4 Affected Environment

Mike Parker/USFWS

Staff working with neighboring landowners to conduct sage grouse surveys on their lands.

This chapter describes the characteristics and resources of the Red Rock Lakes National Wildlife Refuge. It specifically addresses physical, biological, cultural, and socioeconomic resources, as well as recreational opportunities.

4.1 PHYSICAL ENVIRONMENT

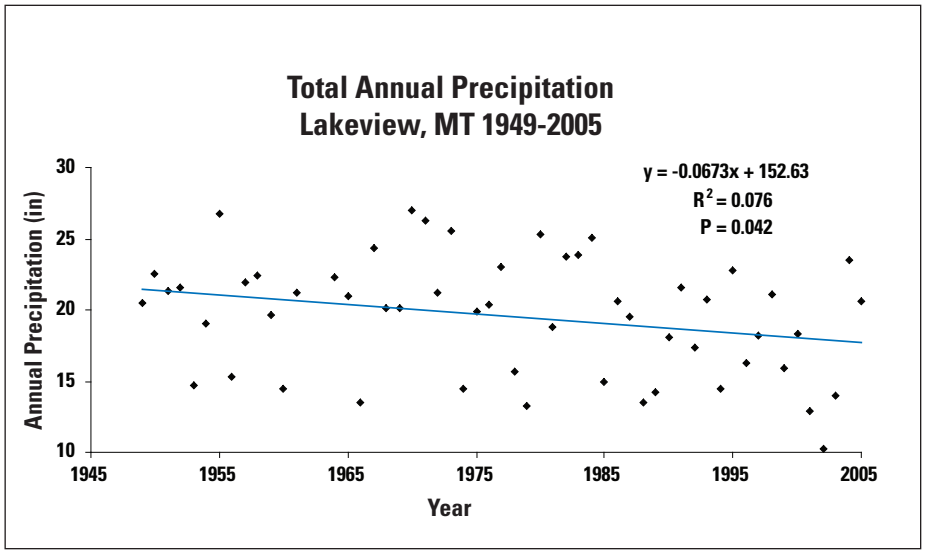
The following sections describe physical environmental resources that may be impacted by the implementation of the CCP. Physical characteristics include climate, physiography, geography, soils, water resources, and the effects of global warming.

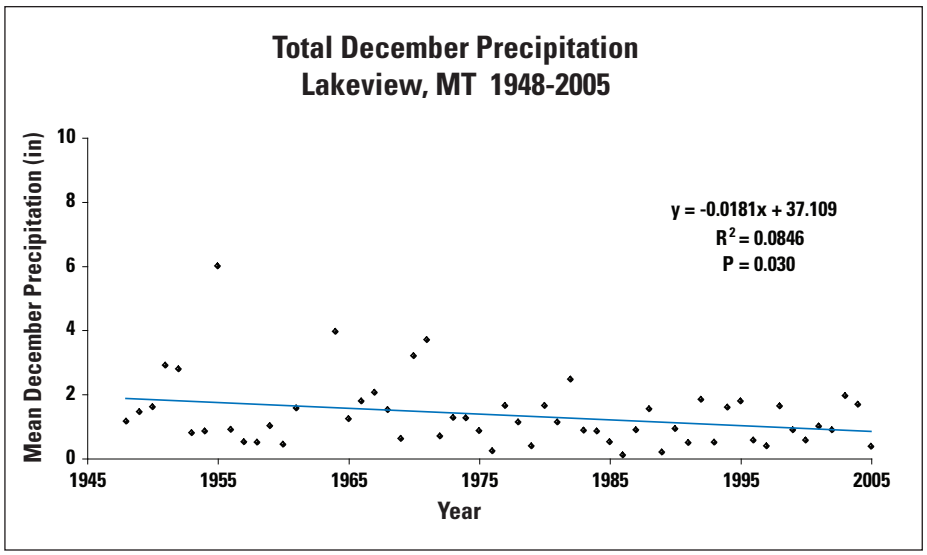
Climate

The climate in the Centennial Valley is characterized by long, cold winters and short, mild summers. Climatic data have been collected by refuge staff at Lakeview, Montana (6,690 feet mean sea level) since July 1, 1948. The data presented below was analyzed through December 31, 2005. This data was submitted to and compiled by the National Oceanic and Atmospheric Administration—Western Regional Climate Center. Information and data (such as precipitation and temperature) presented below are based on this long-term dataset as analyzed by refuge staff.

