Upper Columbia Basin Network
Climate Change Resource Brief

Pacific West Region
Inventory & Monitoring
National Park Service
U.S. Department of the Interior

Pika Monitoring

Localized extirpations of the American pika have recently been documented in isolated mountain ranges of the Great Basin. The hypothesized mechanism for these extirpations is increased warming resulting from accelerated climate change. The Upper Columbia Basin Network (UCBN) has completed a three-year inventory of pika at CRMO and has now begun developing a monitoring protocol based on an occupancy modeling approach in which trends in percent of area occupied, local extinction, and colonization rates will be estimated over time. This monitoring protocol will be implemented at CRMO, CRLA, LAVO, and LABE.

American Pika (*Ochotona princeps*) on lava flow at Craters of the Moon National Monument and Preserve (CRMO).

Water Quality Monitoring

Freshwater habitats are diverse and productive ecosystems, providing habitat for aquatic plant, invertebrate, and vertebrate species. Water resources in the semi-arid west have been strongly affected by human activity and are projected to be profoundly influenced by climate change. Long term projections for water temperatures indicate a substantial range reduction for some species of salmonids due to changes in water temperature. The five core water chemistry parameters being monitored are dissolved oxygen, pH, specific conductance, temperature, and turbidity. In addition, macroinvertebrates are sampled in reaches within each wadeable stream, since they are good indicators of ecosystem conditions.

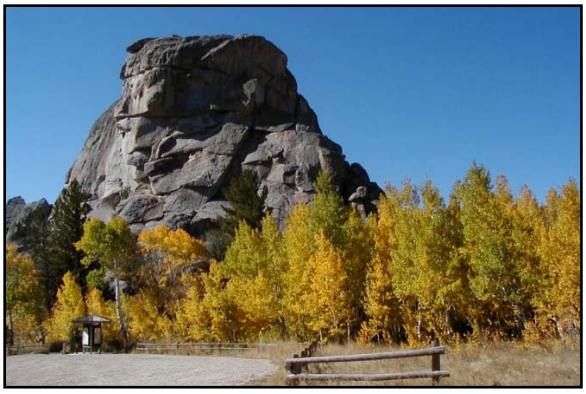
Limber Pine Monitoring

Drought stress has increased the vulnerability of limber pine (*Pinus flexilis*), a five-needle pine, to diseases and insect pathogens. For example, white pine blister rust can kill trees or directly leave them susceptible to mountain pine beetles and mistletoe infections. Limber pines are an important ecological resource, and have a mutualistic relationship with Clark's nutcrackers where the pines provide food for the nutcrackers and the nutcrackers help disperse the pines' seeds. In a pilot monitoring study, transects were placed in separate stands of limber pine to evaluate existing methods and record representative conditions of stand health and composition. This monitoring protocol is being developed with other Pacific West Region Networks in 2010.

Limber pine (*Pinus flexilis*) and Clark's nutcracker (*Nucifraga columbiana*) in Craters of the Moon National Monument and Preserve (CRMO).

Aspen Monitoring

Aspen decline in the West has been observed over the past 50 years. This is commonly attributed to a decrease in fire frequency, caused by fire suppression, and also to aspen 'die-off,' which is possibly a result of drought and early snow melt caused by warming climate trends. Aspen stands in CIRO have been identified and mapped via remote sensing, aerial photo interpretation, and field reconnaissance. Each aspen stand is assigned a number of plots along transects, depending on the stand size. At each plot the number of aspen and conifer stems is recorded in five predefined size classes. These data will provide estimates of aspen regeneration, stem density, dead aspen stems, and conifer abundance.



Aspen (*Populus tremuloides*) in City of Rocks National Reserve (CIRO).

Sagebrush Steppe Vegetation Monitoring

Sagebrush steppe is one of the most threatened ecosystems in the Intermountain West. Substantial portions of the region have been converted to agriculture and heavily grazed rangeland. Much of the remaining sagebrush steppe has been degraded through altered fire regimes and invasion by introduced plants. This year the UCBN measured fundamental steppe community indicators in 2,000 plots at CRMO, HAFO, JODA, and LARO. Describing the composition and structure of these communities is a critical first step to understand park systems, set desired future conditions, and interpret future trends.

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Climate Change at Big Hole National Battlefield

The event that Big Hole National Battlefield commemorates as a park originated in its natural environment. The Nez Perce camped in this area because of its water, fertile soil, vegetation, and wildlife long before they resisted relocation in 1877. By 1933, when BIHO became part of the National Park Service, what the war had left behind—the bullet-scarred trees, the willows, grasses, camas, and other traditional food plants—had been altered by natural succession in the absence of fire, livestock grazing, and the arrival of nonnative plants. Now the consequences of climate change are complicating the goal of maintaining the site to resemble conditions as they were in 1877.

Climate Trends

Even in the Big Hole Valley's relatively cold climate, a slight increase in temperature could have a large effect on the environment. The average number of days per year that temperatures in western Montana reach at least 90ºF has risen from 5 to 15 during the last century, and the average number of days when the temperature remains above freezing has increased by about 16. This results in less snowpack, faster evaporation, reduced runoff to streams, and a longer growing season. Some species may adapt to these conditions and some may thrive, but others will not. Although no simple solutions are available to halt these changes, monitoring BIHO's resources so that we can learn from them is more important than ever.

Aquatic Habitats

Lower streamflow in BIHO as a result of reduced snowpack and higher temperatures could lower the groundwater tables that sustain willow and other riparian species which shade streams during the summer. Flooding during spring runoff replenishes nutrients in the adjacent meadow that supports camas. Reduced ice cover and warmer water may also promote the spread of invasive aquatic plants and animals. The only river-dwelling arctic grayling left in the lower 48 states are in the Big Hole River watershed, where their population has been reduced by the irrigation system and use of streamside land for livestock. The grayling, which evolved to survive long, cold winters, could lose out to introduced nonnative trout in warmer water.

Arctic grayling (*Thymallus arcticus*)

The nonnative spotted knapweed and native spotted frog.

Amphibians

Like other amphibians, the two species that have been found in BIHO—the Columbia spotted frog (*Rana luteiventris*) and the western toad (*Bufo boreas*)—require wetlands for part of their life cycle. Whether caused by warmer temperatures or reduced precipitation, shallower water exposes amphibian embryos to more extremes in temperature and increases the possibility the water may evaporate before metamorphosis occurs. The Big Hole River's oxbows and meanders through the park provide relatively unimpaired habitat for these increasingly rare species, and monitoring of stream and riparian conditions will help the Park Service track changes in them over time.

Invasive Plants

Some of the grasses and other leafy plants in BIHO are not native to the area; they arrived in the park uninvited or as a result of agricultural use. Climate change is expected to further the spread of invasive species, which often have traits such as wide temperature tolerance and resilient means of dispersal that help them adapt to changing conditions and outcompete native plants. In BIHO, park staff are trying to eliminate the most aggressive non-native plants, such as spotted knapweed (*Centaurea stoebe*).

