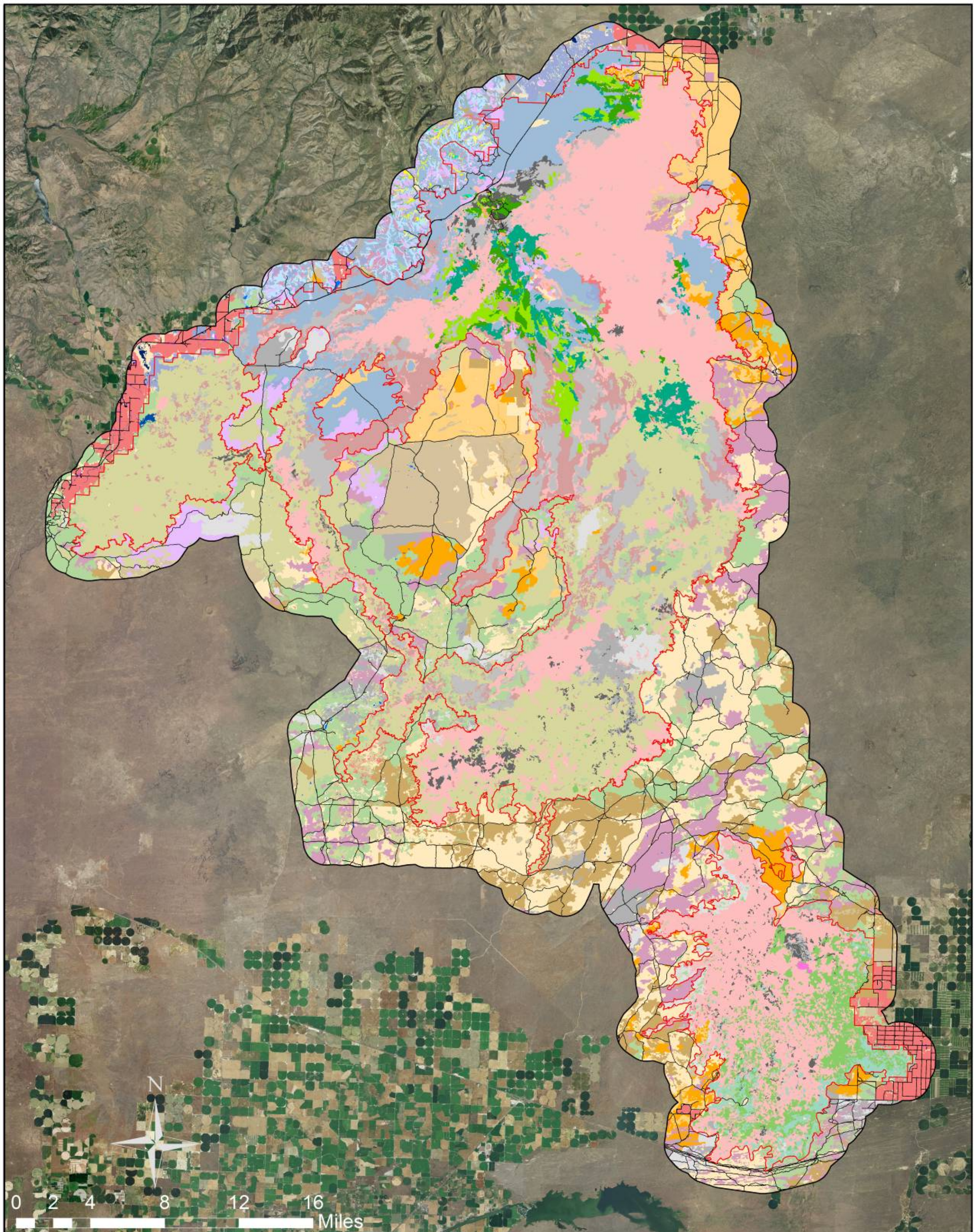


Figure 4. Map of existing vegetation types at CRMO**.**

Legend

CRMO Boundary
Mapping Project Boundary

Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
Pseudotsuga menziesii Forest Alliance

Inter-Mountain Basins Volcanic Rock and Cinder Land Woodland
Pinus flexilis / Chamaebatiaria millefolium / Poa secunda Sparse Vegetation
Pinus flexilis / Purshia tridentata Woodland
Pinus flexilis / Artemisia spp. Woodland
Juniperus (osteosperma, scopulorum) / Mixed Shrub Complex
Juniperus scopulorum / Poa secunda / Penstemon deustus Woodland

Rocky Mountain Aspen Forest and Woodland
Populus tremuloides / Artemisia tridentata Forest
Populus tremuloides / Mixed Herbaceous Forest Complex
Populus tremuloides / Mixed Shrub Woodland Complex

Columbia Basin Foothill Riparian Woodland and Shrubland
Populus balsamifera ssp. trichocarpa Temporarily Flooded Woodland Alliance
Alnus incana / Mesic Forbs Shrubland
Betula occidentalis Shrubland Alliance

Inter-Mountain Basins Volcanic Rock and Cinder Land Shrubland and Herbaceous Vegetation
Cercocarpus ledifolius - Purshia tridentata / Poa secunda Shrubland
Pahoehoe Lava Sparsely Vegetated Herbaceous Vegetation Complex
Pahoehoe Lava Sparsely Vegetated Shrubland Complex
Sparsely Vegetated Cinders
Aa Lava Sparsely Vegetated Shrubland Complex

Columbia Plateau Low Sagebrush Steppe
Artemisia arbuscula Shrubland Alliance

Inter-Mountain Big Sagebrush Steppe and Shrubland
Artemisia tripartita Shrubland Alliance
Artemisia tripartita / Bromus tectorum Shrubland Complex
Artemisia tridentata ssp. tridentata Shrubland Alliance
Artemisia tridentata ssp. tridentata / Bromus tectorum Semi-natural Shrubland
Artemisia tridentata ssp. vaseyana Shrubland Alliance
Artemisia tridentata ssp. vaseyana / Bromus tectorum Semi-natural Shrubland
Artemisia tridentata ssp. wyomingensis Shrubland Alliance
Artemisia tridentata ssp. wyomingensis / Bromus tectorum - (Agropyron cristatum) Shrubland Complex
Ericameria (Chrysothamnus) spp. Shrubland Complex
Grayia spinosa Shrubland Alliance
Purshia tridentata Mixed Shrubland Complex

Northern Rocky Mountain Montane-Foothill Deciduous Shrubland
Prunus virginiana / Leymus cinereus Shrubland

Inter-Mountain Basins Semi-Desert Grassland or North American Arid West Emergent Marsh
Agropyron cristatum - Bromus tectorum Semi-natural Herbaceous Vegetation
Bromus inermis - Elymus cinereus Herbaceous Vegetation
Dry Meadow Mixed Herbaceous Vegetation Mosaic
Mixed Weedy Herbaceous Vegetation Complex

Barren Lava and Cinders
Barren Aa Lava
Barren Cinders
Barren Pahoehoe Lava

Land-Use and Land-Cover
Stream / River
Canal / Ditch
Lake / Pond
Reservoir
Residential
Agricultural Business
Transportation
Quarries / Strip Mines / Gravel Pits
Bare Rock / Sand / Other Bare Ground
Planted / Cultivated
Airstrip
Orchards, Groves, Vineyards, Nurseries, and Horticultural Areas
NPS Facilities

Figure 4. Map of existing vegetation types at CRMO (legend).

Upland Shrublands: Shrublands are the most extensive and diverse community types within CRMO and the surrounding area. Some shrub communities established on cinders and other volcanic exposures have sparse cover, while other communities on deep soils with good water holding capacity are moderately to densely-vegetated. The upland shrubland associations of CRMO are characterized by sagebrush species; three-tip (*Artemisia tripartita*), basin big (*Artemisia tridentata tridentata*), Wyoming big, and mountain big; antelope bitterbrush, fern bush, and green rabbitbrush (*Ericameria teretifolia*), among other shrub species. Some stands support juniper trees (*Juniperus* spp.) with sparse cover, providing a wooded shrubland habitat. Common understory grass species include basin wildrye (*Leymus cinereus*), needle-and-thread (*Stipa comata*), bluebunch wheatgrass (*Elymus spicatus*), Sandberg bluegrass, and Idaho fescue. Forbs are common and include dwarf buckwheat (*Eriogonum ovalifolium depressum*), silverleaf phacelia (*Phacelia hastata*), catseye or cryptantha (*Cryptantha interrupta*), hoary aster (*Aster canescens*), Douglas chaenactis or dusty maiden (*Chaenactis douglasii*), skeletonweed (*Stephanomeria tenuifolia*), and dwarf monkeyflower (*Mimulus nanus*).

Upland shrubland species are subject to negative effects due to drought, insects, fire, invasive grasses/forbs, and grazing/browsing wildlife and livestock. Perhaps the least-affected shrubland stands occur within kipukas that are protected from many outside influences. Characteristic kipuka native plant species include the shrubs three-tip sagebrush, big sagebrush subspecies**,** the grasses bluebunch wheatgrass and needlegrass species (*Stipa* spp.), and a variety of forbs. Where the kipukas are subject to disturbance, the non-native annual cheatgrass (*Bromus tectorum*) can characterize the understory.

Upland Herbaceous Associations: Grass and forb associations are uncommon and restricted in distribution within CRMO and the surrounding area. Most grassland occupies broad flats, alluvial fans, slopes, and kipukas. Stands are typically characterized by bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, needle-and-thread, Thurber's needlegrass, and the invasive species cheatgrass and crested wheatgrass (*Agropyron cristatum*). Fire does not appear to be a major factor in creating or maintaining most of the grassland communities at CRMO, but there are some signs of encroachment by woody shrub species including green and rubber rabbitbrush (*Ericameria nauseosa*) and patches of non-native grasses and forbs. Forb-dominated types tend to result from severe disturbance and are generally weed-dominated. Non-native tall tumblemustard (*Sisymbrium altissimum*) is typical in addition to increaser shrub species. On cinder cones in the early stages of succession, cinder gardens are often colonized by forb species including dwarf buckwheat, silverleaf phacelia, Douglas chaenactis or dusty maiden, dwarf monkeyflower, dwarf onion (*Allium simillimum*), and bitterroot (*Lewisia rediviva*).

Riparian and Wetland Forest and Woodland Associations: Mesic riparian woodlands are restricted in distribution to the drainages of the Pioneer Mountains foothills and associated seeps and springs. Stands vary in species compositon according to the availability of surface and ground water and are typically characterized by quaking aspen (*Populus tremuloides*), black cottonwood (*Populous trichocarpa*), and Douglas-fir on slopes and in canyon bottoms. Associated mesic understory shrubs often include chokecherry, mountain snowberry, and mountain big sagebrush, in addition to the grasses pinegrass (*Calamagrostis rubescens*) and non-native Kentucky bluegrass (*Poa pratensis*). Riparian forbs include cow parsnip (*Heracleum maximum*), bigsting nettle (*Urtica dioica*), small-leaf angelica (*Angelica pinnata*), blackhead coneflower (*Rudbeckia laciniata*), nettle-leaf horsemint (*Agastache urticifolia*), and Sitka columbine (*Aquilegia formosa*).

Riparian and Wetland Shrubland Associations: Mesic riparian and wetland shrub communities are often diverse, limited in both size and distribution within CRMO, and most stands occur in the foothills of the Pioneer Mountains. Stands are restricted to areas with high water tables, including streambanks, seeps, and springs that are associated with Little Cottonwood, Big Cottonwood, Leech, Fish, and Little Wood creeks. Riparian and wetland shrubland associations of CRMO are characterized by speckled alder (*Alnus incana rugosa*), chokecherry, and rubber rabbitbrush. The channels of intermittent washes support sparse shrub communities dominated by rubber rabbitbrush and basin big sagebrush.

Riparian and Wetland Herbaceous Associations: Mesic riparian and wetland herbaceous associations classified within CRMO are uncommon, limited in distribution, occur as patches or small stands, and are represented by Baltic rush (*Juncus balticus*), basin wildrye, and western wheatgrass (*Elymus smithii*). All stands are restricted to areas with water at or near the surface for some or all of the growing season as occur along some perennial drainages, Lava and Huff Lakes, and Carey Lake Marsh. Some seasonal playas may also be ringed by mesic graminoids if the timing of saturation is sufficient to provide such support. Diversity can be high in these mesic herbaceous types.

Invasive Plant Species: Idaho currently lists 64 species of weeds designated as noxious by state law; the list is updated annually and is available online at: http://www.agri.state.id.us/Categories/PlantsInsects/NoxiousWeeds/watchlist.php (ISDA 2010). Over time the influences of wildfire, drought, erosion-control, access roads including railroads, agriculture, ranching, land development, and recreation among other influences have made substantial changes to ecosystems in the UBCN, Idaho, and the CRMO area allowing the introduction of many invasive noxious weeds (Rodhouse 2009). A plant species is considered a weed when it interferes with the use of land or water resources, inhibits the growth of or displaces desired/native plants, or affects human or animal health (IWCC 2005). Weeds are also characterized by an aggressive competition for resources with native flora. Species are considered invasive when they are able to dominate natural vegetation either with or without a preceding disturbance. Some species are more invasive than others due to their physiological attributes such as easily transported seeds, vegetative reproduction, or non-discriminate pollination. Furthermore, a weed is considered noxious when it inhibits natural systems causing negative economic and ecological impacts due to difficult removal and costly control (IWCC 2005).

Invasive exotic vegetation has become more prevalent within CRMO throughout the past several decades. One of the most common and widespread invasive species is cheatgrass which has displaced native grass species in some areas. An example of undesirable weedy species spread within CRMO was observed by field crews during the 2006 vegetation mapping project as the establishment of cheatgrass in the kipukas. Problematic species of noxious weeds identified by resource staff are spotted and diffuse knapweed (*Centaurea diffusa*), leafy spurge (*Euphorbia esula*), Dyer's woad (*Isatis tinctoria*), and rush skeleton weed (*Chondrilla juncea*). The spread of some invasive exotic weeds is thought to be amplified by the past wildfires near the CRMO borders outside of the boundary (Apel 2010).

Watersheds and Water Resources

River and stream drainages are uniquely identified by hydrologic unit codes. These are geographic areas based on surface topography containing a major river or a group of smaller rivers. The Pacific Northwest is number 17 of the 21 regions (HUC1) in the United States. The second level divides the 21 regions into 221 subregions. Subregions are areas drained by a river system, a reach of a river and its tributaries, a closed basin, or a group of streams forming a coastal drainage area. The third level subdivides the subregions into 378 basins. There are also 2,149 fourth level drainages, referred to as subbasins. These are further divided into 2,264 watersheds (HUC5) and over 160,000 subwatersheds (HUC6) in the United States (USGS 2009). Each level is represented by a 2-digit number starting at the left-hand side of the number with HUC6 subwatersheds being represented by a 12-digit number. The CRMO project area is in the Snake River-Fisher Gulch subwatershed (170601030303) and lies along both sides of the Snake River (Figure 5).

Water resources within CRMO are limited and consist primarily of Leech Creek and Little Cottonwood Creek near the northeastern park corner. Temporary pools of standing water fed through groundwater discharge occur in the northwest region of CRMO as isolated ephemeral aquatic systems. Another source of surface water is the unique, perennial cave ice and resultant ice-melt pools (Falter and Freitag 1996).

Wildfire

The fire season at CRMO occurs from mid-June through mid-September. The return intervals for fire throughout the area occur between 25 and 75 years, dependant on the vegetation present (Houston 1973, Wright and Bailey 1982). Lava fields are characterized by discontinuous vegetation which limits fire spread and decreases burn intensity. The history of fire within Craters of the Moon National Monument prior to 2000 is documented in the *Wildland Fire Management Plan* for CRMO (NPS 2000).

Wildlife

CRMO encompasses a variety of important wildlife habitats ranging from montane, foothill, and riparian woodland to sagebrush and bitterbrush shrublands, plains grasslands, and volcanic exposures and sparsely vegetated formations. Adjacent to the park boundary are similar wildlife habitats for most of its length however irrigated agriculture (predominantly center-pivot sprinklers) abuts the Wapi lava field in the south and adjacent to the western and northeastern border segments. Most of the adjacent wildlife habitat occurs on BLM and privately managed lands and is used for livestock grazing/production that does not occur within the CRMO boundary. Several wildlife species (mammals and birds) are hunted (sport and predator control) outside of and adjacent to the CRMO boundary which could result in some congregation within the park during certain seasons, typically fall and early winter (IDFG 2011).

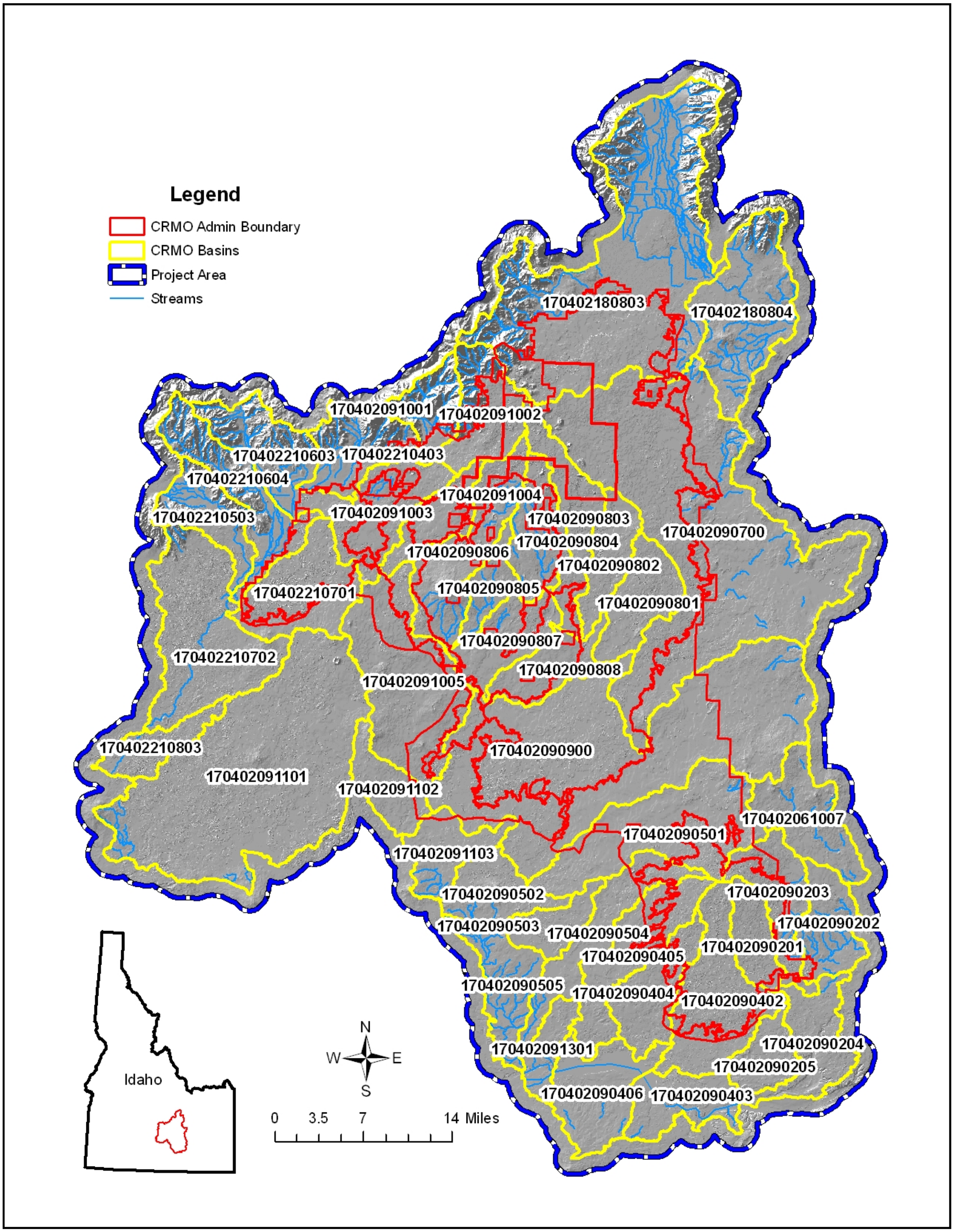


Figure 5. Map of the CRMO subwatershed.

The most common wildlife species using CRMO habitats include a variety of small rodents and passerine birds. The NPSpecies Database (2011) lists 59 mammals, 211 birds, 11 reptiles, and four amphibians as probably present to abundant. Bird monitoring inventories are conducted annually and typically include the breeding season survey, Christmas bird count, mid-winter eagle (raptor) count, migrants including waterfowl and shorebirds, daily bird species listings, and Greater Sage-grouse lek monitoring (Munts 2011). Clark's Nutcracker monitoring within limber pine stands was begun in 2010 in concert with limber pine stand monitoring studies (Munts 2011). A comprehensive wildlife inventory was completed for Craters of the Moon National Preserve during 2003 and an earlier wildlife inventory documented 148 wildlife species in the northern portion of the Craters of the Moon National Monument in 1987-1988 (Hoffman 1988). Voucher specimens representing nine species that were collected from 1921 to 1951 are accessioned into The California Museum of Vertebrate Biology and the Smithsonian Institute. CRMO maintains an MS Access database for wildlife observation data, the fields are summarized and presented in Table 1. It is unknown if but likely that wildlife observation data also exist in field notes or on paper forms awaiting automation into this database.

Land Use

Land use features and patterns have been documented for the project area; the USDA National Agricultural Statistics Service (NASS) produced a raster data set from classified satellite imagery depicting strata of land use areas based on percent of cultivated area. Published and modified in 2005, the strata are defined based on percent cultivated and nonagricultural lands and water surface. Land use surrounding CRMO is predominantly rural (agriculture and livestock production) with road access to small communities and utilities for farmers, ranchers, and other residents. These NASS digital land use data are available for the NRCA analyses and to inform CRMO managers of existing levels and types of development and water sources among other useful management information.

Table 1. Summary of CRMO MS Access wildlife database fields.

MS Access Field	Wildlife Data Summary	Comments
BLM Wildlife	There are 550 entries representing amphibians, reptiles, birds, and mammals. Provided is a four-letter species code based on the common name, number of individuals observed, UTM coordinates and township/range/section/quarter-section, habitat description, habitat code, codes, observation date, observer, and notes.	The entries were recorded between 03/10/68 and 01/28/02; there are 29 undated entries.
Breeding Codes	There are four codes: (1) Confirmed Breeding (Observed Young); (2) Probable Breeding (Defensive Behavior); (3) Possible Breeding (Stayed in the area, no defensive behavior); and (4) Observed Passing Through.	Breeding information occurs as notes in Prairie Sightings field, not as numbered codes.
Class	There are five classes: (1) Amphibian; (2) Bird; (3) Insecta; (4) Mammal; and (5) Reptile.	These classes are not applied in other fields.
Code	There are four codes: (1) V = Visual/Road-kill; (2) A = Audio; (3) C = Capture; and (4) T = Track/Sign.	These codes are applied in the BLM Wildlife, Prairie Sightings, and Wildlife fields.
Habitat Codes	There are 46 habitat codes numbered 1-47 and one code, 0 = birds in flight not observed to land. Sixteen habitat codes represent species/stands of sagebrush.	The habitat codes include 37 vegetation, five land forms, two geologic exposures/formations, and two land use types; they are entered into the Wildlife field.
Invertebrates	There are 88 entries of butterflies and skippers in this database. Provided is the species common name, genus/species, class, order, location, habitat code, codes, observation date, observer, land ownership/manager, and notes.	Invertebrates are identified to the species level of taxonomy. The entries were recorded between 06/13/65 and 09/26/07; there is one undated entry.
Prairie Sightings	There are 29 entries representing Prairie Falcon sightings. Provided is the four-letter species code PRFA based on the common name, number of individuals observed, UTM coordinates, habitat code, codes, observation date, observer, and notes.	The entries were recorded between 05/28/70 and 08/02/98; there are three undated entries.
Road-kill	There are 32 entries representing 11 species of road-killed vertebrates in this database. Twelve entries are of mule deer and four each are coyote and red fox.	The entries were recorded between 10/16/06 and 01/07/08.
Wildlife	There are 7,073 entries representing amphibians, reptiles, birds, and mammals. Provided is the species common name, a four-letter species code based on the common name, number of individuals observed, UTM coordinates, habitat code, codes, observation date and time, observer, land ownership/manager, and notes.	The entries were recorded between 06/12/21 and 07/30/08; there are 533 undated entries.
Wildlife Master List	There are 308 entries representing amphibians, reptiles, birds, and mammals. Provided is the species common name and a four-letter species code based on the common name.	The list is alphabetized by common name.

(Source: NPS-CRMO 2011).

Methods

This NRCA is a collaborative project between the NPS, UCBN, CRMO, and NMI. Stakeholders in this project include the CRMO and UCBN Inventory and Monitoring Program (I&M) staff. A scoping meeting was held and a task agreement was created cooperatively between the CRMO and NMI. This section summarizes scoping meeting constraints, objectives, and project expectations and presents the approach to acquisition and selection of existing data which included electronic datasets, reports and research inventories, and vital signs monitoring data.

NRCA Project Scoping

Preliminary scoping meetings were held in October 15, 2009 and included representatives of the interested agencies and other meeting participants. At this meeting, CRMO, and NMI staff confirmed that the purpose of the CRMO NRCA was to evaluate and report on current conditions, critical data and knowledge gaps, and selected existing and emerging resource condition influences of concern to CRMO managers. Certain constraints were placed on this NRCA, including: (1) condition assessments are conducted using existing data and information, (2) identification of data needs and gaps is driven by the project framework categories, (3) the analysis of natural resource conditions includes a strong geospatial component and (4) resource focus and priorities are primarily driven by CRMO resource management.

This NRCA provides a "snapshot-in-time" evaluation of the condition of a select set of natural resources that were identified and agreed upon by the project team. Project findings will aid CRMO resource managers in 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).

Specific project expectations and outcomes resulting from the scoping meeting included:

(1) for key natural resources, consolidate available park 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 park-specific human and ecological focus areas;
(4) 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 of specific existing data sets 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 the park or controlled directly by park 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 practicable.

Expectations for CRMO staff involvement were detailed in the project scoping meeting. CRMO staff participated in project development and planning, reviewed interim and final products, and participated in ecological/resource assessments. Involvement of CRMO staff in this project ensured that the true needs of CRMO were being met through the efforts of NMI.

In addition to CRMO resource staff, UCBN staff was 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, CRMO 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.

GIS and Geodatabases

The majority of data used in this NRCA report includes points, lines, polygons, and raster data automated to Geographic Information System (GIS) files and layers. GIS software provides spatial analysis capabilities such as overlay, buffer, extraction, and modeling and results may be displayed in map and tabular forms. ArcGIS Version 9.3 software was used for the geo-processing, editing, and graphics display presented in this NRCA.

An ArcMap project file (.mxd) was developed for CRMO to manage, control, and store layer annotation using ArcGIS software. Many geographic datasets were collected within a map project file, including features class, 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"x11" layout template was used in the CRMO map project file for map display (Figure 6).

A geographically defined project area was created for CRMO by selecting the 6th level hydrologic unit code (HUC) watershed basins surrounding the CRMO administrative boundary and adding a 2 kilometer (1.24 mile) buffer. General base map layers and aerial imagery were developed to the full project area extent; all GIS layers were clipped to the Hydrologic Basins extent for analysis and summarization of attributes.

The base map project file was populated with GIS data through an extensive search of NPS sources and several local, state, and federal websites. Data determined to be useful and accurate were re-projected into the North American Datum 1983 (NAD83) datum and the Universal Transverse Mercator (UTM) zone 12 projection. Metadata (data about the data) for each layer were extracted from the original file or generated based on known information. The metadata for each layer are included within the geodatabase for each file in Federal Geographic Data Committee (FGDC) compliant format. Metadata describe the source, accuracy, data dictionary, projection, datum, and many other details about an individual layer.

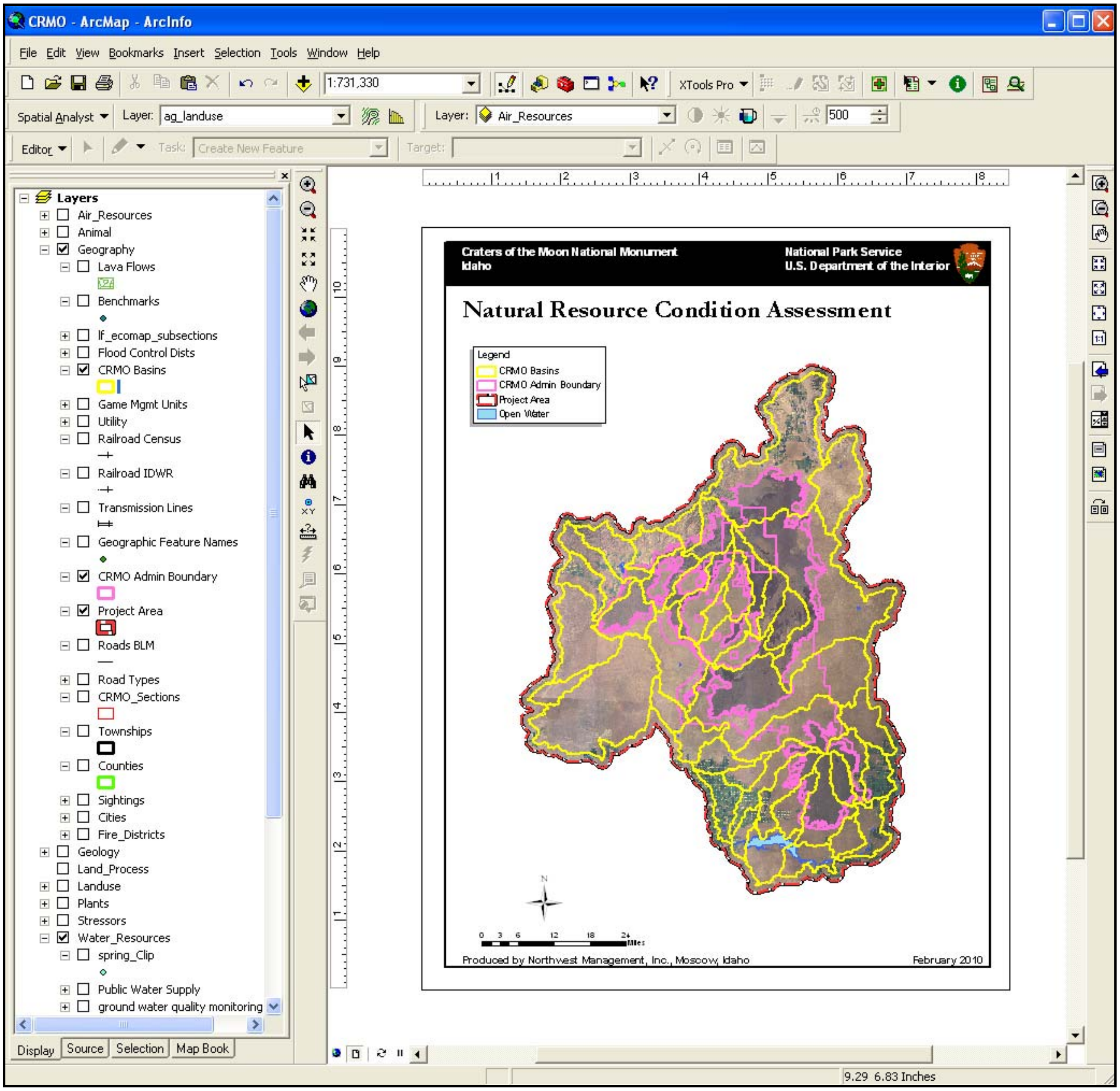


Figure 6. Screen capture of the ArcMap Project file for the CRMO project area.

Digital aerial imagery and Digital Raster Graphics were processed and clipped to the project area using LizardTech GeoExpress software and converted into a MG3 (MrSid Generation 3) file format. Attribute information for all data layers clipped to the HUC watershed basins extent were summarized in a Microsoft (MS) Excel spreadsheet based on the various attribute parts, lengths, acreage, etc. of the various data layers in the map project and associated geodatabase file.

GIS data layers were imported into an ArcGIS File Geodatabase using ArcCatalog ver. 9.3; Feature Data Sets (FDS) 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. FDS 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 from future research and projects.

FDS (Layers) were organized into categories or Feature Classes (Directories) based on general theme type. Although data were not available for each theme type, the category directory is included to incorporate data that may become available in the future. The general themes used in this NRCA include:

- Air Resources (including Air Quality)
- Animal (including vertebrate and invertebrate Wildlife)
- Climate
- Geography (including Physiography and Natural Resources)
- Geology (including Soils)
- Land Use (including Prehistoric/Historic and Current)
- Plant (including Vegetation and Invasive Plant Species)
- Stressors (including Wildfire)
- Water Resources

Aerial photography and digital imagery were not included in the geodatabase due to file size and limitation of processing MG3 file formats. Aerial imagery products are included in a separate directory outside the geodatabase. All GIS data, a project file, and a summary table are included on a digital versatile/video disk (DVD) for distribution with this report. As a by-product of the digital GIS data 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 ArcMap software. The database has a custom query form for conducting searches on the more than 3,000 entries that include three states; Idaho, Oregon, and Washington.

NPS Data Sources

In order to conduct the assessment of natural resources within CRMO, all currently available and relevant reports and publications were identified and reviewed. Data were acquired from searches of the NPS NatureBib, the U.S. Geological Survey (USGS), The Nature Conservancy (TNC), and LANDFIRE (http://www.landfire.gov/index.php) websites.

Additional information was acquired from the UCBN website, interviews with key CRMO staff, NPS and BLM *General Technical* reports, State of Idaho natural resource websites and reports, and peer-reviewed literature.

Natural Resources

Following review of the available literature and the scoping meeting with CRMO resource managers, general natural resource topics of particular relevance were identified. Relevant topics were animal resources (wildlife), vegetation resources (including invasive plants and upland vegetation), water resources, air resources (including weather and climate), geological resources (including geology and soils), and land use. The information contained in available reports and publications were consolidated, summarized, and synthesized in a manner to portray the historic and existing ecosystems within CRMO and guide development of the site specific assessments. All reasonably accessible and relevant data were used to conduct this assessment. The summation of pertinent information is presented in the Introduction section of this report.

The literature review process revealed a few areas of general need or data gaps. Of primary concern was the lack of condition and synthesis information for the ecosystems of CRMO. In general, assessment and condition studies that build upon basic inventories to assess and inform the nature, extent, and/or condition of resources are lacking. To help address these gaps additional non-GIS data were acquired from Internet searches including NPS NatureBib (https://science1.nature.nps.gov/naturebib), and from direct contact with local and state government agencies.

UCBN Inventories and Monitoring Plan

Since CRMO is a unit of the UCBN established under the NPS Inventory and Monitoring Program (NPS 1999) various inventories have already been completed or are underway for CRMO. CRMO inventory projects in progress include the rare and invasive plant species inventories and two subsets of the vascular plant inventory. There are also no fish or invertebrate inventories completed for CRMO. Table 2 presents the status of all the inventories of the species taxa groups for CRMO.

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

Species Taxa	Complete	Year Completed	In Progress	Not Complete
Mammals	√	2004		
Birds[1]	√	2004		
Amphibians	√	2004		
Reptiles	√	2004		
Fish				√
Invertebrates				√
Vascular Plants	√	2008		
Rare Plants			√	
Invasive Plants			√	

1 - The annual bird inventories summarized by Munts (1998-2011) were also acquired and evaluated for this NRCA.

Additional non-biological datasets have been identified by UCBN staff as important for CRMO 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 remain to be completed by the UCBN however some CRMO sites may have data available from other sources.

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

Non-Biologic Data sets	Complete	Year Completed	In Progress	Not Complete
Air Quality/Emissions	√[1]	2001		
Ozone Risk	√	2001		
Water Quality	√	1998		
Landcover				√
Paleo Resources	√	2005		
Geology			√[2]	
Soils			√[3]	
Cultural Landscapes				√

1 – Air Quality trend data from 1999-2008 were analyzed by NPS-AQD and reported in 2010.
2 - Geology of the North Crater was performed in 2003.
3 - Soil Inventory was performed only within the original Monument boundary in 1999.

The UCBN Monitoring Plan (Garrett et al. 2007) identifies a suite of 14 vital signs chosen for monitoring implementation in the UCBN member park units over the next 5 years. Vital signs are "a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values" (NPS-UCBN 2011, available online at: http://science.nature.nps.gov/im/monitor/). Not all vital signs are monitored in each park unit. CRMO has 11 vital signs established for monitoring; water chemistry, aquatic macro-invertebrates, invasive/exotic plant species, sagebrush-steppe vegetation, quaking aspen, limber pine, Sage Grouse, bat species, and land cover and use (Garrett et al. 2007).

UCBN GIS related data were added to CRMO GeoDatabase as needed. Non-GIS data from UCBN was also obtained and later used to help inform the NRCA. Copies the UCBN data are available online at: http://science.nature.nps.gov/im/units/ucbn/inventory/index.cfm#table.

Wildfire

Multiple wildland fire-related data layers were included in the CRMO GeoDatabase under the Stressors heading, and as separate model-derived raster layers. These datasets reside in the public domain from federal agencies. 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 were clipped to the CRMO project area and summarized within the project summary MS Excel Spreadsheet on the DVD.

Fire Regime Condition Class (FRCC) Departure Index data were used to evaluate the condition of vegetation within the CRMO project area. The FRCC 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 depict the amount that current vegetation has departed from simulated historical vegetation reference conditions (Hann et al. 2004). The departure results from changes to species composition, structural stage, and canopy closure. Tables with surmised area and percent of total project area for FRCC and Historic Fire Regime are included in the Results section of this report.

Invasive Species
GIS data representing noxious weeds were acquired from existing studies/investigations and entered into the CRMO geodatabase. These data include lines, points, and polygons (developed from invasive plant surveys and listing of species encounter in the surveys). Federal, State and county level databases and websites were searched for noxious weed locations and local county weed officials were contacted for unpublished data. In addition, databases developed from recent plant surveys were searched for observations of invasive species to identify the location and the frequency of occurrence. Metadata are included with each layer describing the data and source; metadata files are imbedded within the files and are viewable using ArcGIS software.

Animals
Multiple wildlife-related GIS data layers were acquired for the CRMO project area. Data layers include bird survey paths and observation points, rare animal observations and locations, American pika activity locations, range allotment boundaries, pastures, and Greater Sage-grouse leks. The American pika activity data were reported in a 1995 field study by Erik A. Beever, where pika activity and yellow-bellied marmot (*Marmota flaviventris*) burrows were identified near the CRMO visitor center. The 2003 Mammal Inventory for Craters of the Moon National Monument and Preserve identified expected species from existing published information and data sources (Madison et al. 2003). CRMO maintains an MS Access database with automated entries from 1921-2008 populating ten data fields. From these and other datasets, summary statistics by species and maps were developed.

Plants
Several GIS vegetation data layers were previously created for the CRMO project area. Data layers were clipped to the HUC watershed basin extent and summarized in the "project summary" MS Excel spreadsheet. The CRMO geodatabase includes vegetation layers developed from the LANDFIRE Program, National Land Cover Data (NLCD), USGS Sagemap, Idaho GAP Analysis Project, NPS Vegetation Inventory Program, and The National Agriculture Statistics Service (NASS). The raster data files are constructed by individual agencies from visual interpretation classification of satellite imagery, are intended for general geographic display at a scale of 1:100,000 or smaller, and are provided as constructed with many general limitations and overlap to actual ground conditions.