Annual precipitation is highly variable, both temporally and spatially, in the Centennial Valley. Mean annual precipitation at Lakeview, Montana, is 19.69 inches (range: 10.26 inches in 2002 to 27.0 inches in 1970). Mean annual precipitation has declined significantly between 1948 and 2005 (figure 11). In addition, precipitation in the months of December and January has declined significantly during this same time period (figure 11); no other months showed statistically significant changes in precipitation. May and June are typically the wettest months. Precipitation during these months comprises 27% of the annual average.

Air temperature is similarly variable throughout the Centennial Valley. Mean annual air temperature at Lakeview, Montana is 34.8 degrees Fahrenheit (°F) (range: 31.49° in 1985 to 37.68° in 1981) (figure 12). January is typically the coldest month (mean air temperature 11.21°F) and July is the warmest month (mean air temperature 58.59°F). Mean annual air temperature between 1948 and 2005 did not change significantly. However, mean temperatures in March and April have increased significantly (figure 12); no other months showed significant changes during this time period. This indicates that spring temperatures are warmer sooner than in recent decades. The statistically significant increase in March and April temperatures may be an indication of the climate change being documented globally.





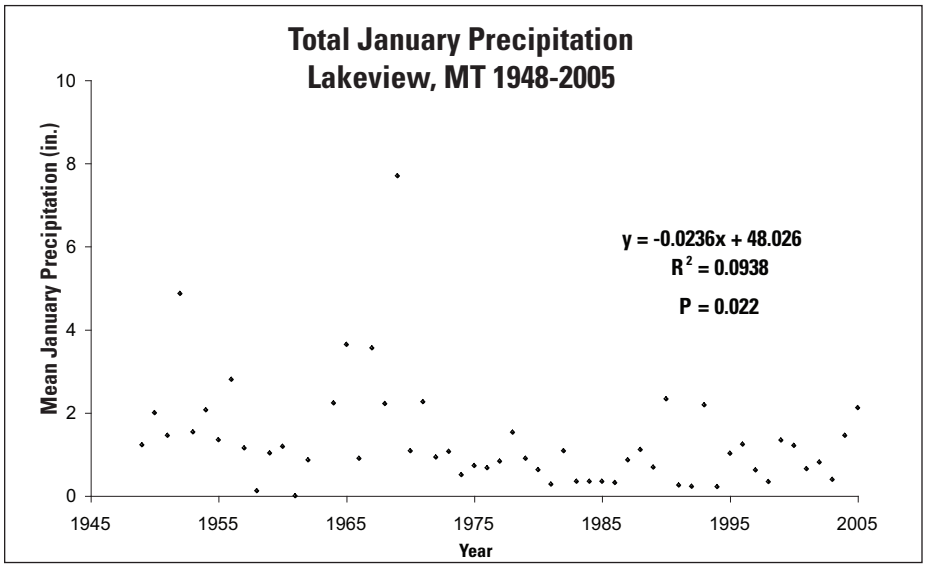
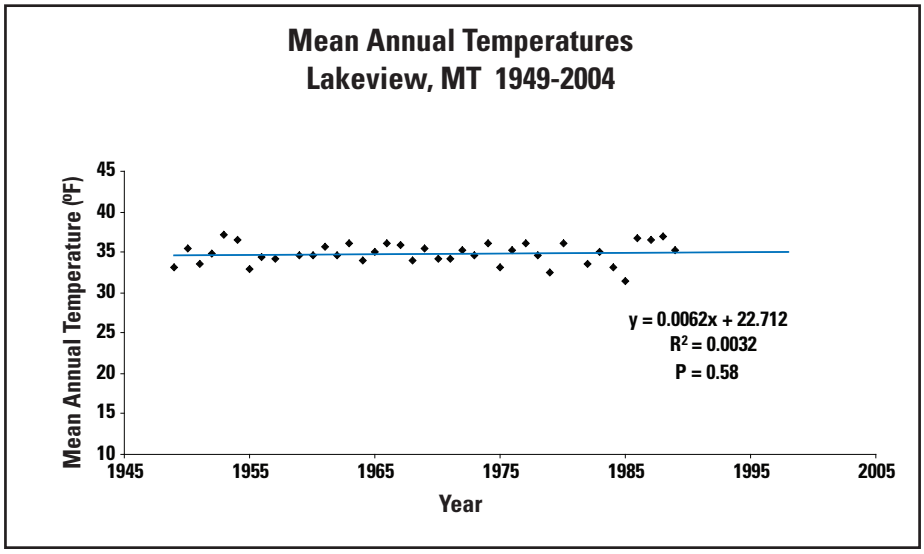
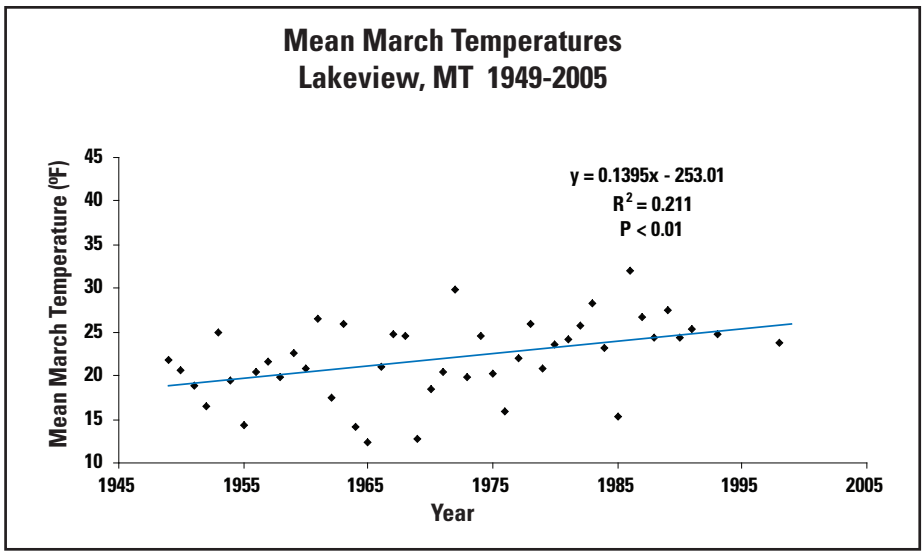