Conifers

Although bark beetles are native to western pine forests, infestations such as those occurring in BIHO and throughout much of Montana are causing the most widespread tree mortality in recorded history. Evidence suggests that warming temperatures have intensified outbreaks of mountain pine beetle (*Dendroctonus ponderosae*) by enabling the beetles to survive the winter even at higher elevations. Earlier snowmelt and warmer temperatures also make many tree species more vulnerable to attack by beetles and more vulnerable to wildfire.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/

Climate Change at City of Rocks National Reserve

While the granite monoliths for which the City of Rocks National Reserve (CIRO) was named are the result of tectonic events that occurred millions of years ago, the effect of natural processes and human activities over the last two centuries is more evident in the plant and animal communities found in the reserve today. Originally set aside to protect a portion of the California National Historic Trail used by thousands of 19th century emigrants, CIRO has pinyon pine and juniper woodlands that were present when Shoshones and Bannocks camped in the area more than 300 years ago. The reserve's unique biogeographic setting provides an outdoor laboratory for studying the effects of climate change on these tree species as well as on many other native plants and animals.

Wildland Fire

Wildland fire is a natural process that helps recycle nutrients, regulate plant succession, and stimulate the regeneration of some species such as aspen. However, the trend toward reduced snowpack, earlier snowmelt, and warmer-than-average spring and summer temperatures in the West during the last 20 years is increasing the risk of more frequent and larger fires. With nearly one-third of the 14,407 acres within CIRO's boundary privately owned and much of the public land used for grazing allotments, all fires are put out as quickly as possible. Nonetheless, about 25% of the reserve has burned since 1926, and more than 18% since 1999, when a fire of unknown cause burned 565 acres. In 2000, a lightning ignition in Utah burned across more than 17,000 acres, 2,090 of them in CIRO. In 2008, the quickly detected Circle Creek Fire was limited to 1.5 acres.

Sagebrush Steppe

About 70% of the land cover in CIRO is sagebrush steppe, where native perennial forbs and grasses were historically interspersed with stands of sagebrush, providing habitat for wildlife including the sage-grouse (*Centrocercus urophasianus*) and songbirds like the Brewer's sparrow (*Spizella breweri*). The sagebrush overstory has increased and conifers have expanded into the reserve's grasslands and aspen stands as a result of fire suppression. However, fires that occur now tend to foster the spread of some non-native plants such as the highly flammable cheatgrass (*Bromus tectorum*) which increases the likelihood of more frequent fires, preventing the recovery of native vegetation. Evidence from recent monitoring suggests that sagebrush areas burned in recent fires have much higher amounts of cheatgrass, and that many areas of the reserve that remain in good ecological condition may be increasingly vulnerable to cheatgrass invasion because of climate change.

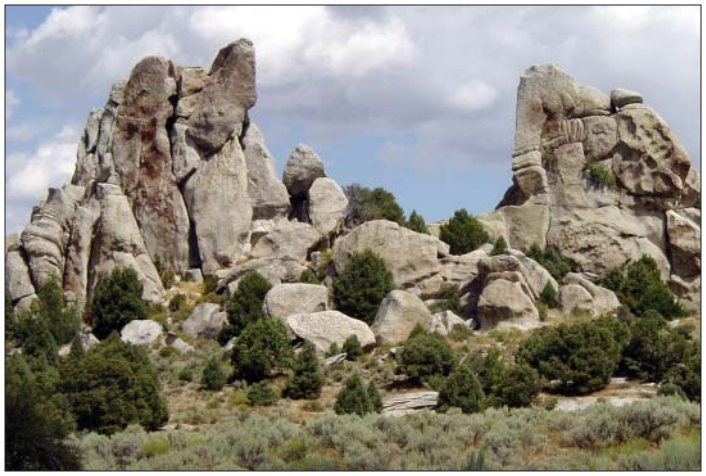

PHOTO BY WALLACE KECK

Sagebrush steppe vegetation in the foreground at City of Rocks.

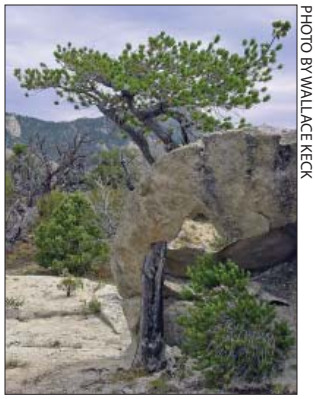

PHOTO BY WALLACE KECK

PHOTO BY ANDERS ILLUM

Old growth pinyon near rock outcrops are favored by cliff chipmunks.

Woodlands

The singleleaf pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*), as well as rodents such as the cliff chipmunk (*Tamias dorsalis*) and pinyon mouse (*Peromyscus truei*) which live in this woodland habitat, reach the northern extent of their range in and around CIRO. Plant and animal populations at the range margins are particularly subject to the effects of climate change as their ranges shift.

An outbreak of the pinyon bark beetle (*Ips confusus*) has impacted about 15% of the woodlands in the reserve. These beetles are native to western forests, but elevated temperatures can speed up the beetles' reproductive cycle and reduce their winter mortality. Drought stress, which may make pine trees more vulnerable to beetle infestations, has been implicated in the widespread die-off of pinyon-juniper woodlands in the Southwest.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
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Climate Change at Craters of the Moon

With 80% of Craters of the Moon National Monument and Preserve (CRMO) covered by lava rock that can reach 170ºF and quickly drain away rain and melting snow, a slight shift in long-term temperature and precipitation patterns can affect plants and animals that have persisted in the area for centuries. Although trends in annual precipitation for southern Idaho are uncertain, warmer temperatures will almost certainly mean reduced snowpack, faster evaporation, altered vegetation communities, and the spread of plants such as Dyer's woad which the state of Idaho has designated noxious weeds. These changes will also make monitoring of the park's resources even more important.

Sagebrush Steppe

The sagebrush and other native shrubs, grasses, and perennial forbs of CRMO's extensive sagebrush steppe communities are used by wildlife including sage-grouse (*Centrocercus urophasianus*) and sagebrush steppe obligate songbirds such as Brewer's sparrows and sage thrashers. Wildfires are occurring here more frequently and at greater intensities, burning over a third of the lands surrounding the lava fields. This encourages the spread of nonnative cheatgrass (*Bromus tectorum*), which is highly flammable and alters fire regimes, preventing the recovery of native vegetation. A loss of biodiversity results from this "cheatgrass–fire cycle" and this dynamic is likely to accelerate with climate change.