Diseases

Databases were searched for occurrences of disease and insect infestations noted during field observations. During the vegetation field data collection task for the CRMO Vegetation Inventory Project, field crews noted disease and/or insect observations. Identification of diseases by field crews was requested by CRMO staff when sampling sagebrush shrubland and woodland/forest plant communities, e.g., note special problem areas that included the presence of white pine blister rust, dwarf mistletoe, root diseases, and dead quaking aspen trees in the woodland/forest communities and the occurrence of sagebrush die-off in the sagebrush communities. Other databases were searched for the presence of white pine blister rust, root disease, and other disease issues within the project area.

Air Quality

Air quality in national parks is expected to improve as regulations designed to reduce tailpipe emissions from motor vehicles and pollution from electric-generating facilities become effective over the next few years (NPS 2010). In addition, states and tribes, with assistance from regional planning organizations, are in the process of implementing programs to improve visibility in national parks and wilderness areas in response to EPA regulations. Information available through the NPS air quality monitoring program has provided a foundation and impetus for pollution control programs that will benefit national parks. The NPS ability to offer expert and constructive assistance to regulatory and permitting agencies has stimulated collaborative efforts to find creative and cost-effective air quality management approaches (NPS 2010).

Progress toward air quality goals is measured annually through target goals (NPS 2010) using data from visibility, ozone, and precipitation monitoring to assess air quality trends. Six measures are used in calculating the goal percentages: two are used to measure progress toward the visibility goal, one measure is used for the ozone goal, and three measures are used for the atmospheric deposition goal (not all parks monitor all six of the indicators). A park is considered to have air quality that is improving or not deteriorating if none of the measures used for that goal show a statistically significant degrading trend.

The air quality of CRMO is among the cleanest air monitored over the U.S.; however, air quality varies within CRMO. An NADP monitoring site is located within CRMO. Established in 1980, the monitoring site provides a long term record of precipitation chemistry and mercury deposition data analyzed from the monitoring station samplers; the data are available on the Internet at: http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=ID03&net=NADP. Extensive precipitation chemistry data (National Trends Network wet deposition) and trend plots are available for multiple time periods on the NADP website. Mercury deposition data from 2006 to October 2010 are available through a query form with output in multiple formats. Under the Interagency Monitoring of Protected Visual Environments (IMPROVE) program established in 1992, the NPS monitors ozone, particulates, and examines the clearest days and haziest days to measure visibility conditions; the EPA uses these measures to assess progress toward the national goal of remedying any existing and preventing any future human-caused visibility impairment in protected Class I areas (NPS 2010). Air quality monitoring is now part of the UCBN I&M Program and data have been collected within CRMO since 1980 (available under NADP- ID03); ozone has been monitored continuously since 1992 (available under IMPROVE-EPA ID 160230101).

Results

This section focuses on the key natural resource topics, identified by CRMO resource managers, as the most important in terms of management priorities. Focal natural resources, threats, and stressors identified for this section include wildlife, soils, aquatic resources, geology, air quality, vegetation, land use dynamics, and climate change. A summary of each natural resource topic is presented using literature review and analysis of known data, threats and stressors, and data gaps to present an overall assessment of what is known about a particular resource topic. Within each topic area, additional specific information on precise habitat of management concern is included. For example, an in-depth discussion of what is known and what is currently being monitored on American pika *(Ochotona princeps*) at CRMO is presented in the wildlife section. Please refer to the table of contents for a complete listing of species of management concern in each topic area.

Wildlife

Mammals

Many wildlife species are listed as common or abundant within CRMO habitats and are summarized herein (NPSpecies Database 2011). Mammal species listed as rare to abundant within CRMO number 49 and ten additional species are listed as probably present (NPSpecies Database 2011). Mammals were inventoried from 1990 to 2003, with species of deer and pocket mice, ground squirrels, and chipmunks considered abundant. Mammal species of interest observed during the 1990 to 2003 survey included the American pika, pygmy rabbit (*Brachylagus idahoensis*), and species of bats. Twelve species of bats are listed for CRMO (NPSpecies Database 2011); three bat species are common breeders, six bat species are present but have unknown abundance status, and three bat species are probably present in CRMO.

Representative large to medium-sized mammals include the pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), black-tailed jackrabbit (*Lepus californicus*), Nuttall’s cottontail (*Sylvilagus nuttallii*), and yellow-bellied marmot (*Marmota flaviventris*). Commonly occurring small mammals include the deer mouse (*Peromyscus maniculatus*), Great Basin pocket mouse (*Perognathus parvus*), western harvest mouse (*Reithrodontomys megalotis*), northern pocket gopher (*Thomomys talpoides*), Ord’s kangaroo rat (*Dipodomys ordii*), bushy-tailed woodrat (*Neotoma cinerea*), least chipmunk (*Tamias minimus*), yellow pine chipmunk (*Tamias amoenus*), golden-mantled ground squirrel (*Spermophilus lateralis*), and American pika and the bats Townsend’s big-eared (*Corynorhinus townsendii*), long-eared myotis (*Myotis evotis*), and western small-footed (*Myotis ciliolabrum*).

Birds

Bird species listed as rare to abundant at CRMO number 191 and an additional 20 species are listed as probably present (NPSpecies Database 2011). From the total of 191 bird species tallied, 95 were confirmed during breeding surveys, 42 during migration surveys, 42 by daily species tallies by NPS staff, and four by outside researchers (NPS 2004b). The complete history of avian investigations in the park since 1927 includes the following studies: (1) the NPS biotic surveys identified 64 bird species from 1927 to 1951 (NPS 2004b), (2) a bird inventory from 1987 to 1988 identified an additional 84 species (Hoffman 1988), (3) a recent vertebrate inventory was completed from 1990 to 2003 and identified 184 bird species and (4) a total of 152 bird species were recorded within CRMO during 2010 (Munts 2011) (Table 4).

Table 4. CRMO Bird Survey Information Summary 2005-2010

Survey Year	Total Number of Birds Observed (BBS) – Annual Number of Species Observed	Ten Most Abundant Species (Number of Individuals)	Notes and Comments
2010 (June and December)	1,797 – 152 species	Brewer's Sparrow (504) Western Meadowlark (158) Rock Wren (155) Spotted Towhee (119) Western Tanager (58) Brewer's Blackbird (54) Lazuli Bunting (49) Sage Thrasher (48) Chipping Sparrow (46) Mourning Dove (45)	A total of 152 species were recorded within CRMO during 2010. Forty-six percent (69 of 152) of the species recorded are listed as sensitive by the state of Idaho, the BLM, the FWS, or are a Partners in Flight priority species. Sage-grouse lek counts recorded a high total count of 112 male birds on the Golden Chariot lek complex in the northwest portion of CRMO. Forty-one Clark's nutcrackers were observed on eleven long-term monitoring pilot transects established and sampled in 2010. Migrant bird surveys focused on water resources adjacent to the highway; a total of 43 species occurred at Lava Lake, the Hot Springs area, and at Little Cottonwood Creek. The quaking aspen groves and riparian areas around Little Cottonwood Creek and Goodale's Cutoff held the highest number of species and had several species that were not found elsewhere in CRMO including the Dusky Flycatcher, House Wren, Song Sparrow, Fox Sparrow, Warbling Vireo, and warblers.
2009	2,011 – 143 species	Brewer's Sparrow (556) Rock Wren (211) American Coot (178) Spotted Towhee (96) Western Tanager (83) Mourning Dove (67) Western Meadowlark (56) Brewer's Blackbird (54) Lazuli Bunting (43) Canada Goose (41)	A total of 143 species were recorded within CRMO during 2009. Forty-seven percent (67 of 143) of the species recorded are listed as sensitive by the state of Idaho, the BLM, the FWS, or are Partners in Flight priority species. Sage-grouse lek counts recorded a high total count of 139 male birds on the Golden Chariot lek complex in the northwest portion of CRMO. Migrant bird surveys focused on water resources adjacent to the highway; a total of 43 species occurred at Lava Lake and the Hot Springs area. The quaking aspen groves and riparian areas around Little Cottonwood Creek and Goodale's Cutoff held the highest number of species and had several species that were not found elsewhere in CRMO including the Dusky Flycatcher, House Wren, Song Sparrow, Fox Sparrow, Warbling Vireo, and warblers. The Christmas bird count recorded 20 species. One golden eagle was observed in the mid-winter count.

2008	1,824 – 146 species	Brewer's Sparrow (493) Rock Wren (184) Western Meadowlark (107) Western Tanager (85) American Coot (85) Mourning Dove (83) Spotted Towhee (78) Mallard (50) Sage Thrasher (44) Brewer's Blackbird (38)	A total of 145 species were recorded within CRMO during 2008. Forty-nine percent (71 of 146) of the species recorded are listed as sensitive by the state of Idaho, the BLM, the FWS, or are Partners in Flight priority species. Sage-grouse lek counts recorded a high total count of 142 birds on the Golden Chariot lek complex in the northwest portion of CRMO. Migrant bird surveys focused on water resources adjacent to the highway; a total of 49 species occurred at Lava Lake and the Hot Springs area. The quaking aspen groves and riparian areas around Little Cottonwood Creek and Goodale's Cutoff held the highest number of species and had several species that were not found elsewhere in CRMO including the Dusky Flycatcher, House Wren, Song Sparrow, Fox Sparrow, Warbling Vireo, and warblers. The Christmas bird count recorded 21 species. One eagle was observed in the mid-winter count.
2007	1,775 – 145 species	Brewer's Sparrow (549) Rock Wren (160) Spotted Towhee (99) Mourning Dove (95) Western Meadowlark (92) American Coot (65) Blue-gray Gnatcatcher (53) Chipping Sparrow (51) Sage Thrasher (47) Brewer's Blackbird (47)	A total of 145 species were recorded within CRMO during 2007. Forty-nine percent (71 of 145) of the species recorded are listed as sensitive by the state of Idaho, the BLM, the FWS, or are Partners in Flight priority species. Sage-grouse lek counts recorded a high total count of 196 birds on the Golden Chariot lek complex in the northwest portion of CRMO. Migrant bird surveys focused on water resources adjacent to the highway; a total of 61 species occurred at Lava Lake and the Hot Springs area. The quaking aspen groves and riparian areas around Little Cottonwood Creek and Goodale's Cutoff held the highest number of species and had several species that were not found elsewhere in CRMO including the Dusky Flycatcher, House Wren, Song Sparrow, Fox Sparrow, Warbling Vireo, and warblers. The Christmas bird count recorded 26 species. No eagles were observed in the mid-winter count.
2006	1,815 - 132 species	Brewer's Sparrow (570) Rock Wren (187) Western Meadowlark (141) Spotted Towhee (119) Mourning Dove (101) Violet-green Swallow (54) Sage Thrasher (49) Mountain Bluebird (47) Brewer's Blackbird (44) Western Tanager (42)	A total of 132 species were recorded within CRMO during 2006. Fifty-four percent (74 of 132) of the species recorded are listed as sensitive by the state of Idaho, the BLM, the FWS, or are Partners in Flight priority species. Sage-grouse lek counts recorded a high total count of 98 male birds on the Golden Chariot lek complex in the northwest portion of CRMO. Migrant bird surveys focused on water resources adjacent to the highway; a total of 59 species occurred at Lava Lake, the Hot Springs area, and at

			Barn Creek Reservoir. The quaking aspen groves and riparian areas around Little Cottonwood Creek and Goodale's Cutoff held the highest number of species and had several species that were not found elsewhere in CRMO including the Dusky Flycatcher, House Wren, Song Sparrow, Fox Sparrow, Warbling Vireo, and warblers. The Christmas bird count recorded 20 species.
2005	1,786 – 73 species	Brewer's Sparrow (492) Rock Wren (178) Spotted Towhee (114) Western Meadowlark (113) Sage Thrasher (67) Violet-green Swallow (65) Mourning Dove (65) Brewer's Blackbird (56) Brown-headed Cowbird (50) Lark Sparrow (50)	A total of 99 species were recorded within CRMO during 2005. Forty-eight percent (47 of 99) of the species recorded are listed as sensitive by the state of Idaho, the BLM, the FWS, or are Partners in Flight priority species. Sage-grouse lek counts recorded a high total count of 144 male birds on the Golden Chariot lek complex in the northwest portion of CRMO. Migrant bird surveys focused on water resources adjacent to the highway; a total of 15 species occurred on the Broken Top Loop, 23 species at the Hot Springs area, and 40 species occurred at Lava Lake. The quaking aspen groves and riparian areas around Little Cottonwood Creek and Goodale's Cutoff held the highest number of species and had several species that were not found elsewhere in CRMO including the Dusky Flycatcher, House Wren, Song Sparrow, Fox Sparrow, Warbling Vireo, and warblers. The Christmas bird count recorded 16 species.

(Source: Munts 2011, 2010, 2009, 2008, 2007, 2006, 2005)

The most common bird species recorded using CRMO habitats during the breeding season (June monitoring surveys) include the Brewer's Sparrow (*Spizella breweri*), Rock Wren (*Salpinctes obsoletus*), Spotted Towhee (*Pipilo maculatus*), Western Meadowlark (*Sturnella neglecta*), Western Tanager (*Piranga ludoviciana*), Sage Thrasher (*Oreoscoptes montanus*), Brewer's Blackbird (*Euphagus cyanocephalus*), Mourning Dove (*Zenaida macroura*), and Violet-green Swallow (*Tachycineta thalassina*) (Munts 2011, Munts 2005).

Raptors and corvids that commonly use available habitats include the Red-tailed Hawk (*Buteo jamaicencis*), Northern Harrier (*Circus cyaneus*), American Kestrel (*Falco sparverius*), Turkey Vulture (*Cathartes aura*), Common Raven (*Corvus corax*), and Black-billed Magpie (*Pica hudsonia*). Mid-winter eagle counts for CRMO were performed in January from 1995-2010; data are presented from 2007-2010 for this discussion (Munts 2011). Observations of eagles are few along the Craters/Big Lost survey route and include the Bald Eagle (*Haliaeetus leucocephalus*), 2010 – immature, and the Golden Eagle (*Aquila chrysaetos*), 2010 – adult, 2009 – adult, 2008 - adult. Other raptors that occurred within CRMO in January include the: Rough-legged Hawk (*Buteo lagopus*), 4-18 individuals; Red-tailed Hawk (0-5 individuals); Northern Harrier (0-6 individuals; Prairie Falcon (*Falco mexicanus*), 0-2 individuals; American Kestrel (0-2 individuals); Common Raven (16-41 individuals); and Northern Shrike (*Lanius excubitor*), 0-2 individuals. During the 2008 survey, approximately one meter (over three feet) of snow had fallen two weeks prior to the survey and only the Golden Eagle, Prairie Falcon, and Common Raven were observed; a nearly duplicate snowfall event with similar effects occurred in 2009 (Munts 2009). Raptors within CRMO are also recorded during the breeding season survey, migrant survey, Christmas Bird Count, and as daily or incidental observations.

A variety of sparrow species commonly occur and include the Vesper (*Pooecetes gramineus*), Chipping (*Spizella passerina*), Lark (*Chondestes grammacus*), Grasshopper (*Ammodramus savannarum*), Song (*Melospiza melodia*), and White-crowned (*Zonotrichia leucophrys*). Additional common to abundant bird species include the Blue Grouse (*Dendragapus obscurus*), Northern Flicker (*Colaptes auratus*), Clark's Nutcracker (*Nucifraga columbiana*), Loggerhead Shrike (*Lanius ludovicianus*), American Robin (*Turdus migratorius*), Swainson's Thrush (*Catharus ustulatus*), Mountain Bluebird (*Sialia currucoides*), Common Nighthawk (*Chordeiles minor*), Common Poorwill (*Phalaenoptilus nuttallii*), Horned Lark (*Eremophila alpestris*), Lark Bunting (*Calamospiza melanocorys*), Lazuli Bunting (*Passerina amoena*), Indigo Bunting (*Passerina cyanea*), Dark-eyed Junco (*Junco hyemalis*), House Wren (*Troglodytes aedon*), Black-capped Chickadee (*Poecile atricapillus*), Mountain Chickadee (*Poecile gambeli*), Pine Siskin (*Carduelis pinus*), Cassin's Finch (*Carpodacus cassinii*), Yellow-rumped Warbler (*Dendroica coronata*), Audubon's Warbler (*Dendroica coronata auduboni*), Macgillivray's Warbler (*Oporornis tolmiei*), Barn Swallow (*Hirundo rustica*), Brown-headed Cowbird (*Molothrus ater*), and Rufous Hummingbird (*Selasphorus rufus*). Waterfowl and shorebirds include the Canada Goose (*Branta canadensis*), Mallard (*Anas platyrhynchos*), Ring-necked Duck (*Aythya collaris*), American Coot (*Fulica americana*), Pied-billed Grebe (*Podilymbus podiceps*), and Killdeer (*Charadrius vociferus*). Non-native bird species common within CRMO include the European Starling (*Sturnus vulgaris*), House Sparrow (*Passer domesticus*), and Rock Dove (*Columba livia*).

Forty-two bird species were identified in and near wetland and riparian habitats within CRMO. The quaking aspen groves and riparian areas around Little Cottonwood Creek and Goodale's Cutoff held the highest number of species and supported several species that were not observed elsewhere in CRMO including the Dusky Flycatcher (*Empidonax olberholseri*), House Wren (*Troglodytes aedon*), Song Sparrow (*Melospiza melodia*), Fox Sparrow (*Passerella iliaca*), Warbling Vireo (*Vireo gilvus*), and warblers (Munts 2011).

Reptiles and Amphibians

Reptile and amphibian species listed as uncommon to abundant within CRMO number 11 and four additional species (one reptile and three amphibians) are listed as probably present (NPSpecies Database 2011). Historically, one amphibian and seven reptile species were documented within CRMO (Blakesley and Wright 1988) including the western toad (*Bufo boreas*). Not listed by NPSpecies Database (2011) were sagebrush lizard (*Sceloporus graciosus*), short-horned lizard (*Phrynosoma douglasii*), western skink (*Eumeces skiltonianus*), rubber boa (*Charina bottae*), racer (*Coluber constrictor*) (listed as western yellow-bellied racer (*C. mormon*) in NPSpecies Database 2011), Great Basin gopher snake (*Pituophis melanoleucus*) (listed as gopher snake (*P. catenifer*) in NPSpecies Database 2011), and the western rattlesnake (*Crotalus viridus*) (Lee and Paterson 2010). The one amphibian listed as present and occasional within CRMO (NPSpecies Database 2011) is the Pacific tree frog (*Pseudacris regilla*). NPSpecies Database (2011) also lists the following reptiles as present within CRMO: desert horned lizard (*Phrynosoma platyrhinos*), long-nosed leopard lizard (*Gambusia wislizenii*), and terrestrial garter snake (*Thamnophis elegans*).

Important Wildlife Species

The overarching vegetation and geology of CRMO provides unique habitat for a number of important wildlife species including the American pika which occurs on lava beds and exposures, species of bats which use a variety of volcanic and woodland habitats, Clark's Nutcracker which depend on limber pine woodlands, and sagebrush obligate or dependent species including the pygmy rabbit, Greater Sage-grouse, Brewer's Sparrow, Sage Thrasher, Sage Sparrow (*Amphispiza belli*), and Black-chinned Sparrow (*Amphispiza bilineata*) among other sagebrush obligate animals and birds. The latter species rely heavily on the sagebrush steppe plant communities established in and around CRMO. In addition, the unique geology within CRMO includes an extensive system of caves and fissures spread across the landscape providing additional habitat important for many of the bat species.

Special status wildlife species within CRMO were summarized in the Monument Management Plan (NPS-BLM 2007); listed were 11 mammals, 33 birds, three reptiles, and three invertebrates. Under federal status designations, two species are listed as threatened and 19 are listed as species of concern. Under BLM status designations, 18 species are on the watch list and 27 are listed as BLM sensitive species. The State of Idaho status designations include one species listed as endangered and 11 are listed as special concern species. The American pika and pygmy rabbit have recently been reviewed by the USFWS for potential listing, which was determined not to be warranted. Of particular importance to CRMO are the Greater Sage-grouse, pygmy rabbit, and several species of bats and other birds (NPS-BLM 2007).

Over the past 25 years there has been a 36% decrease in active Greater Sage-grouse leks on lands (BLM managed Monument) monitored by the Idaho Department of Fish and Game personnel. At CRMO a Greater Sage-grouse is considered to be an uncommon visitor throughout the Monument in the summer and fall. One Greater Sage-grouse nest was observed during the 2000 survey (NPS 2004b) and several lek sites have been recorded.

Several management actions have been summarized by the NPS and BLM (2007) for the Greater Sage-grouse within CRMO, they are: (1) inventory and monitoring of regionally or nationally important species, (2) a monitoring program established to detect species populations in decline and species as indicators of the health of the ecosystem, and to record the presence of species of special concern, (3) designate areas at CRMO with periods of time when no hunting will be permitted, (4) actions and stipulations necessary to protect special status species and their habitats will be made part of land use authorizations and fire planning (e.g., limiting fragmentation of special-status species populations when considering road maintenance), (5) active and historic leks will be protected from disturbance during the Greater Sage-grouse breeding season (examples of potential protective measures are presented in the Idaho Sage-grouse Advisory Committee's 2006 Conservation Plan for the Greater Sage-grouse in Idaho) and (6) modification of livestock grazing management as necessary to ensure that key Greater Sage-grouse habitat achieves site potential (consistent with Idaho Standards for Rangeland Health and Guidelines for Livestock Grazing Management (USDI-BLM 1997) determinations).

Pygmy rabbits use sagebrush stands with dense canopy cover, primarily. They have been documented within CRMO up to 2011 and throughout CRMO the pygmy rabbit range populations have experienced declines (NPS-BLM 2007). Seven species of bats use caves and other roost sites within CRMO. Two maternity colonies of Townsend's big-eared bats occur within Monument boundaries and numerous hibernacula used by the listed sensitive and other bat species occur within CRMO. CRMO caves also provide habitat for two populations of the blind cave leiodid beetle (*Glacicavicola bathysciodes*), a federal and Idaho species of concern.

Avian species of interest observed during the 1990 to 2003 survey and ensuing bird surveys through 2010 were the Bald Eagle (uncommon - a regular visitor to the western edge of CRMO during the winter and observed hunting in the lava flows around Carey Lake). In 2010 CRMO staff also began monitoring the Clark's Nutcracker that uses limber pine stands exclusively (Munts 2011). There are a number of other transitory or migrant avian species that use CRMO habitats and continued surveys of areas visited by transitory birds may identify additional species of concern and patterns of use.

Wildlife Inventories

Wildlife species inventories and monitoring of various designs and intensities have been conducted within CRMO since 1921 and by the UCBN for CRMO since 2001 (Table 5). The resulting species lists were certified on July 19, 2005 and recorded four amphibian, 11 reptile, 60 mammal, and 212 bird species as present or probably present (NPSpecies Database 2011). Of these, seven wildlife species are non-native (one mammal and six birds). Comprehensive wildlife inventories within CRMO were conducted in the early 2000s and reported in 2003 (mammals), 2004 (herpetofauna and birds), and 2006 (sagebrush-steppe dependent birds). The CRMO natural resource staff monitors and inventories bird populations and important individual species throughout each year using several surveying methods that are described in the Monitoring Section.

Table 5. Available Inventories maintained by the UCBN.

Dataset Type	Species Taxa	Certified Species list Year	Inventory Report Year
Animal Resources			
	Mammals	2003	2003
	Birds	2005	2004
	Amphibians	2005	2001
	Reptiles	2005	2001
	Fish	N/A	N/A
	Invertebrates	N/A	N/A

The Animal feature data set included in the CRMO geodatabase includes point locations for Greater Sage-grouse Lek sites, Rare Species Observation sites, Bird Survey sites, Pika evidence locations and polygon files depicting grazing allotments. Grouse data were originally developed by the Idaho Department of Fish and Game for the period 1955 to 2009. Rare species data were provided to the NPS by the Idaho Conservation Data Center (ICDC). Bird Survey sites are GPS collected field locations from the annual bird survey at CRMO following the North American Breeding Bird Survey Protocol. Grazing allotment layers were acquired from the BLM and Interior Columbia Basin Ecosystem Management Program. The following table lists the general characteristics of these data sets (Table 6).

Table 6. Grazing Allotment Layers for CRMO.

Themes	Geodatabase File Name	GIS Acres	Number Parts
Animal			
Range Allotments other	crmo_allotments		172
BLM Livestock Grazing Pastures	rngPasture_id_blm	1,138,408.7	
BLM Livestock Grazing Allotments	rngAllotment_id_blm	1,027,550.0	
CRMO Grazing Allotments	rangeall_crbab_icbemp	1,636,392.0	
Bird Survey Points	BIRDSURVEYPO_clip		68
Rare Animals & Plant Locations	cdcrecords_clip		145
Rare Animal Locations	cdcrecordswl_clip		64
Sage Grouse Lek locations	SG_LEKS_clip		290
Sage Grouse Lek locations 2002	sg_leks_02_clip		294
Pika evidence sites	CRMO_Pika_Loc1283		27

Mammals

The CRMO mammal survey was conducted during 2003 by University of Idaho Department of Fish and Wildlife Resources (UI-DFWR) staff under a cooperative agreement with the UCBN (Madison et al. 2003). The inventory incorporated previous mammal presence/absence work conducted in CRMO boundaries including the baseline inventory conducted by Hoffman (1988) and bat inventory data collected by the Oregon Museum of Science and Industry high school bat research team. Inventory fieldwork occurred from May 20-June 27, 2003 with the primary goal to supplement existing mammal species documentation within CRMO and elevate the percentage of confirmed expected species to approximate 90% if possible. Additional goals included developing baseline data for monitoring and providing the NPS-UCBN and the research community-at-large with new and important information on the regional biodiversity.

To initiate the CRMO mammal inventory, expected species lists were developed from published literature, available historical sources, expert opinion, and previous fieldwork (Madison et al. 2003). Four criteria were used to determine the likelihood of detection and fieldwork used a variety of accepted methods including visual encounter surveys and trapping. Species documentation included collecting voucher photographs, recording digital bat calls, and preparing field observation records. Previous documentation of mammals (1990-2003 sightings) were combined with 2003 fieldwork results to develop a complete list of expected (probably present) and confirmed (present) mammal species. The inventory resulted in mammal species confirmation of 83% with 47 mammal species documented (Madison et al. 2003).

Birds

The bird inventory performed for CRMO largely relied upon data compiled from existing monitoring programs (Munts 2004). The inventory effort required additional field surveys in habitats and during time periods not covered by existing monitoring efforts. The primary goal of the bird inventory project was to confirm as many of the species that utilize CRMO annually. An additional goal included acquiring baseline data for long term monitoring.

Expected bird species lists were prepared from published sources for the region and from historical observation records and museum specimens. Expected bird species were assigned one of four residency criteria; those with a residency value of other than vagrant were used as the expected list. Support fieldwork was performed from 2001 to 2003 and added to existing records from surveys conducted between 1991 through 2003.

This bird inventory produced observations for 184 out of 203 species, a confirmation rate of 91%. From the period 1990 to 2003, 184 species were verified within the CRMO boundary. The most common bird species encountered was the Brewer's Sparrow which accounted for one-third of all individual bird species recorded within CRMO in recent years.

Herpetofauna

The herpetofauna were inventoried from1999 to 2001 and the species list certified in 2005 (NPSpecies Database 2011). Lee and Paterson (2010) inventoried the herpetofauna of CRMO with the goal of providing information about the amphibians and reptiles. The specific objectives were to determine the occurrence, distribution, relative abundance, and habitat relationships of amphibians and reptiles and to establish the basis for a monitoring program. The primary approach was to use 73 drift fence and funnel trap arrays over a 2.5-year period. The herpetofauna inventory approach was to use a GIS-based, stratified-random sampling plan to determine the locations at which the appropriate detection technique would be applied (Lee and Paterson 2010). To develop a list of the species of amphibians and reptiles potentially occurring within CRMO, multiple sources of information (e.g., field guides, databases, etc.) were accessed. Field sampling techniques included terrestrial drift fences with funnel traps, timed visual encounter surveys (combined with dip-netting in wetland areas), road cruising, and opportunistic observations. Sampling stratification was based upon topography and cover types which represented environmental types.

Of eleven species potentially occurring within CRMO, nine (81%) species were confirmed present and included one amphibian species, e.g., Pacific treefrog (*Pseudacris regilla*) and three species of lizards, e.g., western skink (*Eumeces skiltonianus*), pigmy short-horned lizard (*Phrynosoma douglassii*), and sagebrush lizard (*Sceloporus graciosus*). Lee and Paterson (2010) also confirmed five snake species, e.g., rubber boa (*Charina bottae*), racer (*Coluber constrictor*), gopher snake (*Pituophis catenifer*), terrestrial garter snake (*Thamnophis elegans*), and western rattlesnake (*Crotalus viridis*). Absent from CRMO were the Great Basin spadefoot (*Spea intermontana* = *Scaphiopus intermontanus*) and the nightsnake (*Hypsiglena torquata*).

Provided for each of the confirmed species was individual accounts that included information on NPSpecies codes, occurrence, distribution, relative abundance, habitat relationships, conservation status and management, local natural history, local unusual characteristics, anecdotal observations of interest, and focal animal telemetry. Distribution maps were prepared for each confirmed species and the effects of factors such as topography, geology, vegetation, and distance from streams on occurrence and capture rates were analyzed.

NPSpecies codes were assigned to eighteen species that occur on the eastern Snake River Plain. Nine species were classified as "present", two as "unconfirmed", two species as "probably present", one as "historic", and four as "encroaching". The boreal chorus frog (*Pseudacris maculata*) and Columbia spotted frog (*Rana lutieventris*) were classified as "unconfirmed". Two species were classified as "probably present" (Great Basin spadefoot and nightsnake) and one, the boreal toad (*Bufo boreas*) as "historic". The four "encroaching" species included the long-toed salamander (*Ambystoma macrodactylum*), long-nosed leopard lizard (*Gambelia wislizenii*), desert horned lizard (*Phrynosoma platyrhinos*), and striped whipsnake (*Masticophis taeniatus*) (Lee and Paterson 2010).

The spatial distribution of the species ranged from limited to widespread. The Pacific treefrog occurred in two locations (campground and visitor's center). Of the three lizard species, two were widespread (sagebrush lizard and western skink), and one had an intermediate distribution (pigmy short-horned lizard). Of the five confirmed snake species, four had intermediate distributions (rubber boa, racer, terrestrial garter snake, and western rattlesnake), and the gopher snake was apparently limited to the lava flows around the Loop Road and Broken Top areas. Species abundance was relatively low overall; the local abundance for all reptile species combined, all snake species combined, and all lizard species combined were each strongly correlated with local richness and differed by cover type class. Snake abundance and lizard abundance also showed differences correlated with surface geology, usually with high abundance on the older landforms.

No threatened, endangered, or sensitive amphibian or reptile species occurred within CRMO. The nine confirmed species are designated unprotected nongame wildlife by the state of Idaho. The Idaho Conservation Data Center lists each as S5 and G5, reflecting that these species are all demonstrably widespread, abundant, and secure statewide and globally, respectively.

Lee and Paterson (2010) recommended monitoring programs for amphibians and reptiles at CRMO include:

(1) Support and encourage the contribution of field observations from all personnel, especially for amphibians, species observed on the lava flows and wilderness-designated area, and those species not detected in the 2010 study.

(2) Repeat the visual encounter, dipnet, and driving surveys, in addition to repeating the trapping portion of the 2010 study at the 12 long-term sites within 5-10 year intervals, and possibly combine with other monitoring efforts.

(3) Continue to update and improve the habitat-based distribution models to potentially help in predicting the effects of future habitat changes.

(4) Continue protecting habitat within CRMO and the sagebrush-steppe and riparian areas of the northern portion in particular. Other important areas include the communal rattlesnake den and the areas around Devil's Orchard and Broken Top.

Wildlife Monitoring

Ecological monitoring is conducted by UCBN and CRMO natural resource staffs to determine the long-term effects on the system or species and provide for an early warning system in an attempt to identify undesirable changes to the resource (Garrett et al. 2007). During 2009 and 2010 personnel from the UCBN field-tested protocols for forest health monitoring in limber pine stands in CRMO (McKinney et. al. 2011). Limber pine seeds are the principle food source for the Clark's Nutcracker which is the primary dispersal agent for the pine seeds (Tomback 1998). The NPS/UCBN has identified 100 sites at CRMO to survey American pika on an annual basis for long-term monitoring (Jeffress et al. 2011). Additional sites were targeted for pika surveys in 2011 as part of the three-year "Pikas in Peril" research project and these data were used as input into the vulnerability assessment of the species that is forthcoming for CRMO.

The UCBN staff has identified threatened and endangered species as a priority vital sign for monitoring and as a result, several species of management concern are identified and discussed in more detail in the next section of this NRCA. UCBN monitors the known and unknown effects on the species or system to further identify the stressors on the species. For each annual breeding bird survey within CRMO approximately fifty percent of the 73-152 species recorded (47-74 species annually between 2005-2010) are listed as sensitive by the state of Idaho, the BLM, the USFWS, or are a Partners in Flight priority species (Munts 2011-2005).

CRMO natural resources staff monitors bird populations and important individual species throughout each year using several surveying methods, these include: (1) Breeding Bird Survey, (2) Greater Sage-grouse Monitoring, (3) Clark's Nutcracker Monitoring, (4) Migrant Survey, (5) Christmas Bird Count, (6) Mid-winter Eagle Count and (7) Daily Species Listing (Munts 2011). Breeding bird surveys are performed in June annually, ten survey routes were sampled in 2010 (Munts 2011). Methods were designed from the North American Breeding Bird Survey and modified to be usable as trail-based rather than road-based sampling. The methods are described in the Standard Operating Procedures (SOP) for Breeding Season Bird Surveys at Craters of the Moon National Monument and Preserve (1997). The SOP document provides descriptions and maps of the individual survey routes.

During June 2010, bird surveys were conducted on ten point count transects (175 point counts) and breeding season surveys were performed on ten routes within CRMO (Munts 2011). The walking routes included Carey Kipuka (4,250 meters = 2.6 miles), Caves Trail (1,000 meters = 0.6 miles), Little Cottonwood (3,000 meters = 1.9 miles), Sunset Flow (5,750 meters = 3.6 miles), Tree Molds (2,250 meters = 1.4 miles), Wood Road (3,500 meters = 2.2 miles), and Wilderness Trail (6,000 meters = 3.7 miles). Driving routes included Goodale's Cutoff 1 (19,310 meters = 12 miles), Goodale's Cutoff 2 (19,310 meters = 12 miles), and Loop Drive (7,000 meters = 4.4 miles).

Greater Sage-grouse lek monitoring on NPS managed lands was initiated by CRMO staff in 2004 with surveys conducted in April, annually (Munts 2011). Lek surveys are performed using methods developed by the IDFG and the BLM. Surveys consist of three or four visits to designated leks with counting started as soon as morning light conditions allow. Due to access conditions counts are performed on foot and from an observation point near but outside the leks. When close enough together, multiple leks are counted in a single morning but all counts are completed within one and one half hours of sunrise. The standard lek forms in use by IDFG are completed by NPS staff and copies are provided to IDFG for inclusion in the statewide database.

A compilation of NPS and IDFG datasets identified 23 leks located on CRMO, IDFG has classified 15 (65%) as inactive. The inactive criterion is based on at least ten years with no Greater Sage-grouse observations. During the period from 2004 to 2006, half of the inactive historic leks were visited and no sage-grouse were detected (Munts 2011). The remaining eight inactive leks were not accessible without extended backpacking or aircraft. With over ten years of no observations these sites were removed from routine annual monitoring. One lek (New Lava #3 on the Grassy Flow near the edge of Little Park) is surveyed every other year and was last surveyed in 2009. Six of the seven active leks are located on the Sunset Flow and are in close proximity to each other, they are counted annually as a lek route for which the data are used by the IDFG as regional trend data. The group of six leks called the Golden Chariot Complex, are the largest of the leks which include Golden Chariot, MP 237, Lower Big Lost-Circular Water Tank, Pressure Ridge, Blizzard Mountain Road, and Brodie Ranch. In 2010 these leks were observed during the period from April 2 to April 27 and each lek was visited four times during this period. One lek was discovered on the Grassy Flow adjacent to the highway in late April 2009 and it was surveyed with four visits in April 2010 (Munts 2011).

To gather baseline information and to initiate long term data for Clark's Nutcracker status and trend, CRMO staff field-tested survey methods during the fall of 2010 (Munts 2011). Surveys were conducted to coincide with peak seed-gathering behavior when nutcrackers typically occur in family groups and are highly vocal, behaviors that lend to ready observation and counts. To facilitate interpretation of data, transects were selected using the sampling frame generated by the UCBN for monitoring limber pine stands. Random points were generated within the sampling areas to conduct the pine monitoring (McKinney et. al. 2011). By using these locations, trends in nutcracker populations can be tied to limber pine monitoring parameters. Transects were drawn connecting the selected points, they were one kilometer (0.6 mile) in length and were created as random end points where available while avoiding overlapping or adjacent transects (considered to be within 500 meters (0.3 mile)). Clark's Nutcracker can be easily seen at distances of 500 meters (0.3 mile) in open woodland stands (Munts 2011).

Twelve counts of Clark's Nutcracker transects were completed during the August to October 2010 time period. Parameters recorded included: date, start and end times, temperature, wind speed, cloud cover, precipitation, and cone status (cones open or closed and whether cones were hardened or still green). A single stand may have cones in several stages so several trees were examined and the dominant state of the mature (2nd year) cones was recorded.

Beginning in 2002, migrant and spot bird surveys were performed in habitats of interest within CRMO which added to the above-described transect data (Munts 2011). During 2010 the survey areas selected were: Lava Lake and the adjacent lava flow (including the Preserve and all of Lava Lake); the hot springs cluster and the associated wetland (including the portion of the marsh inside the livestock exclusion fence); and the Little Cottonwood drainage (surveyed in May). The hot springs marsh and Little Cottonwood surveys were conducted as a walking transect and Lava Lake was surveyed using a long point count. Counts were generally performed until the observer determined that all birds in the area were recorded. Counts were usually performed in the morning and the number of visits was opportunistic and varied between locations. During 2010 the number of visits included two to the hot springs, three to Lava Lake, and one to Little Cottonwood.

Daily listing of bird species was begun by CRMO staff in 1999 as an informal survey resulting in a list of species identified each day. Species are observed in the course of performing other tasks therefore effort varies substantially from day-to-day or season-to-season. These informal data yield useful information in the form of a list of bird species observed from day-to-day or month-to-month, provides information on first arrival and last departure dates for migrant species, and can provide an early warning to problems with particular species that may be showing significant shifts in the number of days a year they are observed or shifts in the time of year they may be observed. For example, presence information of this type is expected to be the first observable response to local climate change by migrant populations.

During December of 2005 a Christmas Bird Count (CBC) was restarted in the headquarters area, as it had not been performed since 1969 (Munts 2011). The 2010 CBC was performed on December 17th. The CBC is the continent-wide winter bird survey program sponsored by the National Audubon Society (NAS). It is performed in a 15-mile (24 kilometer) diameter circle and all birds observed within the circle during a single day are recorded. Detailed criteria and methods have been published by the NAS and are available at the following website: http://www.audubon.org/bird/cbc/index.html. The CBC is a volunteer count and nine people including the public and park staff participated in the CRMO count (December 17, 2010 from 0820 to 1700). Each of three groups of observers included one or more persons experienced in bird identification and together logged 19 hours of observation.

An additional winter bird monitoring project conducted by CRMO staff is the Craters/Big Lost route of the Mid-winter Eagle Count (Munts 2011). This count is administered under the USFWS; however, the route has been counted by NPS personnel since project inception. In 2009 the count was conducted on January 7th using standard procedures published by the USFWS; in addition to eagles, other birds of prey (hawks, falcons, etc.) and the raven and shrike are also recorded.