Figure 11. Significant declines in annual, December, and January precipitation totals between 1945 and 2005. (Service data)





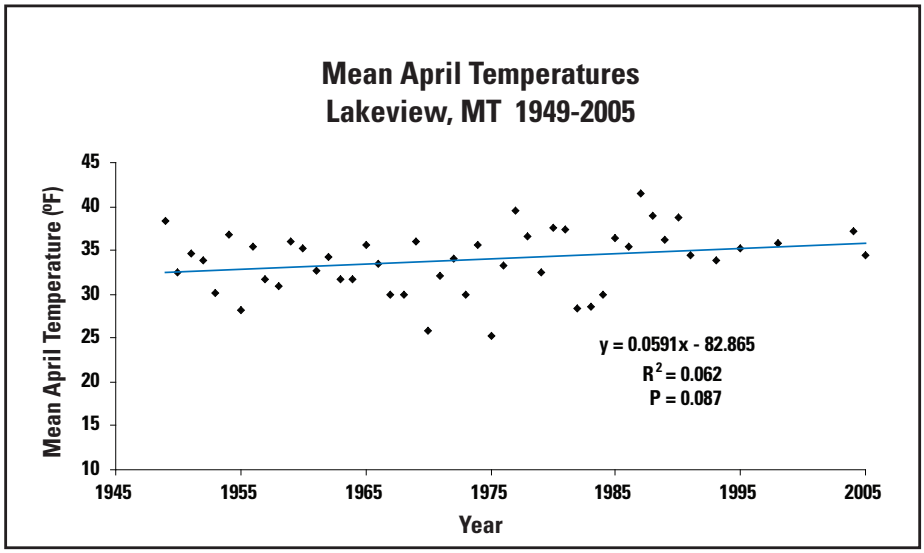


Figure 12. Mean annual, March, and April air temperatures at Lakeview, Montana, between 1949 and 2005. Significant increases are shown for the months of March and April. (Service data)

Physiography and Geology

The information contained in this section was taken from "Centennial Valley 1820–1930 Volume 1" (Centennial Valley Historical Society 2006) and information obtained from Dr. Ken Pierce. A detailed geologic history of the Centennial Valley Region was written by Mr. Rob Thomas for the Centennial Valley Historical Society. Portions of Mr. Thomas' narrative are re-written here with the permission of the Centennial Valley Historical Society.