Aspen

Quaking aspen (*Populus tremuloides*) may benefit from occasional fires, which can stimulate their regeneration and deter the spread of conifers into aspen stands. Aspen may also be helped by rising CO_2, but how aspen will react to a changing climate is uncertain. Most aspen in CRMO are limited to high elevation sites where melting snowpack and subsurface run-off keep the soil sufficiently moist. Increased aridity from elevated temperatures and evapotranspiration will further stress these trees. Management actions to help the park's aspen cope with climate change could include prescribed fires and mechanical removal of conifers from aspen stands.

NPS PHOTO

D. OWENS

The direct and indirect effects of climate change may contribute to declining numbers of sage-grouse and pika.

NPS PHOTO

Limber pine (Pinus flexilis) are the most common tree in the park.

Limber Pine

Limber pine (*Pinus flexilis)* can survive in places too arid for tree species that would otherwise out-compete it, and the flexibility of its branches can withstand high winds and heavy snowfall. It grows slowly in scattered stands in the park where water collects on north-facing cinder fields and lava flows in the north end of the park. However, many limber pines in the Northern Rocky Mountains have been killed by white pine blister rust, an introduced Eurasian fungus that was first observed at CRMO in 2006. Blister rust has spread in varied climate conditions across the West, but drought-stressed trees are more susceptible, and infected trees become more vulnerable to mistletoe infections and mountain pine beetle infestations, which may intensify in milder winters. The park's monitoring program may be able to help in the nation-wide effort to determine whether some limber pine are genetically resistant to blister rust.

Pika

Extended exposure to temperatures above 80ºF can be fatal to the pika (*Ochotona princeps*), whose range is contracting and shifting to higher elevations across the West. Pikas in CRMO survive by using deep crevices in the lava flows to escape from heat on the surface. Recent surveys indicate that these pikas are restricted to the highest elevation lava flows at the north end of the park in a pattern similar to that exhibited by aspen and limber pine. Therefore, increased warming could further limit the capacity of the lava habitat to provide long-term refugia for pika. The UCBN is participating in a National Park Service program to monitor trends in pika occupancy of sites in eight parks.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
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Climate Change at Hagerman Fossil Beds

About 3.5 million years ago the Hagerman area was a mostly forested floodplain that received more than 20 inches of precipitation a year and provided habitat for many long-extinct species, including bears, birds, horses, and mastodons. Evidence of their existence is preserved in Hagerman Fossil Beds National Monument (HAFO), which has averaged about 10 inches of precipitation a year since the 1980s and now sustains a very different assemblage of plant and animal communities. Ongoing monitoring provides evidence of how this ecosystem is changing as a result of the relatively rapid climate change now underway as well as other stresses such as fire, water diversions, and surrounding land use.

Sagebrush Steppe

Historically, most of the vegetation in the Hagerman area was sagebrush steppe with a sparse understory of perennial bunch grasses. However, the native grasses and forbs have been displaced in many areas of HAFO by non-natives such as cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*). Climate change is expected to further the spread of invasive species like these, which have wide temperature tolerance and resilient means of dispersal that help them adapt to changing conditions and out-compete native plants. The spread of cheatgrass and other invasive plants in the park's sagebrush steppe is reducing suitable habitat for the desert horned lizard (*Phrynosoma platyrhinos*) and sagebrush lizard (*Sceloporus graciosus*), which are increasingly rare in many parts of their range.

PHOTO BY CHRIS BROWN

Wildland Fire

Areas that are infested with cheatgrass, which is both highly flammable and apt to move into disturbed areas, are more likely to burn and experience further degradation in the event of fire because the native seed stock has been reduced. Fire is a natural process that helps recycle nutrients from dead biomass into growing plants, but cheatgrass may be increasing the frequency of fires in HAFO by providing a continuous layer of flash fuels on some sites. Since the late 1970s, wildland fire has occurred about seven times in HAFO. All of these fires were suppressed as quickly as possible and none exceeded 100 acres until the Long Butte Fire in August 2010. Started by lightning about 30 miles southwest of the park, it burned more than 300,000 acres, including more than 80% of the park's 4,351 acres. In addition to the loss of most of the upland sagebrush steppe, the burning of steep slopes increases the risk of erosion and landslides which can damage the fossil beds.

NPS PHOTO

Most of HAFO's eastern boundary is adjacent to the Snake River.

Riparian Communities

The transformation of the Snake River from a primarily free-flowing, cold-water system to an impounded, slower-moving, warmer habitat has caused the decline of much of its native fauna, including the federally listed sockeye salmon (*Oncorhynchus nerka*), Chinook salmon (*O. tschawytscha*), and Bliss Rapids snail (*Taylorconcha serpenticola*). Climate change is likely to increase the water temperature and the frequency of summertime low flows in the Snake River watershed and encourage the spread of the New Zealand mudsnail. More frequent fire could reduce the native willows, cottonwoods, bulrush, and cattails that shade riparian areas and provide habitat for thousands of migratory waterfowl. These plants have been displaced in many areas along the Snake River by stands of Russian olive (*Eleagnus angustifolia*), purple loosestrife (*Lythrum salicaria*), and other nonnative vegetation.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
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PHOTO BY DAN GARBER, USFWS

American white pelicans (Pelecanus erythrorhynchos) make extended stays in HAFO, but they have not been documented nesting there.

Climate Change at John Day Fossil Beds

The rocks at John Day Fossil Beds National Monument tell the story of how plants and animals responded to climate fluctuations over a span of more than 40 million years. As the local environment gradually became cooler and drier, species adapted to it, migrated elsewhere, or became extinct. The park's living flora and fauna today are those with strategies for survival in a place with 9 to 16 inches of precipitation a year and temperatures that range from above 100ºF to below zero. Coyotes and beaver grow thick coats, some species hibernate, and others head south for the winter. Resource monitoring at the park can provide clues as to what future fossils may reveal about the unprecedented rate of climate change now underway.

NPS PHOTO

The John Day River in the Sheep Rock Unit.

Sagebrush Steppe

Contemporary vegetation in the park is dominated by bunchgrass steppe that supports diverse wildflowers and provides habitat for elk and other wildlife. Livestock grazing in the area began in the late 1800's and the John Day country was important to sheepherders in the early 20th century. However, this left an ecological legacy that challenges park managers and is likely to interact with climate change in complex ways. Invasive annual grasses such as cheatgrass and medusahead introduced during the historic era have infested many areas of the park. Drought and fire are expected to increase and may exacerbate these weed invasions. Furthermore, shifts in the boundaries of vegetation types, such as juniper encroachment into bunchgrass steppe, may also increase under expected changes in rainfall patterns.