Threats and Stressors: Loss of habitat due to conversion of the sagebrush-steppe communities and changes in the environment are the largest regional threats to the wildlife species identified herein. Annual weather patterns and local weather events represent significant stressors to wildlife when drought, heavy snowfall, heavy rainfall, hail, temperature changes, etc. occur (Munts 2011, USFWS 2010). Climate change further exacerbates the issues with wildlife species and habitats over the long term as conversion or changes in the habitat complicate matters. For specific threats to the selected species of concern see the individual inventory and monitoring sections provided herein.

White-nose syndrome (WNS) is a recently discovered infection believed to be associated with a fungus which causes white spots on the nose of infected individual bats (USGS 2011). WNS once introduced into bat populations can have devastating effects on the population. This fungus is believed to be transmitted from bat-to-bat (USFWS 2011).

Beginning in 2000, a declining pattern of bird observations emerged and continued through 2004, possibly due to drought conditions (Munts 2011). With the return to near average rainfall in the period from March through June of 2005 and 2006 overall numbers of birds again increased with a record number recorded in 2008 and counts in 2009 and 2010 only slightly lower. The number of species recorded paralleled the pattern of total bird count increases.

One bird species for which a trend emerged after ten years of surveys (they were not observed in 1997 or 1998) is the Blue-gray Gnatcatcher (*Polioptila caerulea*). Three individuals were observed in 1999 and count numbers steadily increased to 53 in 2007 then decreased in 2008 when 33 individuals were observed. In the western U.S. it is generally associated with pinyon/juniper woodlands (Cornell University 2008). The use of other pine habitats by Blue-gray Gnatcatchers is not well documented; the limber pine woodland stands within CRMO where the species occur are unique and in many ways resemble pinyon/juniper stands in their structure and function. The colonization of the northern portions of CRMO by gnatcatchers may also be indications of a northward range expansion over the 20th century (Cornell University 2004, Ellison 1992). This range expansion is thought to have been influenced by both fire suppression during the 1900s and climate change (Ellison 1992). The rise in observed individuals through 2007 then the fall in numbers in 2008 may indicate that the suitable habitat is now occupied and the population is reaching equilibrium within CRMO. Like gnatcatchers, the Northern Mockingbird (*Mimus polyglottis*) is also expanding its range northward (Munts 2011). This species is abundant in the southwestern U.S. but fewer than five occurrences were documented within CRMO prior to 2010 when five mockingbirds were recorded on the survey of the Wood Road Trail. Other pinyon/juniper woodland bird species have been documented using CRMO limber pine stands including the Bushtit (*Psaltriparus minimus*) and Pinyon Jay (*Gymnorhinus cyanocephalus*). Threats to limber pine stands and habitat value within CRMO, including prolonged drought, wildfire, pine beetle infestation, and white pine blister rust would also affect the range expansion by the above bird species.

Data Gaps: Additional research is needed for several of the species of concern identified below (e.g., American pika, pygmy rabbit, pronghorn, nine bat species, Greater Sage-grouse, Clark's Nutcracker, and five sagebrush-obligate bird species). Due to the natural history of many of these species and related habitat requirements, continued monitoring of the sagebrush-steppe is desirable. Little is known, at the time of this report, on the sagebrush-steppe obligate bird species; inventory and monitoring efforts should focus on these species and habitat use. An extensive survey of the pronghorn migration routes and the species will help to identify the habits used by this large ungulate.

American Pika

The American pika *(Ochotona princeps)* is distributed discontinuously in rocky and often mountainous areas from southern British Columbia and southern Alberta, south to southern California, Nevada, southern Utah, and northern New Mexico, and east to Wyoming and Colorado. The species occurs from sea level to 9,800 feet (3,000 m) in northern mountain ranges and infrequently occurs below 8,200 feet (2,500 m) in southern mountain ranges (Smith and Weston 1990). Unique American pika habitat is present in CRMO where the landscape is characterized by rather recent lava flows and is not representative of typical habitat such as mountain talus slopes and boulder-strewn alpine fell fields (Bunnell and Johnson 1974).

Due to its sensitivity to temperature, the American pika is considered an important species for monitoring and assessing the potential impacts of climate change. Rodhouse et al. (2010)

suggests climate change could reduce the size and proximity of suitable habitat for American pika in CRMO. The NPS identified concerns for changes to American pika distribution due to climate change and is currently studying pika distribution and habitat associations using presence/absence surveys in eight national park units, including: CRMO; Crater Lake National Park, Oregon; Grand Teton National Park, Wyoming; Lava Beds National Monument, California; Lassen Volcanic National Park, California; Great Sand Dunes National Park and Preserve, Colorado; Rocky Mountain National Park, Colorado; and Yellowstone National Park, Wyoming. The NPS has identified 100 sites at CRMO to survey on an annual basis for long-term monitoring (Jeffress et al. 2011). An additional 134 sites were surveyed in 2011 as part of the three-year “Pikas in Peril” research project and these data will be used to conduct a vulnerability assessment of the species for CRMO starting in 2012 (Resource Brief 2011).

Site Specific Information: The NPS conducted an American pika survey within CRMO in 2007, establishing a baseline population inventory using 72 inventory sites selected from modeled electronic data of potential species distribution. Research sites were 12 meter (39.4 feet) radius circular plots (452 m^2) and were evaluated by two observers for 20 minutes per visit. Nineteen of the 72 research sites represented a sub-sample of 32 historically evaluated American pika habitat locations. Six of the 19 historic research sites (32%) exhibited recent evidence of American pika use (fresh scat, fresh hay, calls, or visual sightings). Listed as a potential future vital sign in the monitoring plan, the UCBN now considers American pika a vital sign for CRMO management and will monitor them long term.

In 2007, 2008, 2009, and 2011, additional pika inventory surveys were conducted in CRMO. A total of 144 sites were surveyed, of which 45 (31%) contained evidence of American pika use (Rodhouse et al. 2010). This research determined that the pika distribution was restricted to approximately 96.5 square miles (250 square kilometers) in the northern portion of CRMO and at elevations of approximately 5,248 feet (1,600 meters). Should 38% of this range be occupied by American pika territories, there could be over 135,000 occupied locations (this calculation uses figures based on the evaluation of American pika distribution plots sampled in 2007 and assessment of habitat types, substrate attributes, and assumptions of habitat quality importance) (Rodhouse et al. 2010). Exposures of pahoehoe lava provided the best pika habitat partially due to higher cover (albeit still sparse cover) of forbs and other vegetation. Other substrates and lava habitat types assessed in CRMO supported less vegetation cover and fewer pikas.

Surveys conducted in July through September 2010 resulted in pika detections at 21% of the sites (Jeffress et al. 2010). The occupied sites were generally located at higher elevations within CRMO, which is similar to the previous results of Rodhouse et al. (2010). Resurveys of existing research sites and surveys of newly-established sites are planned for the future. Figure 7 illustrates American pika survey sites and data from 2007-2009 (Rodhouse et al. 2010).

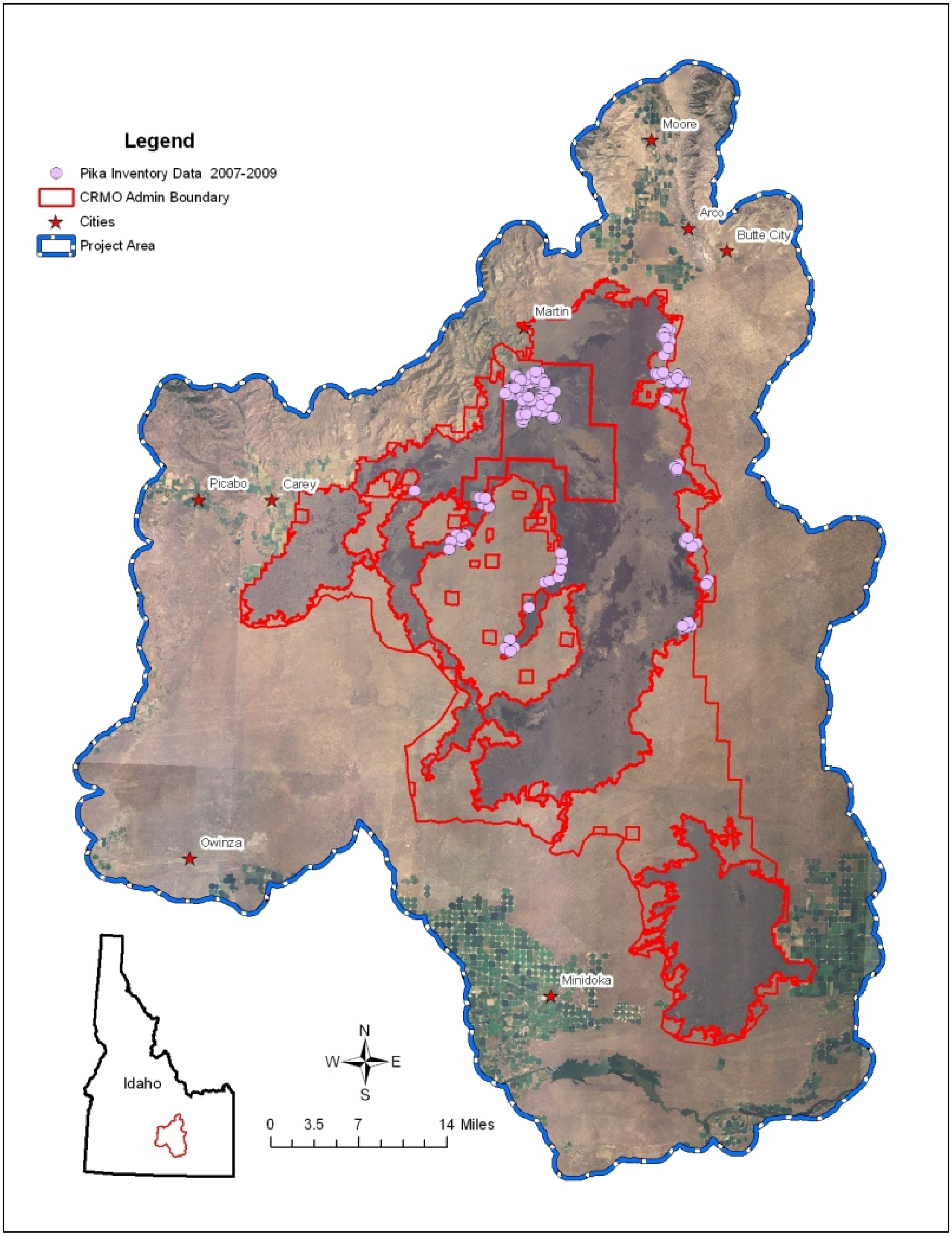


Figure 7. American Pika Inventory Data for CRMO, 2007-2009.

<u>Threats and Stressors</u>: Climate change resulting in higher temperatures poses a threat to the American pika because it may reduce the available forage, size of hay piles, and the species is sensitive to changes in temperature (USFWS 2010b). High temperatures might limit the pika's ability to forage effectively and build adequate haypiles resulting in winter starvation; snowpack provides insulation for pikas in the winter, reduction of snowpack as a result of climate change may expose pikas more to the other elements such as freezing rain, cold wind, etc.; and climate change may lead to changes or shifts in habitat (such as changes to the plant species used as forage). Recent elevational range contractions have been observed in certain areas, such as the Great Basin, and there is reason to believe these changes are due to climate change effects (Beever et al. 2003, Grayson 2005). Computer-generated models suggest the American pika population may disappear from up to 80% of the known range by the turn of the century (Craighead 2008).

American pikas may be a strong indicator species for the response of alpine, mountain, lava bed, and other systems to warming trends because they occupy habitat with cool, relatively moist climates (WWF 2011). Should temperatures rise due to increasing natural and anthropogenic emissions of heat-trapping gases, many montane animals are expected to seek higher elevations or migrate north in latitude to find suitable habitat. Living essentially on high-elevation islands means that American pikas have little option for refuge from the pressures of climate change because migration across low-elevation valleys would be of high risk or impossible. Recent research suggests that climate may be interacting with other factors such as proximity to roads and smaller habitat area to increase extinction risk for pikas, creating detrimental synergistic effects (WWF 2011).

According to recent USGS research (Beever et al. 2003 in WWF 2011), global warming appears to have contributed to local extinctions of pika populations in the Great Basin area during the last part of the 20th century; pikas disappeared from seven of twenty-five studied areas. The American pika is vulnerable to climate change resulting in warming due to several factors (WWF 2011), the factors include: (1) pikas cannot easily migrate in response to climate change, (2) in general pikas do not move large distances (individuals may spend their entire lifespan within a half-mile (0.8 km) radius), (3) pikas do not inhabit burrows which could mitigate extreme temperatures, (4) pikas are highly active above ground during the hottest months of the year, (5) pikas must cure grasses and forbs for overwinter survival (pikas are active year-round and food is scarce in winter in the alpine environment), (6) earlier maturation of vegetation due to a warming climate may result in inadequate food supply for the entire year, (7) hotter temperatures during high activity periods can create direct thermal stress and (8) pikas are densely furred thus cannot dissipate heat easily.

Pygmy Rabbit
The pygmy rabbit (*Brachylagus idahoensis*) is the smallest member of the family *Leporidae* (rabbits and hares) in North America and is considered a sagebrush-obligate species (heavily dependent on the sagebrush-steppe habitat established within CRMO and elsewhere). Burrows are typically located in the tall, dense stands of sagebrush with cover of greater than 30% and deep, loose soils. The general historical and current geographic range of the pygmy rabbit includes most of the Great Basin a portion of the Columbia River Basin and some of the adjacent intermountain areas of the western U.S. The general boundaries can be described as follows: (1) the northern boundary extends into southeastern Oregon and southern Idaho, (2) the eastern

boundary extends into southwestern Montana and south central Wyoming, (3) the southeastern boundary extends into southwestern Utah and (4) central Nevada and eastern California provide the southern and western boundaries (FR 2010).

Population trends are normally defined in terms of distribution or abundance and in the case of the pygmy rabbit, the available scientific information does not allow for an analysis of abundance over time (FR 2010). Abundance trends for the pygmy rabbit in each state and throughout its range are unknown. How impacts to the sagebrush habitat from various events or actions have affected pygmy rabbit abundance remains unclear. Distribution information obtained from early literature and records represent a collection of sightings documented by different individuals over time. The early records were not collected in a systematic, comprehensive manner with the goal of determining the pygmy rabbit distribution; however, they do reflect the historical distribution known at that time (which was modified as previously unknown locations were recorded). Scientific understanding of the distributional trend throughout the range has improved only recently (FR 2010).

Due in part to fragmentation of the historical range, habitat within the range, and uncertainty in population numbers, the pygmy rabbit has been petitioned for listing as a threatened or endangered species by the USFWS (Ulmschneider et al. 2008). However, listing the pygmy rabbit was determined to be not warranted by the USFWS on September 30, 2010 (FR 2010). The potential factors that may affect the habitat or range of the pygmy rabbit include: (1) habitat conversion, (2) agriculture, (3) sagebrush treatment, (4) livestock grazing, (5) non-native invasive plants, (6) fire, (7) pinyon-juniper woodlands encroachment, (8) urban and rural development, (9) mining, (10) energy exploration and development, (11) habitat fragmentation, (12) habitat manipulation conducted to benefit Greater Sage-grouse, and (13) conservation strategies and actions (FR 2010).

The Idaho population of pygmy rabbits is declining due to large areas of habitat lost to development, agricultural production, fire, and other land uses (Roberts 2003). Agricultural land uses have removed or altered more than 20% of the potential pygmy rabbit natural habitat. As the land use is modified to agricultural crops or invasive grasses dominate (resulting from fire) and change the diversity, structure, or composition the habitat is lost to pygmy rabbits. Large stands of sagebrush-dominated potential habitat occur within CRMO; however, information is limited on population trends and locations of pygmy rabbits. The key components of pygmy rabbit habitat include the structure of the overstory vegetation and the composition of the understory (where the sagebrush-steppe plant community is relatively intact, potential habitat exists).

Site Specific Information: There are few pygmy rabbit surveys in southern Idaho and the population trends, distribution, and status are not well understood. Records indicate pygmy rabbit observations within the Monument and in CRMO from 1930 to early 2011. Davis (1939, in FR 2010) listed locations of 10 pygmy rabbit specimens examined as study skins, one was from the Monument. Rachlow and Witham (2004) surveyed three potential sites within CRMO in 2004 and found no evidence of pygmy rabbit presence. Hoffman (1988) noted pygmy rabbits in the southern-most portion of the Monument. Recently, Apel (2011) documented (using photographs) pygmy rabbits in the lower Cottonwood Creek area and along Highway 20 east of the visitor center within CRMO (Figure 8). Other observations were noted by NPS Vegetation

Inventory Program field crews from 2006 to 2008, however, no photographs were acquired and the reports remain unconfirmed to date.

Bell et al. (2009) classified and interpreted nine sagebrush shrubland mapping units and one rabbitbrush shrubland mapping unit that represent 82,692 ac (33,586 ha) of the CRMO land area. A portion of these mapping units with sufficiently high shrub cover could support additional pygmy rabbit individuals and populations.

Threats and Stressors: The USFWS staff has identified the 13 above-listed threats to the pygmy rabbit population in the western U.S. Generally, fragmentation of the sagebrush steppe habitat negatively affects pygmy rabbit and other sagebrush-obligate species. Other human activities resulting in the loss of sagebrush steppe include conversion to agricultural production, livestock grazing, and invasive and noxious plant introductions. Additionally, naturally occurring and human-ignited wildfires poses a further risk to pygmy rabbits and other species discussed herein (Roberts 2003). The level of impact for CRMO sagebrush habitat due to the nature of the land use surrounding the boundary is variable. Each threat can have contributing factors and compound the issue as discussed herein.

Loss of habitat due to agricultural conversion likely contributes to the decline in localized populations of the pygmy rabbit in Idaho (USFWS 2010a). Since large scale conversion of the sagebrush-steppe began with the Homestead Act in the 1800s, more than 18% of the potential habitat for pygmy rabbits has been converted in Idaho (USFWS 2010a). Other researchers have determined as much as 25-50% of historic pygmy rabbit sites were disturbed by agricultural land use (Welch 2005, White and Bartels 2002).

Compatibility between livestock grazing and pygmy rabbit populations can occur under certain livestock management systems; however, overgrazing can be detrimental to the species. The primary area of concern is the loss of sagebrush steppe habitat (Belsky and Gelbard 2000). Also, due to the introduction of invasive plant species, the degradation of potential habitat results in less desirable habitat and forage available to the pygmy rabbit resulting in the decline of local populations. Within CRMO approximately 25% of the total sagebrush shrubland map unit area has been invaded by cheatgrass in the understory and in spaces between individual shrubs (Bell et al. 2009).

Invasive plant species, most predominately the non-native annual cheatgrass, poses threats to pygmy rabbits through habitat loss and a decrease in the ability of individuals to identify and escape from predators (Weiss and Verts 1984). BLM field studies conducted in 2005 determined that no pygmy rabbits occurred on sites with a high percentage of cheatgrass in the understory. Other studies identified pygmy rabbits using sites with cheatgrass at or below 1% cover (Burak 2006). Bell et al (2009) classified and interpreted 21,307 ac (8,630 ha) of sagebrush shrubland within CRMO having cheatgrass as the common herbaceous species.

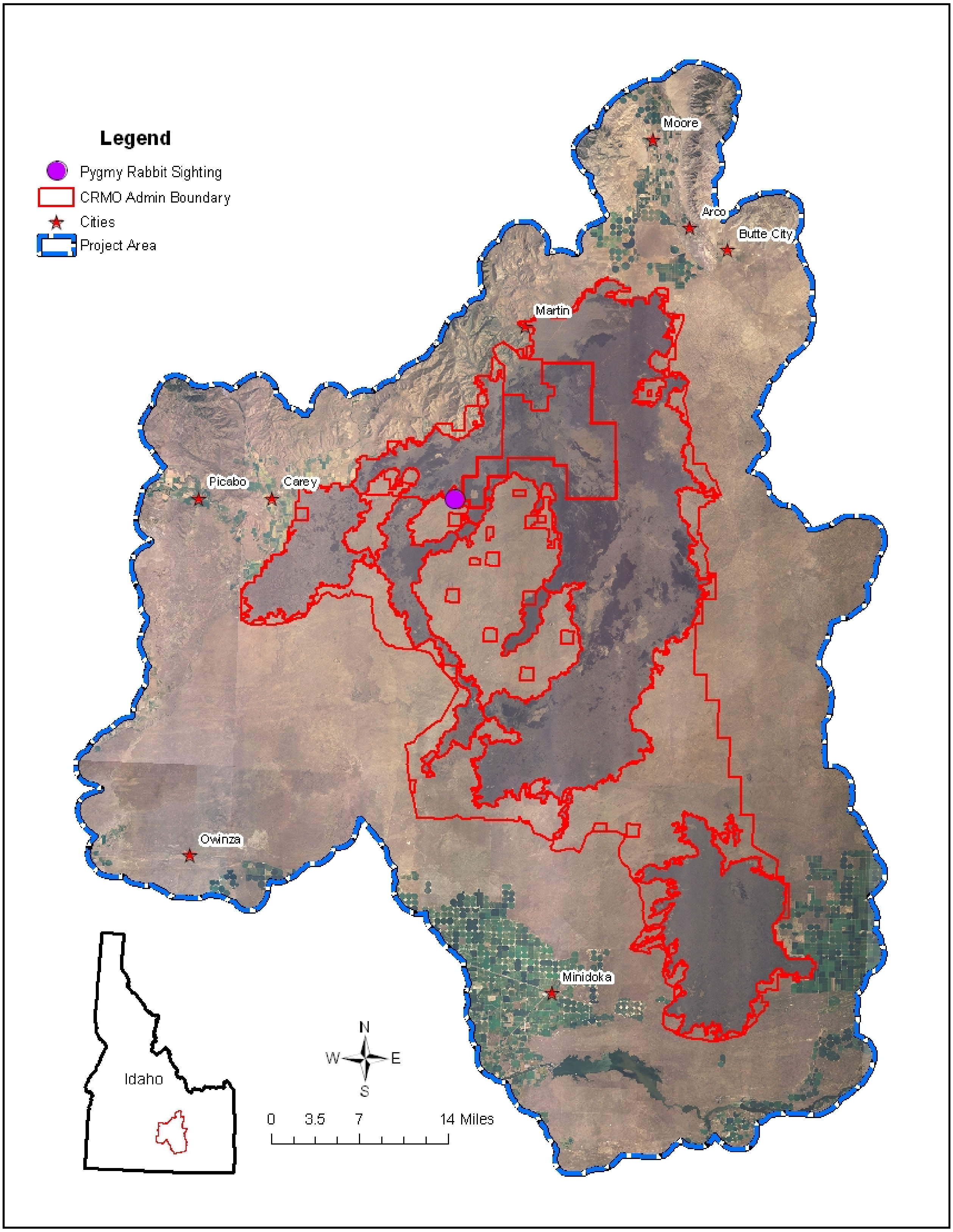


Figure 8. Pygmy Rabbit Field Observation Location.

Additionally, cheatgrass increases the frequency and rate of spread of wildfires in sagebrush plant communities (USFWS 2000). Sagebrush shrublands are slow to recover and the sites are sometimes fully occupied by invasive species following fire (Connelly et al. 2004). Sagebrush is slow to recolonize following fire because it does not resprout from stumps or roots and can take more than 30 years to reestablish from seeds (Bunting 1987). The resulting lost sagebrush habitat results in localized reduction in the populations of pygmy rabbits.

Encroachment by trees, including species of juniper (*Juniperus* sp.), has resulted in the loss of sagebrush steppe community structure (Miller 2005). The loss is primarily due to the decrease in fire frequency in wooded shrublands and the reduction of fine fuels associated with domestic grazing. Expansion of pinyon/juniper woodlands in the Great and Columbia River basins may have resulted from poor habitat management and climate change, however, the encroachment of pinyon/juniper trees into occupied pygmy rabbit habitat is a slow process, and they may be able to inhabit those areas or shift home ranges to adjacent areas if pinyon/juniper woodland habitat becomes established at a site (FR 2010).

Climate change may exacerbate invasive species spread and establishment and further complicate wildfire issues. Fire frequency and the intensity of fire in sagebrush shrubland communities will increase with warmer temperatures. A documented increase in temperature over the past 100 years of 0.7 degree C has contributed to the range for pygmy rabbits moving higher in elevation by nearly 400 feet (122 meters) (Peters and Bunting 1994). Increasing temperatures will continue to shift the range of the pygmy rabbit higher in elevation. In California and Nevada, Larrucea and Brussard (2008) determined that extant historical pygmy rabbit sites averaged 515 ft (157 m) higher than extirpated sites. With local downward shift effect accounted for, overall upward elevation shift of extant sites was 721.8 ft (220 m). The researchers attributed the upward shift to climate (FR 2010).

The USFWS acknowledged that environmental changes resulting from climate change could facilitate invasion and establishment of invasive species or exacerbate the fire regime, possibly accelerating the loss of sagebrush shrubland habitats (Connelly et al. 2004, in FR 2010). Based on the USFWS (FR 2010) review of the available information, there is no demonstrated direct link between predicted climate change and reduced abundance and survival of pygmy rabbits. The best scientific and commercial information currently available does not indicate that climate change is a significant threat to the species now or in the foreseeable future (FR 2010).

Pronghorn

The pronghorn (*Antilocapra americana*) is distributed across the plains, grasslands, and mountain parks/broad valleys of North America from Saskatchewan to Mexico and from Oregon to Nebraska. This large game mammal typically occurs from 4,000 to 6,000 feet (1,219 to 1,829 meters) in elevation on flat to undulating open valleys and grasslands with an annual precipitation range of ten to 15 inches (25.4 to 38.1 centimeters). Since the 1800s there has been an estimated 95% pronghorn population reduction (Smyser et al. 2005) and in Idaho the population of pronghorn had declined between 1984 and 1997 from approximately 23,500 to 12,000 individuals (Smyser et al. 2004); current statewide population estimates for pronghorn could not be obtained for this NRCA. Researchers estimate current pronghorn migration across CRMO to be between 100-200 animals (WCS 2009).

Both common and unique pronghorn habitat is present in south-central Idaho, including CRMO, where the landscape is largely characterized by rather recent lava flows not typical of deep alluvium deposited on plains and in basins and valleys (Bunnell and Johnson 1974). The CRMO landscape provides important pronghorn migration corridors in addition to habitat supporting other population needs. During the fall and spring seasons, pronghorn often migrate between high mountain summer ranges to lowland winter ranges (Braun 2009). In southern Idaho, pronghorn travel up to 80 miles (129 kilometers) one-way using a narrow corridor from the Pioneer Mountains through CRMO to the Continental Divide on the Beaverhead Mountains within the Idaho National Engineering Laboratory near Idaho Falls (Cohn 2010; WCS 2009). This research indicates pronghorn travel through lava beds and exposures on narrow corridors as little as 600 feet (183 meters) wide leading to highway crossings (WCS 2009).

Site Specific Information: Limited current information for pronghorn distribution, population density, and use of CRMO lands is available for this NRCA. Biologists from the Wildlife Conservation Society (WCS) and Lava Lake Institute for Science and Conservation attached global positioning system (GPS) transmitters onto captured pronghorn in 2008 to determine the migration corridors and other use areas within CRMO and the surrounding region. It is estimated that 100 to 200 individual pronghorn use the migration route through CRMO annually and these animals join with other herds to form a wintering ground population of approximately 1,000 animals, the largest wintering herd in Idaho (WCS 2009). The location of wintering grounds and pronghorn behavior on them is little known. NPS Vegetation Inventory Program field crew staff documented eight observations of pronghorn during the 2006 to 2008 timeframe (Figure 9).

CRMO lies within the Big Desert and Pioneer Hunt Areas (52A and 50, respectively) (IDFG 2011) and is closed to hunting. However, the pronghorn population outside of the CRMO boundary experiences hunting take of 4-22 and 51-66 individuals killed annually in the two hunt areas, respectively (2002-2010 hunt data). Most pronghorn killed by hunters have larger horns and are likely males; it is unknown if hunting outside the CRMO boundary pushes additional pronghorn into the park during and following the season.

Threats and Stressors: The USFWS staff identified improper fencing, highways, and habitat loss as the primary areas of concern for healthy pronghorn populations. Predation of pronghorn fawns by coyotes (*Canis latrans*) and golden eagles (*Aquila chrysaetos*) primarily, limits recruitment of young animals into pronghorn herds (Smyser et al. 2004). WCS (2009) identified planning and development of large-scale wind farms to generate electricity (plus attendant power transmission lines and access roads) as a credible potential threat. Critical to the pronghorn regionally (also to local pygmy rabbit and Greater Sage-grouse populations) are the seasonal and daily travel corridors and special use areas (wintering range, leks, etc.). Maintaining and protecting the ecological integrity of the corridor and special use habitats is a priority of the NPS

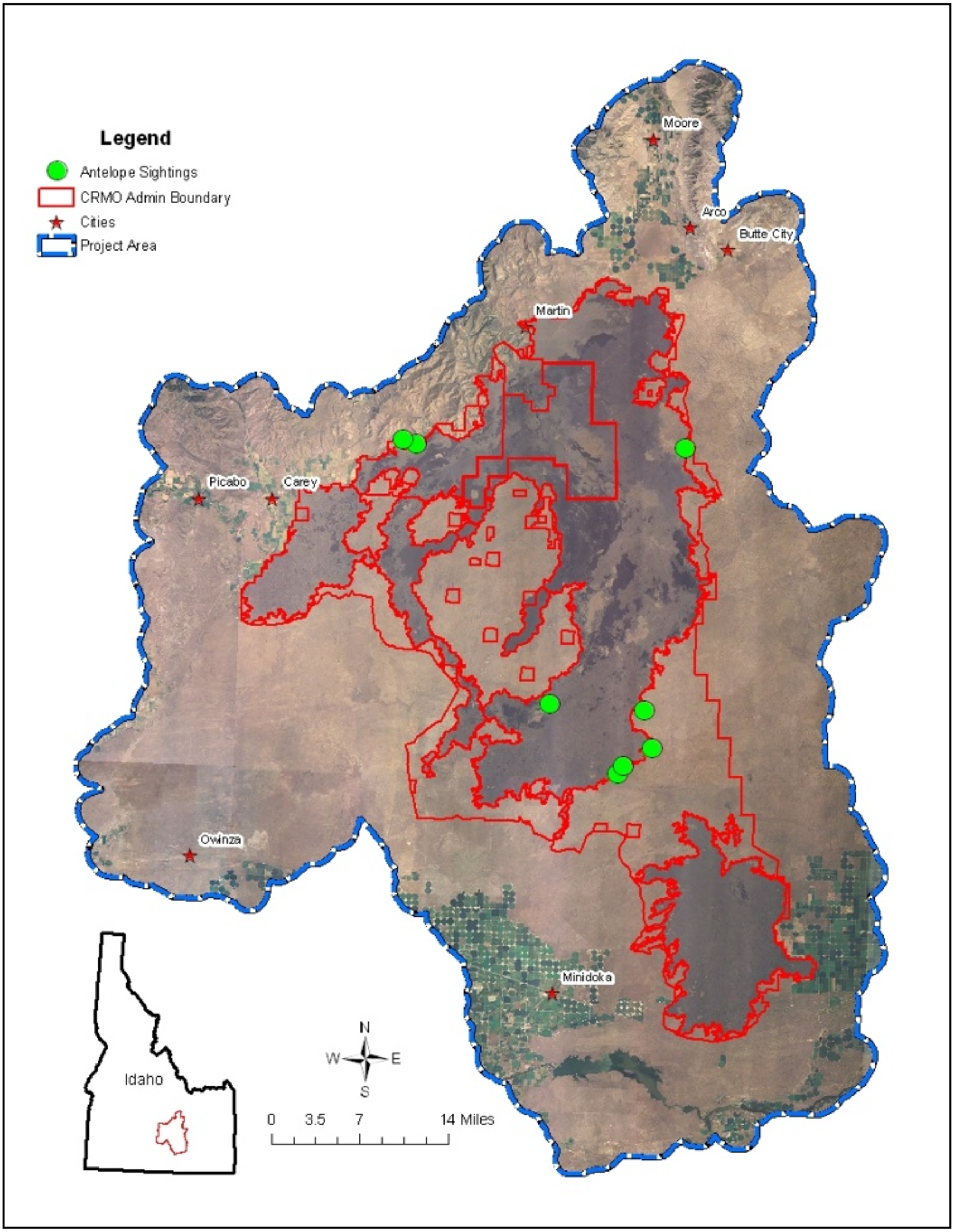


Figure 9. Pronghorn Observations Documented Within CRMO.

Bats (Nine Species)

There are 14 bat species documented in Idaho habitats (dense evergreen forests to riparian woodlands to arid desert shelters) and nine to twelve of these species occur within CRMO plant communities and the exposed lava features. Three bat species are common breeders and develop maternity colonies within CRMO, they are the Townsend's big-eared bat (*Corynorhinus townsendii*), western small-footed bat (*Myotis ciliolabrum*), and long-eared myotis (*Myotis evotis*) (NPSpecies Database 2011; Ave et al. 2004). Six bat species are present in CRMO but little is known about the species abundance or habitats. Included are the pallid bat (*Antrozous pallidus*), big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), fringed myotis (*Myotis thysanodes*), long-legged myotis (*Myotis volans*), and Yuma myotis (*Myotis yumanensis*) (NPSpecies Database 2011). Additionally, three bat species are listed as probably present within CRMO (NPSpecies Database 2011) they are the silver-haired bat (*Lasionycteris nocitivagans*), hoary bat (*Lasiurus cinereus*), and California myotis (*Myotis californicus*).

The unique occurrence of caves/caverns, alcoves, crevices, boulders, and lava tubes within CRMO represents important habitat for extant bat species. Seven types of caves within CRMO provide good bat habitat, they are: (1) differential weathering, (2) lava tubes, (3) rift/fissure, (4) spatter cones and hornitos, (5) talus, (6) tumuli and (7) lava blisters (Owen et al. 2011). Not all caves have been inventoried, but of the 329 known caves, most are lava tubes. Bat species use the caves for day roosting, as hibernacula, and by maternity colonies (Owen et al. 2011). Five of the caves have been minimally developed for recreation access (the cave interiors are wild and unimpaired), they are: (1) Indian Tunnel, (2) Dew Drop, (3) Boy Scout, (4) Beauty and (5) Buffalo. These caves have improved trails constructed to the entrances (four of them paved) and attract/support approximately 40,000 visitors annually (Owen et al. 2011).

Bats represent a significant portion of diversity among mammals within the UCBN (20% of the mammals listed for CRMO) and many of the 14 species occurring in Idaho have been identified as federal or state species of concern (Ave et al. 2004). The UCBN monitoring program recognizes bat species as important indicators of biodiversity and ecosystem health. Idaho bat species feed on a variety of prey, including mosquitoes and midges (*Diptera*), moths (*Lepidoptera*), beetles (*Coleoptera*), crickets (*Orthoptera*), scorpions (*Scorpionida*), and mayflies (*Ephemeroptera*) (Tuttle 1997 and Richardson 2002_in Miller et al. 2005). Newson et al. (2009) stated that the interrupted hibernation cycles for bats due to excessive temperatures and changes in food supplies of insects and flowering plants due to changes in weather patterns is possibly impacting bat populations world-wide. The commonness of the Townsend's big-eared bat, western small-footed bat, and long-eared myotis within CRMO are of particular interest to the NPS I&M Program due to colonial roosting behavior and sensitivity to human disturbance (Ave et al. 2004, Csuti et al. 2001).

The NPS has identified bats as species of interest within CRMO and are presently determining presence/absence, distribution, and migration patterns at this and other park units in Idaho, Montana, and Washington (City of Rocks National Monument, Idaho; Big Hole National Battlefield, Montana; Glacier National Park, Montana; and North Cascades National Park, Washington). CRMO includes the largest known cavernous lava habitat in the U.S. and NPS staff will conduct bat surveys in the areas identified as North Caves, Screaming Jaws of Death Cave, Little Cottonwood Canyon, and Lava Lake.

The Idaho Bat Working Group (IBWG) also recognizes the ecological significance of bats; it is a subcommittee of the Western Bat Working Group and is an assemblage of wildlife scientists and interested individuals dedicated to the conservation, protection, management, and restoration of the Idaho bat fauna. Since 1998 the IBWG has led efforts to research species life history and habitat requirements, monitor habitat use, inventory species occurrence, and conserve bats and habitats. In 2003, the IBWG began development and planned implementation of an Idaho Bat Conservation Plan (Miller et al. 2005) to complement the Comprehensive Wildlife Conservation Strategy being developed for Idaho. Conservation landscape assessments for the Challis Volcanics area, including CRMO, have been summarized and goals and objectives for bat conservation have been outlined and defined.

Site Specific Information: The Oregon Museum of Science and Industry and the University of Idaho partnered with NPS in 2004 to conduct a survey of pallid and Townsend's big-eared bat maternity colony habits as well as presence/absence counts of bat species within CRMO. Surveys were completed using a combination of 8.5 foot tall (2.6 meter tall) variable-width mist nets, roost exit counts, and echolocation call recording and analysis using Sonobat and Anabat acoustics.

During the 2003-2004 bat inventory within CRMO eight species of bats were identified directly using mist net capture or indirectly through echolocation acoustic detection. Sites inventoried included the North Caves area (Two-Step, Sandtrap, and Screaming Jaws of Death lava tube caves), Pond Cave, Lava Lake, and within Little Cottonwood and Cottonwood canyons (Ave et al. 2004). Bat species identified in this research project were the pallid bat, Townsend's big-eared bat, fringed myotis, hoary bat, long-legged myotis, western small-footed myotis, long-eared myotis, and the big brown bat (Ave et al. 2004).

In the North Caves area, Ave et al. (2004) determined the Screaming Jaws of Death Cave as the location of a Townsend's big-eared bat maternity colony. Although no bats were captured, the large numbers of Anabat-recorded calls suggested the species presence and several Townsend's big-eared bats were observed "light testing" two cave entrances (Screaming Jaws of Death and Two-Step) during placement of the Anabat recorder. Summer concentrations of male Townsend's big-eared bats are rarely observed. Screaming Jaws of Death, Sandtrap, and Two-Step caves and possibly Antelope Cave appear to be alternate roost sites for one colony of Townsend's big-eared bats (Ave et al. 2004). Owen et al. (2011) states that the little brown bat is the most common bat species within CRMO.

Recent concern over the decline of bat populations on local, national, and global levels has prompted natural resource management agencies, non-governmental organizations, private industry, and individuals to focus increased attention on bat conservation (Miller et al. 2005). Reasons for decline vary according to individual species and populations and include natural and human-related causes. Common themes include habitat alteration, loss, and degradation, roost disturbance and destruction, pesticide application, and lack of public awareness (Miller et al. 2005).

Threats and Stressors: Within CRMO human disturbance, including recreational cave exploration, vandalism, and destruction/degradation of forage habitat, poses the greatest threats to the pallid and Townsend's big-eared bats as these species are known to be sensitive to disruption. A disease that has recently affected the bat population in the U.S. is white-nose syndrome, a fungus which affects hibernating bats. Once the population is infected with white nose syndrome the disease can devastate colonies of bats killing up to 97% of the populations (USGS 2011). The little brown bat and the big brown bat occur within CRMO and are particularly susceptible to white-nose syndrome (Owen et al. 2011).

Currently the Townsend's big-eared bat and the fringed myotis are listed as Type 3 species of concern (Regional/State Imperiled); the California myotis is listed as a Type 4 species of concern (Idaho Peripheral Species); and the Yuma myotis, long-eared myotis, long-legged myotis, and western small-footed bat are on the Watch List (BLM 2011; Ave et al. 2004). All bats are listed as Protected Nongame species by the IDFG (Miller et al. 2005).