The Centennial Mountains and the adjacent Centennial Valley are very recent topographic features that formed from extension and uplift of the earth's crust over the last 2 million years. The crust of the earth in the Centennial region was heated, causing it to rise, spread, and crack into mountains and valleys. The resulting uplift of the land (and formation of the Centennial Mountains) has exposed rocks that record over 2.5 billion years of Earth history.

The oldest rocks exposed in the Centennial region are metamorphic and igneous rocks (known by geologists as "basement" rocks) that formed from the high pressures and temperatures produced by collisions of continents between 2.7 and 1.7 billion years ago (Archean and early Proterozoic Eons) (O'Neill and Christiansen 2002). Roughly during this time, the Centennial region was part of an area geologists call the Dillon Block. The basement rocks of the Dillon Block continued to erode until about 600 million years ago (late Proterozoic Eon). At this time, the western part of the North American continent began to break apart to form a new ocean basin.

Approximately 520 million years ago (Cambrian period), a global sea-level rise flooded the Centennial region with shallow water, covering the eroded basement rocks with oceanic sedimentary deposits. During the Cambrian period, the North American continent was located near the Earth's equator; as such, the water was tropical and teemed with animal and plant life. The hard shells of the organisms that lived in these waters were buried and cemented together to form thousands of feet of sedimentary rock called limestone. This limestone can be observed today on the steep light-colored walls on the north-facing side of the Centennial Mountains.

Over the next 320 million years, fluctuations in sea level caused the deposition of marine and nonmarine sediment in the Centennial region. The intermittent tropical waters that covered the Centennial region finally withdrew about 200 million years ago (Jurassic period). Marine and nonmarine deposition resumed again during the remainder of the Mesozoic era, but the marine waters were contained in an interior seaway that was north/south trending (connecting the Gulf of Mexico to the Arctic Ocean). The mountains along the western margin of this interior seaway consisted, in part, of a chain of volcanoes. The collision of the continental crust and the Pacific Ocean floor caused the production of liquid rock (magma and lava) in a process called subduction.

Approximately 80 million years ago (Cretaceous period), the sedimentary rocks that were deposited above the basement rocks were compressed by this collision between the continental crust and the Pacific Ocean floor, forming features known as thrust faults. In the Centennial region, the basement rocks were also included in this folding and faulting, which helped to expose these deeply buried rocks at the surface. As the compression continued during the Cretaceous period, streams and alluvial fans carried gravel eastward away from the mountains and toward the interior seaway. The mountains also migrated eastward over time, causing the gravel to be buried and crushed by the weight of the overlying rock. The weight of the moving mountains caused the cobbles to be cemented back together—geologists call these deposits the Beaverhead Group. The deposits are well exposed near Lower Red Rock Lake.

The last 50 million years (Cenozoic era) marks a transition from compression to extension of the Earth's crust and ultimately the formation of the valley (or basin) and range topography that are the Centennial Valley and Centennial Mountains today. This formation of the valley and range topography of the Centennial region started at least 17 million years ago (Miocene Epoch). This type of topography is formed when the crust of the Earth rises and is pulled apart or extended to form linear mountains and valleys along high-angle fractures in the crust called normal faults. The Odell Creek Fault is an example of a normal fault in the Centennial Valley.

Over the last 4 million years, westward movement of the North American continent caused the Yellowstone hot spot to move eastward and formed west to northwest trending mountains, like the Centennial Mountains (Sears and Fritz 1998; Thomas et al. 2000). The Centennial Mountains present today may have started to uplift as recently as 2 million years ago (Pliocene Epoch). The timing of the uplift is constrained by the Huckleberry Ridge Tuff, a ground-hugging volcanic ash flow that erupted from the Yellowstone and Island Park area around 2.05 million years ago (Christiansen 2001, Lanphere et al. 2002). The distribution pattern of this particular ash flow suggests that the Centennial Mountains could not have existed at the time of the eruption. As a result, the Centennial Mountain range has probably risen over 5,000 feet in the last 2.0 million years (Sonderegger et al. 1982). The faults in the area remain active today, with an average of 40 earthquakes recorded each year in the Centennial Valley (Stickney, personal communication. through Mr. Thomas, 2006).

The topography of the Centennial region was significantly modified by glacial action over the last 200,000 years (Pleistocene Epoch). Alpine glaciers deeply eroded the mountains to produce the rugged landscape of the high country and deposited glacial outwash gravels that built large alluvial fans along the northern flank of the Centennial Mountains (for example, the Odell Creek alluvial fan) (O'Neill and Christiansen 2002).