Riparian Corridors

Chinook salmon and steelhead trout swim up the John Day River to spawn in the spring and the resulting smolts return to the Pacific Ocean. The upstream agricultural irrigation that reduces water flow in the park also reduces habitat for fish and other aquatic species, especially during late summer when lower flows can become too warm for the survival of trout and other cold water species. Climate change is likely to exacerbate these conditions and more frequent fire could reduce riparian vegetation and wildlife habitat. By providing shade and preventing riverbank erosion, cottonwood, willows, sedges, and rushes help maintain water quality and provide leaf matter for the insects eaten by fish. The riparian vegetation is also used as nesting and roost sites for neotropical birds, swallows, and geese. Great blue heron, osprey and kingfishers feed on fish and frogs year-round, while bald eagles arrive in winter to hunt for fish.

S. ANDERSON

A spotted bat captured in 2003 and healthy bunchgrass steppe in the Clarno Unit of the park.

Amphibians

Although predation by birds, fish, and the non-native bullfrogs limit the presence of native amphibians along the John Day River, the small seeps and springs scattered throughout the park provide secure habitat for western toads, spade foot toads, Pacific tree frogs, and long-toed salamanders. Like other amphibians, these species require wetlands for part of their life cycle and tend to be highly sensitive to environmental change. Whether caused by warmer temperatures or reduced precipitation, shallower water exposes amphibian embryos to more extremes in water temperature and increases the likelihood of evaporation before metamorphosis occurs.

Bats

The bats that use the park's riparian areas to forage for insects may shift their ranges seasonally or year-round as a result of climate change. Some of the 14 species that have been documented in the park migrate to warmer areas where they can feed on insects all winter while others hibernate in cold, damp roosts. Warmer roosts could disrupt hibernation patterns and the associated timing of fetus development and gestation. Bats are also vulnerable to collision with wind turbines, and the rapid growth of this alternative form of energy production may pose additional risks to bat populations along the John Day River.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/

Climate Change at Lake Roosevelt

Lake Roosevelt was created by the completion of Grand Coulee Dam in 1941 for purposes of irrigation, power generation, and flood control along the Columbia River. Although these activities and the resulting fluctuations in the water level have transformed the 154-mile riparian corridor through Lake Roosevelt National Recreation Area (LARO), preservation of its natural and cultural resources continues to be part of the park's mission. The impacts of long-term climate change on those resources will therefore affect management of the entire reservoir, which is jointly overseen by the National Park Service, the Bureau of Reclamation, the Bureau of Indian Affairs, the Colville Confederated Tribes, and the Spokane Tribe.

Wildland Fire

Although fire is a natural part of Columbia Basin ecosystems, LARO generally puts out all fires as quickly as possible because of its small, narrow land units and the proximity of private property. Most fires in the park are caused by human carelessness rather than lightning, but warmer temperatures in the western U.S. in the last three decades have reduced fuel moisture during the summer, promoting easier ignition and faster spread of fires. Mechanical thinning and prescribed burns are used in and around LARO to reduce fuel loads, create defensible space around structures, improve tree health and resistance to disease and insects, and partially replicate fire's natural role in recycling nutrients, eliminating diseased trees, and natural selection. However, fire is not effective in eliminating most of the nonnative plants that are spreading through much of the park, and fire can increase their presence by leaving bare ground conducive to the establishment of some invasive species.

Invasive Plants

While resource and recreational uses have contributed to the spread of nonnative plants in LARO, an increase in fire frequency and intensity or changing precipitation patterns that result from climate change would also give an advantage to some invasive plants. The southwest part of the park, which still contains some areas of intact sagebrush-steppe vegetation, has been invaded by dalmation toadflax and the highly flammable cheatgrass, leading to loss of native vegetation and habitat for species such as the sagebrush lizard. Knapweeds, exotic thistles, vetch, and a host of other plants are widespread in the northern half of the park where they grow amid conifer stands and easily resprout from roots or sprout from seeds buried in the ash and soil after a fire. Park staff use chemical and mechanical methods to control weeds, but this is not feasible for species that become widespread and well established.

PHOTO BY JEFFREY JOH

NPS PHOTO

An osprey nesting in LARO and a sagebrush lizard.

NPS PHOTO

Prescribed burn at Whispering Pines, 2006.

Forest Communities

Bark beetles are native to western forests, but some infestations in the West are causing the most widespread tree mortality in recorded history. Earlier snowmelt, milder winters, warmer temperatures, and extended droughts have made trees more vulnerable to attack, and longer summers may make it possible for some pests to complete more reproductive cycles. The most prolific forest pests in LARO have been the western pine beetle, pine engravers, and western dwarf mistletoe, all of which are causing mortality in the park's ponderosa pine. The park's long extent from south to north also makes the area a likely candidate for climate-related shifts in range for ponderosa pine, which is tolerant of a relatively warm climate with dry summers, and for the Douglas fir found along north slopes and wetter canyon bottoms. These range shifts would have impacts on the wildlife species that use the habitats created by these trees. Shrub-steppe habitat may expand northward, affecting bald eagles and osprey who use large ponderosa pine trees and snags for nesting and roosting habitat.

For More Information

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Upper Columbia Basin Network
Resource Brief

National Park Service
U.S. Department of the Interior

Inventory & Monitoring Program

Climate Change at Nez Perce National Historical Park

The 38 sites across Idaho, Montana, Oregon, and Washington that comprise Nez Perce National Historical Park (NEPE) commemorate the history and ongoing traditions of the Nez Perce. Efforts to preserve the natural resources that shaped Nez Perce culture and, where possible, to restore plant and animal communities that have been altered by subsequent human activities, are likely to be made more difficult by long-term climate change. In the Pacific Northwest, warmer temperatures and wetter winters are predicted to result in more rain, less snow, and stream flows that are larger in the winter and spring but smaller and warmer in the summer and fall than in the past.

Wildland Fire

Historically, the ecology of the Pacific Northwest was influenced by both lightning-caused fires and fires set by indigenous peoples to increase the productivity of various roots, berries, and other plants used for food. Because of the relatively small size of NEPE sites, the proximity of private land, the need to preserve historic resources, and the risk of furthering the spread of non-native plants, all fires occurring in NEPE are put out as quickly as possible. Regardless of fire suppression efforts, however, warmer temperatures in the western U.S. in the last three decades have been associated with reduced summer moisture, promoting easier ignition and faster spread of fires, especially where highly flammable nonnative species have moved in.

Camas

The camas lily (*Camassia quamash*) is one of the most widely used traditional foods of the Nez Perce. The seasonally wet prairies of the interior Columbia Basin where camas grows have declined as a result of agricultural use, the spread of nonnative plants, irrigation, and flood control. Climate change could further reduce camas habitat because early drying and excessive soil temperature can interrupt or prevent the plant's germination and flowering. Significant camas populations are still found at two NEPE units, Weippe Prairie and Big Hole National Battlefield. At the 274-acre Weippe Prairie, where the species is the key cultural resource, camas density appears to have increased slightly since livestock grazing and hay production ended in 2007, but competitive nonnative forbs, especially orange hawkweed (*Hieracium aurantiacum*) and sulfur cinquefoil (*Potentilla recta*), require ongoing treatment.