Greater Sage-grouse

The Greater Sage-grouse (*Centrocercus urophasianus*) is the largest grouse in North America it is dependent on the sagebrush steppe habitat established on large areas of the western U.S. Up to 56% of the Greater Sage-grouse historical range has been lost in the past century. Population numbers have declined and the species is a candidate for listing as either threatened or endangered (USFWS 2011). The decline of the Greater Sage-grouse population has been documented over several decades (IDFG 2004). Recent trends in Idaho are a decline of Greater Sage-grouse up to 40%. Declines occur where the sagebrush steppe is altered or fragmented. As rangeland use shifts to agriculture or introduced grasses, the diversity in structure, density, and composition is lost to Greater Sage-grouse as habitat. Because the Greater Sage-grouse is a migratory species in Idaho, the loss of one or more of the seasonal habitat components (e.g., winter range, leks/breeding/nesting/brood rearing, etc.) negatively affects the entire population.

Greater Sage-grouse require large to expansive areas of sagebrush steppe habitat as occurs in the vegetated portion of CRMO. Up to 90% of the shrublands classified and mapped within CRMO under the NPS National Vegetation Inventory Program (82,692 ac [33,586 ha]) are considered critical sagebrush steppe habitat (Bell et al. 2009; NPS 2008). This critical habitat is used by the Greater Sage-grouse for breeding and summer range and in areas of low snow levels (less than 12 inches (30.5 centimeters) annually) important winter range. In addition, the Greater Sage-grouse is considered an umbrella species for monitoring the health of the sagebrush steppe (Connelly and Braun 1997; Connelly et al. 2003; Schroeder et al. 2004; ISGAC 2006) in addition to other sagebrush-obligate wildlife species.

Site Specific Information: Greater Sage-grouse are monitored by NPS annually during the April strutting period on the Golden Chariot Complex lek sites in the northwestern portion of CRMO (Munts 2011). Since 2005, male sage-grouse observed on the Golden Chariot Complex leks have ranged from 98 to 196 in number; in 2010, 112 males occurred (Munts 2011-2005). The 'Animal' feature dataset included in the CRMO geodatabase includes point locations for Sage Grouse Lek sites, Rare Species Observation sites, and Bird Survey sites. Greater Sage-grouse data were originally developed by the IDFG staff for the period 1955 to 2009. Rare species data were provided to the NPS by the Idaho Conservation Data Center (CDC). Bird Survey sites are GPS-collected field locations from the annual bird survey at CRMO following the North American Breeding Bird Survey Protocol. A summary of the Greater Sage-grouse lek sites and location are provided in Figures 10 and 11.

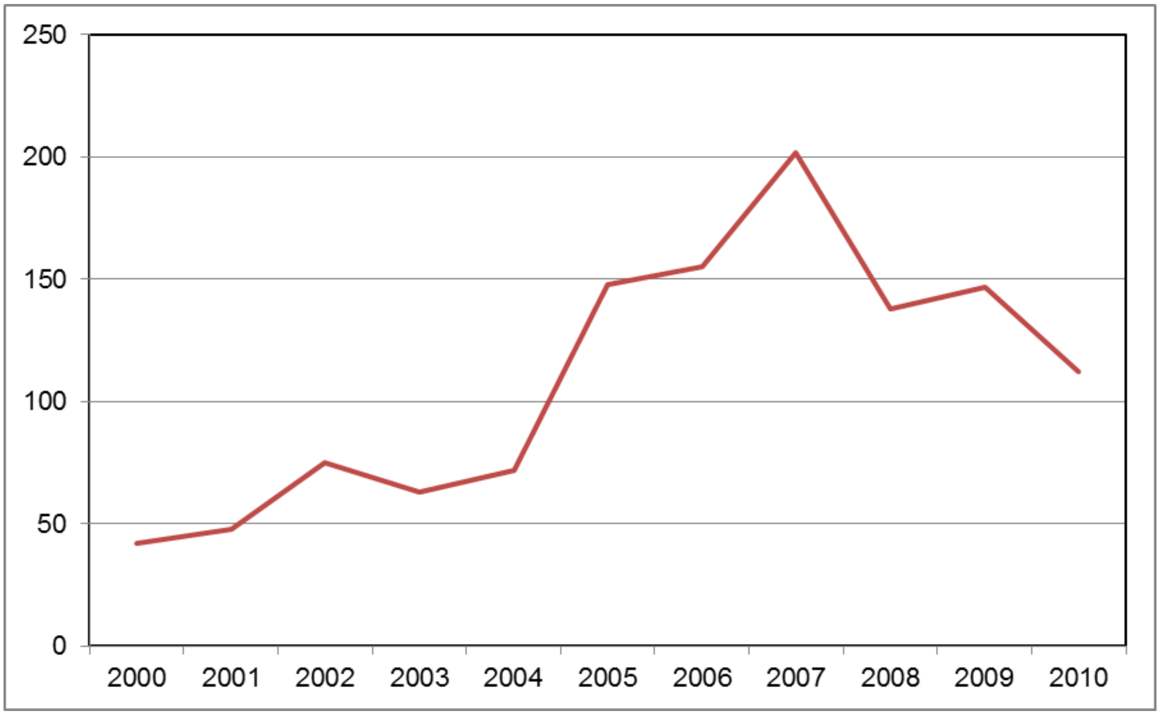


Figure 10. Greater Sage-grouse Lek Data.

CRMO staff began monitoring Greater Sage-grouse leks on NPS managed land in April 2004 (Munts 2011). Lek surveys were performed using the established methods of IDFG and the BLM. Surveys consisted of three or four visits to designated leks during the month of April. Counting began as soon as light conditions allowed visual recognition each morning. Due to difficult access conditions counts were performed by researchers on foot and from an observation point near but outside the leks to avoid disturbing the mating behavior. All counts were completed within 1.5 hours of sunrise and when leks were sufficiently close, multiple leks were counted in a single morning.

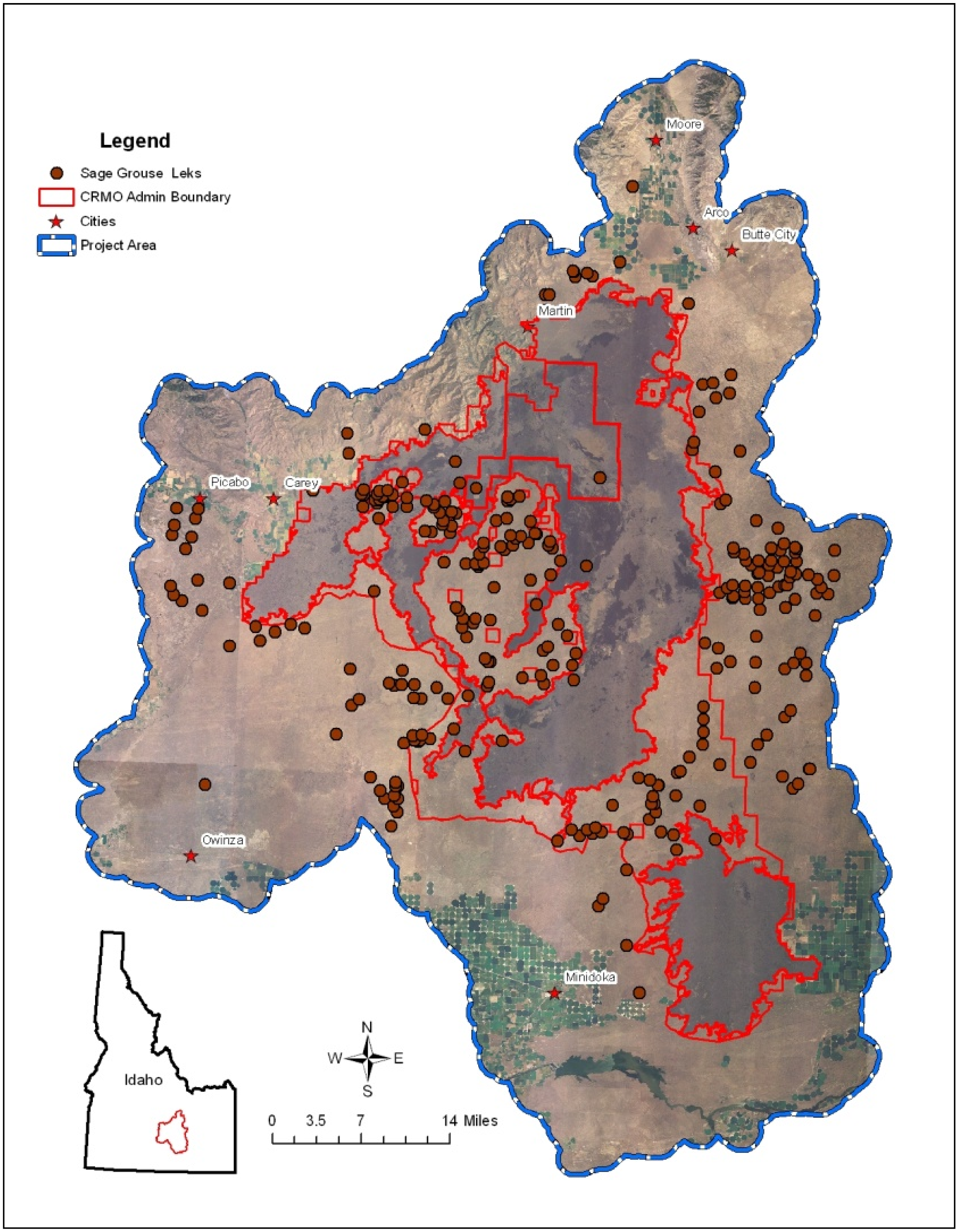


Figure 11. Location of Greater Sage-grouse Leks In and Near CRMO.

Data were recorded on standard lek observation forms designed and used by the IDFG and copies of completed surveys were sent to IDFG for inclusion in the statewide database (Munts 2011). Twenty-three leks used by Greater Sage-grouse recently to historically have been identified on NPS managed land. Fifteen of the leks (65%) have been classified as inactive by the IDFG based on at least ten years of survey with no detections. From 2004 to 2006, seven inactive, historic leks were visited during April and monitored; however, no birds were observed. The remaining eight historic leks were not accessible without extended backpacking or aircraft overflights. These 15 historic leks with over ten years of no observations were removed from routine monitoring consideration (Munts 2011). No leks with status unknown occur on NPS managed land within CRMO.

Six leks, known as the Golden Chariot Complex are located on the Sunset Flow, lie in close proximity to one another, and are surveyed annually. One lek (New Lava #3 on the Grassy Flow near the edge of Little Park) is surveyed every other year and was last surveyed in 2009 (Munts 2011). The Golden Chariot Complex leks are named the Golden Chariot, MP 237, Lower Big Lost-Circular Water Tank, Pressure Ridge, Blizzard Mountain Road, and Brodie Ranch. In 2010 the six leks were each visited four times during the period from April 2 to April 27. One previously unknown lek was discovered in 2009 on the Grassy Flow adjacent to the highway, it was surveyed four times in April 2010.

Within the Golden Chariot Complex, the Pressure Ridge and MP 237 leks had no Greater Sage-grouse breeding activity during 2010 (Munts 2011). Both leks are associated with the highway and vehicle traffic was high, likely leading to disturbance and curtailment of breeding behavior. Because both leks occur within 0.5 mile (0.8 kilometer) of either the Golden Chariot or the Brodie Ranch lek, it was assumed that Greater Sage-grouse moved to these higher quality (less disturbed) sites (Munts 2011). Each occupied lek site survey results and conclusion statements are summarized below:

(1) Brodie Ranch lek was discovered in 2006; in 2010 it had a peak count of 11 male birds. This lek had a peak of 21 male sage-grouse in 2006 and 42 male sage-grouse in 2008.
(2) Lower Big Lost-Circular Water Tank lek had a peak count of 51 male sage-grouse during 2010, a number slightly above the ten-year average of 41 male sage-grouse occurring on this lek. It is located approximately one third within CRMO and about two thirds on private land; as such, it is often subject to heavy grazing of the private lands during the last half of the normal lekking season.
(3) Golden Chariot lek supported the largest count of sage-grouse within the complex during 2010; counts ranged from 26 on April 2nd to 134 on April 8th. The male sage-grouse count on the Golden Chariot lek decreased significantly in 2010, the second decrease since its discovery (a 39% decrease occurred in 2008, a 14% increase occurred in 2009, and a 19% decrease occurred in 2010).
(4) The peak count of 112 males was recorded on four of the six leks of the Golden Chariot Complex which compares to a ten year average of 99 and record high of 202 male sage-grouse in April 2007.

The winter of 2007-8 was unusually cold and Greater Sage-grouse counts declined throughout Idaho (Munts 2011). The 2009 rebound of male sage-grouse on leks suggests that the 2008 decline may be weather related; the winter of 2008-9 was relatively mild. The spring of 2010 was unusually cool and wet which likely depressed male sage-grouse numbers (annual fluctuations are common in sage-grouse populations). Greater Sage-grouse lek routes surveyed by IDFG staff in the northern half of the Magic Valley region exhibited a 65% decline in male sage-grouse numbers from 2006 to 2008. These April counts stabilized in 2009-10, representing a 55% decline from the five-year average (Munts 2011). In contrast, the lek surveys within CRMO exhibited a 60% increase in male sage-grouse numbers during the last five years (Munts 2011). This increase likely was influenced by favorable winter conditions and survival.

The importance of CRMO to Greater Sage-grouse emerges from these breeding bird surveys. The Golden Chariot Complex supports the largest male sage-grouse count in the region and few lek routes in Idaho and no other routes in the region of CRMO have experienced a continuous increase during the current ten-year period. The number of Greater Sage-grouse and other sagebrush-obligate bird species was cited as a primary factor in CRMO meeting the criteria for designation as an Important Bird Area of global significance during 2009 (Munts 2011).

Given the significance of the Golden Chariot lek complex there is additional information that is needed to preserve the sage-grouse population. Lek counts are an excellent way to measure the population but account for only a brief period in the annual sage-grouse life cycle. Nesting, brood rearing, and wintering areas are critical for the survival of the species but none of these habitats/areas have been identified for the individuals that use the Golden Chariot Complex leks. Additional research needs to be conducted to protect and manage the Greater sage-grouse population into the future.

Threats and Stressors: IDFG staff identified five threats to the Greater Sage-grouse, they are: (1) livestock grazing, (2) wildfire, (3) invasive and noxious weed invasion, (4) Mormon crickets and grasshopper infestations, and (5) climate change. The level of impact for CRMO habitats vary due to the myriad land uses adjacent to the boundary and each threat may interact, compounding the severity. The counties encompassing CRMO are within IDFG Area 2 for upland game bird management/hunting including sage-grouse. In 2010 there was a seven-day season (September 18-24, 2010) with a one-bird daily limit and two-bird bag limit per license holder (see: Sage-grouse Seasons and Rules; http://fishandgame.idaho.gov). Hunting is not allowed within CRMO.

Livestock grazing may have positive to very negative effects on the Greater Sage-grouse habitat and populations. While grazing is not permitted within CRMO, much of the land surrounding CRMO is administered by the BLM or is privately held. These landowners and land managers support grazing livestock near the NPS administered lands. The area near the Wapi lava flow has some agricultural production adjacent to CRMO lands. In either case, a change in plant species composition is expected when livestock grazing or agricultural practices are not conducted in a sustainable manner.

Wildfire drastically alters the species diversity, structure, and soils of the sagebrush steppe habitat. Wildfires remove sagebrush cover and result in herbaceous vegetation communities, including invasive species stands, for many years. The potential for invasive plants and noxious weeds to become established following wildfire and other disturbance types is high; e.g., the annual invasive cheatgrass alters the plant community by out-competing native bunchgrasses and by increasing fire return intervals. Increase in invasive plant species cover results in increased fire frequency and reduced availability or elimination of desirable plant species supporting Greater Sage-grouse (habitat loss and plant community value decline).

Mormon crickets (*Anabrus simplex*) and grasshoppers (Order Orthoptera: Families Acrididae and Tettigoniidae) are common to abundant and may infest sagebrush steppe communities. Pesticides used for treating Mormon cricket and grasshopper infestations poses a threat to Greater Sage-grouse chicks which may consume recently killed or treated living insets. Pesticides are typically applied in late May and early June to control insect populations that have reached high densities resulting in vegetation/livestock forage damage.

Climate change poses a threat to the Greater Sage-grouse as precipitation patterns in the sagebrush steppe community change. Nesting sites are an important component for the Greater Sage-grouse population. Drought cycles decrease the available cover required for nesting and generally decrease the quality and quantity of available forage leading to further declines in the Greater Sage-grouse population.

Clark's Nutcracker

Clark's Nutcracker (*Nucifraga columbiana*) is a corvid distributed across the western U.S. and Canada to northern Mexico in an elevation range of 3,000 - 12,900 feet (914 - 3,932 meters). Additionally, Clark's Nutcracker is an altitudinal migrant which moves downslope in the fall season in advance of harsh winter conditions that occur at higher elevations, then moves upslope in the spring season in response to warming temperatures and snow melt.

In terms of forage, it is largely dependent on the cold-climate pine species limber pine (*Pinus flexilis*) and whitebark pine (*Pinus albicaulis*). The Clark's Nutcracker creates winter caches of five to 15 seeds per site which are used for forage in the late winter and early spring seasons (Brock et al. 1973). Cache sites typically occur in openings and are important for establishing seedling trees following fire. Within CRMO, limber pine is the most common pine species forming sparse to dense woodland and forest stands. Both limber and whitebark pine benefit from Clark's Nutcracker foraging behavior, because regeneration occurs from seeds that may be carried for more than 14 miles (22.5 kilometers) from the source tree (Lanner 1980).

Limited range-wide data are available on actual population density of Clark's Nutcracker and no specific management plans are currently in place (Taylor 2002). Long-term fire suppression has generally resulted in advanced forest succession that when coupled with loss of conifer stands due to disease or insect outbreaks has resulted in loss or degradation of some historic habitats. Changes to pinyon pine communities related to livestock grazing have also resulted in some decreases in habitat quality for Clark's Nutcracker (Taylor 2002).

Site Specific Information: The field crews conducting the NPS National Vegetation Inventory Program vegetation classification and mapping project from 2006 - 2008 recorded two observations of Clark's Nutcrackers (Figure 12) (Bell et al. 2009). Long term monitoring of Clark's Nutcracker within CRMO was initiated in 2010 using 11 transects located relative to limber pine distribution (Munts 2011).

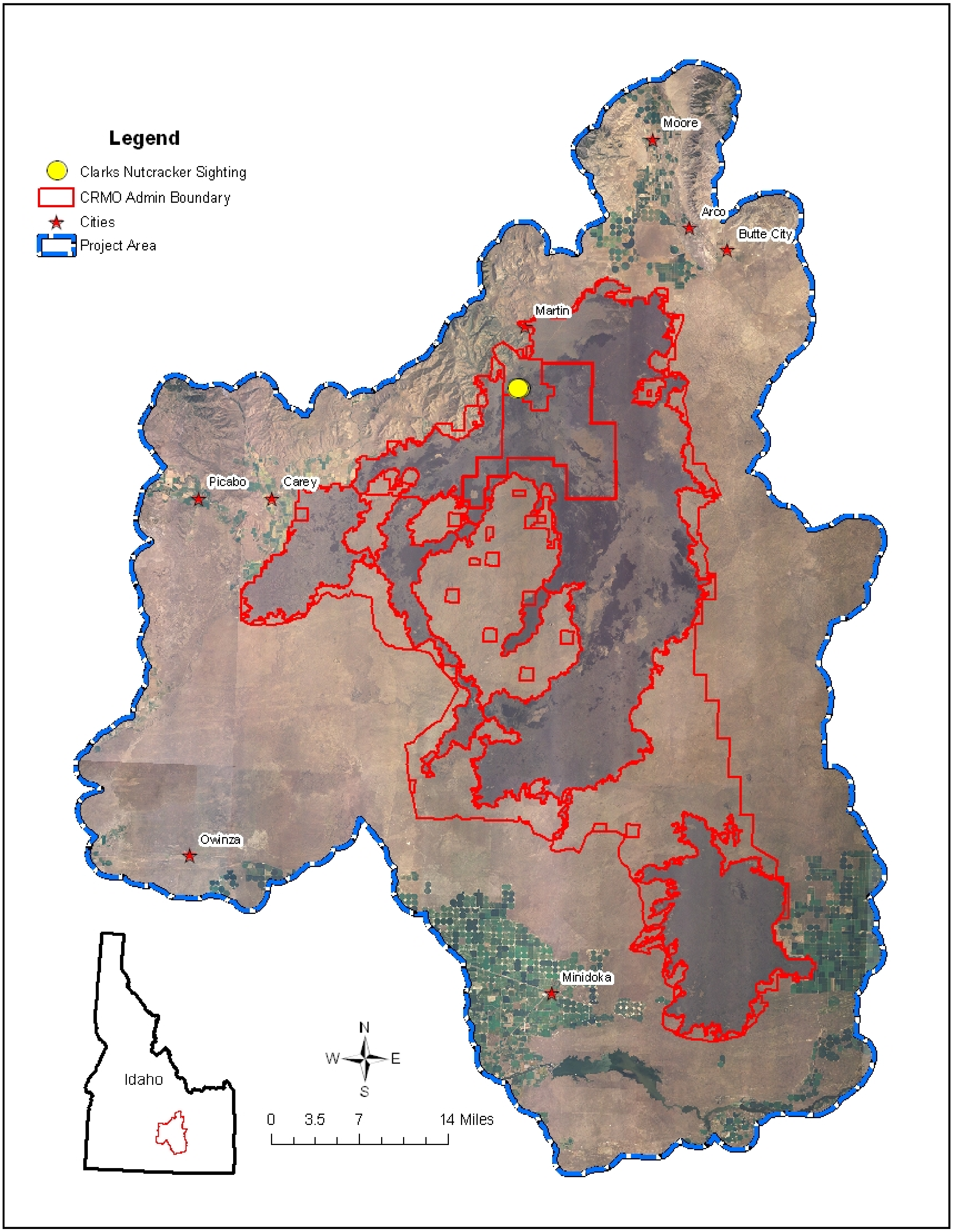
Limber pine trees are a critical component of the ecosystem of CRMO (Munts 2011). The linber pine is the only tree species established in some of the park (distributed on the Pioneer Mountains footslopes, lava flows, and alluvial fans in a range of elevations) and the woodland stands provide habitat for several plant and animal species that would not otherwise occur. Limber pine and the closely related whitebark pine are under significant stress throughout their range (McKinney et al. 2011). During 2009 and 2010 field personnel from the UCBN field-tested protocols for forest health monitoring in limber pine stands in CRMO.

Limber pine seeds are the primary food source for the Clark's Nutcracker which in turn is the primary dispersal agent for limber pine seeds (Tomback 1998). Survey methods to gather baseline information and to initiate long term data for Clark's Nutcracker status and trend within CRMO were field-tested during the fall of 2010, to coincide with peak seed gathering activity (Munts 2011).

During the fall season, Clark's Nutcracker typically occurs in family groups and is highly vocal, behaviors that enhance observation and counting (Munts 2011). To facilitate interpretation of data, transects were established using the sampling framework generated by the UCBN for limber pine stand monitoring. Random points were generated within the sampling areas selected to conduct limber pine monitoring to relate the nutcracker population to stand parameters (McKinney et. al. 2011). Twelve transects of one kilometer (0.6 mile) in length were drawn between the random points on a GIS map layer, avoiding overlapping or adjacent transects (within 500 meters) (1,640 feet) because nutcrackers can be easily seen at distances of 500 meters in open woodland stands (Munts 2011).

Eleven Clark's Nutcracker counts were completed during the August to October, 2010 time period. Parameters recorded included: (1) date, (2) start and end times, (3) temperature, (4) windspeed, (5) cloud cover, (6) precipitation and (7) limber pine cone status, including cones open or closed and whether cones were hardened or less mature (still green). Each woodland stand may have cones in several stages of maturation, therefore several trees were examined along each transect to record the dominant state of the mature (second-year) cones.

Clark's Nutcracker counts within CRMO ranged from two to 35 individuals and averaged 12.7 nutcrackers per kilometer. The two highest counts occurred on September 10, 2010. All counts conducted after September 15 recorded fewer than five individuals. A close examination of limber pine cones sampled on October 1, 2010 determined that most cones contained few seeds (the stand examined was the lowest elevation site and it is likely additional nutcrackers may have foraged here earlier in the season). Munts (2011) recommended surveys be completed earlier in the fall in future years, completion by the third week of September was recommended for 2011.



(Source: Bell et al. 2009).

Figure 12. Clark's Nutcracker sightings by Vegetation Mapping Crew.

Threats and Stressors: The threats to Clark's Nutcracker are associated in large part to potential threats to the whitebark and limber pine woodland and forest habitat. Clark's Nutcracker is the primary disperser of whitebark pine seeds and whitebark pine is in decline throughout its range. Habitat threats agents include white pine blister rust (*Cronartium ribicola*) and mountain pine beetle (*Dendroctonus ponderosae*) infestations which threaten the critical habitat for Clark's Nutcracker. Additionally, climate change contributes to the size and severity of the disease/insect outbreaks in the western U.S. (Kurz et al. 2008).

Sagebrush-obligate Birds (Five Species)

The sagebrush steppe ecosystem provides important food sources and cover for many species of wildlife including the pronghorn, pygmy rabbit, and Greater Sage-grouse previously discussed; during the winter season these species forage nearly exclusively on the foliage of sagebrush. Sagebrush-obligate birds listed within CRMO include the Sage Sparrow, Black-throated Sparrow, Brewer's Sparrow, Sage Thrasher, and Greater Sage-grouse. Of these the Brewer's Sparrow is the most abundant bird species in terms of individuals present within CRMO occurring as a migrant during the breeding season (Munts 2011). The Greater Sage-grouse occurs in moderate numbers and is present year-round while the sage thrasher is a breeding season migrant that occurs in low numbers (Munts 2011). The Sage Sparrow and Black-throated Sparrow are migrants that rarely occur and have not been observed within CRMO for the past five and four years, respectively (Munts 2008 and 2006). Sagebrush-obligate birds rely nearly entirely on the unique habitat within the sagebrush-steppe of CRMO for escape cover, nesting, and brood rearing. The Brewer's Sparrow densities are highest in areas where the sagebrush steppe habitat has received little or no livestock grazing (Rich et al. 2005).

Greater Sage-grouse are the most commonly studied member of the sagebrush-obligate bird species and are on the decline in terms of population, several other bird species have also undergone population decline as a result of habitat loss and alteration. It is estimated that 30% of the historical sagebrush steppe has been lost to conversion for agricultural uses, invasive species, and/or livestock overgrazing within the Columbia Basin. As a result, eight species of concern dependant on this ecosystem are declining including the five species of CRMO discussed herein (Rich et al. 2005).

Several studies of sagebrush-obligate birds have occurred outside of CRMO performed by the USFS and BLM. Nearly annual breeding bird surveys have been conducted on the Idaho National Laboratory (INL) since 1985 to monitor changes in bird populations (Vilord 2007). INL surveys were conducted in 2009 during May and June; a total of 5,072 individuals representing 55 species of birds were recorded along 13 permanent routes. Sagebrush-obligate bird species numbers during 2009 on the INL were slightly higher than the long term average (1985-2009), the trend in population abundance remained stable (Shurtliff and Whiting 2010). Since 1985, sagebrush-obligate birds occurred most often on the Big Lost River route, but since the 2000 Tin Cup fire their numbers have dramatically declined. Brewer's Sparrow was the most abundant sagebrush-obligate species observed. Twenty-eight percent of the total numbers of birds observed during the 2009 Breeding Bird Survey are sagebrush-obligate.

Birds counted on INL during the 2009 Breeding Bird Survey continue to remain well above the annual mean. Species closely associated with shrub-steppe/grassland habitats were detected in the greatest numbers (Shurtliff and Whiting 2010). Horned Larks continued to be the most common species detected, boosting the overall total of birds observed in 2009. Western Meadowlark, Brewer's Sparrow, Sage Thrasher, and Sage Sparrow continued to be the five most abundant species observed. Data analysis showed a significant difference in the total number of birds detected from 1985 to 2009 over the entire INL.

The sagebrush-obligate assemblage of INL had the second highest species abundance with 1,626 individuals (32.1% of total; (Shurtliff and Whiting 2010). This assemblage includes Brewer's Sparrow, Sage Sparrow, Sage Thrasher, and Greater Sage-grouse. The Sage Thrasher was the most abundant sagebrush-obligate within INL with 516 individuals. These data indicate that populations of sagebrush-obligates are thriving on the INL site. In many other western states, sagebrush obligates are facing significant habitat loss, and consequently sagebrush-obligate species are experiencing population declines (Knick et al. 2003; Sauer and Link 2008). The population trends across the INL site show a consistently high abundance of sagebrush-obligates (Vilord 2007), which is likely because the INL site is comprised of a large area of relatively undisturbed sagebrush-steppe habitat compared with other areas in the Intermountain West.

Site Specific Information: The breeding bird surveys indicate that CRMO provides habitat for many sensitive species, several of which are either sagebrush-obligate or sagebrush-dependent species (Munts 2011). Included as sagebrush-obligate is the most numerous species within CRMO, the Brewer's Sparrow, which is on the BLM, IDFG, USFWS, and Partners in Flight (PIF) sensitive lists (Table 7). Most sagebrush-adapted bird species have experienced substantial declines in either part or all of their range including the Snake River Plain. Within CRMO, counts of the Brewer's Sparrow peaked in 2006 with annual fluctuations less than ten percent of that peak. Short term fluctuations this small are likely a result of weather or other minor effects and are unlikely to indicate a change in density (Munts 2011). The continued increases in numbers since 2004 coincide with a return to average or higher precipitation in the April-to-June period which likely resulted in improved forage and cover. Patterns are also observable in some other sagebrush-associated bird species.

Table 7. Selected Sagebrush Obligate Bird Species Totals Observed During the Past Six Annual Breeding Bird Monitoring Surveys on CRMO.

Bird Species	2005	2006	2007	2008	2009	2010	Notes
Brewer's Sparrow	492	570	549	493	556	504	Most abundant species recorded each year. Status: BLM Sensitive, FWS Conservation Concern, Idaho Greatest Conservation Concern, Partners in Flight Priority.
Sage Sparrow	1	0	0	0	0	0	Rare, recorded only in 2005. Status: BLM Sensitive, FWS Conservation Concern, Partners in Flight Priority.
Black-throated Sparrow	0	2	0	0	0	0	Rare, recorded only in 2006. Status: BLM Sensitive, FWS Conservation Concern, Partners in Flight Priority.
Sage Thrasher	67	49	47	44	33	48	Commonly recorded in low numbers each year. Status: BLM Watch, FWS Conservation Concern, Partners in Flight Priority.
Greater Sage-grouse	7 (148)	1 (157)	0 (202)	4 (122)	3 (139)	0 (112)	Strutting males recorded during focused surveys conducted in April appear as the number in parentheses. Status: BLM Sensitive, FWS Conservation Concern, Idaho Greatest Conservation Concern, Partners in Flight Priority.

Source: Munts 2011-2005

Sage Thrashers, a sagebrush-obligate, show a different pattern to the Brewer's Sparrow annual count with a significant dip in 2004 (38 individuals) and numbers decreasing since 2005, followed by an increase in 2010. Sage Thrashers are insectivorous and are more likely to respond to short term conditions than are sparrows which will forage on seeds as well as insects (Munts 2011). Other sagebrush-obligate species such as the Loggerhead Shrike, like the Brewer's Sparrow, appears to have been quite stable in terms of count within CRMO. Shrikes occur in much lower numbers, however, and to determine accurate trends for this species would require additional effort through targeted surveys and collection of productivity data (Munts 2011). The Green-tailed Towhee and Vesper Sparrow are sagebrush-dependent but not obligate, and show a gradual increasing trend within CRMO over the last ten years (Munts 2011).

Threats and Stressors: Habitat fragmentation is a primary area of interest for researchers investigating sagebrush-obligate bird species. Habitat fragmentation due to conversion or the introduction and spread of invasive species, results in the loss of critical habitat. Because the relationship between the obligate birds and the sagebrush-steppe habitat are directly related, any loss of habitat will result in a downward trend in the species population on a local and possibly regional scale (USGS 2002).

Overgrazing by domestic livestock, particularly cattle, contributes to the loss or alteration of the sagebrush-steppe ecosystem. While the cause and effect of the impact on sagebrush-obligate birds is not fully understood, the research suggests adverse affects primarily due to changes in plant species composition and vegetation structure and cover (Rich et al. 2005).

Wildfire is a threat to sagebrush-obligate species because of the habitat and possibly nests, eggs, and young (depending on burn timing) lost during a wildfire in the short term and the vegetation may be significantly altered for decades. Sagebrush communities recover slowly due to lack of stump sprouting following fire and in some cases burned stands are replaced entirely by invasive species including cheatgrass which can out-compete much of the native vegetation including shrub seedlings.

On the nearby INL, Vilord (2007) reported factors that stressed sagebrush-obligate bird populations ranged from natural events, such as drought, wildfires, and normal population fluctuations, to non-natural events including the removal of resources through development or chemical application, and observer bias and experience. Factors that influenced species richness ranged from a change in habitat (creation or destruction) to the dispersion of individuals from nearby habitats looking for new nesting sites (Vilord 2007).

Vegetation

CRMO's vegetation has been inventoried and classified at the landscape, plant community, and individual species levels in the recent past. At the landscape level, CRMO is located in the Snake River Basin/High Desert (Omernik, 1986) and encompasses a small portion of the Idaho Batholith/Foothill Shrublands-Grassland ecoregion and a large portion of the Snake River Plain/Lava Fields ecoregion (McGrath et al., 2002). Extant vegetation and associated wildlife habitat is broadly characterized as belonging to montane, foothill, steppe, or plain formations and includes mostly dry and some mesic forest, woodland, shrubland, herbaceous vegetation, and sparse vegetation within volcanic, foothill, and plateau settings. The distribution of the general vegetation and habitat types is driven in large part by elevation, aspect, substrate, and disturbance history.

At the local plant community level, most of the lava exposed within CRMO appears to be unvegetated but various studies including the Gap Analysis of Idaho Land Cover mapping from 1996, shows approximately 33% to be vegetated lava compared to 20% non-vegetated lava flows. Other studies including Day and Wright (1985) have further described and mapped the vegetation types of the Monument portion of CRMO and Rust and Wolken (2008) and Bell et al. (2009) classified and mapped vegetation and land use types within CRMO and on adjacent land. The results of these studies show that CRMO's flora is diverse and supports more than 700 certified vascular plant species; estimates of the extant plant communities range from 26, Monument only (Day and Wright 1985; Whipple 1992; Jurs and Sands 2004), 35, Monument only (NPS, unpubl. data), and 93, entire CRMO and environs (Rust and Wolken 2008; Bell et al. 2009).

Based on the CRMO vegetation/habitat inventory studies, the native vegetation occurs in the following pattern based on location and substrate (e.g., Location/Substrate/Dominant Species): (1) North Environs - Pioneer Mountain Foothills/Paleozoic Sedimentary Rocks/Douglas-fir, limber pine, quaking aspen, low sagebrush, mountain big sagebrush, bluebunch wheatgrass, needle-and-thread, (2) North CRMO - Craters of the Moon Lava Field/Basaltic Lava with Soil Deposits (Silt, Eolian Sands)/limber pine, mountain big sagebrush, antelope bitterbrush, Idaho fescue, (3) North CRMO - Craters of the Moon Lava Field/Basaltic Lava (Pahoehoe and Aa Lava)/antelope bitterbrush, fern bush, ocean spray, mock orange, dwarf goldenbush, mountain big sagebrush, Sandberg bluegrass, (4) North and Central CRMO - Craters of the Moon Lava Field/Cinders/Cushion Buckwheat, Silverleaf Phacelia, Douglas Dustymaiden, Bitterroot, (5) Central Environs and CRMO Kipukas/Various Substrates/Wyoming big sagebrush, threetip sagebrush, basin big sagebrush, rabbitbrush, western wheatgrass, Idaho fescue, cheatgrass, crested wheatgrass, (6) South CRMO - Wapi and Kings Bowl Lava Fields/Basaltic Lava (Pahoehoe and Aa Lava)/Rocky Mountain juniper, Utah juniper, antelope bitterbrush, Wyoming big sagebrush, dwarf goldenbush, Sandberg bluegrass, (7) South Environs/Various Substrates/Wyoming big sagebrush, rabbitbrush, cheatgrass, crested wheatgrass and (8) CRMO – Riparian/Various Substrates/black cottonwood, chokecherry, speckled alder, Baltic rush, cheatgrass.

The most recent and detailed study of the vegetation and wildlife habitat occurred between 2006 and 2009 and resulted in 12 forest and woodland, 57 short and tall shrubland, 18 herbaceous, six sparsely vegetated, three geologic, and 13 other land use types (Bell et al. 2009). More specifically, this vegetation inventory determined that there are 93 plant associations within 47 vegetation alliances that were accurately mapped into 38 vegetation map/habitat units, three unvegetated geologic exposures, and 13 land use/land cover types that include open water, roads and trails, and CRMO facilities, among other land use/habitat types.

At the species level there are two special status plant species within CRMO, the Obscure Phacelia (*Phacelia inconspicua*) and the Picabo Milkvetch (*Astragalus onicifomis*). Obscure Phacelia is rare a Idaho species with six area occurrences statewide; it occurs on the north- and east-facing slopes of volcanic mountains and buttes (Slaton and Novey 2007). Picabo Milkvetch occurs on sandy soils in the north-central portion of the Eastern Snake River Plain (NPS-CRMO 2005). Areas of likely habitat within and surrounding CRMO have been systematically surveyed for both obscure phacelia and picabo milkvetch (NPS-CRMO 2005).

Vegetation Condition and Health

Kaltenecker et al. (2006), assessed sagebrush-steppe habitat for sagebrush-dependent bird species within CRMO to supplement a basinwide effort to assess distribution and habitat associations for at-risk bird species. It is estimated that shrub-steppe habitat has been reduced by greater than one-third in the Interior Columbia River Basin and that less than 1% of remaining shrub-steppe habitat exists in its original condition (West 2000). Remaining shrub-steppe habitat exists in a patchwork of habitat islands which are often highly separated and this fragmentation has serious implications for wildlife species (Sands et al. 2000, Knick and Rotenberry 2002). A significant number of shrub-steppe species are declining rangewide. A recent analysis and summary of issues within the shrub-steppe region examined breeding bird survey results for 25 upland bird species that depend on or are found in shrub-steppe ecosystems. Reports from this analysis showed that 10 of these species have exhibited long-term (1968-2001) population declines and 13 species have shown short-term (1984-2001) declines (Dobkin and Sauder 2004). Of these 25 species, 11 were commonly detected within CRMO during 2006, and of those, eight currently have federal or state special conservation status (Kaltenecker et al. 2006).

The shrub-steppe habitat assessment within CRMO was designed to use standardized protocols, beginning in 2002 and was conducted by the Boise State University, Idaho Bird Observatory (Kaltenecker et al. 2006). CRMO represented a site within a larger statewide effort which surveyed shrub-steppe bird species and habitat at 50 sites across southwestern and south-central Idaho during 2002 and 2003. In 2004, an effort to survey shrub-steppe bird species and habitat within CRMO was undertaken and followed similar design as the two previous years of study. The study objectives of Kaltenecker et al. (2006) were to: (1) survey a representative sample of shrub-steppe habitats for obligate bird species within CRMO, (2) obtain quantitative estimates of habitat attributes at the sample locations, (3) identify habitats with the highest numbers of special-status shrub-steppe bird species, (4) describe the habitats needed to provide viable populations of these species and (5) assess the relative value of fragmented islands of shrub-steppe habitat (kipukas, vegetated lava) as habitat for shrub-steppe bird species.