The Red Rock lakes are pluvial lakes (formed from rainfall) that formed during the last glacial period due, in part, to increased moisture. The lakes have shrunk as the climate became warmer and drier during the last 10,000 years. As the sandy shorelines of the lakes became exposed, the sand was windblown into sand dunes, forming the sandhills area in the northeast corner of the Centennial Valley. Hot springs activity in the valley is the result of groundwater that is heated by the high geothermal gradient in the area. The heated groundwater migrates to the surface following active faults. During this glacial period, the valley was home to an array of Pleistocene mammals, including mammoths, camels, bison, horses, and saber-toothed cats. Many of these animals went extinct near the end of the Pleistocene Epoch. The first humans were in the valley by at least 10,500 years ago, as shown by radiocarbon dating of artifacts found in the valley (Albanese et al. 1995).

Soils

Information contained in this section is taken from a soil survey that was conducted by the Soil Conservation Service in cooperation with the Red Rock Lakes National Wildlife Refuge. The survey was completed in 1965.

Characteristics of the soils on the refuge are extremely varied due to changes in parent material, vegetation, and the effect of climactic forces such as wind, water, and ice. Topography and time have also had important influences. Soils range in texture from loamy sand in the Breca series to heavy clay of the Castle series. The better drained soils on the fans are predominately loamy-textured containing variable amounts of gravel, cobble and stone. Soils in the glaciated and mountainous region vary considerably in depth and have a high percentage of rock fragment in the profile. The soil in the Centennial Mountains east of the Odell Creek drainage consists principally of carbonitic mineral. The mountainous area west of Odell Creek is both igneous and sedimentary in origin, and the soils are more clayey with less lime carbonate. The soils north of the Red Rock lakes become more sandy and have considerably less gravel in the profile.

Eleven soil association descriptions were developed for the Red Rock Lakes National Wildlife Refuge as reported in the 1965 soil survey report.

Group 1. Peat and Marsh associations:
These are very poorly drained soils on the bottomlands that lie adjacent to the open water areas and live streams. These are represented in the soils survey by marshland, peat and muck, Centennial clay, and alluvial lands and have a 5–12 inch layer of peat over a clay mineral soil that is strongly gleyed (greenish-gray in color and oxygen-deprived due to high water content).

Group 2. Lamoure and Ching associations:
These are imperfectly to poorly drained soils on the bottomlands that are not as wet as the soils in group 1. The soils are deep and vary in texture from clay to sandy loam. They are calcareous (consisting of or containing calcium carbonate), slightly to moderately alkaline, and have water tables within moderate depths of 2–5 feet from the surface. The soils common to this group are Bug sandy loam, Centennial clay, Ching loam, and Lamoure loam.

Group 3. Arvada and Beckton associations:
These are imperfectly drained saline-alkaline soils that occur on the bottomlands but usually occupy a slightly higher position than the associated soils in groups 1 and 2. The soils are fine-textured and have a high sodium saturation at shallow depths, which makes them strongly alkaline and toxic to many plants. Strong columnar or prismatic structure in the subsoil is common to these sodic soils (containing sodium) . They are frequently found in complex with many of the imperfectly drained soils in group 2.

Group 4. Breca and Breece associations:
These are well-drained sandy soils that occupy the fans and dune topography to the north of the Red Rock lakes. The majority of the soil is loamy sand in texture and erodes very easily if not protected with vegetative cover. They are rapidly permeable and responsive to light showers.

Group 5. Sangrey and Big Elk associations:
These are well-drained soils that occupy the footslopes and fans at the base of the Centennial Mountains. They are predominately loamy-textured and contain variable amounts of gravel, cobble, and stone. They are the most maturely developed of all the soils in the survey. Other soils common to this group are the Melville, Adel, and loamy type of Breece. The Adel and Breece soils are less developed than other soils in this group.

Group 6. Castle soil associations:
These are imperfectly to well-drained heavy clay soils that occupy both smooth fans and buckled or slumped landscapes in the very southwest portion of the refuge. They are limited in area and very slowly permeable.

Group 7. Hanson and Raynesford associations:
These are well-drained, high lime soils that occupy

the fans, footslopes, and glacial moraines to the south and east of Upper Red Rock Lake. They are predominately loamy textured and have a high percentage of limestone, gravel, and cobble in the profile. The Snowcrest soils in this group have a thick dark surface.