PHOTO BY JOHN MOSESSO /life.nbii.gov

The native western toad and nonnative American bullfrog.

NPS PHOTO

The perennial camas in bloom at Weippe Prairie.

Riparian Communities

Recent monitoring indicates that water temperatures in Lapwai Creek (the Spalding unit) exceed those considered optimum for fish and benthic macroinvertebrates. The warmer water and lower flows likely to result from climate change, especially during late summer, also increase the presence of phosphates and fecal coliform, impairing the water quality. Lapwai Creek is especially vulnerable to warmer summer temperatures because of the sparse shade over it. Nonnative plants such as reed canarygrass (*Phalaris arundinacea*) and Bohemian knotweed (*Polygonum cuspidatum*) have formed dense stands there, preventing understory colonization by native plants that would more effectively shade the creek.

Amphibians

Whether caused by warmer temperatures or reduced recipitation, lower water depth increases the likelihood of evaporation before metamorphosis of amphibian embryos occurs. Climate change could also result in dry areas that fragment amphibian habitat and create barriers to dispersal. In a 2002 inventory of five of the largest NEPE sites, the western toad (*Bufo boreas*) was the most frequently recorded amphibian, but the second most abundant was the nonnative bullfrog (*Rana catesbeiana*). It is not yet clear if the spread of this frog in the Pacific Northwest may benefit from or be impaired by climate change.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
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Climate Change at Whitman Mission

A primary management goal for this 138-acre national historic site (WHMI) is to restore it to its appearance when the mission founded by Marcus and Narcissa Whitman was active among the Cayuse, from 1836 to 1847. However, the mission developed an irrigation system, planted crops, grazed livestock, and removed riparian vegetation for wood—activities that over the long term and throughout a larger geographic area have changed the site's ecology by spreading non-native plants and altering stream flow and aquatic habitats. Efforts to minimize and reverse those unwanted alterations may be hampered by the impacts of long-term climate change.

Invasive Plants

When the mission was established, the Walla Walla River flowed through the site during high water, creating floodplains for riparian vegetation while perennial bunch grasses, shrubs and native forbs grew at higher, drier elevations. Since 1985, when a major initiative was launched to control non-native plants, nearly 80 acres have been revegetated with grasses that were present during the Whitmans' era or are of similar appearance and can gradually be replaced with native species. However, climate change is expected to further the spread of invasive species such as yellow starthistle (*Centaurea solstitalis*) that have wide temperature tolerance and resilient means of dispersal that help them adapt to changing conditions and out-compete native plants.

Wildland Fire

Although fire is a natural part of Columbia Basin ecosystems, unplanned ignitions are put out as quickly as possible at WHMI because of the proximity of private property and the need to preserve the park's cultural resources. However, warmer temperatures in the western U.S. in the last three decades have been associated with reduced fuel moisture during the summer, promoting easier ignition and faster spread of fires regardless of efforts to extinguish them. Working with Umatilla National Forest personnel, WHMI staff plans to burn 10 to 20 acres of the park each year to remove hazardous fuels and non-native plants, and partially replicate fire's natural role in recycling nutrients. However, fire is not effective in eliminating all of the non-native plant species in the park, and it can increase their presence by leaving bare ground conducive to the growth of some invasive species if not soon restored with native vegetation.

PHOTO BY ERIC STARKEY

Potential steelhead habitat in Mill Creek, August 2008.

NPS PHOTO

Evidence of the Oregon Trail in the Whitman Mission.

Water Quality

Withdrawals for irrigation reduce the quantity and quality of water in the park's streams. The warmer water that results from low summer flows, the loss of shading within and upstream from the park, or higher air temperatures can promote the growth of fecal coliform bacteria and reduce the productivity of bull trout (*Salvelinus confluentus*) and steelhead (*Oncorhynchus mykiss*), which have experienced drastic population declines throughout the Pacific Northwest. In some recent years, Doan Creek and Mill Creek have exceeded the state Department of Environmental Quality's criteria for water temperature. Since 2006, the straight irrigation ditch at Doan Creek has been replaced with a meandering channel and the reed canary grass (*Phalaris aurundenacia*) has been replaced with native willows, wild rye (*Leymus cinereus*), and other bunchgrasses that will promote bank stability, shade the water, and provide wildlife habitat and food for the benthic invertebrates that are forage for fish. However, this restoration will be jeopardized if climate change exacerbates the problem of low summer stream flows.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/

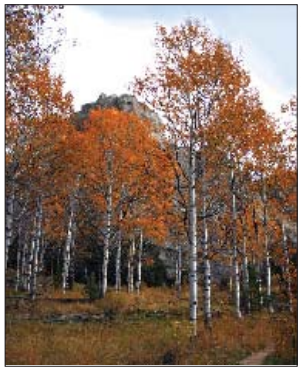
Aspen and Climate Change

Although quaking aspen (*Populus tremuloides*) is the most widespread tree in North America, it needs to receive at least 16 inches of precipitation a year to persist over the long term. Big Hole Battlefield and John Day Fossil Beds National Monument both have some aspen, but the species is more abundant at City of Rocks National Reserve (CIRO) and Craters of the Moon National Monument and Preserve (CRMO) in areas that are often near or below that precipitation threshold. These trees will be especially vulnerable if climate change results in reduced rainfall, earlier snowmelt, or warmer temperatures that increase their evapotranspiration and need for moisture. Although aspen comprise only a small percentage of the land cover in these parks, they contribute disproportionately to biodiversity by creating conditions for a community of understory plants, butterflies, and cavity-nesting birds not found in nearby coniferous forest.

Western Aspen in Decline

The prolonged moist conditions required for the establishment of aspen seedlings are rare in the Rocky Mountains, where the primary means of aspen reproduction is by suckers that grow from the roots of an aspen clone. The aspen decline that has been observed in some parts of the West since the 1930s is commonly attributed to suppression of fires that would stimulate suckering, the encroachment of conifers and sagebrush into aspen stands, browsing by ungulates, fungal infections, and sustained drought.

An aspen clone, which can survive for thousands of years through periodic fires, may produce a stand of trees extending across many acres, each stem of which may live 100 to 150 years. Over time, however, conifers often become established in aspen stands and, if not removed by fire, their shade begins to overtop the aspens, resulting in the death of stems within the clone and deterring regeneration in the understory. Aspen regenerates in some stands even in the absence of fire, and fire does not always result in a long-term increase in sucker density. The highly variable responses of aspen to fire may reflect genetic variability among clones.



NPS PHOTOS

Fall foliage at City of Rocks National Reserve.

NPS PHOTO

Aspen at Craters of the Moon National Monument and Preserve.