The UCBN identified 14 priority vital signs that are indicators of ecosystem health and which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales (Garrett et al. 2007). Yeo et al. (2009) addressed one UCBN vital sign, e.g., monitoring the sagebrush-steppe habitat with the intent to develop a balanced and integrated vital sign that meets the needs of current park management and that will also accommodate unanticipated environmental conditions and future management questions. Sagebrush-steppe is a high priority vital sign for CRMO and four additional UCBN parks. Sagebrush-steppe occupies over 90% of vegetation land cover in CRMO (Yeo et al. 2009) and historic and current land use practices both within and adjacent to CRMO continue to fragment and alter the steppe ecosystem. Long-term climate change will likely exacerbate these changes.

The sagebrush-steppe protocol and standard operating procedures details tasks required to collect, manage, and disseminate ecological condition data representing the status and trend. The intent of the protocol is to ensure that a scientifically credible report about the ecological condition of sagebrush-steppe communities and response to management actions, changing precipitation patterns, and other stressors can be presented. Within this protocol, CRMO has the goal to maintain and restore native ecosystems and ecological processes (i.e., ecosystem integrity/health) while being affected by biological invasions, fire, past and current grazing on parklands or surrounding lands, and climatic trends and fluctuations. Plant invasion, altered community composition, and altered species abundances are the principal concerns for UCBN park managers (Garrett et al. 2007).

Pilot data collected within CRMO during 2008 and 2009 have answered preliminary questions about current sagebrush-steppe condition and resolved outstanding logistical and methodological questions for the monitoring program. From this task, the focus has shifted toward status and trend analysis, in which baseline conditions of sagebrush-steppe ecological condition will be described, and biologically meaningful declines or increases in indicators of sagebrush-steppe ecological condition will be detected over longer time intervals. These long-term data will contribute to the development of informative models of relationships between sagebrush-steppe community conditions and key environmental factors and management actions.

Monitoring objectives respond to CRMO management concerns and focus to maintain and restore ecosystem health of sagebrush-steppe communities. The objectives focus on the status and trends of key indicators of biotic integrity, soil stability, and hydrologic function. The protocol addresses monitoring objectives, as follows: (1) determine the status (current condition) and trends (change in condition over time) in the composition and abundance (cover) of principal native plant species in CRMO sagebrush-steppe communities, (2) determine the status and trends in composition and abundance (cover) of principal invasive plant species, including annual grasses, in UCBN sagebrush-steppe communities and (3) determine the status and trend in the amount of exposed soil (cover), a fundamental indicator of soil stability (Yeo et al. 2009).

CRMO is a large park with limited access and lengthy travel times making subdivision into discrete sample frames a necessary and more efficient monitoring approach. Of particular importance is the elevation gradient that occurs in a north-south pattern, and the arrangement of independent sample frames is along this gradient. Accessible regions in CRMO were defined as all sample locations ≤ 1 km from a reliable vehicle access point. Special areas of interest beyond the 1 km buffer have also been included as sampling frames.

CRMO managers noted that weed invasion threatens from the southwest and along the Highway 20 corridor through the northern portion. Sample frames were positioned to monitor these areas using the vegetation map produced by Bell et al. (2009) to delineate existing and potential target vegetation types. The approach for CRMO entails monitoring a combination of sagebrush-steppe communities around the perimeter (vegetated lava), and areas of special management interest identified by resource managers. The perimeter boundary is the interface between BLM-managed lands with greater likelihood of disturbance from livestock grazing, public access, wildfire, and noxious weeds, and the more protected, less accessible interior portions of CRMO. The special interest areas include three research natural areas, a proposed National Natural Landmark area, and areas of recent wildfires. Three sample frames occur within designated wilderness. A total of thirty-four 12 ha sampling frames and one 17.5 ha sampling frame are arrayed across CRMO for the sagebrush-steppe monitoring program.

Invasive Plants

Noxious and exotic non-native species have recently been discussed in the CRMO Fire Management Plan (2008) and the National Vegetation Inventory Program Report (Bell et al. 2009). Non-native exotic plant species are widespread contributors to the vegetation diversity within CRMO. Human activities including livestock grazing, infrastructure development, visitation of CRMO, and wildfires have contributed to the establishment and spread of several non-native plant species. Recently fire has become a stand-altering effect by burning over 300,000 acres of habitat within CRMO between 1970 and 2005 (mostly on BLM-managed lands). Vectors for introduction include the U.S. Highway 93/20/26 corridor and the numerous 2-track and other roads surrounding CRMO. As of 2006, 91 of the 701 plant taxa (13%) known to occur or likely to occur within CRMO are non-native (NPSpecies Database 2011).

Among the most invasive are 10 confirmed plant species designated by the state of Idaho as noxious weeds. These include spotted knapweed (*Centaurea maculosa*), diffuse knapweed (*Centaurea diffusa*), Russian knapweed (*Acroptilon repens*), rush skeletonweed (*Chondrilla juncea*), leafy spurge (*Euphorbia esula*), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), Scotch thistle (*Onopordum acanthium*), dalmatian toadflax (*Linaria dalmatica*), field bindweed (*Convolvulus arvensis*), and Dyer's woad (*Isatis tinctoria*) (Slaton and Novey 2007). Other invasive/exotic plants, such as cheatgrass and crested wheatgrass are extremely widespread especially in the sagebrush-steppe habitats. Cheatgrass is a common, widespread, and competitive invader throughout the West and was likely introduced in the early 1900s when domestic sheep grazed the area (Slaton and Novey 2007). Cheatgrass can also be an herbaceous component of undisturbed or otherwise healthy sagebrush-steppe (NPS-CRMO 2005). Crested wheatgrass is also common on and near CRMO where it was likely introduced through seeding to control erosion and support livestock grazing.

Water Resources

Surface water is limited within CRMO and two perennial streams, Leach and Little Cottonwood creeks, flow within CRMO (NPS-GRD 2000). Both streams are located near the northern CRMO boundary and carry runoff from the Pioneer Mountains and groundwater seeps and springs. Additional surface water resources within CRMO consist of scattered vernal pools (occur during years of increased precipitation where depressions and low areas collect water) and year-round ice deposits located in some lava tube caves and pit craters. Groundwater aquifers represent a very important aspect of the water resources for the arid area around CRMO as this source generally provides the only available water during the late summer and fall seasons. Within CRMO, determination of groundwater quality, quantity, and aquifer depth is important because it may prove to be a better water source to support park operations than the existing surface water system (NPS-GRD 2000). A new test well was drilled in November 2000 and is now used to provide the majority of water for the visitor center complex (IDWR 2011).

Condition

Until 2004, park operations were the only non-natural factor influencing the flow rates of Little Cottonwood Creek due to diversion to acquire drinking water at a rate averaging approximately 20 gallons (75.7 liters) per minute. Following 2004, CRMO transitioned its water system to using groundwater wells which minimized the impacts to the limited surface water resource. Seeps and springs emerge in the foothills of the Pioneer Mountains within the park boundary and provide flow to Little Cottonwood Creek and Leach Creek; the NPS has acquired the land comprising these watersheds in order to more effectively manage the hydrologic resource for future generations (NPS-GRD 2000). Surface water is an important resource within CRMO due to the scarcity of water in this semi-arid environment, support of aquatic wildlife, and to support stands of riparian and wetland trees and shrubs which provide unique wildlife habitat. The average total precipitation for the months of June, July, and August is low at 3.1 inches (7.9 centimeters) thus surface water quality is strongly affected by runoff during storms and the groundwater discharge of high-quality water with little to no sediment.

Vernal pools and wetlands are limited in distribution and small at each site of occurrence within CRMO making these rare and unique water features critical to protect. Typically they occur in the foothills of the Pioneer Mountains near the northern boundary of CRMO and are closed to visitors to minimize degradation and anthropogenic impacts (NPS-GRD 2000). The recently reclaimed Martin Mine was the only known source of water contamination within CRMO (NPS-GRD 2000). Surface water resources evaluated for baseline water quality data included Little Cottonwood Creek, Leech Creek, and other perennial or intermittent creeks; Bearsden and Little Prairie waterholes; Little Cottonwood Spring; and Moonshine and Boy Scout ice caves (Falter and Freitag 1996, NPS 1998). The data inventories and analyses determined that the surface water within CRMO appears to be of good quality with minimal impacts from historic mining and other anthropogenic activities to date.

Inventory

The inventory of surface and groundwater resources within CRMO primarily consists of the NPS (1998) and Falter and Freitag (1996) papers evaluating baseline water quality conditions. Additional water resource information is presented in the Water Resources feature GIS dataset within the CRMO geodatabase (includes data from local, state, and federal agencies). This geodatabase includes feature classes pertaining to natural and developed waters and points of diversion, use, and monitoring stations (Table 8). Figure 13 displays water resource information available within the geodatabase for the CRMO area that has aided park managers in inventorying critical areas for further research. It is interesting to note that the lava flow boundaries correspond to both the administrative boundary and a moderate to high (orange color) vulnerable state of water resources. Overlap of these two boundaries is likely due to the geology of the lava flows and the boundary of CRMO being directly linked to the edge of the lava fields.

Table 8. Water Resources feature classes for CRMO.

Themes	Geodatabase File Name	GIS Acres	Number Parts	Length Ft
All Water Gage Stations	allgageusgs		44	
2002 305b Lakes	CRMO_lake305b2002_id_ideq	8,646.0	4	
Open Water	CRMO_Open_Water	10,891.0	51	
CRMO Streams	CRMO_Streams		858	6,013,776.0
USGS Water Gage Stations	gageusgs		3	
Geothermal locations	geothermal		22	
Ground water quality monitoring station	ground_water_quality_monitoring		49	
Public Water Supply Locations	Pub_water_supply		19	
Range Improvement water development	Range_Imp_Proj_water_developments_sgca		6	
Springs	spring_clip		53	
Vulnerable Water Areas**	vulnerability		530	
Water Rights Point of diversion	Water_Rights_Point_of_diversion		7743	
Water Rights Point of use	Water_Rights_Point_of_use		5826	
Well Locations	wells		1740	
Wetlands	wetlands	15,788.0	5	

** Groundwater vulnerability highlights areas sensitive to ground water contamination in a generalized way. The map (data) should be used for regional interpretive purposes only, and should not be used for making site-specific decisions. This data does not show areas what will be contaminated, or areas that cannot be contaminated. It also does not show if a particular area has already been contaminated. Whether the areas will have ground water contamination depends upon the likelihood, type, frequency, and volume of contaminant release. This map data only considers the ability of water to move from the land surface to the water table and does not consider the individual characteristics of the specific contaminants. (IDWR 2011 metadata)

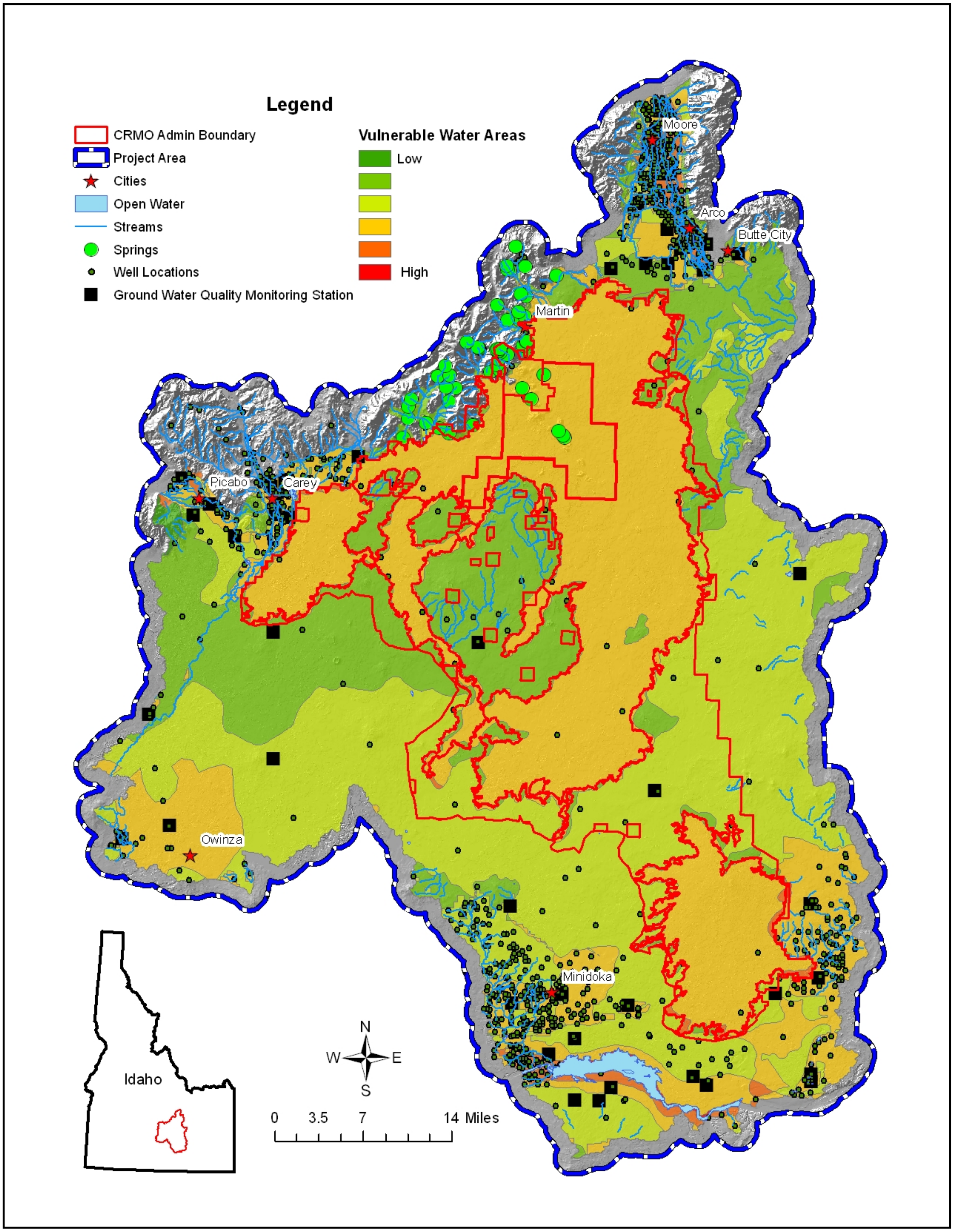


Figure 13. Water Resources feature classes within CRMO.

The baseline water quality sampling report by NPS (1998) stated many of the monitoring stations within CRMO represent either one-time or intensive single-year sampling efforts, however five stations within the boundary yielded longer-term records. These stations were: (1) Upper Little Cottonwood Creek, (2) Lower Leech Creek, (3) Middle Little Cottonwood Creek, (4) Lower Little Cottonwood Creek and (5) Upper Leech Creek. Screening for water quality was based on EPA water-quality criteria and concentration values published by the Water Resource Division of NPS (WRD) (NPS 1998). Baseline water quality testing determined that four parameters were in excess of testing criteria, at least once within the study area. These constituents were pH, copper, and zinc (for the respective EPA criteria of freshwater aquatic life) and fecal coliform (for the WRD screening limits for freshwater bathing; NPS 1998). As of the date of this assessment, no additional water quality sampling has been completed within CRMO at these locations therefore no comparison of water quality can be made to assess the success of mine reclamation and human exclusion from critical areas.

Additional water resource sampling completed within CRMO included testing water quality in caves containing ice and water of sufficient quantities (Falter and Freitag 1996). Four caves provided conditions that met the desired water quality sampling criteria, they were: (1) Bear's Den Cave, (2) Little Prairie Waterhole, (3) Moonshine Cave and (4) Boy Scout Cave. All four caves contained ice during one or both of the sampling seasons of 1992 or 1993. The water temperature, dissolved oxygen, electrical conductivity, pH, CO_2, turbidity, and three nutrients were measured at each cave (Falter and Freitag 1996). The sampling results were focused on the influence of surface water inflow on cave water quality and the presence of water and ice rather than discussion of groundwater infiltration inputs. All four caves were within acceptable levels of water quality; the Boy Scout Cave had notably higher levels of turbidity and nutrients specifically ammonia (Falter and Freitag 1996). The elevated levels of turbidity and ammonia resulted from in-cave visitor traffic and deposition of human wastes as Boy Scout Cave is part of an established park-guided tour.

Monitoring

Streamflow directly reflects climatic variation because changes in stream morphology and streamflow are indicators of changes in basin dynamics and land use. Natural variations in streamflow predominate, but can be strongly modified by human actions. Water quality parameters sampled during the 2010 inventory include the core parameters for CRMO and the Idaho Department of Environmental Quality (IDEQ) regulatory thresholds for surface water criteria of cold water aquatic life. Results from the 2010 inventory report combined with the NPS (1998) and Falter and Freitag (1996) publications should be considered baseline water quality data for Little Cottonwood Creek (due to the limited and inconsistent sampling of water resources within CRMO (Starkey 2011). Table 9 includes the results from Starkey (2011) representing the five core water quality parameters sampled by the UCBN during the 2010 field season.

Threats and Stressors

Potential threats to the water resources of CRMO include groundwater contamination from abandoned or reclaimed mine sites and the introduction of excess nutrients into surface water which can infiltrate shallow groundwater reserves. The threat of contamination of surface waters from concentrated visitor use was evaluated and visitation negatively impacted the water quality of Boy Scout Cave, a unique feature. The surface waters of CRMO represent important resources to manage in this semi-arid environment because of potential changes in climate including regional variations in weather patterns and temperature thereby decreasing the amount of precipitation available for groundwater recharge and temporary surface water ponding (e.g., vernal pools and wetlands).

Data Gaps

The need for a park-wide assessment of vernal pools, seeps and springs, wetlands, and riparian areas within CRMO has been identified from an analysis of the available literature. There have not been focused studies identifying the location, providing a description, and determining the quality of these mesic resources or of their importance to CRMO plant communities, wildlife and habitat, or surface and groundwater quality.

Table 9. Vital sign summary table for water chemistry in Little Cottonwood Creek, 22-23 June 2010

Measure	Current Condition (June 22-23, 2010)	NPS Baseline Data 1998 *(Site CRMO0021 Upper Little Cottonwood)*	State DEQ Thresholds***
Temperature	MDMT* = 10.45 °C MDAT** = 10.45 °C	mean = 9.13 °C max. = 15.0 °C	MDMT < 22 °C, MDAT < 19 °C
Specific conductance	mean = 223.97 µS/cm	mean = 160.86 µS/cm max. 228 µS/cm	Not designated
Dissolved oxygen	daily min = 8.8 mg/L	mean = 7.92 mg/L min = 5.4 mg/L	> 6.0 mg/L
pH	daily max = 8.8 pH Units	max. = 8.0 pH Units	< 9.0 pH Units
pH	daily min = 8.56 pH Units	min = 6.2 pH Units	> 6.5 pH Units
Turbidity	daily max < 0.2 NTU	max. 3.4 NTU	< 50 NTU (instantaneous), < 25 NTU for 10 consecutive days

*MDMT – Maximum Daily Maximum Temperature, **MDAT – Maximum Daily Average Temperature
***Note that Little Cottonwood Creek is considered "undesignated surface water" meaning that it has not been assigned a beneficial use. In Idaho undesignated streams are assumed to support cold water aquatic life and primary or secondary contact recreation. As a result, the state thresholds listed above are the criteria for cold water aquatic life.

Source: Starkey 2011

Site Specific Information

CRMO currently pumps drinking water from two shallow wells located near the headwaters of Little Cottonwood Creek. The drinking water quality should be monitored to protect the health and safety of park staff and visitors. Monitoring drinking water quality will also provide insight into the degree of treatment and maintenance for the water supply infrastructure and treatment systems needed to comply with human consumption standards.

Contaminants such as road salt, lubricants, rust, and brake lining materials resulting from normal park visitation and highway travel near CRMO may contribute to groundwater pollution along the highway corridor (NPS-GRD 2000). It is not known if there were any disposals or leaks of toxic materials associated with the Craters of the Moon Inn, cabins, and gas station (removed in the 1950s) or from past waste disposal practices.

Additional water quality monitoring and testing of the cave water resources should be conducted due to the low level of knowledge regarding visitation impacts to these unique environments and habitats (NPS-GRD 2000). Currently, it is unknown what role human waste plays as a surface or groundwater contaminant in remote areas of CRMO; it has been reported that some of the high visitation lava tubes smell of urine during the summer season (Falter and Freitag 1996). Where irrigated agricultural fields or livestock corrals occur adjacent to the CRMO boundary, groundwater should be monitored via wells designed for this purpose to determine if contaminants such as fertilizers, pesticides, nitrates, etc. are present in elevated levels in the shallow groundwater table.

Geology and Soils

CRMO is located on the extensive Snake River Plain (SRP) and contains some of the youngest and most diverse basalt lava terrain (Owen 2008). The plain includes almost all of the Great Rift, the best-developed example of a volcanic rift zone (an elongate system of crustal fractures associated with an area that has undergone extension – where the ground has spread apart). The igneous rocks exposed in the foothills of the Pioneer Mountains are Eocene in age (55-38 million years ago) while the sedimentary rocks are Mississippian in age (360-330 million years ago). The rocks associated with the Great Rift were deposited predominantly during the Pleistocene (2 million years ago to 10,000 years ago) and Holocene (10,000 years ago to present) times (Figure 14). Some Archean (>3 billion years old) rocks have been raised to the surface by the basalt flows as xenoliths (inclusions in igneous rock during magma emplacement and eruption). Although there are some basalt flows exposed that approach 425,000 years old, most of the lava flows within CRMO are less than 10,000 years old.

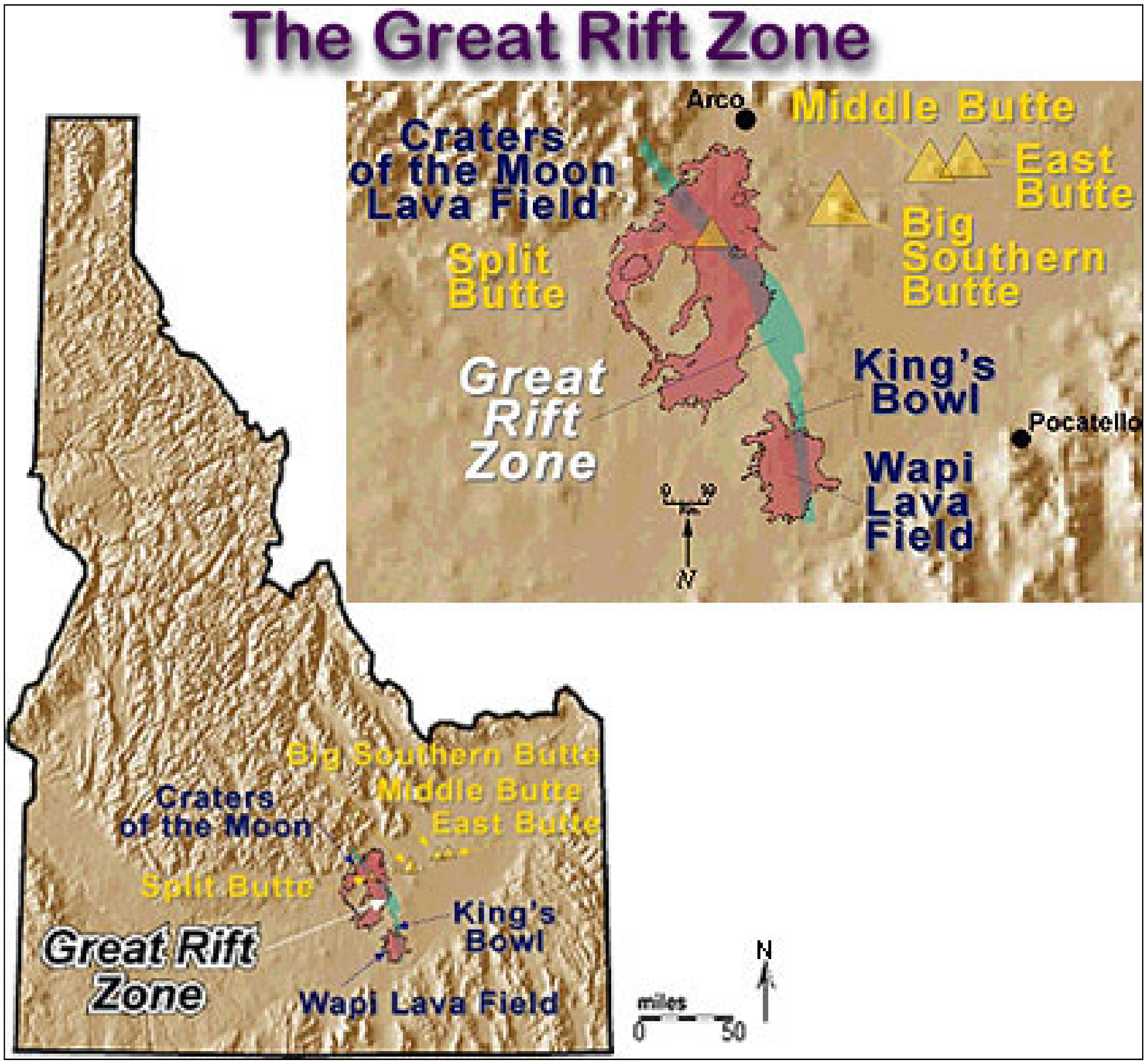


Figure 14. Great Rift Zone near and within CRMO.

The Great Rift occurs as a belt of open cracks, eruptive fissures, shield volcanoes, and cinder cones that vary in width between approximately one to five miles (1.6 to 8 kilometers) wide. It originates north of CRMO about six miles (9.6 kilometers) from the topographic edge of the SRP in the vent area of the Lava Creek flows located in the southern Pioneer Mountains (Kuntz et al. 1992; Owen 2008). The Great Rift extends southeasterly from the Lava Creek vents for more than 50 miles (80 kilometers), to south of Pillar Butte on the Wapi Lava Field (WLF) on the southern edge of CRMO (Kuntz et al. 1982). The Craters of the Moon Lava Field (COMLF) is the northernmost and largest of three young lava fields, King's Bowl Lava Field (KBLF) is the smallest and lies between the COMLF and the WLF, which is located on the southern end of the Great Rift. The remaining areas within CRMO that are located between the young lava fields or surrounding them consist of Pleistocene-age pahoehoe and aa flows, near-vent tephra deposits (generic term for any airborne fire-fragment accumulation), cinder cones, lava cones, and shield volcanoes (Kuntz et al. 1982).

The COMLF is the largest dominantly Holocene basaltic lava field in the contiguous U.S. (Kuntz et al. 1992); it covers 618 mi^2 (1,600 km^2). COMLF is a composite field made up of at least 60 lava flows and 25 tephra cones that formed during at least eight major eruptive periods over the past 15,000 years, in contrast to most of the other lava fields on the eastern SRP that represent single eruptive events. KBLF formed about 2,200 years ago during a single burst of eruptive activity that may have lasted as little as six hours (Kuntz et al. 1992); it exposes a central eruptive fissure set that is about four miles (6.4 kilometers) long, flanked by two sub-parallel sets of non-eruptive fissures. KBLF is a phreatic explosion pit 280 feet (85 meters) long, 100 feet (30 meters) wide, and 100 feet (30 meters) deep caused by lava contacting groundwater and producing a steam explosion. Adjacent to the bowl is a lava lake with well-developed levees, a plume of ash or tephra blanket on the east side of the pit that resulted from the explosion, fissure caves including Crystal Ice Cave and Creons Cave, feeding dikes, drain back features, and spatter cones.

The WLF formed about 2,200 years ago and is a classic shield volcano with a flattened dome shape. Kuntz et al. (1992) postulated the WLF began as a fissure eruption, but with prolonged activity developed a sustained eruption from a central vent complex (made up of five major and six smaller vents, each steep-sided circular depressions typically about 300 feet (91 meters) in diameter and 30 feet (9 meters) deep. Rising about 60 feet (18 meters) above the south side of the largest vent is Pillar Butte, a mass of agglutinate and layered flows. The medial and distal parts of the lava field are mostly composed of tube-fed pahoehoe flows while pressure plateaus, flow ridges, and collapse depressions characterize the field margins where local relief can be over 30 feet (9 meters) (Kuntz et al. 1992).

One explanation advanced for the existence of the SRP and the CRMO lava fields is the mantle plume theory, which states that beneath the crust lies a hot spot or localized heat source (NPS 2009). The Yellowstone Hotspot at the minimum has been imaged to a depth of 404 miles (650 kilometers) (Smith et al. 2009), shows it to be at least a depth of 621 miles (999 kilometers). The plume is not vertical, but dips to the northwest at approximately 60^{o}, possibly due to mantle winds (Smith et al. 2009). The hotspot is believed to have remained in a relatively fixed position and the North American plate floated over it to the southwest. As the plate moves over the hotspot and crustal rocks are melted, volcanic eruptions occur, which are initially very violent and produce huge volumes of rhyolite (the Huckleberry Ridge Tuff, e.g., has a volume of 600 cubic miles (2,501 cubic kilometers) and formed about 2 million years ago). Over 150 rhyolite types have been identified that were spawned by these massive eruptions. Huge calderas of up to 30 miles (48 kilometers) in diameter were formed when these eruptions occurred; later more fluid basalt lava flows onto the surface and covers the rhyolitic flows. Yellowstone National Park (YELL), the area where the hotspot is presently located, experienced large rhyolitic eruptions approximately 600,000 years ago. CRMO represents the second stage of the eruptions where fluid basaltic lava covered portions of the landscape as recently as 2,100 years ago.

Condition
CRMO is an active volcanic area that is presently in a dormant stage of the eruptive sequence. Eruptions have been dated by several methods, e.g., tree rings, paleomagnetic, radiocarbon (C-14), and Argon 40/39. Tree rings showed young-looking flows to be well over 1,000 years old. Paleomagnetic dating is used to extrapolate C-14 data by comparing the alignment of magnetic minerals in lava flows with past orientations of the magnetic field. Radiocarbon dating uses C-14

in charcoal from vegetation overrun by lava flows; the dates are considered accurate to within approximately 100 years. Argon 40/39 dating compares the ratio of two argon isotopes to determine the age of rocks and is used effectively to date older lava flows. By dating the extant lava flows, volcanic activity along the Great Rift has been determined to be persistent over approximately 15,000 years (occurring approximately every 2,000 years) and new eruptions are likely within the next 1,000 years (NRCS-NPS 2010).

Soils within CRMO include older deposits formed prior to lava extrusion and protected between flows and younger deposits blown in or developed from more recent volcanic exposures. The older volcanic rocks are typically mantled with loess deposits (windblown silt) and in some places by eolian (wind-transported) sand. Older areas surrounded by younger flows are called kipukas, have deep soils, and often support "islands" of more abundant vegetation. Thirteen general soils mapping units were described by the USDA-SCS (Johnson 1991) for this region and include: (1) well drained and somewhat excessively drained soils on fan terraces and stream terraces (three units), (2) well drained soils on basalt plains (five units) and (3) well drained soils on mountainsides and foothills (five units).

CRMO soils were recently classified, described, and mapped (NRCS-NPS 2010). They are primarily developed in wind-blown loess or are developed in alluvium derived from the basaltic lava. The recent soils data included 11 general mapping units, 85 detailed mapping units (including playas and water), and 70 soil series which represented 37 ecological sites (a distinctive kind of land, with specific physical characteristics which differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation, and in its response to management).

Soils within CRMO are largely classified and generally mapped (Table 10) as: (1) Lava flows (34%), (2) Lava flows-Cinderhurst (26%), (3) McPan-Starbuck-Chijer (9%), (4) McCarey-Beartrap-Pedelford (11%) and (5) Deerhorn-Rehfield-Wildors (12%) (NRCA-NPS 2010). The remaining 8% of CRMO soils are included within a variety of soil types, origins, and locations; Johnson (1991) described soil associations under the general locations and descriptions of basalt plains and mountainsides and foothills.

Table 10. General Soil Map Units for CRMO.

Map Unit Description - % of CRMO	Map Unit Number; % of CRMO	Notes
Lava Flows and Soils that Formed in Volcanic Ash, Cinders, Alluvium, and Eolian Deposits on Lava Fields and Lava Plains – 61%	1 – Lava flows; 34 % 2 – Lava flows–Cinderhurst; 26% 3 – Starbuck-Lava flows; 1%	1 – Lava flows on lava fields 2 – Lava flows and Cinderhurst soils that are very shallow to bedrock on lava fields with slopes of 2 to 15% 3 - Lava flows on lava fields and Starbuck soils that are shallow to bedrock on lava plains with slopes of 1 to 20%
Soils that Formed in Volcanic Ash, Cinders, and Eolian Deposits on Volcanic Cones, Mountain Slopes, and Lava Plains – 2%	4 – Infernocone-Huddle-Lavacreek; 2% 5 – McPan-Starbuck-Chiger; 9% 6 – McCarey-Beartrap-Pedleford; 11% 7 – Deerhorn-Rehfeld-Wildors; 12% 8 – McBiggam-Bancroft; 1% 9 – Rock outcrop-Trevino-Portino; 2% 10 – Techicknot-Nargon-Atom; 1%	4 - Infernocone soils that are moderately deep to cinders and are on volcanic cones with slopes of 2 to 40%, Huddle soils that are deep to bedrock and are on lava plains with slopes of 2 to 12%, and Lavacreek soils that are deep to bedrock and are on mountain slopes with slopes of 15 to 60% 5 - McPan soils that are moderately deep to a duripan and are on lava plains and buttes with slopes of 1 to 10%, Starbuck soils that are shallow to bedrock and are on lava plains with slopes of 1 to 20%, and very deep Chijer soils on buttes with slopes of 1 to 4% 6 - McCarey soils that are moderately deep to bedrock and are on lava plains and buttes with slopes of 0 to 30%, Beartrap soils that are deep to bedrock and are on lava plains with slopes of 2 to 20%, and Pedleford soils that are moderately deep to bedrock and are on buttes with slopes of 2 to 30% 7 - Deerhorn soils that are moderately deep to a duripan and are on buttes with slopes of 2 to 15%, Rehfield soils that are deep to a sandy substratum and are on lava plains with slopes of 1 to 8%, and Wildors soils that are moderately deep to a duripan and are on buttes with slopes of 2 to 15% 8 - Very deep McBiggam soils on lava plains with slopes of 2 to 8% and very deep Bancroft soils on lava plains with slopes of 1 to 8% 9 - Rock outcrop, Trevino soils that are shallow to bedrock and are on lava plains with slopes of 0 to 20%, and Portino soils that are moderately deep to bedrock and are on lava plains with slopes of 0 to 20% 10 - Very deep Techicknot soils on lava plains with slopes of 0 to 12%, Nargon soils that are moderately deep to bedrock and are on lava plains with slopes of 2 to 20%, and very deep Atom soils on lava plains with slopes of 2 to 20%
Soils that Formed in Alluvium and Colluvium on Mountain Slopes, Hillslopes, and Fan Remnants – 1%	11 – Vitale-Blackspar-Drage; 1%	11 - Vitale soils that are moderately deep to bedrock and are on mountain slopes with slopes of 30 to 60%, Blackspar soils that are shallow to bedrock and are on mountain slopes with slopes of 30 to 75%, and very deep Drage soils on fan remnants and hillslopes with slopes of 0 to 20%

Source: NRCS-NPS 2010

Generally, pygmy rabbits burrow in loamy soils deeper than 20 in (50.8 cm). Soil composition needs to be soft enough for digging, yet be able to support a burrow system. On the lava plains of southern Idaho, pygmy rabbits will often burrow between or under lava boulders. In Idaho, pygmy rabbits are typically found in mima mound formations (alluvial plains dotted with mounds about 20 to 30 ft (6.1 to 9.1 m) in diameter, 1 to 2 ft (0.3 to 0.61 m) tall, several hundred ft or yds apart, where the sagebrush is taller than in the surrounding intermound spaces) (FR 2010). Other topographic features that support pygmy rabbit burrows include the bottoms and lower slopes of small drainages where the sagebrush is denser and taller (indicates deeper soils). The soils are sufficiently deep and moist to support greater total shrub cover, sagebrush shrubs, forbs, and litter cover, and significantly less bare soil and rock than in unoccupied areas. Total shrub, sagebrush, and snowberry shrub canopy cover was greater in occupied pygmy rabbit habitat (FR 2010).

Inventory
Geology within CRMO is unique and has received large interest within the geology community of scientists. Owen (2008) represents the latest synopsis of geologic classification, deposits, topographic features, and mapping. CRMO soils were recently classified, described, and mapped in the NRCS-NPS (2010) report and geodatabase.

Monitoring
Feature classes placed in the CRMO Geology feature dataset include lava flows, aquifer, volcanic craters, fault lines, the NRCS STATSGO general soils association units, general geological classifications polygon boundaries from the digital geology map of Idaho, and other geologic features. Table 11 lists the various layers found in this feature dataset. For the Geology and Soils feature classes, acres and percent of total area encompassed by that feature's attributes are listed.

Site Specific Information
A general description of the types of geology exposed within CRMO is provided below. A detail map of the geology is available http://pubs.usgs.gov/sim/2007/2969/downloads/pdf/2969_map.pdf. An inventory of the geologic resources is in progress at this time. Kuntz et al. (1988) prepared the geologic map of CRMO; some of the primary geologic features are (oldest to youngest):

Copper Basin Formation (Mississipian): Paleozoic (310-345 MYA) sedimentary rocks include sandstone, siltstone, claystone, and minor conglomerate in the Pioneer Mountain foothills comprising the north end of CRMO. The conglomerate is gray with clasts to cobble size; the sandstone is very fine to fine grained, olive gray to medium gray, and sole marks are common in places; the siltstone is locally laminated and medium to dark gray; and the claystone is dark gray to black, locally laminated, and contains pebbles of chert and quartzite in places.

Challis Volcanics (Eocene): Tertiary (25-40 MYA) volcanic rocks in the northern portion of CRMO consist of welded tuff, lava flows interbedded with tuff breccia, and tuff breccia. The Challis tuff is an ash-flow deposit that overlies the tuff-breccia unconformably. The tuff ranges in color from light brownish gray to moderate orange pink with silica veins and lenses. The tuff breccia consists of lithic fragments (including pumice), crystals, and devitrified glass. These fragments were apparently derived from previously deposited or interbedded rhyodacite lava flows. Both units probably originated from ash flows and breccia flows issuing out of eruptive centers north of the CRMO boundary during Eocene times.

Granite and monzonite (Eocene): Tertiary (25-40 MYA) formations occur in the northern portion of CRMO near Goodale's Cutoff and Little Cottonwood Creek.

Volcanic Formations and Surficial Deposits (Pleistocene and Holocene): Pleistocene and Holocene (0-2 MYA) volcanic exposures and surficial deposits at CRMO include kipukas, lava fields, lava flows, cinder cones, shield volcanoes, alluvium, and eolian loess deposits and sand dunes. There is great diversity of basaltic features, in a small area almost all the features of basaltic volcanism are visible. In this region, much of the volcanism of the Snake River Plain was confined to volcanic rift zones which are concentrations of volcanic landforms and structures along a linear zone of cracks in the earth's crust. The Great Rift is an example of basaltic fissure eruption characterized by extrusion of lavas from fissures or vents that is relatively quiet in comparison with highly explosive eruptions (e.g., 1980 Mount St. Helens eruption).