Wildfires are predicted to increase in severity, frequency, and areal extent, which will have large impacts on forest composition. Although increased CO^2 appears to accelerate the growth of aspen more than that of other tree species, global warming scenarios generally couple relatively large increases in temperature with modest increases in precipitation. The area occupied by aspen is therefore expected to decrease greatly by the end of the century, especially at lower, drier sites and south facing slopes, while moving upward in altitude. Aspen's expansion upslope on southern exposures in Colorado in the last century has been attributed to climate warming, and the relatively warm and dry conditions for many aspen in the Rocky Mountains from 2000 to 2003 may be responsible for a phenomenon first observed in 2004 known as "aspen die-off," referring to the sudden death of mature trees and, in many cases, of the entire clone.

Aspen Monitoring

Formal monitoring of aspen regeneration, stem density, and conifer density began at CRMO in 2007 and CIRO in 2008, too recently to detect any significant trends. However aerial photographs of CIRO taken in 1950, 1977, 1990, and 2004 indicate that although the extent of clones appears to have remained about the same, the number of stems within several clones has declined. The majority of aspen stands monitored in CIRO and CRMO are regenerating and contain a distribution of age classes. Management actions to help aspen survive climate change could include use of prescribed fire and mechanical removal of conifers from aspen stands.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/

Bats and Climate Change

Of the 45 bat species found in the United States and Canada, 14 have been documented in Upper Columbia Basin Network (UCBN) parks. While some species, such as the little brown bat (*Myotis lucifugus*) are commonly seen, nine are considered species of concern by federal or state agencies because of their limited numbers, including two cliff-dwelling desert specialists: the spotted bat (*Euderma maculatum*) and the pallid bat (*Antrozous pallidus*). All of these species feed on insects and use riparian areas for foraging and commuting corridors. They may roost in cliffs, caves, or tree trunk crevices, as well as in bridges, buildings, and abandoned mines.

Bats are considered likely to be affected by climate change because of their sensitivity to roost temperatures and their need for large insect populations. In arid regions such as occur in the UCBN, bats must drink every night, particularly females when nursing their pups in summer. Reductions in available moisture projected to occur in the region might affect bat's ability to reproduce. While bats could shift their ranges more rapidly in response to climate change than most mammals, bat populations are likely to decline due to climate change, habitat loss, and the disease known as white-nose syndrome.

Migration and Hibernation

Most UCBN bats migrate short distances from summer roosts where they rear their pups to winter roosts where they hibernate. In response to a prolonged drop in temperature or the food supply, their body temperature drops to a few degrees above air temperature. Townsend's big-eared bats (*Corynorhinus townsendii)* prefer hibernacula with stable temperatures below 50°F and high humidity, while the big brown bat (*Eptesicus fuscus*) can survive body temperatures well below freezing.

Hibernating bats prepare for winter by building up their fat reserves, but they occasionally awaken from their torpor and leave the roost to drink or mate. These arousals from hibernation consume a lot of energy, and an increase in their frequency or duration could result in starvation. Fertilization is delayed until the female emerges from hibernation, but the timing of fetus development and gestation can be affected by temperature and other environmental conditions.

S. ANDERSON

The pallid bat emerges after sunset to forage for insects. It has been documented at CIRO, CRMO, HAFO, and JODA.

The hoary bat (*Lasiurus cinereus*) and the silver-haired bat (Lasionycteris noctivagans), which roost in trees in UCBN parks, migrate to areas in the Southwest and Mexico where the temperature and insect supply remain high enough for continued activity. However, these species are vulnerable during migrations to collisions with wind energy turbines.

White-Nose Syndrome

White-nose syndrome (WNS), first reported in New York in 2006, has killed nearly all of the bats in some locations as far west as Tennessee. It has been found in seven species of bats, including several species present in the UCBN. The die-offs are associated with a fungus (*Geomyces destructans*) that thrives in dark, damp places below 50ºF and grows on the muzzles, ears, and wings of hibernating bats. No link has been found between WNS and climate change, but unusually warm or erratic winters could affect bat hibernation, making bats more susceptible to the disease. Concern is growing that WNS could spread west into the UCBN within a few years.

Monitoring Bats in Network Parks

During UCBN mammal inventory surveys, unusually high bat diversity and large, regionally important roosts were documented in several UCBN parks. The UCBN plans to monitor bats during summer pup-rearing at City of Rocks National Reserve, Craters of the Moon National Monument and Preserve, and John Day Fossil Beds National Monument. The use of automated bat echolocation call detectors set up along streams in these parks will make long-term surveys cost-efficient, contribute to regional estimates of bat population trends, and can guide park managers in decisions about riparian restoration and visitor use near roosting areas.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/

S. ANDERSON

Although difficult to track because it forages for high-flying moths up to 50 meters above ground, the spotted bat has been recorded at CIRO and JODA, where this photo was taken in 2003.

Rare Plants and Climate Change

The influence of climate change, especially warmer temperatures and less available moisture, is evident in the seasonal timing of flowering, range shifts northward or up in elevation, and changes in plant density or size at some sites. Many plant species have used these kinds of adaptations to survive climate change throughout their evolution. However, habitat fragmentation, competition from invasive plants, and consumption and trampling by livestock and native ungulates may make it difficult for rare species to adapt quickly enough to climate change. While fire suppression has contributed to the decline of native species vulnerable to encroachment by woody plants or requiring bare soil to become established, increasing fires can further the spread of non-native plants that compete for water, nutrients, and light. The rareness and cultural significance of several plants in the Upper Columbia Basin Network, described below, are of particular interest to park managers and may be vulnerable to the effects of accelerated climate change.

Spalding's Silene

Silene spaldingii is a small perennial related to the carnation and endemic to grasslands of the interior Northwest, most of which have been developed for agricultural use. Of the 99 known remaining occurrences of this flowering plant, Oregon's Lake Wallowa population is one of only 10 that have more than 500 plants. It is located on private land except for the five-acre Old Chief Joseph's Gravesite, part of Nez Perce National Historical Park. The U.S. Fish and Wildlife Service designated *S. spaldingii* a threatened species under the Endangered Species Act in 2007 because its remnant populations are at risk of further decline.

Yellowhair Indian Paintbrush

Castilleja xanthotricha is a perennial forb found only in the John Day and Trout River watersheds of Oregon, where it has been reported in seven locations. A 2007 survey of the Painted Hills unit of John Day Fossil Beds National Monument documented an average of 15 yellowhair Indian paintbrush at each of 307 sites on sagebrush slopes. This abundant population, most of which grows in the higher areas of the Painted Hills dominated by native species, is considered secure at present.

NPS PHOTO

The camas lily produces a bulb high in protein and nutrients.