Unconsolidated Sediments: are primarily windblown silt (loess) and sand deposits, cinder deposits, alluvium along streams, colluvium at the base of steep slopes, and lacustrine deposits associated with ponds. The thickness of the sediments in the north end of CRMO ranges up to 30 meters (100 feet) along some of the stream drainages based on the well logs derived from groundwater wells. Eolian silt and sand mantles some of the older lavas and continue to be eroded, transported, and deposited, particularly following events including fire (fires in the Kings Bowl area freeing sediments of their anchors clearly demonstrated eolian processes in action, i.e., deflation, active ripple migration and formation and migration of small sand dunes). Cinders are often observed saltating on cinder cone slopes on windy days, thus the cones are a landform in flux and changing with time.

Kipukas: are islands of native vegetation that have become established in soils that have developed on old lava flows surrounded by newer flows. The kipukas were isolated between 2,100 to 15,000 years ago (ISU 2011). There are currently more than 600 kipukas identified within CRMO.

Cinder Cones: have gentle footslope, moderate side-slope, and steep upper slope habitats that support three physiognomic types; cinder garden, shrub, and limber pine and/or juniper woodland or tree stands (these communities are determined primarily by aspect and by succession). The tallest cinder cone is approximately 213.4 meters (700 feet).

Lava Flows: are mostly classified as aa, pahoehoe, or blocky lava. Of the more than 60 lava flows of the COM Lava Field, 20 have been dated and ages ranged from about 15,000 years before present to about 2,100 years before present. The flows were laid down in eight distinct eruptive periods that recurred on an average of every 2,000 years. Some lava flows are very dense and have a surface of angular blocks referred to as block lava. New basaltic lava generally has a dark brown-black surface, however as lava ages and weathers, the surface color may change and lichens and mosses become established on some surfaces. Pahoehoe lava may take on a glossy, iridescent veneer due to chemical composition, i.e., the Blue and Green Dragon pahoehoe flows and the Vermilion Chasm are named for the characteristic lava colors of those sites.

Aa Lava: has rough, jagged or clinker surfaces with sharp points and is often devoid of vegetation other than nonvascular lichens and mosses. The slabby and spiny varieties of pahoehoe are transition phases to aa lava.

Pahoehoe Lava: is more fluid before hardening, spreads into sheets with smooth, glistening surfaces that are often billowy or are twisted into ropelike wrinkles, pleats, and folds. Three kinds of pahoehoe may be observed in the COM Lava Field: (1) slabby pahoehoe is made up of jumbled plates or slabs of broken pahoehoe crust, (2) shelly pahoehoe, which forms from gas-charged lava, contains small open tubes, blisters, and thin crusts and (3) spiny pahoehoe, which is very thick and pasty and contains elongated gas bubbles on the surface that form spines.

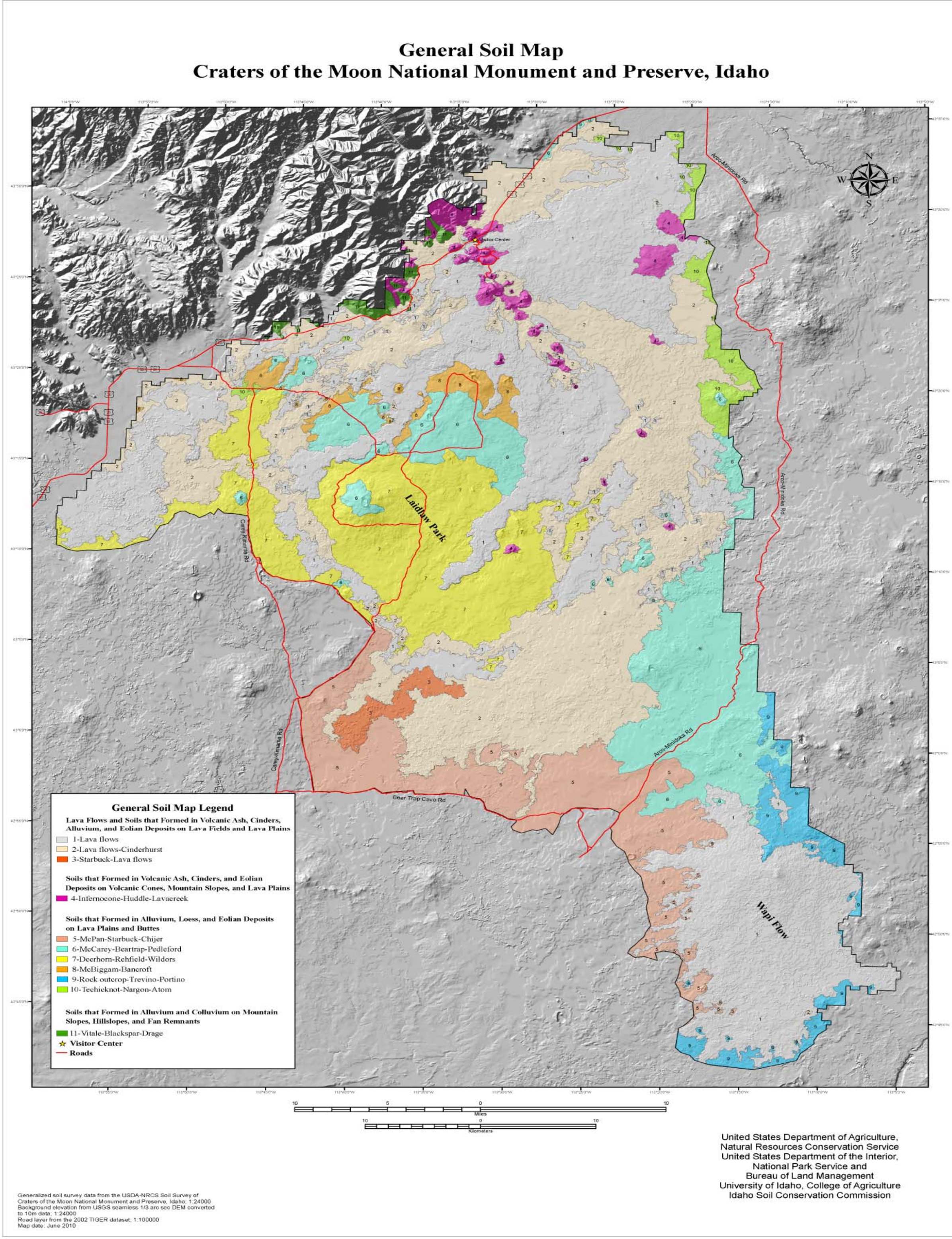
Slabby Pahoehoe Lava: continued flows of pahoehoe lava that are cooling and getting thicker or that have been stressed by a steeper gradient or rougher bed surface causes the congealing crust to shear into jagged blocks that resemble aa lava but do not have the characteristic sharp surface projections and spines and in which the ropey structure of the pahoehoe is still evident.

Soils: Soils of CRMO predominantly include the Lava flows and Lava Flows-Cinderhurst complex map unit (NRCS-NPS 2010; Johnson 1991) and surrounding lands include a variety of loams (Figure 15). Cinderhurst soils form in depressions on basalt plains and are derived predominantly from volcanic tephra; they are considered very shallow, well drained, of moderate permeability, with very low available water capacity, and with 4-10 inches (10.2-25.4 centimeters) potential rooting depth. The typical profile includes 0-3 inches (0-7.6 centimeters) of brown extremely cobbly silt loam at the surface underlain by 3-8 inches (7.6-20.3 centimeters) of yellowish brown very cobbly silt loam then basalt that has vertical fractures 1-2 inches (2.5-5.1 centimeters) wide.

Twenty-one soil associations with prime farmland properties occur within CRMO and many acres/hectares of arable land have been converted to agricultural land use outside the CRMO boundary (NRCS-NPS 2010; Bell et al. 2009; Johnson 1991). Some soils would be designated prime farmland only if adequate and dependable quantities of precipitation or groundwater for irrigation are available. The soil map units within CRMO that meet the requirements for prime farmland if irrigated are (Source: NRCS-NPS 2010):

- Bancroft silt loam, 1 to 4 percent slopes (Map Unit 1)
- Carey Lake loam, 0 to 2 percent slopes (Map Unit 6)
- Drage gravelly loam, cool, 2 to 15 percent slopes (Map Unit 13)
- Drage very gravelly loam, cool, 0 to 3 percent slopes (Map Unit 14)
- Goodalfs-Craters association, 0 to 5 percent slopes (Map Unit 17)
- Infernocone gravelly ashy sandy loam, 2 to 20 percent slopes (Map Unit 23)
- Justesen loam, 2 to 4 percent slopes (Map Unit 25)
- Justesen loam, 4 to 8 percent slopes (Map Unit 26)
- McCarey-Beartrap complex, 1 to 6 percent slopes (Map Unit 37)

- McCarey-Justesen complex, 2 to 8 percent slopes (Map Unit 40)
- McCarey-Molyneux complex, 2 to 8 percent slopes (Map Unit 41)
- McPan-Chijer complex, 1 to 6 percent slopes (if reclaimed of excess salts and sodium) (Map Unit 47)
- Molyneux loam, 2 to 4 percent slopes (Map Unit 48)
- Portino silt loam, 2 to 4 percent slopes (Map Unit 55)
- Portino cobbly loam, 2 to 4 percent slopes, stony (Map Unit 57)
- Portneuf silt loam, bedrock substratum, 0 to 2 percent slopes (if reclaimed of excess salts and sodium) (Map Unit 60)
- Portneuf silt loam, bedrock substratum, 2 to 4 percent slopes (if reclaimed of excess salts and sodium) (Map Unit 61)
- Rehfield loamy sand, 1 to 6 percent slopes (Map Unit 66)
- Roundknoll gravelly ashy loamy sand, 2 to 20 percent slopes (Map Unit 70)
- Soen clay loam, 0 to 4 percent slopes (Map Unit 71)
- Techick-Soelberg-Lesbut complex, 0 to 4 percent slopes (Map Unit 78)



Source USDA 2011

Figure 15. Soils Layer for CRMO .

Prime farmland is defined as “land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, the land is also used as cropland, pastureland, rangeland, forest land, or other land, but cannot be used as urban built-up land or water” (USLegal 2011). In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. These soils are permeable to water and air, not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding.

Prime farmland designation can be interpreted for CRMO as relating to older more established soils that could support crops or forage. This includes areas of the Monument that have deeper soil development outside of the recent lava flows (including kipukas). Currently these soils contain mixes of herbaceous and sagebrush dominated vegetation and some areas are being grazed. Areas just outside of CRMO (especially in the northwest and south of CRMO) that contain similar prime farmland soils are being irrigated using center pivots. In contrast the more recent or geologically young soils at CRMO (resulting from lava flows) have little soil development, mostly occurring from windblown deposits. The younger parent material type structure in many areas of the lava flows combined with the localized arid climate are either devoid or support sparse vegetation.

Table 11. Geology layers stored in the CRMO geology feature dataset.

Attribute	GIS Acres	% of Total Area
Devonian bedded dolomite and limestone interval	2,389.3	0.13%
Devonian thrusted, deep-water siliceous argillite and quartzite	272.5	0.01%
Eocene intrusions	2,857.7	0.16%
Eocene mixed silicic and basaltic volcanic ejecta, flows, and reworked debris	57,162.3	3.12%
Lower Permian to Lower Pennsylvanian (Carboniferous shallow-water detritus	3,191.9	0.17%
Lower Permian to Middle Pennsylvanian thrusted, marine detritus	4,306.8	0.24%
Lower Pleistocene to Pliocene basalts with associated tuffs and volcanic detritus	119,413.9	6.52%
Mississippian shallow-water carbonates-to-clastic sequence	18,661.1	1.02%
Mississippian thrusted, shallow-to-deep marine detrital units	25,179.3	1.38%
Open Water	10,033.3	0.55%
Pleistocene and Pliocene stream and lake deposits	615.2	0.03%
Pleistocene outwash, fanglomerate, flood and terrace gravels	2,275.8	0.12%
Pliocene silicic welded tuff, ash, and flow rocks	5,212.3	0.28%
Quaternary alluvium	67,739.9	3.70%
Quaternary colluvium, fanglomerate, and talus	10,622.3	0.58%
Quaternary detritus	5,507.5	0.30%
Quaternary surficial cover	55,060.0	3.01%
Recent active sand dunes and eolian deposits	1,204.9	0.07%
Recent, relatively unweathered Snake Plain basalt flows and cinder cones	514,716.4	28.12%
Silurian to Middle Ordovician marine carbonate-to-clastic strata	814.6	0.04%
Upper Pleistocene Snake Plain lava flows	923,102.4	50.43%

The following map (Figure 16) depicts the lithology layer and other features automated within the Geology feature dataset in the CRMO geodatabase. This layer is titled major_lithologic_units and is a dataset produced by the USGS to provide geologic process and mineral resource information for the Interior Columbia Basin Ecosystem Management Project a USFS and BLM interagency project. The data layer represents the major bedrock lithologic units for the Pacific Northwest and is of a very general scale.

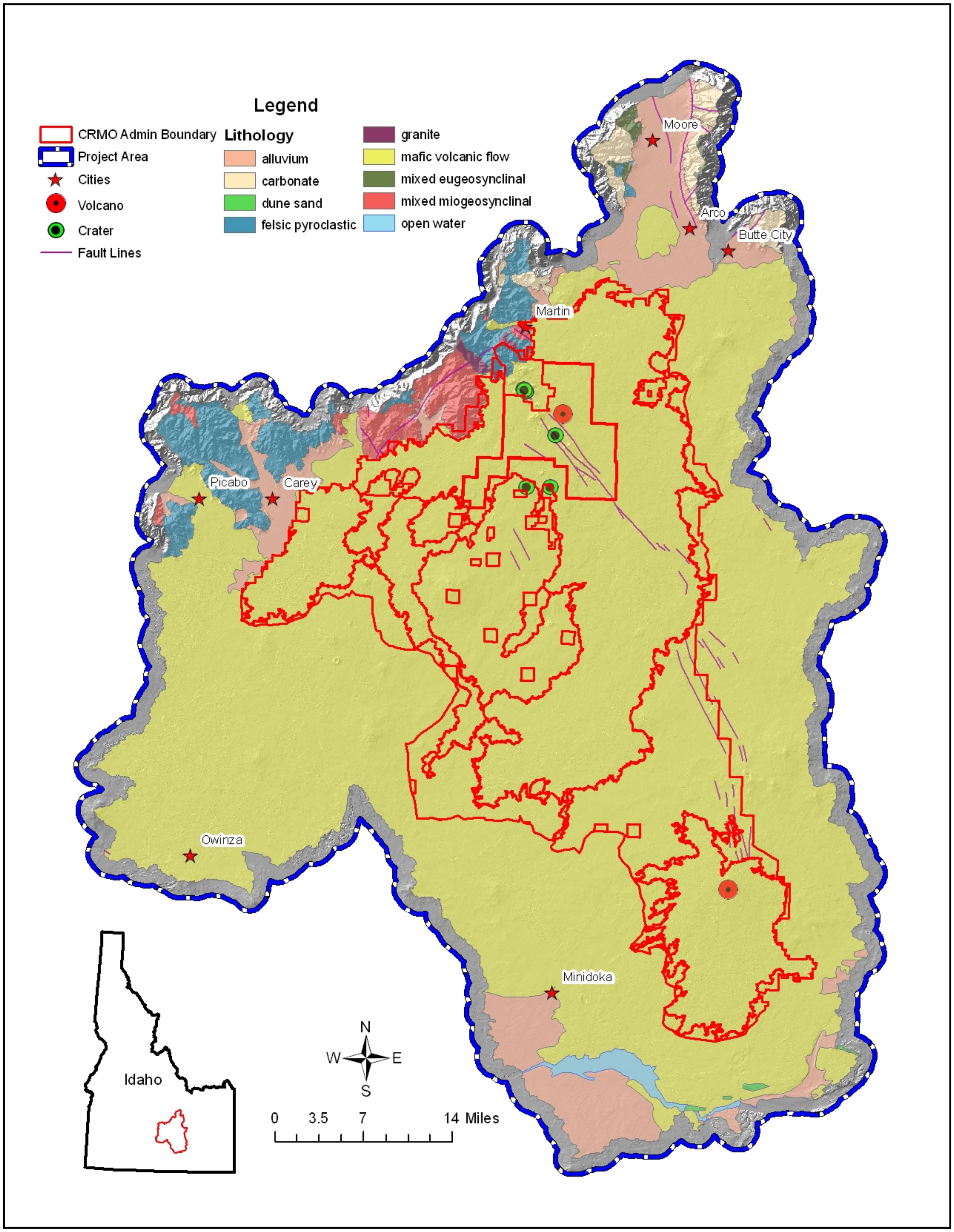


Figure 16. Major Lithology Layer for CRMO.

Threats and Stressors

The threats and stressors to the geology of CRMO are limited due to the nature of the resource. Roads and trails provide the greatest threat to the resource providing access which can lead to theft or destruction through vandalism of the geologic resources (NPS 2000). Cave resources have had some vandalism and graffiti events where located near roads or trails resulting in minor to major impacts on this resource (NPS 2005). Foot traffic into an area allows for erosion and compaction issues to occur. NPS (2005) notes the movement of unconsolidated or poorly consolidated material down slope in areas with foot traffic on cinder cones, spatter cones, hornitos, and spatter ramparts. Geologists identified as much as two feet (0.6 meters) in elevation being lost from some of the cinder cones in the original Monument due to human interaction with this unconsolidated material. Where unconsolidated volcanic material is exposed to sunlight the surface typically becomes darker in color and present paths and foot traffic are noticeable on the landscape as lighter-colored areas for many decades following the visit.

Natural processes, including wind and water erosion, freeze/thaw cycles, erosion following lichen establishment, etc., are described as the dominant agent of change to the geologic formations within CRMO (NPS 2007). A potential threat to this process is the introduction of airborne pollutants/toxicants and anthropogenic aspects from surrounding land uses (e.g., dust generation from roads, agricultural production, livestock herding, etc.). As noted in the Air Quality section of this document, several potential point source pollutants occur near the perimeter of CRMO and regional air pollution sources exist. Whether chemical, metal, or natural, each pollutant can have a negative effect on the geologic resource and/or the associated lichen and moss communities.

Soils generally would receive threats during drought periods or following wildland fires that result in the loss of protective vegetation and biotic crust or during patterns of heavy rainfall or local cloudbursts where the thin deposits could be washed away and redistributed to drainage banks or depressions. Winds can remove fine organic and mineral materials from the soil surface and deposit coarser cinders. Soils developed on mountain and foothill slopes may be subject to erosion by wind and water and may be locally affected by landslides. As described under the geology section, pollutants transported by air including chemicals, particulates, and others would likely have a negative effect on soil development, soil microorganisms, biotic crust development, and vegetation cover.

Data Gaps

At the time of this report, no monitoring plan had been established regarding specific areas of impact to geologic features or soils within CRMO. An assessment of the current condition and the affect of the potential pollutants would provide beneficial baseline information to park managers. This is an important analysis of the geology and magnitude of any land-based stressors.

Air Quality

CRMO is within airshed 19 of the Idaho Division of Environmental Quality (IDEQ 2010). Generally the air quality of CRMO is thought to be relatively pristine; however, CRMO air quality is adversely affected by local and regional sources (NADP 2011, NPS-CRMO 2005, Wright 1993). Air quality at CRMO is protected under both the 1916 Organic Act and the Clean Air Act of 1970, as amended (NPS-CRMO 2005). Near and distant air pollutant emission sources affect air quality in CRMO. The INL is located 25 km (15.5 mi) east of the wilderness area, emits significant amounts of sulfur dioxide and nitrogen oxides, and is the highest emitter of hazardous air pollutants in the state (NADP 2011). The City of Pocatello, located 80 km (50 mi) southeast of the Wilderness Area, has large mineral and chemical plants with significant emissions. There are several sugar beet processing plants in southern Idaho and other industrial plants in the region. In addition, mining operations and agricultural activities (including field burning), windblown dust from fields and roads, highway traffic, and wildland fires (including prescribed burns and campfires) contribute air pollution to CRMO. Distant sources of air pollution, include coal-fired power plants, industrial facilities, and agricultural and wildland fires.

Generally, air quality of CRMO is poorest in the winter when air inversions occur (IDEQ 2011). Air quality is impaired during inversions in the winter months due to the higher levels of sulfates and nitrates in the air. Generally the air quality is good in the summer months except when wildfires occur in southern Idaho and the regional area. CRMO wilderness area is designated as a Class I airshed beginning in 1977 under the Clean Air Act of 1970, as amended. This 43,243 acres is not subject to the strict regulations and monitoring required of a Class I airshed, however, national ambient air quality standards must be met within the park.

Visibility and atmospheric deposition are two key air quality indicators identified by the NPS (NPS 2009a). Visibility affects the sight distance and clarity of the natural surroundings available for viewing by park visitors. One major area of concern for CRMO wilderness area is haze associated with fires and roads within the park and in the surrounding area. Wildfires and prescribed burns contribute to the fine particulate matter (PM) within the smoke (NPS 2005). Vehicles, fires, wood stoves, and dust are the major point source contributors to air pollution within CRMO. In addition to contributing to haze and reducing visibility by absorbing and scattering light, PM can be harmful to humans as small particulates can enter the lungs and cause health problems (EPA 2009). Particulate matter is measured by diameter, e.g., particles less than 2.5 micrometers are referred to as fine particles (sources include motor vehicles, power plants, wood burning, forest fires, and some industrial processes) and coarse particles (dust on roads and other particles resulting from crushing or grinding processes) are those greater than 2.5 micrometers but less than 10 micrometers (EPA 2009).

The air quality related values (AQRVs) of CRMO (those resources that are potentially sensitive to air pollution) include visibility, water quality, soils, vegetation, and wildlife (NADP 2011). Visibility is a very sensitive AQRV in CRMO. Although visibility within CRMO is still superior to that in many parts of the country, it is often impaired by light-scattering pollutants (haze) from near and distant air pollution sources. Visibility is monitored as part of the IMPROVE network, using an aerosol sampler (1992-present) and an automatic 35mm camera (1982-2001).

CRMO has few aquatic resources including two streams, scattered ponds, and ice caves. Water quality monitoring data indicate that the streams are well buffered but occasionally have pH values slightly lower than the EPA criterion (pH 6.5) for the protection of freshwater aquatic life. Copper and zinc each exceed respective EPA criteria; water quality is more likely affected by local influences like leachate from mine tailings than by atmospheric deposition of acidifying pollutants (nitrogen and sulfur) (NADP 2011).

Soils and vegetation within CRMO may be sensitive to nitrogen deposition (NADP 2011). In some parts of the U.S. nitrogen deposition has altered soil nutrient cycling and vegetation species composition; native plants that have evolved under nitrogen-poor conditions have been replaced by invasive species that take advantage of increased nitrogen levels. It is not known if nitrogen deposition is affecting soils and vegetation in CRMO, but data for wet deposition from 1993-2003 indicate that deposition of nitrogen is increasing and deposition of sulfur is decreasing (NADP 2011). Wet deposition of atmospheric pollutants has been monitored in CRMO since 1980 as part of the NADP/National Trends Network. The site identification is ID03; no dry deposition estimates are available for the area.

Several plant species that occur in CRMO, including quaking aspen and Scouler's willow, are known to be sensitive to ozone (NADP 2011). Ozone has been monitored with a continuous analyzer from 1992- present and data indicate that ozone concentrations and doses are approaching levels known to cause injury to vegetation. Ozone increased significantly from 1993-2002 and may be cause for concern in the future (NADP 2011). No systematic surveys to assess vegetation injury have been performed in CRMO.

Condition

The NPS measures progress toward improving park air quality by examining trends for key air quality indicators, including: (1) visibility - which affects how well and how far visitors can see, (2) ozone - which affects human health and native vegetation and (3) atmospheric deposition - which affects ecological health through acidification and fertilization of soil and surface waters (NPS 2010). Air quality trends provide one measure of performance and progress (NPS 2010). In general, air quality that is improving, or showing no deteriorating trend, may be considered a sign of success. In accordance with the Government Performance and Results Act, the NPS has established performance goals based on trends, and reports annually on progress. For fiscal year 2009, nationwide, these goals are improving or not degrading: (1) visibility in 95% of NPS reporting parks (improved or shows no deteriorating trend), (2) ozone in 86% of NPS reporting parks (improved or shows no deteriorating trend) and (3) atmospheric deposition in 76% of NPS reporting parks (improved or shows no deteriorating trend).

CRMO has a significant improving trend for haze index (measured in deciviews: one deciview represents the minimal perceptible change in visibility to the human eye) on clearest days (1999–2008 data) and no trend for the haziest days. The clearest days are defined as the clearest 20% of those days each year for which visibility measurements are available, and the haziest days are the haziest 20%. Fenn et al. (2004) used 2002 visual range data for CRMO to determine an average annual visual range of 160 kilometers (99.4 miles), best 20% of 238 kilometers (148 miles), and worst 20% of 89 kilometers (55 miles).

The EPA has established a primary NAAQS for ozone concentrations that is designed to protect the public health (the metric used by EPA is the three-year average of the annual fourth-highest eight-hour ozone concentration). NPS (2010) chose to evaluate ten-year trends in ozone concentrations using the annual fourth-highest daily maximum eight-hour ozone concentration, instead of the three-year average, as the annual statistic is available over a longer period. In January 2010, EPA proposed to lower the ozone standard from 0.075 ppm (75 ppb) to a level within the range of 0.060–0.070 ppm (60–70 ppb). EPA will continue to use the same indicator and averaging time for the new standard, although its proposal does contain some minor changes to the procedures for calculating the indicator. CRMO has no trend in annual fourth-highest eight-hour ozone concentration (1999–2008 data).

Ammonium, nitrate, and sulfate ions in precipitation (rain and snow) are used as indicators of atmospheric deposition because they can be directly linked to ecological effects (e.g., acidification of surface waters or nutrient enrichment that disrupts natural systems) (NPS 2010). CRMO has a possible degradation in ammonium concentrations in precipitation based on 1999–2008 data. Ammonium forms from emissions of ammonia released by agricultural activities, feedlots, fires, and catalytic converters and is not currently regulated. CRMO has a possible improvement in nitrate concentrations in precipitation and no trend in sulfate concentrations in precipitation. Reductions in sulfate and nitrate are primarily due to reductions in sulfur dioxide and nitrogen oxide emissions from electric utilities and industrial boilers required by the Acid Rain Program and the NOx SIP Call (EPA 2010).

Inventory

To assess condition, NPS-AQD staff used all available monitoring data from NPS, EPA, state, tribal, and local monitors over the period 2004–2008 to estimate air quality parameters for CRMO and other park units (NPS 2010). Estimated values for the air quality parameters were selected from the interpolation for individual parks and an index was determined for each type of air quality data collected (visibility, wet deposition, and ozone) that assigns the park to one of three condition categories where air quality is in: (1) Good Condition, (2) Moderate Condition, or (3) is of Significant Concern.

For ozone and deposition, good air quality generally supports ecosystem health and is not expected to be harmful to natural resources, moderate air quality may affect very sensitive resources, and conditions that are of significant concern are at levels known to be harmful to sensitive resources or human health (NPS 2010). For ozone or deposition, a rating of significant concern is not based on park-specific documented harm to resources, but rather potential impacts based on information from a broad body of scientific research. For visibility, condition is based on direct measurements of haze, interpolated for all parks. Good visibility is within 20 percent of natural background visibility, where natural is presumed to be free of human-caused haze, moderate visibility is from 20 to 80 percent hazier than natural conditions, and visibility of significant concern is greater than 80 percent hazier than natural conditions.

NPS (2010) reports CRMO, using 2004-2008 data, is: (1) moderate for air quality condition assessments for visibility (condition assessments derived from interpolations of average visibility conditions), (2) is of significant concern for air quality condition assessments for nitrogen deposition (condition assessments derived from interpolations of wet nitrogen deposition), (3) good for air quality assessments for sulfur deposition (condition assessments derived from interpolations of wet sulfur deposition), (4) moderate for air quality condition assessments for ozone (condition assessments derived from interpolated values of the mean annual 4th-highest 8-hour ozone concentrations), (5) degrading air quality trend for long-term trends in annual 4th-highest 8-hour daily maximum ozone concentration and (6) degrading air quality trend for ammonium, no trend for nitrate, and improving trend for sulfate (long-term trends in wet deposition concentrations).

Monitoring

The Climate Friendly Parks Program was funded through July 2009 via an interagency agreement between the NPS and the EPA. NPS assumed full funding for the program in August 2009. The program encourages and enables national parks to develop strategies to reduce their greenhouse gas emissions. The program also entails a commitment on the part of participating parks to educate the public about the actions the park is taking to mitigate emissions.

The Pacific West Region was on schedule to have member parks be Climate Friendly Parks by FY 2011. NPS interpreters have been working in partnership with National Aeronautics and Space Administration and other scientists to develop climate change training materials and interpretive products such as brochures and exhibits. NPS, in cooperation with EPA, BLM, FWS, USFS, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration, developed a product entitled "Climate Change: Wildlife & Wildlands, a Toolkit for Formal and Informal Educators." The kit will aid educators in teaching how climate change is affecting our nation's wildlife and public lands, and how everyone can become "climate stewards." The toolkit is available online at: http://www.globalchange.gov/resources/educators/toolkit. The information, expertise and management concerns that the NPS brings to many external decision making arenas have made a difference in the past and will continue to do so in the future.

Air quality in CRMO is some of the cleanest air in the U.S.; however, the quality does vary within the Monument and Preserve portions (NPS 2005). A National Atmospheric Deposition Program monitoring site is located on the Monument portion. Established in 1980, the monitoring site provides a long term record of precipitation chemistry in the area. Precipitation chemistry and mercury deposition data from the monitoring station are available Online at: http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=ID03&net=NADP. Table 12 lists the location of the monitoring station and the parameters monitored at the site.

Table 12. Air Quality Data for CRMO.

Craters of the Moon National Monument, ID

Site: Visitors Center

Latitude: 43.4606 deg N Longitude: 113.5550 deg W Elevation: 1807 m

Parameter	Start	End	Years	Seasons	Period	Interval	Instrument	Operating Agency	Network
				Deposition Monitoring					
Precip. vol. & ions	8/22/1980	present	29.6	-	year-round	Weekly	Sampler	NPS	NADP/NTN
Hg in precip.	10/20/2006	present	3.5	-	year-round	Weekly	Sampler	EPA	MDN
				Gaseous Monitoring					
Ozone	9/24/1992	present	17.5	-	year-round	1-hour average	Analyzer	NPS	NPS-GPMP
				Meteorology Monitoring					
Relative Humidity	9/1/1998	present	11.6	-	year-round	1-hour average	Sensor	NPS	NPS-GPMP
Standard Deviation for Wind Direction	9/1/1992	present	17.6	-	year-round	1-hour average	Sensor	NPS	NPS-GPMP
Solar Radiation	9/24/1992	present	17.5	-	year-round	1-hour average	Sensor	NPS	NPS-GPMP

Craters of the Moon National Monument, ID									
Site: Visitors Center									
Latitude: 43.4606 deg N Longitude: 113.5550 deg W Elevation: 1807 m									
Parameter	**Start**	**End**	**Years**	**Seasons**	**Period**	**Interval**	**Instrument**	**Operating Agency**	**Network**
Scalar Wind Speed	9/24/1992	present	17.5	-	year-round	1-hour average	Sensor	NPS	NPS-GPMP
Ambient Temperature (aspirated)	9/24/1992	present	17.5	-	year-round	1-hour average	Sensor	NPS	NPS-GPMP
Vector Wind Direction	9/24/1992	present	17.5	-	year-round	1-hour average	Sensor	NPS	NPS-GPMP
Vector Wind Speed	9/1/1992	present	17.6	-	year-round	1-hour average	Sensor	NPS	NPS-GPMP
Visibility Monitoring									
IMPROVE Sampler Module A - ver2	7/1/2000	present	9.8	-	year-round	24-hour average	Sampler - VII	NPS	IMPROVE
IMPROVE Sampler Module B - ver2	7/1/2000	present	9.8	-	year-round	24-hour average	Sampler - VII	NPS	IMPROVE
IMPROVE Sampler Module C - ver2	7/1/2000	present	9.8	-	year-round	24-hour average	Sampler - VII	NPS	IMPROVE
IMPROVE Sampler Module D - ver2	7/1/2000	present	9.8	-	year-round	24-hour average	Sampler - VII	NPS	IMPROVE

Source NPS 2010

The NPS-ARD is providing guidance, data, and information to assess air quality conditions for ozone, deposition, and visibility as part of the CRMO NRCA; Air Quality Guidance for Natural Resource Condition Assessments is available Online at: http://www.nature.nps.gov/air/planning/index.cfm. Extensive precipitation chemistry data (National Trends Network wet deposition) and trend plots are available for multiple time periods on the website. Mercury deposition data from 2006 to the present is also available through a query form with output in multiple formats.

Threats and Stressors

Roads and wildfire are the primary contributors to air pollutants within CRMO. Both naturally ignited and human-caused wildfires contribute significant smoke emissions over the life of the fire (NPS-CRMO 2005). Dispersion varies depending on the weather conditions at the time of the fire. The major pollutants of concern in smoke from fire include fine particulate matter (PM2.5 and PM10).

Suspended dust is the second most common air pollutant from local sources within CRMO (NPS 2005). Particulate matter is the primary associated pollutant in the dust. Both human activity (including driving, cattle grazing, and agricultural uses) and natural events (wind and moisture) contribute to the amount of fugitive dust. The best indicator of potential fugitive dust is non-vegetated ground including burned areas and unpaved roads. Table 13 indicates the air quality standard Vital Signs for CRMO (NPS 2011).

Table 13. UCBN Vital Sign Air Quality Data for CRMO.

UCBN Vital Sign – Air Quality	Measures
Ozone (Av 3 yr 4th High 8-hr)	0.40 ppb/yr
Ammonium annual deposition	0.839 kg/ha (2006)
Nitrate annual deposition	1.485 kg/ha (2006)
Sulfate annual deposition	0.899 kg/ha (2006)

Data Gaps

At the time of this report, the description of the airshed for the original Monument was clearly defined. Outside the Monument, the airshed was not defined beyond that of the Idaho Department of Environmental Quality mapping. Continuous air quality sampling and analysis every five to ten years is necessary because of increasing tourism, surrounding agricultural land use, operation of the INL and existing industrial sites, low levels of new industrial development, and relatively slow population growth around CRMO.

Site Specific Information

Specific air quality data are available from the NADP monitoring sites located on the Monument. Daily to annual NADP/NTN Wet Deposition data are available for download as well as Trend Plots for elements and precipitation sampled at the sites. In addition to these data, NADP/MDP (Mercury Deposition Network) data are collected (mercury concentrations present in precipitation). Data on mercury concentrations is made available through external links to the NADP website. GIS data are not available from this website.

One feature class pertaining to Air Resources is included in the CRMO geodatabase. This file is the Class 1 Airshed Zone polygon layer within the CRMO project boundary. Airshed Zones are used by the Smoke Monitoring Unit at the Aerial Fire Depot in Missoula, Montana to issue restrictions on prescribed fires in each airshed based on air quality and atmospheric dispersion conditions. Source Pollutants within CRMO is limited to automobile emissions and other localized sources (NPS-CRMO 2005). The primary environmental threats to the air quality of CRMO are from INEEL and other industrial sites from the surrounding area (NADP 2011, Wright 1993). The major industrial point sources and the contribution to air pollutants are identified in Table 14.

Table 14. Point source pollutants for CRMO (tons per year)

Source	County	Carbon Dioxide	Nitrogen Oxide	PM2.5	PM10	Sulfur Dioxide	Volatile Organic Compounds
Amalgamated Sugar	Minidoka	131	431	214	630	511	1.76
FMC	Power	2	9	1391	1657	2935	0
JR Simplot	Bannock	11	1011	244	307	7133	0
Ash Grove Cement	Bannock	0	124	184	288	488	0
Idaho Supreme Potato	Bingham	2	64	70	243	67	0
INEEL-DOE	Butte	8	518	3	5	657	0

Land Use

Land cover by vegetation, geologic exposures, water, cropland, and development provides visible evidence of changes in the land use and insight into the change over time. Landscape characteristics can be used to evaluate and understand the extent of change, condition, change in structure, and other potential influences on the landscape (NPS 2011). Monitoring on a multi-spatial basis provides managers an opportunity to evaluate changes in and around the park unit and the surrounding areas, extending into the region. The EPA uses land cover as a reflection of land use to identify various nonpoint sources of pollution including chemical and air pollution.

Changes in vegetation cover and ultimately land use types are important, as measurable changes in land use can affect the integrity of the park ecosystem. Historically, the sagebrush-steppe common to the CRMO region occupied over 25 million acres in Idaho. Today more than one-third of the sagebrush-steppe has been converted to agricultural uses and other development resulting in fragmentation of this important short shrub community (ISU 2011). Activities which may affect the ecological integrity of CRMO can include farming, grazing, logging, infrastructure development, and recreational activities near the boundary or in the surrounding areas. One of the most important considerations identified for CRMO is the construction of access roads and trails (BLM 2011). Access provides for recreational activities and livestock grazing in the areas in and directly adjacent to CRMO and unpaved surfaces contribute to local particulate and haze generation. Roads and trails can provide corridors for the introduction of non-native plant species including noxious weeds; this introduction is exacerbated by agricultural and residential development.

Condition

Limiting the development of roads and/or trails is a high priority for maintaining the existing land use within CRMO (NPS 2005). The road system within CRMO currently consists of 30 miles (48.3 kilometers) of paved roads maintained by both the NPS and Idaho Department of Transportation. One hundred thirteen miles (181.9 kilometers) of improved roads are maintained by Blaine, Butte, Lincoln, Minidoka, and Power counties as appropriate and the BLM within the CRMO boundary. Natural surface roads comprise 396 miles (637.3 kilometers) of the transportation network and are primarily maintained by the BLM with some county maintenance.

In addition, 173 primitive roads are constructed within the CRMO boundary but are not maintained (NPS 2007).

Fourteen miles (22.5 kilometers) of trails are maintained within CRMO. The trail system is comprised of seven miles (11.3 kilometers) of Class 1 which limit motorized or mechanized use on the trail. One mile (1.6 kilometers) of primitive trail is located in the park as are six miles (9.7 kilometers) of pristine trails (NPS 2007). In addition, some expansion of the North Flow Trail is being considered to allow for improvements in the surface and grading; with improvements the trail will be wheelchair accessible (NPS 2011b). Figure 17 shows the roads and trails network within and surrounding CRMO.

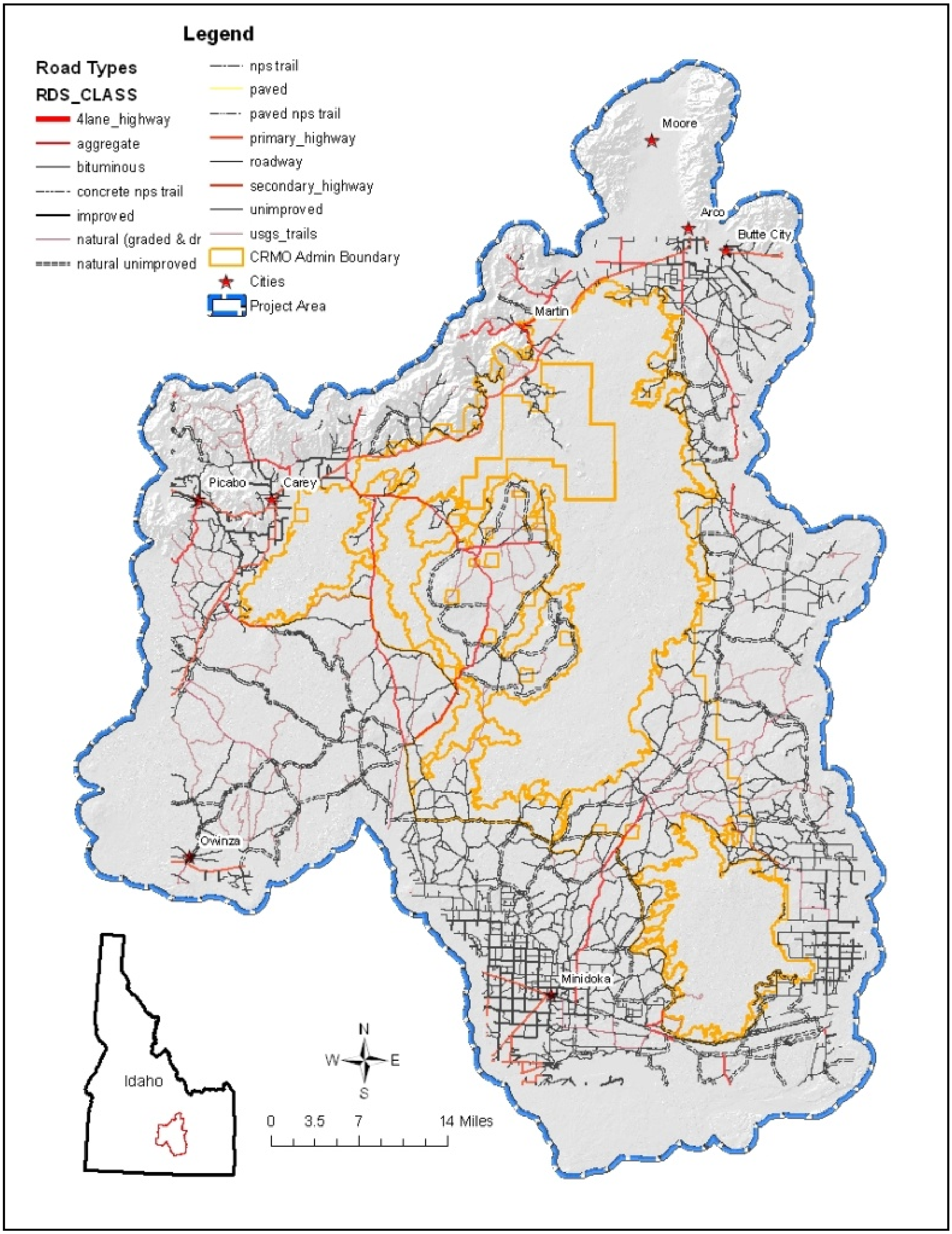


Figure 17. Road and Trail Network Within and Adjacent to CRMO.

Grazing

Animal unit months (AUM) of livestock grazing equaling 36,965 head are permitted on 286,487 acres within CRMO (NPS 2007). An AUM represents the amount of forage needed by a mature 1,000 pound (454 kilogram) cow and her suckling calf (typically 26 pounds (11.8 kilograms) of dry matter/forage per day or 780 pounds (354 kilograms) per month). Permitted lands include nine grazing allotments on BLM, private, and state lands; the allotments are administered by three BLM field offices (Burley, Craters of the Moon, and Shoshone) in the Twin Falls District (NPS 2005). Livestock developments (e.g., fencing, cattle guards, water ponds, etc.) are the primary tools used by ranchers and public land managers to control the distribution of stock grazing within the allotments. Cattle guards control livestock movement between some of the allotments (NPS 2005); other allotments use natural boundaries to restrict livestock movement. Figure 18 shows the grazing allotments and administration of the allotments within and surrounding CRMO.

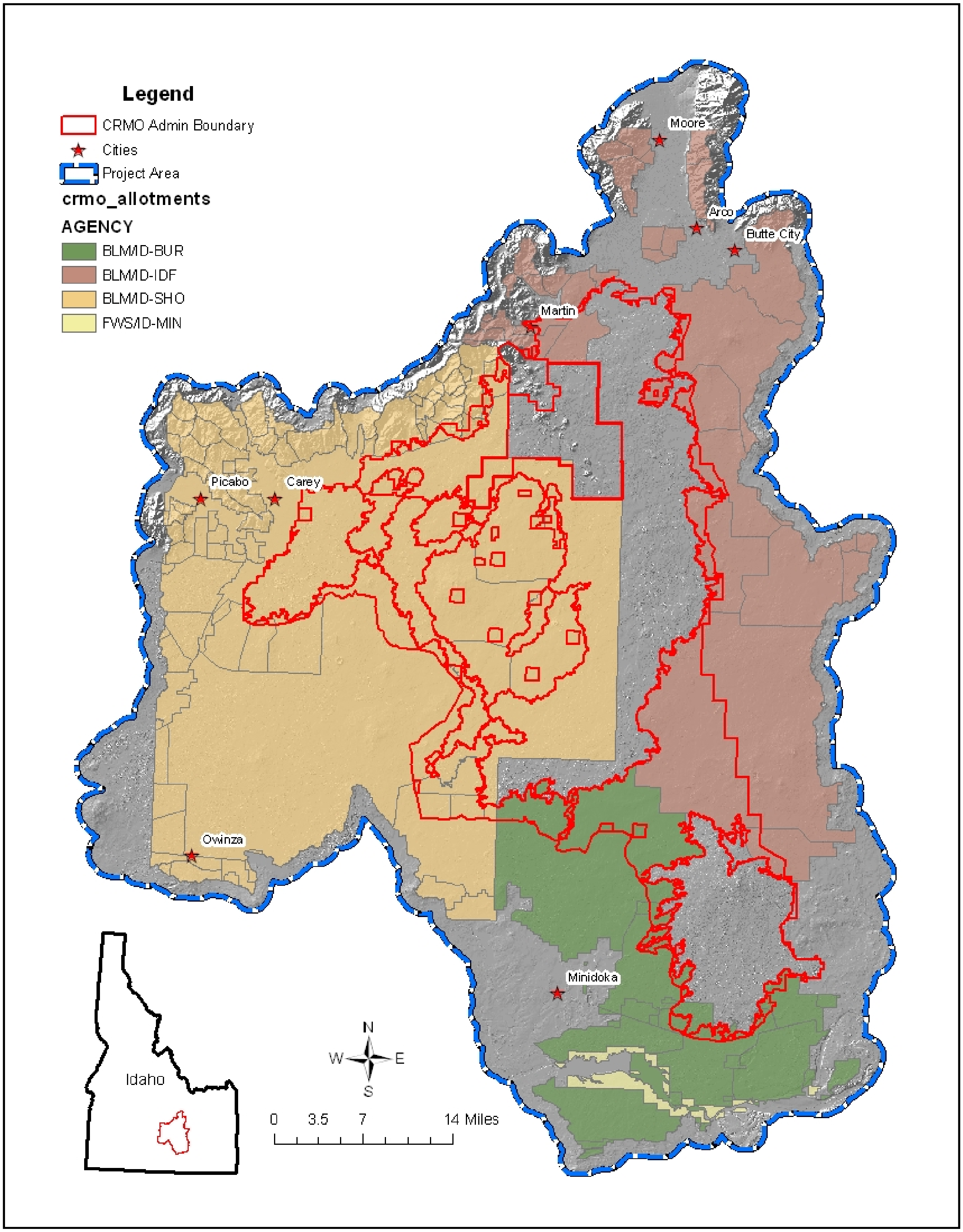


Figure 18. Management Agencies, Grazing Allotments, and Cities of CRMO and the Region.

Monitoring

The Land Use Feature dataset in the CRMO geodatabase contains classes pertaining to human development, ownership, land classification, and infrastructure. Several layers in the dataset are specifically associated with infrastructure in and around the CRMO administrative/headquarters area. Major road and utility features were gathered from public agencies and private organizations with some overlap in coverage. Table 15 lists the feature classes or themes, file names, and other information within the CRMO Land Use Feature dataset.

Table 15. Land Use Features within CRMO.

Land Use Themes	Geodatabase File Name	GIS Acres	Number Parts	Length Ft	Length Miles
FCC ASR Towers	ASR_towers_sgca		8		
Cell Phone Towers	cell_towers_sgca		3		
Vegetation Polygons	craters_veg_data_poly		134		
Roads from BLM	CRMO_Roads_BLM				3280.5
Road Types	crmo_roads_smallset		15		2940
Headquarters Utility Locations	HQ_utility		19		
Headquarters Building Locations	Hqbldgs		7		
Headquarters Water System Locations	Hqwatsys		32		
FCC IBFS Com Towers	IBFS_towers_sgca		4		
Headquarters Irrigation System	Irigsys		143		
Land Ownership	Lanowners		12		
Municipal Boundary	municipal_boundary	619.0	2		
Railroads from Census Bureau	Railroad_census				79.6
Railroads from Idaho Dept Water Res	Railroad_IDWR				103.9
Recreational Opportunities Spectrum	recroppo_id_icbemp		5		
Headquarters Sewer System	Sewsys		13		
General Landuse	strata_a_id		9		
Headquarters Structures	Structures		148		
Transmission Lines	Transmission_Lines				205
Utility Types	Utility		4		
NWS Weather Stations	Weather_Stations		4		

The General Land Use Feature class (strata_a_id) listed in Table 16, provides a general overview classification of the homogeneous land use areas of the region and illustrates 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 these are intended for display and analysis at the state level and are limited for use at the landscape level. For example, per Table 16, the majority of area clearly identifiable on aerial photography as rangeland or “non-agriculture” is classified as “lightly cultivated”. Table 16 also identifies the various classified land units within the General Land Use Feature class along with the acreage of each unit within the CRMO project area.

Table 16. Tabulated Land Use Acres for CRMO.

General Landuse USDA-NASS (strata_a_id)	Acres	% Total Area
> 50% Cultivated	8,183.2	4.4
Snake River, Intensive Cultivated	101,800.9	5.6
15% - 50% Cultivated	23,202.8	1.3
Snake River, Extensive Cultivated	57,125.6	3.1
Agri-Urban: > 20 Homes per Sq. Mi.	2,654.1	0.14
Lightly Cultivated (SPEC 40: S-Cen)	1,538,218.8	84.0
Lightly Cultivated (SPEC 40: South)	30,438.4	1.6
Non-Agricultural	59,416.9	3.2
Water	9,298.8	0.5

Another feature class in the Land Use Feature dataset is Recreational Opportunities Spectrum (ROS). This somewhat limited layer, developed through the Interior Columbia Basin Ecosystem Management Project, displays the recreational opportunities the visiting public can reasonably expect to experience on federal lands in the Columbia Basin. The following table (Table 17) lists the various attributes in this layer along with the acreage of each attribute.

Table 17. Land Use Attributes within CRMO.

ROS Code	ROS Class	Acres
NODATA	No Data	37,585
NULL	Private or Not Inventoried	281,851
P/SP	Primitive/Semi-Primitive	533,727
R/U	Rural/Urban	202
RN	Roaded Natural	976,975

The following figures/maps (Figures 19 and 20) display the General Landuse (USDA-NASS), Recreational Opportunities Spectrum (ROS), and Ownership feature classes in the Land Use Feature dataset along with utilities and other infrastructure features.

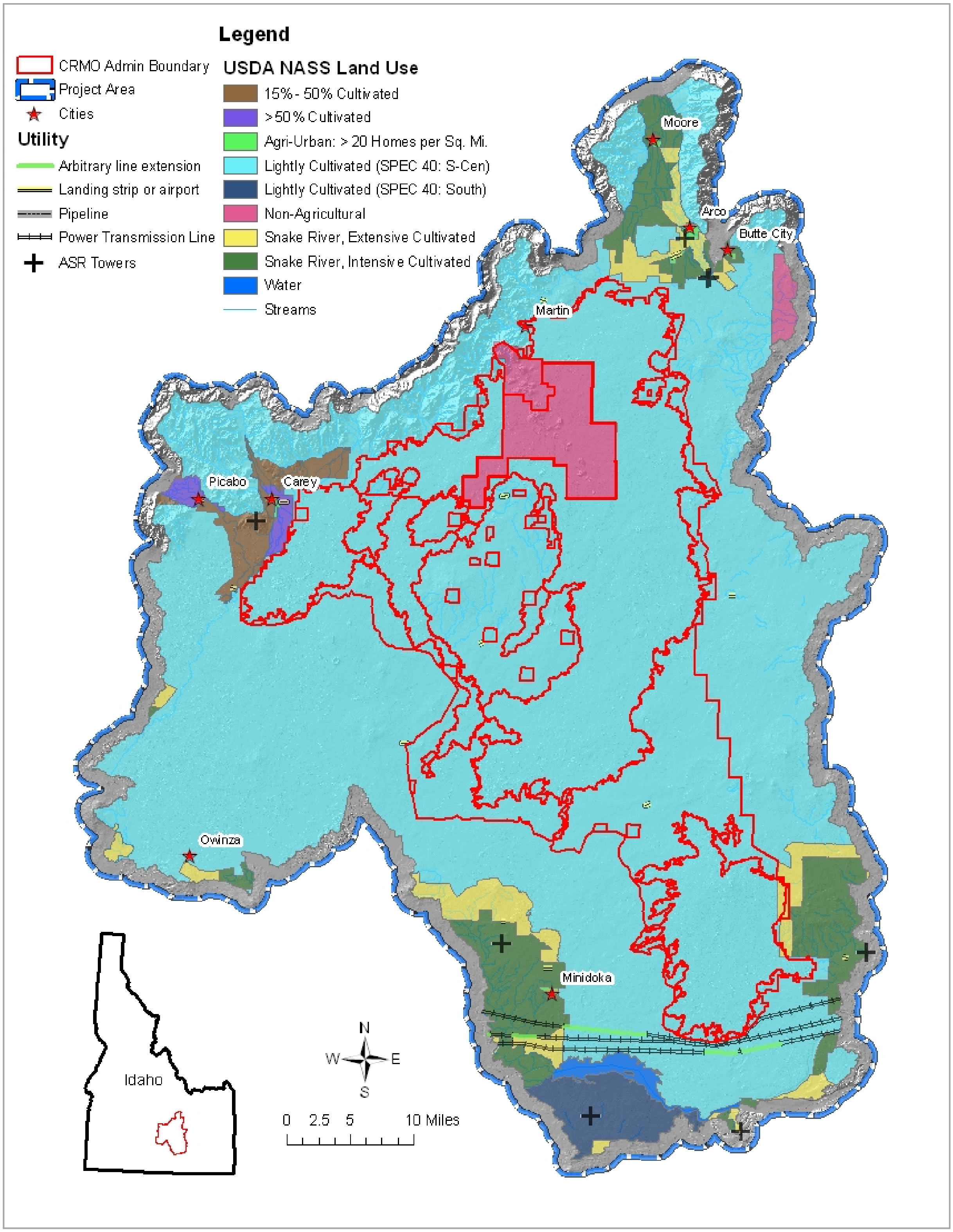


Figure 19. USDA NASS Land Use for CRMO.

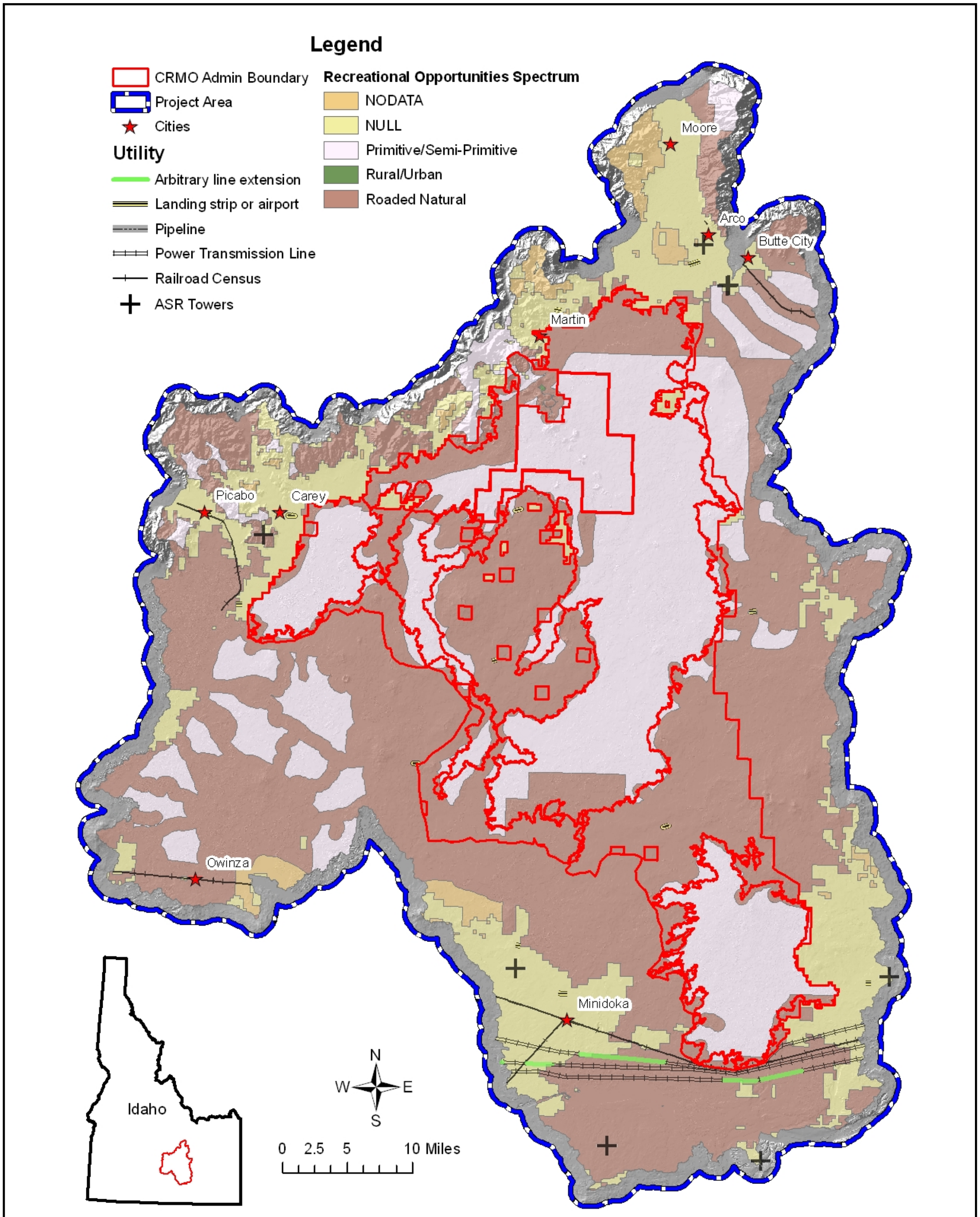


Figure 20. Recreational Opportunities in CRMO.

A total of sixteen map units (3 geology and 13 land-use/land-cover) were developed (Table 18) to describe sites that were unvegetated or were vegetated with non-native plant species and crops (Bell et al. 2009). Because these data extend 2.0 kilometers (1.24 miles) outside the CRMO boundary, they provide an important baseline established on 2007 digital aerial imagery from which to monitor adjacent land use. For example, in 2007 there were approximately 8,095 hectares (19,989 acres) of cultivated cropland within 2.0 kilometers (1.24 miles) of the CRMO boundary (Table 18). Additionally, the spatial distribution of the cropland is available on the 2009 vegetation and land use map as an electronic GIS layer. A reasonable time span to conduct monitoring for land use changes would be approximately every five years, or some proximity as new aerial imagery becomes available for interpretation.

Table 18. Land Use and Unvegetated Geologic Exposures Within and Adjacent to CRMO.

Map Unit	Map Unit Description	[1]NPS Polygons	NPS Acres	NPS Hectares	[2]TPA Polygons	TPA Acres	TPA Hectares
39	Barren Pahoehoe Lava: Unvegetated pahoehoe lava beds and exposures.	561	8,098.6	3,279.9	584	8,137.4	3,295.6
40	Barren Aa Lava: Unvegetated aa lava fields and exposures.	2,028	41,880.7	16,961.7	2,055	42,029.7	17,022.0
41	Barren Cinders: Unvegetated cinder cones.	21	357.7	144.9	21	357.7	144.9
42	Stream / River: Natural linear drainage features	0	0.0	0.0	9	26.1	10.6
43	Canal / Ditch: Man-made linear water conveyance systems.	10	190.0	77.0	53	387.8	157.1
44	Lake / Pond: Natural and small human-made water impoundments.	7	2.7	1.1	331	410.8	166.4
45	Reservoir: Large human-made water impoundment.	0	0.0	0.0	4	175.0	70.9
46	Residential: Single-family housing.	0	0.0	0.0	24	37.3	15.1
47	Agricultural Business: Ranch/Farm facilities.	4	1.6	0.6	147	407.1	164.9
48	Transportation: Paved and Earthern Roads.	180	317.1	128.4	336	2,874.7	1,164.3

Map Unit	Map Unit Description	[1]NPS Polygons	NPS Acres	NPS Hectares	[2]TPA Polygons	TPA Acres	TPA Hectares
49	Quarries / Strip Mines / Gravel Pits: Sites disturbed by humans to extract sand, gravel, rock or other minerals	0	0.0	0.0	3	15.4	6.2
50	Bare Rock / Sand / Other Bare Ground: Unvegetated bare rock / sand / bare ground.	13	21.6	8.7	348	620.4	251.3
51	Planted / Cultivated: Tilled and cropped agricultural fields.	45	95.2	38.6	201	20,084.3	8,134.1
52	Airstrip: Paved or earthern landing strip.	0	0.0	0.0	4	28.8	11.7
53	Orchards, Groves, Vineyards, Nurseries, and Horticultural Areas: Planted woody vegetation used for fruit production.	0	0.0	0.0	17	15.9	6.4
54	NPS Facilities: Visitor center, Headquarters, Housing, Maintenance yard, etc.	5	7.5	3.0	5	7.7	3.1
	Total Land use / Land Cover	264	635.7	257.5	1,170	25,091.3	10,162.0

1 – National Park Service within CRMO boundary. 2 – Total Project Area including CRMO plus 2.0 kilometers (1.24 miles) of adjacent environs (Bell et al. 2009).

Threats and Stressors

While conducting this assessment it was very apparent that a major threat to the natural resources at CRMO are from possible future changes on adjacent private, BLM, and USFS administered land (CRMO is bordered by both private land and federally administered land). Some of these changes can already be seen as evidenced by the conversion of sagebrush-steppe to agricultural crop production areas to the southeast of the Wapi Flow (nearly to the eastern CRMO boundary) and by the continued grazing of livestock on areas surrounding CRMO. All of these changes to the landscape may be compounded by new management policies that include the possible establishment of wilderness areas, joint management agreements (to increase or decrease grazing), and the establishment of management zones (NPS-BLM 2007). Combined, the restriction or creation of more recreational lands could put more pressure on neighboring lands and result in fire suppression, denial or continuation of grazing leases, increased recreational access or use and increased pressure from urban expansion.

Any change in existing land uses can lead to significant changes in the environmental conditions of CRMO and vicinity. An example occurs near the southeast boundary where agricultural land is often identified for development of rural homesites because of the gentle topography, cleared surface, developed groundwater, and reduced costs for infrastructure development. NPS-managed land will not be developed, which makes adjacent land attractive for private development. Additional homes and other developments, such as roads and recreation facilities, will increase susceptibility to social trailing by homeowners, invasive plants, roving domestic pets, and may negatively impact habitat value and use of park land by sensitive wildlife species. Future development could negatively affect surface water flow and quality by changes to natural landscape patterns and percolation to the ground water table. Development would likely include excavation and construction that would redirect and concentrate surface water flow and increase flow velocity/erosion potential; hard surfaces would prevent water infiltration, increase overland flow, and would add sediments and pollutants affecting water quality. Water quality could be further affected by drilling/pumping ground water wells, leaking septic systems, pesticide application to landscaped areas, and irrigation of landscape vegetation. Trespass issues may also increase in areas where the park boundary is not well marked.

Loss of habitat due to conversion of land use can lead to changes in the environment which may further threaten rare and/or sensitive wildlife species described herein. Development and human presence whether for agricultural purposes or rural home sites may disrupt the migration patterns of wildlife and would further fragment the important habitat extant in and near CRMO. Some non-native mammal and bird species would likely become more abundant or new species introduced to CRMO and some tolerant native wildlife species may be attracted to the agricultural/residential landscapes along the boundary. Additionally, development may have a measurable negative effect on the air quality within and surrounding CRMO.

Data Gaps

An initial inventory of the land use and the associated land cover provides park managers with key information related to the status and the extent of the ecological systems. Analyzing and monitoring the changes in land use can indicate changes in these systems which may be detrimental to CRMO ecosystems and the wildlife associated with some of the important plant communities established within CRMO. A long term monitoring program incorporating annual to five-year updates should be employed at CRMO to provide managers with this important information. It is important that CRMO staff stay informed and be active as necessary in local and county planning meetings, federal agency planning meetings, noxious weed districts, state natural resource agency planning and monitoring programs, federal natural resource agency monitoring programs, and provide comments to draft NEPA documents prepared to address potential development in the region. Public outreach programs focused on the unique resources of CRMO and responsible ownership actions adjacent to the CRMO border would be invaluable to help preserve the natural resources.

Climate

Idaho lies entirely west of the Continental Divide and numerous mountain ranges act as barriers to the free flow of air (WRCC 2011). Comprising rugged mountain slopes, canyons, high grassy valleys, arid plains, and fertile lowlands, the CRMO region reflects in its topography and vegetation a range of local climates. Even though located some 300 miles (483 kilometers) from the Pacific Ocean, Idaho is influenced by maritime air borne eastward on the prevailing westerly winds (WRCC 2011). Particularly in winter, the maritime influence is noticeable in the form of greater: (1) average cloudiness, (2) frequency of precipitation and (3) mean temperatures (above those at the same latitude and altitude in midcontinent). The eastern Idaho climate has a more continental character than the west and north, evident in the somewhat greater range between winter and summer temperatures and in the reversal of the wet winter-dry summer pattern (WRCC 2011).

Climate change will fundamentally alter the ecosystem within CRMO. Currently, the temperature can reach over 170 ˚F (76°C) on the surface of the lava (NPS 2011), however, the average high air temperature within CRMO is 85°F (29.4°C) during July, the hottest month (WRCC 2011). With climate change, temperature is expected to increase globally by 2–4 ˚F (1–2°C) with some localized variation (Aston 2010). Additionally, summers are expected to be drier and winters are expected to be wetter resulting in higher evaporation rates of rainwater and rapid snowmelt which would result in less available water for both the common and unique plant communities of CRMO (NPS 2011).

Accelerated global climate change may be the most far-reaching and consequential challenge facing NPS natural resource managers (UCBN 2011). The Intergovernmental Panel on Climate Change (IPCC), a scientific intergovernmental body formed from the World Meteorological Organization and the United Nations Environment Program, focuses on climate change impacts, adaptation, and vulnerability (Parry et al. 2007). The IPCC has generally noted climates in the region becoming warmer and drier and has also identified affects between climate change and terrestrial ecosystems in North America (Field et al. 2007, Parry et al. 2007). Reported changes included variations in seasonal precipitation and temperature, timing of life-cycle events, plant growth or primary production, and biogeographic distribution. Increased temperatures and variations in precipitation also support wildfires through extended summer seasons that cause a reduction in fuel moisture levels (Running 2006). In the last three decades burn duration of large wildfires has increased and the wildfire seasons in the western U.S. are estimated to have lengthened by approximately 78 days in response to spring/summer warming of 1.6 °F (0.87 °C) over average temperatures (Westerling et al. 2006).

The threats to CRMO resources from climate change include altered precipitation patterns, seasonal weather patterns, and temperature that could lead to degradation of habitats, loss of or shifts in biodiversity, and species composition changes. Climate change could alter available water regimes through alteration of precipitation patterns; alteration could result in larger spring-season flows, increased flood stage, and induce hotter, drier summers. These climate change effects would pose a threat to the American pika, pygmy rabbit, Greater Sage-grouse, Clark's Nutcracker, pronghorn and other species of management concern for CRMO. Local or regional changes on a large scale would impact natural resources of CRMO, including water availability, soil development, possible migration patterns of animals (may lose seasonal benefits the area previously provided and competition from species capable of using the altered environment), encroachment of invasive, non-native, noxious, and otherwise undesirable plant species, and overall diversity of local species composition.

Condition

The IPCC Working Group II focuses on climate change impacts, adaptation, and vulnerability. Parry et al. (2007) published a technical summary of their most recent findings and listed below are a few of the notable findings from the report:

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

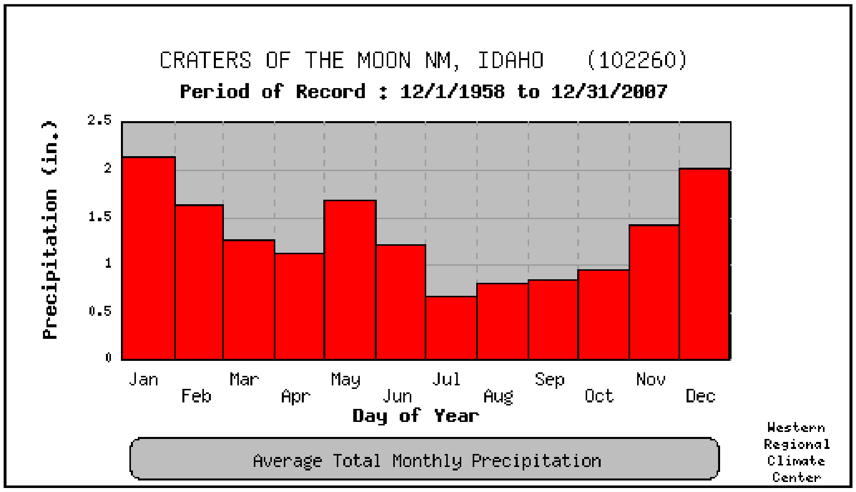
The IPCC Working Group II published reports on many areas of the world. North America was addressed by Field et al. (2007) which documented three observable connections between climate change and terrestrial ecosystems. Changes occurred in seasonal timing of life-cycle events and phenology, plant growth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

In general, plants green-up and flower earlier in the spring and leaf drop occurs later in the fall; primary production has increased in North American forests over the past ten years (Boisvenue and Running 2006). Nesting and breeding behavior occurs earlier, migration occurs earlier and migratory species stay longer. Some species are shifting home ranges to higher elevations or to more northern latitudes.

A warming climate supports more wildfires because of a longer summer period that further reduces fuel moisture promoting easier ignition and faster spread (Running 2006). Westerling et al. (2006) found that in the last three decades the wildfire season in the western U.S. has increased by 78 days and burn durations of fires greater than 1,000 hectares (2,480 acres) in area have increased from 7.5 to 37.1 days, in response to a spring/summer warming of 0.87°C.

The Joint Institute for the Study of Atmosphere and Oceans (JISAO) is a cooperative institute between the National Oceanic and Atmospheric Administration (NOAA) and the University of Washington. JISAO has published a report titled "Impacts of Climate Variability and Change in the Pacific Northwest" (Mote et al. 2005). The modeling predicts warmer, wetter winters, an increase of 3.1° F. by 2030 and a 5% increase in precipitation which would mostly occur in the form of rain with smaller snowpacks. Additionally, predicted seasonal stream flows will shift markedly toward larger winter and spring flows and smaller summer and autumn flows (Hamlet and Lettenmaier 1999). The changes in flows will likely coincide with increased water demand, principally from regional growth, but also induced by climate change.

Climate features included in the CRMO Geodatabase include data layers showing the average precipitation and temperature within the CRMO region (Figures 21 and 22). Annual precipitation ranges from 9.6 inches (24.4 centimeters) at Arco (Station 100375), 15.5 inches (39.4 centimeters) at CRMO (Station 102260), and 33 inches (83.8 centimeters) at the highest elevation in the Pioneer Mountains northwest of the park boundary (WRCC 2011). Snowfall contributes to the annual precipitation with 89.4 inches (227.1 centimeters) falling in CRMO and 59.2 inches (150.4 centimeters) falling in Arco (WRCC 2011). Temperature ranges from 29-49 degrees C (84-120 degrees F) annually based on these data layers; at the CRMO Meteorological Station (102260), average low and high temperatures range from minus 6 to plus 12 degrees C (21-54 degrees F)



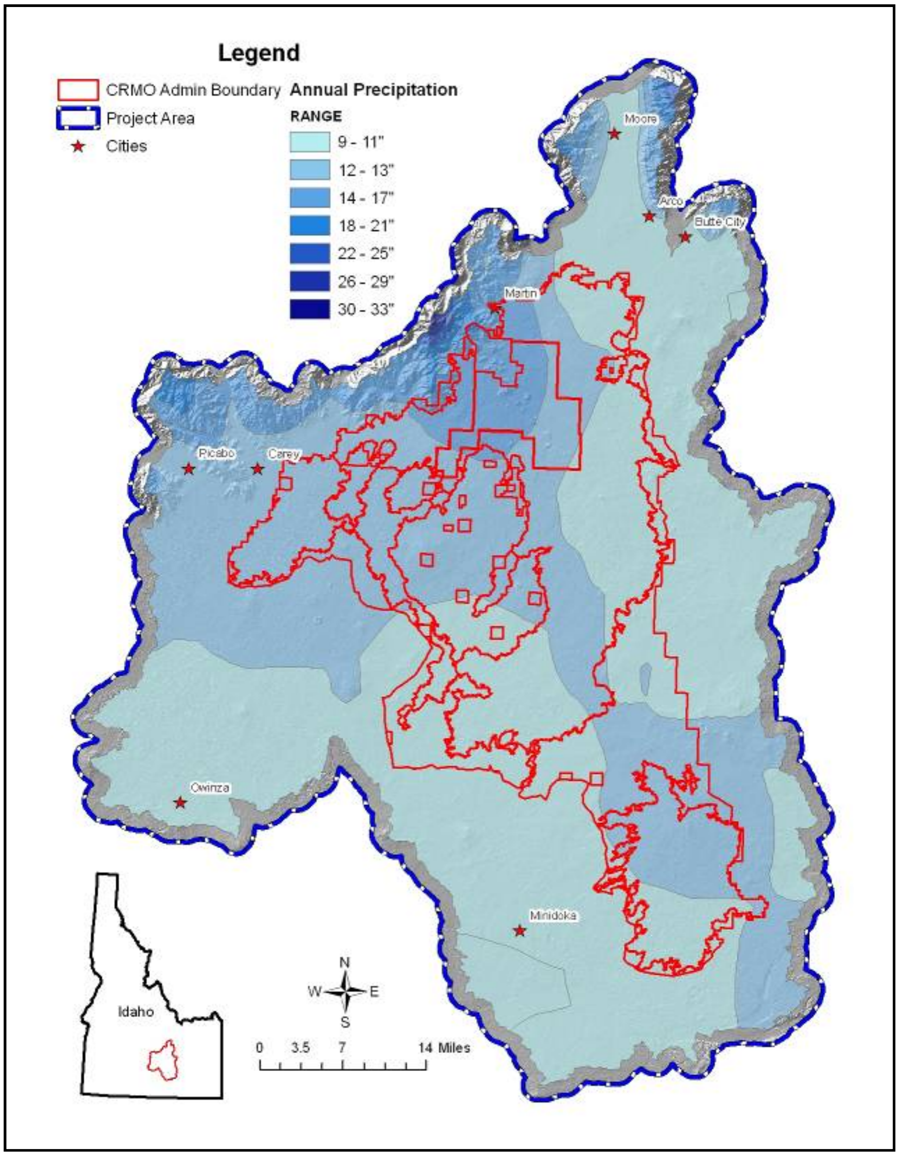
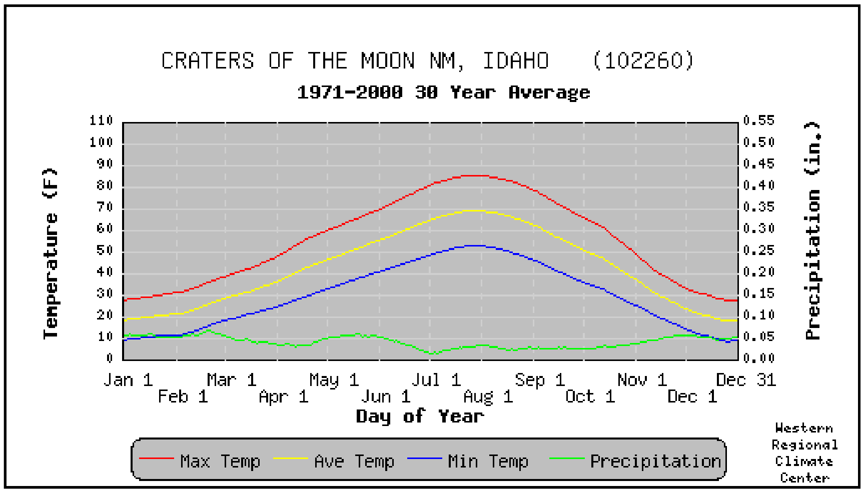


Figure 21. Average Precipitation and Precipitation Gradients for the CRMO Region.



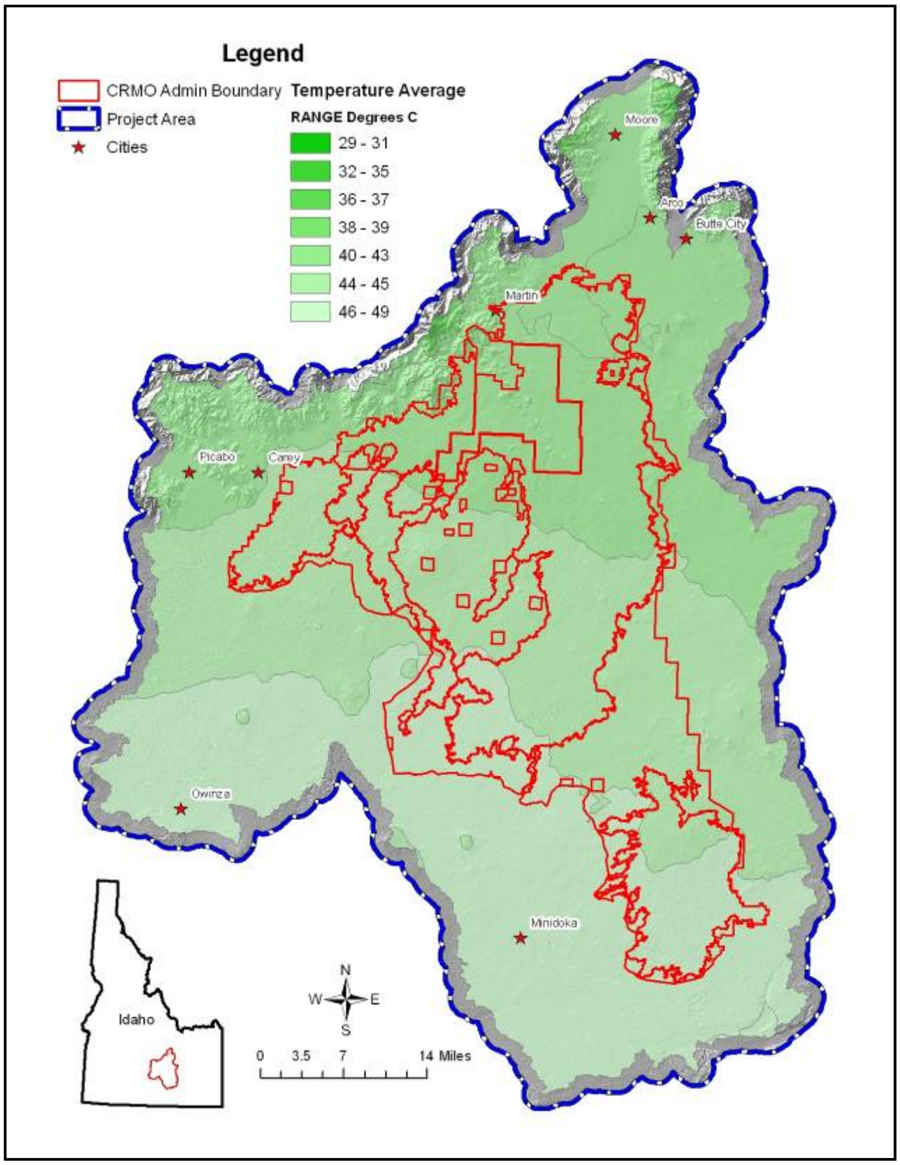


Figure 22. Average Temperature and Tempature Gradients for the CRMO Region.