BLM PHOTO

NPS PHOTO

Yellowhair Indian paintbrush and Lemhi penstemon

Hidden Phacelia

Phacelia inconspicua is an herbaceous annual that has been found in small, isolated populations on volcanic and limestone substrate in southern Idaho and northern Nevada, especially where snow banks persist until late in the year. The species is difficult to monitor because its populations fluctuate widely from year to year in response to climatic and habitat conditions. "Hidden phacelia" was documented at several sites in Craters of the Moon National Monument and Preserve in 1993; although extensive surveys in 2001 could not find any specimens, it was reported in a vegetation mapping project completed in 2007.

Lemhi Penstemon

Penstemon lemhiensis is a large showy blue "beardtongue" of eastern Idaho and southwestern Montana. Recent UCBN surveys have confirmed that the largest reported population is at Big Hole National Battlefield, where it is concentrated on steep slopes and along an old road cut where slope movements maintain the open sites the species requires. Grass and shrub canopy closure may be the biggest threat to the species there. Flowering is most abundant when spring and early summer are cool and wet; hot, dry summers cause high mortality. The seeds can remain viable for at least six years, enabling germination in years with suitable conditions.

Camas

Camassia quamash is culturally significant as a food source for tribes of the Pacific Northwest. Although not a rare species *per se*, many of the wet prairies where it grows have been lost to agricultural use. Camas populations are below historical levels at Weippe Prairie in Nez Perce National Historical Park and along the river in Big Hole National Battlefield, and wetland restoration plans are designed to help them recover. Each spring student volunteers assist park staff by walking through dense wetland vegetation at sampling sites to count camas plants and check for the presence of invasive species. Positive trends in camas density have been detected at Weippe Prairie, a possible sign that initial restoration efforts are working.

R.K. MOSELEY, ID CONSERVATION DATA CENTER

Hidden phacelia (CRMO)

BLM PHOTO

Snowball pediocactus (CIRO, JODA)

BLM PHOTO

Giant helleborine (HAFO)

BLM PHOTO

Spalding's silene (NEPE)

Rare Plant Species in the Upper Columbia Basin Network

Listed below are the scientific and common names for species documented in Big Hole National Battlefield (BIHO), City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), John Day Fossil Beds National Monument (JODA), Lake Roosevelt National Recreation Area (LARO), or Nez Perce National Historical Park (NEPE). The relative scarcity of these 45 species is evident in that only one—*Pediocactus simpsonii*—occurs in more than one park.

BIHO	Camissonia subacaulis	longleaf suncup, northern evening primrose
	Eriogonum umbellatum	buckwheat
	Orobanche corymbosa	clustered broomrape
	Penstemon lemhiensis	Lemhi penstemon
CIRO	Cymopterus davisii	Davis springparsley
	Pediocactus simpsonii	snowball pediocactus, Simpson's hedgehog cactus
	Polystichum kruckebergii	Kruckeberg's hollyfern
CRMO	Astragalus oniciformis	Picabo milkvetch
	Downingia bacigalupii	Bacigalupi downingia, Bach's calicoflower
	Phacelia inconspicua	hidden phacelia, obscure phacelia
HAFO	Astragalus purshii var.ophiogenes	Snake River milkvetch
	Cymopterus acaulis var. greeleyorum	Greeley spring parsley
	Epipactis gigantea	giant helleborine, giant hellebore, stream orchid
	Eriogonum shockleyi var. shockleyi	Shockley's buckwheat, Shockley buckwheat
JODA	Achnatherum hendersonii	Henderson's needlegrass, Henderson ricegrass
	Allium pleianthum	manyflower onion
	Asclepias cryptoceras	Humboldt milkweed, mountain milkweed
	Astragalus diaphanus	transparent milkvetch
	Astragalus misellus var. misellus	pauper milkvetch
	Castilleja xanthotricha	yellowhair Indian paintbrush
	Chaenactis nevii	John Day's pincushion
	Juncus torreyi	Torrey's rush, torrey rush
	Lomatium hendersonii	Henderson's desert parsley
	Pediocactus simpsonii	snowball pediocactus, Simpson's hedgehog cactus
	Penstemon eriantherus	fuzzytongue penstemon, crested tongue penstemon
	Silene scaposa	scapose catchfly
LARO	Gilia leptomeria	sand gily-flower, sand gilia, slender gilia
	Lobelia kalmii	Ontario lobelia, brook lobelia
	Mimulus washingtonensis	Washington monkeyflower
	Nicotiana attenuata	coyote tobacco, coyote tabacco
	Salix candida	sage willow, sageleaf willow
NEPE	Astragalus gilviflorus	loco weed
	Calochortus macrocarpus var. maculosus	Nez Perce mariposa lily
	Cheilanthes feei	slender lipfern, slender lip fern, fee lipfern
	Coryphantha vivipara	prickly pear
	Juncus acuminatus	sharp-fruit rush, tapertip rush
	Penstemon globosus	globe penstemon
	Phlox idahonis	Clearwater phlox
	Polygonum polygaloides ssp. confertiflorum	fruitleaf knowweed, denseflower knotweed, fruitleaf knotweed
	Ranunculus orthorhynchus	straightbeak buttercup
	Ribes velutinum	desert gooseberry
	Rubus nigerrimus	dark raspberry
	Sidalcea oregana	Oregon checkermallow, Oregon checkerbloom
	Silene spaldingii	Spalding's silene
	Sisyrinchium montanum	blue-eyed grass
	Tauschia tenuissima	Leiberg's umbrellawort

For More Information: Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/

Sagebrush-obligate Birds and Climate Change

Bird species that rely on sagebrush for foraging, nesting, and/or brood rearing are considered sagebrush obligates. They include the greater sage-grouse (*Centrocercus urophasianus*), Brewer's sparrow (*Spizella breweri)*, sage thrasher (*Oreoscoptes montanus*), and sage sparrow (*Amphispiza belli*). Each of these species is found in at least two Upper Columbia Basin Network (UCBN) parks. However, their abundance and distribution has declined across the West during the last century as their habitat has been reduced and altered by changes in land use and fire regimes. The sage-grouse is gone from 5 of the 16 states in which it once resided. The warmer temperatures associated with climate change are expected to magnify the two primary threats to the remaining sagebrush-steppe habitat: invasion by nonnative plants and more frequent and intense fires. Climate change may also increase outbreaks of West Nile virus in bird populations.

Wildland Fire and Invasive Plants

When sagebrush steppe covered vast expanses of the West, fire helped recycle nutrients from dead biomass into growing plants, a cycle disrupted by the introduction of livestock, non-native plants, and fire suppression. Without periodic fire, pinyon-juniper woodlands often spread into upland sagebrush steppe, reducing the understory. But the recent phenomenon of more frequent fire has exacerbated the fragmentation of sagebrush-steppe habitat and made it more vulnerable to invasion by cheatgrass (*Bromus tectorum*) and other non-native plants. Warmer temperatures and higher concentrations of atmospheric carbon dioxide and possibly nitrogen deposition are favorable for the highly flammable cheatgrass. Its proliferation can reduce fire intervals to a few years and prevent sagebrush recovery.