Monitoring
Climate is an additional factor which contributes to the diversity of park units and also presents a potential stress to many ecosystem components. The UCBN is committed to tracking changes in member park natural resources that may be influenced or caused by accelerated climate change and monitoring activities would contribute to fulfilling this commitment. The direct and indirect impact of predicted changes in climate on natural resources within CRMO is complex and difficult to manage. Climate changes could be positive or negative depending on the ecosystem processes, communities, and/or species under consideration. Plant and animal species dependent upon existing conditions, including amphibians and aquatic reptiles, could experience possible habitat disruption. Warming temperatures may also alter the composition of plant communities and allow non-native plant species to invade from warmer regions.

Listed below are specific effects on species and ecosystems attributed to global climate change (Mawdsley et al. 2009).

(1) Shifts in species distribution, often along elevation 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 inland habitat due to increased fire frequency, bark beetle outbreaks, altered weather patterns, and direct warming of habitats.

(8) Increased spread of wildlife diseases, parasites, and zoonoses (an infectious disease in animals that can be transmitted to humans).

(9) Increased populations of species that are direct competitors of focal species for conservation efforts.

(10) Increased spread of invasive or non-native species, including plants, animals, and pathogens.

Mawdsley et al. (2009) identified 16 adaptation strategies in the four major adaptive strategy categories to conserve species and ecosystems from the effects of global climate change. Many of the strategies are focused at the national and regional level and would not be applicable to individual park units. The major category titled “Strategies Related to Monitoring and Planning” identifies four adaptation strategies that could be implemented at the park level: (1) evaluate and enhance monitoring programs for wildlife and ecosystems, (2) incorporate predicted climate-change impacts into species and land management plans, programs, and activities, (3) develop dynamic landscape conservation plans and (4) ensure wildlife and biodiversity needs are considered as part of the broader societal adaptation process.

The Climate Friendly Parks Program was funded through July 2009 via an interagency agreement between the NPS and the EPA. NPS assumed full funding for the program in August 2009. The program encourages and enables national parks to develop strategies to reduce greenhouse gas emissions. The program also entails a commitment on the part of participating parks to educate the public about the actions the park is taking to mitigate emissions.

The Pacific West Region has been working to have member parks be Climate Friendly Parks. NPS interpreters have been working in partnership with NASA and other scientists to develop climate change training materials and interpretive products such as brochures and exhibits. NPS, in cooperation with the EPA, BLM, FWS, USFS, the NASA, and NOAA, developed a product entitled "Climate Change: Wildlife & Wildlands, a Toolkit for Formal and Informal Educators." The kit will aid educators in teaching how climate change is affecting the U.S. wildlife and public lands, and how citizens can become "climate stewards." The toolkit is available online at http://www.globalchange.gov/resources/educators/toolkit. The information, expertise, and management concerns that the NPS provides for many external decision-making arenas have made a difference in the past and will continue to do so in the future. The NPS-ARD is providing guidance, data, and information to assess air quality conditions for ozone, deposition, and visibility as part of the CRMO NRCA; Air Quality Guidance for Natural Resource Condition Assessments is available Online at: http://www.nature.nps.gov/air/planning/index.cfm.

Threats and Stressors
A change in climate will have a broad ecological affect on much of the habitat established or exposed within CRMO. Species dependent on critical habitat like that of the sagebrush steppe shrubland, limber pine woodland, or quaking aspen forest stands will likely migrate upslope or to the north (Ashton 2010, NPS 2011). The rate of change is expected to be variable depending on other stressors in the environment which may include wildfire, the occurrence of invasive species, or changes in land use (Ashton 2010). The threat of changing climate is real, and research points to the likelihood of broad ecological changes as a result. An important and immediate trend to monitor and consider is the warmer and drier summer periods (NPS 2011).

The temperature in the Northern Rocky Mountains has increased by 2 – 4 ˚F (1-2 ^{o}C). The resulting amount of change in regional and local plant communities is not well understood at this time but some change will likely occur due to reduction in the water holding capacity of soils and available water in general. Other research suggests that with the higher temperatures and likelihood of changes in the plant communities, an increase in invasive and non-native plant species is possible (Ashton 2010). Research suggests that biodiversity is a likely casualty of changing global temperature (Ashton 2010). Threatened, endangered, and sensitive species are likely to be most negatively affected by climate change. The species particularly susceptible to change are those linked to specific vegetation/environments like those that occur within CRMO.

With an increase in temperature and the loss of available water, wildland fires are expected to increase in frequency and severity. While much of the habitat established or exposed within CRMO is not susceptible to large fire, the surrounding environment would support large-scale fires. This is especially true in the areas administered by the BLM such as Laidlaw Park and the Cottonwood Creek area on the north end of CRMO. Ashton (2010) notes an increase in total acres burned is likely the first indicator of climate change.

Data Gaps
The direct and indirect impact of predicted changes in climate on natural resources of CRMO is a complex and difficult issue to address. Changes could be positive or negative depending on the

ecosystem processes, communities, and/or species under consideration. CRMO managers should review which plant and animal communities and/or species of special interest could be affected and address the possible impacts of the predicted changes in climate to each entity, individually. Where possible, plans could be developed to mitigate potential negative impacts to natural communities and/or species.

Since climate is the product of long-term weather variables, simply initiating weather data collection now will not yield useful information for some time unless it is used to calibrate the dataset available for CRMO. Climate data should continue to be collected, added to the long-term CRMO and regional databases, and modeled for developing short- and long-term trends.

Utilizing vegetation mapping products produced by Bell et al. (2009), it is possible for CRMO to maintain a basic phenological information dataset. Using this dataset can quantify changes in plant phenology and associations over a relatively short period of time. Park managers can identify specific events or changes in plant associations which could be used to identify early changes in the broader ecological system.

Summary Discussion and Recommendations

This NRCA used GIS databases for primary analyses of upland and aquatic plant communities. All GIS data layers were imported into an ArcGIS File Geodatabase using ArcCatalog version 9.3. In addition, all currently available and relevant reports and publications were identified and reviewed to inform the introduction, results, natural resources analyses and these summary and recommendation statements. Threats and stressors thought to be the most important to management of CRMO natural resources were examined using available information and a summary of existing information. The conclusions and recommendations are provided in the following subsections.

Fire

Fire is a major disturbance event and the influence of fire at CRMO is consistent with other areas of the Snake River Plain (NPS 2000). The effect of fire can be observed in almost all vegetation types. The establishment of cheatgrass in much of the central and western portions of the Snake River Plain has been promoted by fire and in some areas cheatgrass has replaced native shrub species following resulting in the loss of critical sagebrush-steppe habitat. However, historic fire regime mapping within CRMO has not been specifically assessed as of the date of this publication making it challenging to infer effects over time. The presence or absence of natural fires within a given ecosystem is recognized as an important factor promoting, slowing, or eliminating various components of an ecosystem. The CRMO fire management program is designed around resource management objectives.

Historically and prehistorically, fire was the most prevalent natural and human-ignited disturbance process in the extant ecosystems. Fire is the dominant process influencing composition, diversity, energy, and nutrient cycles (Kauffman et al. 1997). Wildfire originating within or adjacent to CRMO lands poses a threat to the upland resources, particularly due to the establishment of undesirable weed species and degradation of unique kipuka environments. Depending on the fire intensity and extent, effects could range from woodland or shrubland stand removal and replacement to combustion of fine fuels or thinning of understory shrubs and herbaceous growth. The former scenario would reduce the overall wildlife habitat structure for many species, although there may be increased use by grazing species; ground surface cover would be removed (increasing soil erosion potential and potential for non-native plant species invasion/establishment).

During 1992 a large area (approximately 2,000 acres) of contiguous vegetation in the Little Prairie area located in the southeast corner was burned by a wildfire (NPS 2000). Many charred limber pine boles are all the tree remains in this area which is now covered by sagebrush shrublands with grass understory vegetation in the Split Butte area. Small areas around Two Point Butte and Fissure Butte show signs of recent fire, however, these fires appeared to be very localized due to constraints on fire spread by surrounding lava flows. Farther north around Crescent Butte, there are also burned boles of standing limber pine that remain dotting the area indicating the presence of fire. Other fire evidence has been noted in the Big Cinder Butte area and in the vicinity of Tree Molds parking area (NPS 2000). Fire has influenced the composition of vegetation communities across CRMO; some areas once dominated by big sagebrush are now composed of rubber rabbitbrush and in some areas undesirable weed species.

The plant communities north of Highway 93 were thought to be more influenced by fire than those to the south (NPS 2000). Almost all the vegetation within CRMO was said to show evidence of fire, with the exception of the dwarf sagebrush ecosystems along ridge tops which have been observed to be resistant to carrying fire (Gipe 1976, Bunting et al. 1987). Some dwarf sagebrush communities were observed to act as natural fire breaks due to resistance to ignition and sparse fuels buildup (NPS 2000). Currently a majority of the landscape consists of pockets of vegetation surrounded by barren lava flows and cinder fields potentially limiting the spread of many fires. However, the known sensitivity of limber pine to fire and its widespread occurrence throughout CRMO suggest fire frequencies are fairly long throughout, on average, and have been limited over large areas for some time.

Within CRMO land managers need to understand historical fire regimes, the fire return interval (frequency), and historic fire severity, to be able to define ecologically appropriate goals and objectives for management. Additionally, understanding ecosystem/community departures from expected conditions can provide the necessary context for managing sustainability. Information on historic fire regimes, burned area mapping and departure values could be incorporated into an updated fire management plan aimed at conservation and re-establishment of native species as well as curtailing the spread of noxious and invasive species for CRMO. For example, in the event of a wildfire where an invasive species, such as cheatgrass, is not presently abundant and may become more widely established, managers may want to focus their reclamation efforts on re-establishment of fire tolerant native species that can adapt to a changed ecosystem and out-compete cheatgrass thus reducing its proliferation.

Water Resources

The water resource survey for CRMO was accomplished during the field seasons of 1992 and 1993 by the University of Idaho. These surveys evaluated Leech and Little Cottonwood creeks on the northern CRMO area. The surveys entailed surface water discharge, macroinvertebrates, cave water resources, and stream channel and riparian characteristics. Macroinvertebrate data from Leech Creek showed a slightly different species composition than Little Cottonwood Creek by comparison. Leech Creek was dominated by a relative balance of Ephemeropterans (mayflies), Dipterans (two-winged flies), and Plecopterans (stoneflies) compared to Little Cottonwood Creek which exhibited a dominance of two-winged flies. The dominance of two-winged flies suggests the possibility of higher metal concentrations as two-winged flies are more tolerant of metals than the other groups. The lower site for Little Cottonwood Creek was located below the Martin Mine and water quality samples showed levels of arsenic and lead at 6.8 parts per billion (ppb) and 2.0 ppb, respectively (Falter and Freitag 1996).

Another water resource present within CRMO is the occurrence of ice and meltwater in caves. The caves found to have sufficient quantities of water for sampling were: Bear’s Den, Little Prairie Waterhole, Moonshine, and Boy Scout Cave. All the caves showed more water in 1993 than in 1992 as well as less turbidity, lower water conductivity, and better water quality. The 1993 data are assumed to be the result of increased snow accumulation during the winter of 1992-1993. Boy Scout Cave water contained higher levels of ammonia and nitrate than water in the other caves sampled. The higher levels were assumed to be from human wastes because the ammonia level was tested at 0.971 milligrams per liter (mg/L) and this cave is known to be a popular tourist site (Falter and Freitag 1996).

Throughout the 1992-1993 field season stream channel and riparian attributes were also recorded for Leech Creek and Little Cottonwood Creek. The riparian assessments were difficult to draw conclusions from as riparian vegetation and wetland-type conditions are scant or non-existent throughout most of CRMO. The northern CRMO boundary where Leech and Little Cottonwood Creeks are located contains sparse riparian vegetation however, during the survey stream beds were dry in 1992 and nearly entirely inundated in 1993. The results of identified vegetation and stream classifications can be found in the Appendices of Falter and Freitag (1996), and were not included in this report as different methods for stream and riparian area evaluation have been developed yielding substantially more comprehensive results and ratings for proper functioning condition (PFC) assessments of lotic areas (Prichard et al. 1998). The application of PFC assessments to the water resources of CRMO would aid natural resource managers in developing management plans for the intermittent yet critical water resources. Additionally, CRMO staff expressed the need for a survey and possible assessment of the occurrence and location of vernal pools within CRMO in order to understand their role and importance to the unique ecosystems and wildlife.

Animal Resources

The numerous species supported by the ecosystems and variable habitats that exist within CRMO is a testament to the importance of this Monument and Preserve. According to NPSpecies Database (2011) there are 183 birds, 47 mammals, seven reptiles, three amphibians and no fish which are certified as present or probably present. Currently, some species with the greatest management concern are; the Greater Sage-grouse, pygmy rabbit, Sage Sparrow, Brewer’s Sparrow, fringed myotis, and Townsend’s big-eared bat. Degradation due to cheatgrass, recreational use, nearby agricultural development, grazing, and road and power line right-of-ways negatively impact habitat critical to these species. In particular, the relationship of sagebrush-obligate birds and critical sagebrush-steppe habitat are directly correlated and any loss in habitat or changes in vegetative species composition has been shown to result in a downward trend in these avian populations (USGS 2002, Knopf et al. 1990, Rotenberry and Wiens 1980a).

The impacts of vegetative changes and land development are not fully understood in relation to sagebrush-obligate birds and bat species, however, research has shown that changes to this habitat type (cover, distribution, understory, etc.) can negatively impact these species. Habitat lost during wildfire is similarly detrimental to sagebrush-obligate species due to significant rapid changes in vegetation and potential permanent shifts in population due to decreased fire reoccurrence intervals and loss of mature sagebrush shrubs. The loss of sagebrush communities from fire tends to occur as a product of the slow maturation of sagebrush with relatively long time periods between the return of fire, 50+ years. In some cases these sites are entirely overtaken by invasive species such as cheatgrass which has the ability to out-compete much of the native vegetation and commonly decrease the fire return interval to as little as 5 to 10 years (Link et al. 2006, Whisenant 1990). The vegetation inventory project was completed by Northwest Management, Inc. with cooperation from the NPS in 2009 and is anticipated to aid in the identification of critical habitat types, through extensive vegetation mapping, species identification, and accuracy assessment field investigations. This digital information benefits NPS management conservation efforts with sagebrush-obligate species as well as other concerns related to CRMO vegetation.

Human disturbance in the form of recreational cave exploration, vandalism, and destruction/degradation of localized habitat poses the greatest threat to the five species of bats known within CRMO (Ave et al 2004). Currently the fringed myotis and Townsend's big-eared bat are listed as species of concern by both the State of Idaho and the FWS (Rodhouse et al. 2009, Ave et al. 2004, Wackenhut and McGraw 1998). The largest known threat to all bat species of North Americaand the little and big brown bats in CRMO is from the fungus (*Geomyces destructans*) which causes what is known as white-nose syndrome. The mortality in hibernating bat populations from white-nose syndrome is between 90 to 100% and is thought to primarily be related to starvation (USGS 2011). Humans may spread white-nose syndrome fungi and CRMO has established goals in response (Owen et al. 2011), as follows: (1) reduce risk of human-assisted spread of the fungi to bats, (2) allow bats to remain undisturbed, (3) allow visitor use of selected caves but apply screening techniques and (4) increase public awareness of white-nose syndrome. Visitation to remote caves at CRMO now requires an approved NPS research permit and no recreational permits to caves are issued. Currently five caves are accessible to the public via the recreational trail network and these will likely be evaluated in the future for the presence of bats. Further assessment of these caves and the impacts to cave ecosystems and specifically bats is a concern of CRMO staff. Whether these caves will be closed to public entry will be addressed by the additional research on local bat populations and the impacts of public visitation.

Additional monitoring of the bat species existing within CIRO is warranted to aid in determining critical habitat and any trends in species population numbers. Owen et al. (2011) indicated that bat populations of CRMO: (1) lack survey information, (2) are difficult to identify without handling, (3) are represented by only basic inventories, (4) need better inventory information including distribution and status and (5) were selected as a Vital Sign with protocol development to occur in 2012. Therefore, future bat research will include reconnaissance surveys; distribution and diversity studies; long-term status, population variability, and utilization patterns; and hibernacula and maternity colony counts.

Vegetation Classification and Mapping

CRMO supports a variety of plant communities serving as wildlife habitat varying from sagebrush-steppe and coniferous forest ecotones to rolling park-like kipukas, lava rock formations, and intermittent areas of riparian vegetation. CRMO is characterized by sagebrush-steppe shrublands, intermixed with limber pine forests, and grasslands distinguished by lava formation and islands. A certifeid list of plant species is available in NPSpecies Database (2011) and in NPS (2002).

To further understand the distribution of plant assemblages within CRMO, the NPS Vegetation Mapping (Inventory) Program funded the task to classify and map vegetation types in CRMO commencing in 2007 under the UCBN Inventory and Monitoring program oversight. The initial phase of the project was directed by NPS staff in conjunction with Northwest Management, Inc. and the Idaho Conservation Data Center to develop a vegetation classification using the National Vegetation Classification System (NVCS). The Final Vegetation Inventory Report and geodatabase was completed in 2009 by Bell et al., and is currently available on the NPS Inventory and Monitoring website.

The vegetation products and GIS databases completed for CRMO are an integral part of the threat and stressor analyses for plant and animal species as well as vital habitats. Particularly important is the use of accurate vegetation mapping to manage fire fuels potential and develop various future monitoring plans.

Threatened, Endangered, Sensitive, and Species of Special Concern (TESS)

Rare species within natural to urbanized habitats often become classified by federal agencies as sensitive, threatened, or endangered or are given a status rank by state agencies, typically heritage programs. TESS species within CRMO were determined using the certified species list (NPSpecies Database 2011), Idaho BLM, and FWS resources for rare animal and plant species within Idaho. Invertebrates, bryophytes, and lichens were not included due to lack of survey information within CRMO.

Of the 40 TESS wildlife taxa identified in the Monument Management Plan (NPS-BLM 2005) there were 11 mammals, 33 birds, three reptiles, and three invertebrates. Conversely two species are listed as threatened and 19 are listed as species of concern under federal designation with 18 species on the BLM watch list and 27 on the BLM sensitive species list. The State of Idaho status designations include one species listed as endangered and 11 listed as special concern species including the American pika and pygmy rabbit. A complete list of species of concern is presented in Table 19.

Table 19. Complete list of wildlife species of concern within CRMO prepared by the USFWS, BLM, and the State of Idaho.

Species	Status		
	Federal*	BLM**	Idaho***
Mammals			
Townsend's big-eared bat (*Corynorhinus townsendii*)	I	S	S
Western small-footed myotis (*Myotis ciliolabrum*)	I	W	
Long-eared myotis (*Myotis evotis)*		W	
Fringed myotis (*Myotis thysanodes)*		S	S
Long-legged myotis (*Myotis volans)*	I	W	
Western pipistrelle (*Pipistrelle idahoensis*)	I	W	S
Pygmy rabbit (*Brachylagus idahoensis)*	I	S	S
Kit fox (*Vulpes macrotis*)	I	S	
Piute ground squirrel (*Spermophillis mollis*)		S	
Birds			
White-faced Ibis (*Plegadis chihi*)	I	S	
Bald Eagle (*Haliaeetus leucocephalus*)	T		
Northern Goshawk (*Accipiter gentilis*)	I	S	S
Ferruginous Hawk (*Buteo ragalis*)	I	S	
Swainson's Hawk (*Buteo swainsoni*)		W	
Prairie Falcon (*Falco mexicanus*)		S	
Peregrine Falcon (*Falco pergrinus*)			E
Blue Grouse (*Dendrogapus obscurus*)		W	

Species	Status		
	Federal*	BLM**	Idaho***
Greater Sage-grouse (*Centrocercus urophasianus*)	I	S	
Columbia Sharp-tailed Grouse (*Tympaa nuchus phasianellus columbianus*)	I	S	S
Wilson's Phalarope (*Phalaropus bicolor*)		W	
Long-billed Curlew (*Numenius americanus*)	I	W	
Black Tern (*Chilidonias niger*)			S
Short-eared Owl (*Asio flammeus*)		W	
Western Burrowing Owl (*Athene cunicularia*)	I	W	S
Calliope Hummingbird (*Stellula calliope*)		S	
Lewis' Woodpecker (*Melanerpes lewis*)		S	
Red-naped Sapsucker (*Sphyrapicus nuchalis*)		W	
Williamson's Sapsucker (*Sphyrapicus thryoideus*)		S	
Olive-sided Flycatcher (*Contopus borealis*)		S	
Loggerhead Shrike (*Lanias ludovicianus*)	I	S	SA
Cordilleran Flycatcher (*Empidonax occidentalis*)		W	
Hammond's Flycatcher (*Empidonax hammondii*)		S	
Willow Flycatcher (*Empidonax traillii*)		S	
Pinyon Jay (*Gymnorhinus cyanocephalus*)		W	
Sage Thrasher (*Oreoscoptes montanus*)		W	
Green-tailed Towhee (*Pipilo chlorurus*)		W	
Grasshopper Sparrow (*Ammodramus savannarum*)		W	
Brewer's Sparrow (*Spizella breweri*)		S	
Sage Sparrow (*Amphispiza belli*)		S	
Black-tailed Sparrow (*Amphispiza bilincata*)		S	
Brewer's Blackbird (*Euphagus cyanocephalus*)		W	
Cassin's Finch (*Carposdacus cassinii*)		W	
Reptiles and Amphibians			
Western night snake (*Hypsiglena torquata*)		S	
Western toad (*Bufo boreas*)	I	S	S
Short-horned lizard (*Phrynosoma douglassi*)	I		

*Federal Designation (E=endangered, T=threatened, I= Species of Interest);
**BLM Designations (S=Sensitive species, W=Watch list species);
***Idaho State Designation (E=Endangered, S=Special concern)

There are two special status plant species within CRMO; the Obscure Phacelia (*Phacelia inconspicua*) and the Picabo Milkvetch (*Astragalus onicifomis*). Obscure Phacelia is rare Idaho species with six area occurrences statewide; it occurs on the north- and east-facing slopes of volcanic mountains and buttes (Slaton and Novey 2007). Picabo Milkvetch occurs on sandy soils in the north-central portion of the Eastern Snake River Plain (NPS-CRMO 2005).

Climate change within the regional area of CRMO resulting in drought, vegetation cover conversion to other land uses, water diversion to irrigate crops, and more rapid runoff would negatively affect TESS taxa. All vegetation communities within CRMO are subject to change over time; drought, insect outbreaks, and fire are the most likely agents of change in woodland

and shrubland communities, whereas encroachment of exotic plants threatens nearly all vegetation types. Because of recent regional drought and a predicted change over time to a warmer and drier climate, species of concern like the pygmy rabbit, American pika, Clark's Nutcracker, the Greater Sage-grouse, and other sagebrush-obligate bird species are threatened by change or loss of critical sagebrush habitat. While the sagebrush habitat favored by these species is abundant in CRMO, the status of these species is not well known.

Non-native Plant Species, Invasive Plant Species, and/or Noxious Weeds

The management and control of invasive non-native plant species has been identified as a high priority issue within the NPS and is a primary (accountable) goal under the Government Performance Results Act of 1993 (USDA 2011). Prevention and early detection of invasive plants and noxious weeds within CRMO is critical to effective management. Monitoring status and trend detection for a prioritized list of target invasive species would be a cost-effective approach that would rely on integration with other terrestrial vegetation monitoring efforts. CRMO staff would benefit from a concerted effort to locate, identify, and treat non-native plant species with proven procedures to guarantee that federally and state listed noxious weeds and other non-native plant species do not become established and replace native plant communities. Management of the 23 identified species of non-native and/or noxious invasive plant species within CRMO is important for responsible stewardship of the natural resources.

The Pacific Northwest Weed Management Handbook (Peachey 2008) describes five major options for land managers, summarized as follows:

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

Maintaining updated maps of occurrences and status of invasive plant species is a key element to an efficient strategic management program and will help ensure that park unit resources are used as effectively and efficiently as possible. A database comparing descriptions of status and maps that show the locations, sizes of invasive plant species occurrences, the invasive plant species present and their abundance, as well as treatment information would be invaluable. The data collected from inventory and mapping would provide fundamental information that could be used for assessing and prioritizing invasive plant management efforts. An invasive species management plan would serve the following purposes:

- Decrease invasive plant species cover and increase native plant species cover.
- Document and standardize best management practices to more effectively meet CRMO goals and objectives relative to invasive plant species management.

- Provide options or tools to managers in reducing the threat to natural and cultural resources.
- Use monitoring to more effectively implement and adapt management practices.
- Determine the minimum tool/treatment or combinations of treatments needed to restore functioning native plant communities.
- Develop a document that will meet required federal and state environmental compliance.
- Develop a document that will provide future direction for invasive plant species management projects that fall under its scope.
- Assist in restoring native plant communities and wildlife habitat to reduce the CRMO resources dedicated to invasive plant species control and removal.
- Cooperation with adjacent landowners, both private and public, is the most effective method to prevent and control noxious weeds.

From the analyzed GIS raster data, Stressors Feature dataset, historic undesirable species information from several agencies was acquired. Weed information in the geodatabase is a compilation of many data sources obtained from the Idaho Department of Agriculture. Table 20 summarizes specific weed species infestations by acres and year within the CRMO project area and Figure 23 depicts the location of known weed locations.

Table 20. Infestation acres of weed species 2000-2007 CRMO weed point feature class.

Species	2000	2001	2002	2003	2004	2005	2006	2007	Grand Total
Black Henbane		0.1		0.3	0.3	0.1		3.8	4.6
Buffalobur						0.1			0.1
Canada Thistle	0.1	0.2	3.3	19.2	125.1	21.3	11.5	51.1	231.8
Dalmatian Toadflax						0.2		0.1	0.3
Diffuse Knapweed		0.1	4	4.1	5.5	26.4	1.4	23.7	65.2
Dyers Woad		0.2	1	0.1		0.6	0.2	31.6	33.7
Field Bindweed		0.1	0.1	2.2	0.6	3	0.8	1.6	8.4
Houndstongue				4.3	0.4			9	13.7
Jointed Goatgrass						0.1			0.1
Leafy Spurge				83	117	7.8	139.2	111.6	458.7
Musk Thistle			3.5	0.5	0.6	20.2	1	0.5	26.3
Poison Hemlock				0.1	0.2	0.5			0.8
Puncturevine					0.1			0.5	0.6
Rush Skeletonweed			2	2.5	1.1	12.3	0.8	89.5	108.2
Russian Knapweed		0.5	0.7	19.9	7.6	0.1	6.5	2.3	37.6
Saltcedar			0.1	2.7	0.2	0.6	1		4.6
Scotch Broom			6.1						6.1
Scotch Thistle	0.2	33.1	25	30.4	26.4	11.7	107	20143.3	20377.1
Spotted Knapweed				15.2	17	39.8	5.9	35.4	113.3
Syrian Beancaper		0.4				0.1		0.2	0.7
White Bryony				5.6				5.5	11.1
Whitetop		0.1	0.1	5.1	2.3	0.2	5.6	3.4	16.8
Yellow Toadflax								0.1	0.1
Grand Total	0.3	34.8	45.9	195.2	304.4	145.1	280.9	20513.2	21519.9

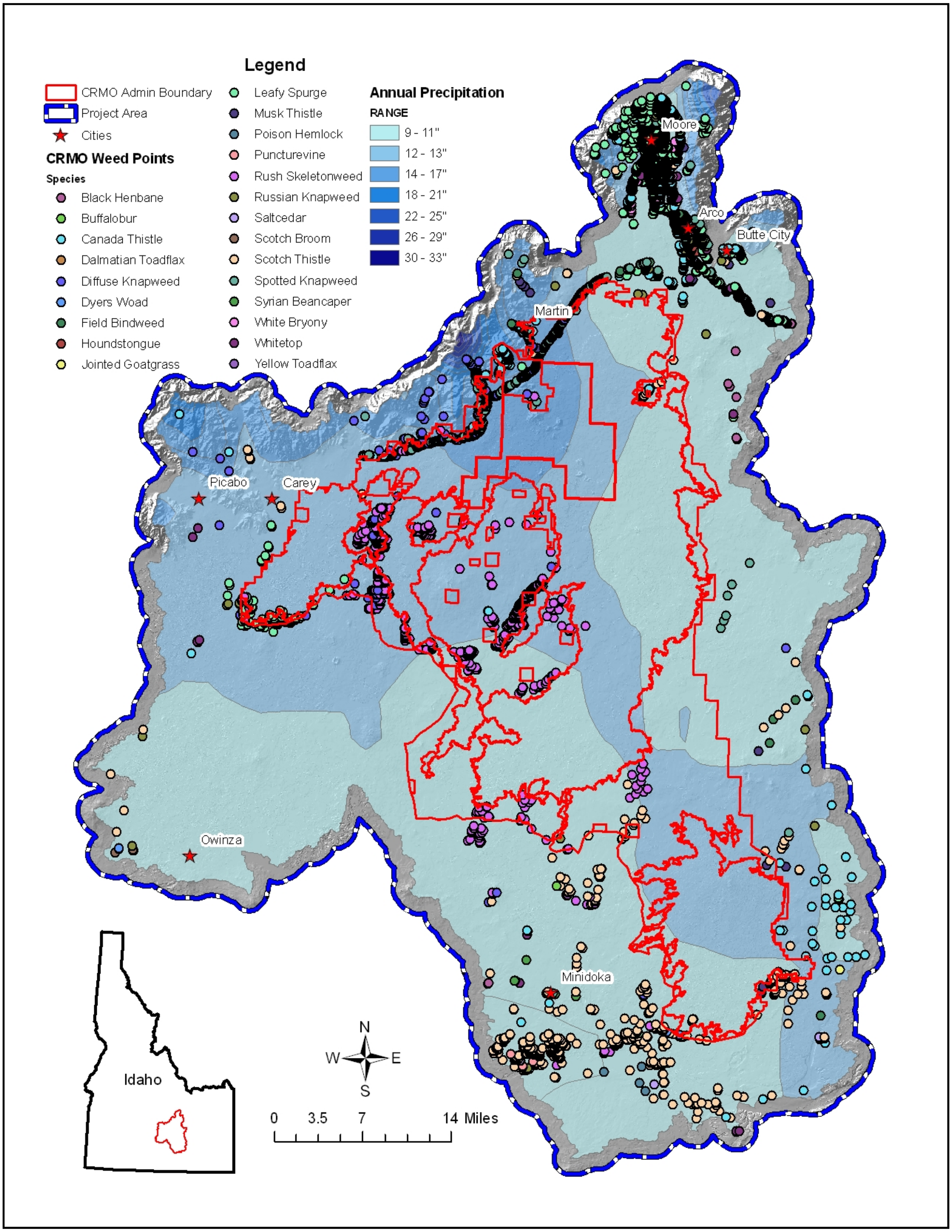


Figure 23. Map depicting weed point locations for CRMO from the Stressors and Climate Feature datasets within the geodatabase.

Climate Change

Records of climatic conditions have been maintained continuously near the CRMO Visitor Center since 1958 (WRCC 2010). Precipitation is weighted toward the winter and spring months with the majority occurring as snowfall in January and February averaging approximately 79 inches annually. The northern boundary extends into the foothills of the Pioneer Mountains where elevations range from 5,200 feet to 7,730 feet (1,585 to 2,356 meters). Temperature changes significantly between seasons with summers averaging 84.9 °F (29.4 ^{o}C) and the hottest days at or in excess of 100 °F (37.8 ^{o}C). Winters are relatively cold with an average minimum temperature of 10.3 °F (-12.1 ^{o}C) occurring in January. Prevailing winds are from the north and average 6.2 mph (10 kph). The growing season for this region is approximately 125 days.

Accelerated global climate change may be the most far-reaching and consequential challenge facing NPS natural resource managers (NPS-UCBN 2011). A change in climate will have broad ecological affects on much of the habitat present within CRMO. Species dependent on critical habitat like that of the sagebrush-steppe, limber pine, or quaking aspen will likely migrate upslope or to the north (Ashton 2010, NPS 2011a). The rate of change is expected to be variable depending on regional stressors which may include the occurrence of invasive species or changes in land use (Ashton 2010). The threat of changing climate is real, and research points to the likelihood of broad ecological changes as a result. An important and immediate trend to monitor is the warmer and drier summer weather (NPS 2011a).

The Intergovernmental Panel on Climate Change (IPCC), a scientific intergovernmental body formed from the World Meteorological Organization and the United Nations Environment Program, focuses on climate change impacts, adaptation, and vulnerability (Parry et al. 2007). The IPCC has generally noted climates in the region becoming warmer and drier and has also identified affects between climate change and terrestrial ecosystems in North America (Field et al. 2007, Parry et al. 2007). Reported changes included variations in seasonal precipitation and temperature, timing of life-cycle events, plant growth or primary production, and biogeographic distribution. Increased temperatures and variations in precipitation also support wildfires through extended summer seasons that cause a reduction in fuel moisture levels (Running 2006). In the last three decades burn duration of large wildfires has increased and the wildfire seasons in the western U.S. are estimated to have lengthened by approximately 78 days in response to spring/summer warming of 1.6 °F (0.87 °C) over average temperatures (Westerling et al. 2006).

The UCBN is committed to tracking changes in park natural resources that may be influenced or caused by accelerated climate change and monitoring activities would contribute to fulfill this commitment. The direct and indirect impact of predicted changes in climate on natural resources within CRMO is complex and difficult to manage. Climate is an additional factor which contributes to the diversity of the park units and also presents a potential stress to many ecosystem components. Climate changes could be positive or negative depending on the ecosystem processes, communities, and/or species under consideration. Plant and animal species dependent upon existing conditions could experience habitat disruption. Warming temperatures may also alter the composition of plant communities and allow exotic plant species to invade from warmer regions.

Listed below are specific effects on species and ecosystems attributed to global climate change (Mawdsley et al. 2009).

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

Mawdsley et al. (2009) identified 16 adaptation strategies in the four major adaptive strategy categories to conserve species and ecosystems from the effects of global climate change. Many of the strategies are focused at the national and regional level and would not be applicable to individual park units. The major category titled "Strategies Related to Monitoring and Planning" identifies four adaptation strategies that could be implemented at the park-level: (1) evaluate and enhance monitoring programs for wildlife and ecosystems, (2) incorporate predicted climate-change impacts into species and land management plans, programs, and activities (3) develop dynamic landscape conservation plans and (4) ensure wildlife and biodiversity needs are considered as part of the broader societal adaptation process.

The threats to CRMO resources from climate change include altered precipitation patterns, seasonal weather patterns, and temperature that could lead to degradation of habitats, loss of or shifts in biodiversity, and species composition changes. These local or regional changes on a large scale would impact all natural resources within CRMO, including water availability, possible migration patterns of animals (may lose seasonal benefits the area previously provided and competition from species capable of using the altered environment), encroachment of invasive, non-native, noxious, and otherwise undesirable plant species, and overall diversity of local species composition.

General Threats and Stressors

Due to the lack of consistent quantitative information on many threats and stressors, impacts were evaluated in a qualitative manner. Table 21 is an overall estimate of the potential impact to the major landscape attributes from the threats and stressors reported previously, including wildfire, noxious weeds, climate change, and land use changes for existing habitats. The actual impact from these threats and stressors to any specific site will vary depending on the existing natural resource and landscape setting.

Table 21. Matrix of potential impact from threats/stressors to the major resources/processes of CRMO.

Threats/Stressors		Major Resource/Process		
		Soils	**Hydrologic**	**Biotic**
Upland Habitats	Wildlife			
	Noxious Weeds			
	Land Use Change			
Aquatic Habitats	Fine Sediments/Flooding			
	Invasive Riparian Species			
	Recreational Land Use			
	Land Use Practices			
All Habitats	Climate Change			
Key to Rating for Threats and Stressors				
Potential Impact to Resource		High	Moderate	Low

Data Gaps

Several types of information were not available or were too dated to inform this NRCA. Summarized herein are the important data which would improve natural resource management by CRMO staff. We did not estimate cost or indicate agency responsibility due to the extensive nature of the data. This summary should provide guidance to staff for future research/data collection efforts within and outside CRMO:

- Additional research is needed for several wildlife species of concern identified as sagebrush-obligate. Due to the natural history of these species and habitat requirements, continued monitoring of the sagebrush-steppe is desirable. An extensive survey of the pronghorn migration routes and the species habits would be informative. Additionally, little is known beyond annual monitoring data for sagebrush-obligate birds. Inventory and monitoring efforts should focus on these species.
- The need for an assessment of vernal pools, seeps and springs, wetlands, and riparian areas within CRMO has been identified from an analysis of the available literature. There have not been focused studies identifying the location, providing a description, and determining the quality of these mesic/aquatic resources or of their importance to CRMO plant communities, wildlife and habitat, or surface and groundwater quality.
- Drinking water pumped from the two shallow wells located near the headwaters of Little Cottonwood Creek should be monitored for water quality in order to protect the health and safety of park staff and visitors. Monitoring drinking water quality will also provide insight into the degree of treatment and maintenance for the water supply infrastructure and treatment systems needed to comply with human consumption standards.
- Accurate and standardized land cover/use mapping for the project area that meets National Map Accuracy Standards (±40 ft = ±12.2 m) and is repeatable over time. This

information is very important for watershed modeling using water quality attributes, wildfire risk assessment, wildlife habitat structure, soils, and other resource values. A long term monitoring program incorporating annual to five-year updates should be employed at CRMO to provide managers with this vital information. Public outreach programs focused on the unique resources of CRMO and responsible ownership actions adjacent to the CRMO border would be invaluable to help preserve the natural resources.

- Studies focused on bat species were lacking for CRMO beyond the OMSI paper (Ave et al. 2004); many bat species within Idaho are species of concern and further research on population distribution and occurrence would aid efforts to provide species conservation and possibly provide insight into climate variations based on bat behavioral patterns.

Management Action Recommendations

This NRCA examined the literature, GIS databases, monitoring study research, interviews with CRMO natural resource staff, and field observations of vegetation inventory and accuracy assessment field work. Management practices structured toward attaining proper functioning condition of ecosystems through suggested recommendations and the use of additional resources is expected to accomplish the NPS goals and objectives for conservation for future generations. Recommended management actions include but are not limited to: (1) acquire subsurface mineral rights for the Monument area of CRMO, (2) acquire a water right for all waters of the State of Idaho put to beneficial use, (3) account for visitor access by updating all trails to meet Americans with Disability Act standards, (4) determine the potential for oil and gas developments, (5) determine control methods for invasive and noxious plant species in accordance with neighboring land managers, (6) monitor plant communities and wildlife species to determine climate change effects within the CRMO area, (7) regularly update the vegetation inventory and land use geodatabase to provide current habitat support information for all research applications particularly modeling studies, (8) continue collecting climate data to add to the long-term CRMO and regional databases, and model for developing short- and long-term trends, (9) complete an assessment of current water resources including vernal pool locations and attributes to determine benefits to CRMO resources and (10) complete an assessment and status report of all kipukas to determine proper functioning condition and the possibility of use in wildfire and climate change monitoring.

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