Sage-grouse

As a game bird and a candidate for listing under the Endangered Species Act, the sage-grouse has been the most closely monitored of the sagebrush-obligates. An annual grouse hunting season is held in 10 states, including portions of the two UCBN parks where the sage-grouse is found: Craters of the Moon National Monument and Preserve (CRMO) and City of Rocks National Reserve (CIRO). In response to the significant declines of sage-grouse numbers, the Idaho Fish and Game Department reduced the season to seven days in 1996 and established a conservation plan to maintain and, where possible, increase sage-grouse populations and habitat in the state.

PHOTO BY TOM MUNSON

PHOTO BY MICHAEL WOODRUFF

The sage thrasher and Brewer's sparrow.

PHOTO BY DOMINIC SHERONY

USFWS PHOTO

The sage sparrow and greater sage-grouse.

Sage-grouse prefer sagebrush mixed with grassy areas and are apt to return to the same breeding site each year. In the spring, the males gather on leks, open areas where they perform courtship displays. One of the most active leks in CRMO (107 males counted in 2007) probably developed after the sagebrush there burned in 2000. The linear nature of the 150-acre fire left sagebrush nearby for nesting and brood-rearing. Cheatgrass is present throughout the park, but at the site's 5,500 elevation it grows profusely only within the burned areas; the adjacent land continues to be dominated by native shrubs, grasses, and forbs.

Monitoring Sagebrush-obligate Birds

In addition to the monitoring of sage-grouse at CRMO and CIRO, the other sagebrush-obligate species are surveyed at UCBN parks as part of more general bird monitoring. Brewer's sparrows, for example, are the most common bird species in CRMO, accounting for about one-third of all birds recorded there. They prefer dense stands broken up with grassy areas, a habitat type prone to fires that can result in landscapes dominated by grasses and non-native plants. The American Bird Conservancy has designated CRMO as an Important Bird Area (IBA) of global significance, in part because it provides habitat for sagebrush-associated species, especially Brewer's sparrow and sage-grouse. CRMO is adjacent to or near three other IBAs, which together comprise one of the largest protected sagebrush areas in North America, at approximately 1.3 million acres.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/

Wildland Fire and Climate Change

For thousands of years the ecology of the Columbia Basin was influenced by fires caused by lightning strikes and set by indigenous peoples. Fire promotes the growth of plants that are fire-adapted or require bare soil to become established, so the absence as well as the presence of fire results in changes to the natural environment. Mechanical thinning and prescribed burns are used in some UCBN parks to reduce fuel loads, create defensible space around structures, improve tree resistance to disease and insects, and partially replicate fire's role in eliminating diseased trees and natural selection.

Although wildland fires in UCBN parks are generally put out as quickly as possible because of the proximity of private property or the need to preserve historical artifacts, they still have a significant impact. Wildland fire has burned more than a third of Craters of the Moon National Monument since 1970 and about 18% of City of Rocks National Reserve since 1991. (At Craters of the Moon, fires are sometimes allowed to burn where they have little chance of spreading from patches of vegetation isolated by lava flows and cinder gardens.) More than 80% of the 4,351 acres in Hagerman Fossil Beds National Monument burned in a lightning-caused fire that started 30 miles from the park in 2010. In addition to the loss of most of the park's upland sagebrush steppe, the burning of steep slopes increased the risk of erosion and landslides which can damage the fossil beds.

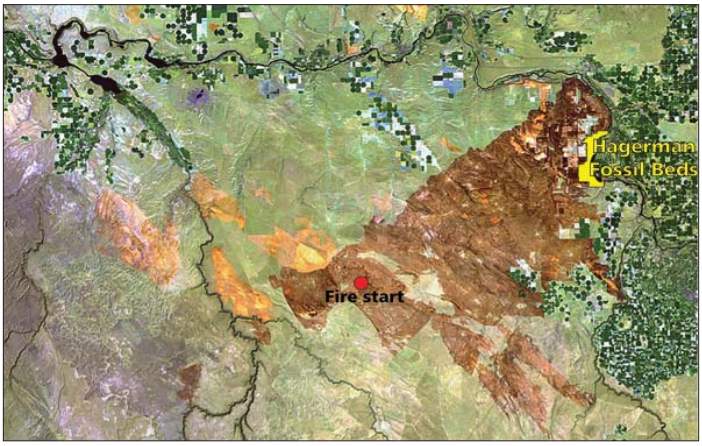
Warmer temperatures in the western U.S. in recent decades have reduced fuel moisture during the summer, promoting easier ignition and faster spread of fires regardless of efforts to extinguish them. The increasing frequency of warm spring and summer temperatures is expected to continue to cause increases in the frequency, severity, and areal extent of fires in the West.

Sagebrush-Steppe Habitat

When sagebrush steppe covered vast expanses of the West, fire helped recycle nutrients from dead biomass into growing plants. Without periodic fire, pinyon-juniper woodlands often spread into upland sagebrush steppe, reducing the understory.

NPS–UCBN PHOTO

Sagebrush steppe at City of Rocks National Reserve.



USGS LANDSAT IMAGERY

UCBN parks are vulnerable to fires that start far from their boundaries; Long Butte Fire, August 2010.

But where fire has become more frequent, it has exacerbated the fragmentation of sagebrush-steppe habitat. A hot surface fire tends to release plant-available nitrogen, creating an environment that favors non-native pioneers such as thistles and cheatgrass (*Bromus tectorum*). Cheatgrass turns brown early in the season, speeding the depletion of soil moisture and driving out native grasses that would provide forage for wildlife later in the summer. Areas infested with cheatgrass, which is highly flammable, become prone to more frequent fire and further degradation because the native seed stock has been reduced.

Forest Communities

Fire-caused injury changes conifers' volatile emissions, increasing their susceptibility to insect infestations. Earlier snowmelt, milder winters, and extended droughts have also made conifers more vulnerable to attacks by bark beetles, which can influence the probability, extent, and behavior of fire events by affecting tree health and mortality. The quaking aspen (*Populus tremuloides*) found in some UCBN parks may benefit from more frequent fire, which can stimulate aspen regeneration and deter the spread of conifers into aspen stands. The thick bark of the ponderosa pine (*Pinus ponderosa*) in Lake Roosevelt National Recreation Area enable the tree to survive ground fires that deter competition from more fire-sensitive species such as Douglas-fir (*Pseudotsuga menziesii*). But without those low-intensity fires, ponderosa pine becomes vulnerable to the high-intensity crown fires expected to become more common in the changing fire regime.

For More Information

Upper Columbia Basin Inventory and Monitoring Network
http://science.nature.nps.gov/im/units/ucbn/