Group 8. Gilispie and Merino associations:
These are well-drained upland soils that are <20 inches deep to igneous rock (primarily Rhyolite with some Basalt scarps). They occupy moderately steep to steep rolling upland and occur in the northeast portion of the survey area, close to Elk Lake.

Group 9. Skaggs soil associations:
These are well-drained upland soils that are <20 inches deep to limestone rock and have a high percentage of rock outcrop. They occupy steep to very steep mountainous areas to the east and south of Upper Red Rock Lake.

Group 10. Loberg-Little Horn associations:
These are well-drained forest soil areas that occupy steep north-facing slopes of the Centennial Mountains. Douglas-fir and lodepole pine are the dominant tree species. The soils are predominately more than 20 inches deep and are both loamy- and clayey-textured, having variable amounts of gravel, cobble, and stone. Other soils common to this group are the Whitefish soils on the glacial moraines, Wishard, Sapphire, Carnet, and Worock series.

Group 11. Rockland areas:
These are very steep mountainous areas having more than 50% rock outcrop that occupy the steep scarps of the Centennial Mountains.

Water Resources

Surface Water Resources

The refuge is located in the upper (headwaters) end of the Red Rock River watershed. This watershed is the headwaters of the Missouri River. The refuge encompasses approximately 25,000 acres of natural, enhanced, and created wetlands. Upper and Lower Red Rock lakes have a surface water area of approximately 6,300 acres. These two lakes, along with Swan Lake and the River Marsh area, are remnants of a post-glacial lake that is believed to have covered most of the valley floor at one time (Ken Pierce, 2005, personal communication). This wetland complex has many sources of surface and groundwater inputs. Spring runoff plays an important role in the hydrology of the mountain creeks that flow into this wetland complex (see figure 13). Major sources of input into the Upper Red Rock Lake include Red Rock and Tom creeks. In addition, Elk Springs Creek (which originates from Elk and Picnic springs) ultimately provides surface water to the Upper Red Rock Lake after the water flows through Swan Lake. The River Marsh, a wetland area that connects Upper and Lower Red Rock lakes, receives surface water input from Teepee Creek. Lower Red Rock Lake has Odell Creek as a major source of input. The outlet of the Lower Red Rock Lake, known as Red Rock River, flows west toward Lima Reservoir and eventually becomes the Beaverhead River.

Most Upper Red Rock Lake tributaries have their origins to the south at the east end of the Centennial Mountains. Red Rock Creek begins at an elevation of about 8,400 feet mean sea level (here this creek is know as Hell Roaring Creek) and flows north and west about 13 miles to the east shore of Upper Red Rock Lake. Tom Creek, about 6.2 miles long, originates at an elevation of 7,910 feet mean sea level and flows northwesterly toward its junction with the eastern shore of Upper Red Rock Lake. Picnic Creek, formerly known as Hackett Creek, originates at two large springs on the eastern boundary of the refuge. In the late 1800s, homesteaders dammed Picnic Creek, creating Culver Pond; this pond was enlarged by the refuge in 1959 to 27 acres. Widgeon Pond (132 acres), which was created by impounding Picnic Creek downstream of Culver Pond in 1964, flows into Elk Springs Creek. MacDonald Pond (5 acres) was created by impounding Elk Springs Creek near the spring heads. Elk Springs Creek flows into Swan Lake and then into the Upper Red Rock Lake.

Odell Creek, the major source of surface water input for Lower Red Rock Lake, originates at an elevation of 9,200 feet mean sea level and flows north approximately 12 miles to the east shore of the lake. Other sources of input into Lower Red Rock Lake that originate in the Centennial Mountains and flow north into the valley include Humphrey, Duff, and Matsingale creeks.

There are a few surface water inputs that flow from the north side of the Centennial Valley into this wetland complex. Teepee Creek originates on lands owned by the state of Montana and flows onto the refuge. This creek is an important source of groundwater recharge to the lands north of River Marsh (Steve Custer, Montana State University, personal communication). In addition, Metzel Creek flows into the Red Rock River just west of the Lower Red Rock Lake. This creek is also an important source to the high water table that exists north of Lower Red Rock Lake.

Water Rights Chronology

When Red Rock Lakes National Wildlife Refuge was established in 1935, with a checkerboard of acquired private land and land reserved from public domain, there were numerous notices of appropriation that had been filed in the county courthouse. Early inspection reports documented evidence of ditches and headgates built to put water to use. Apparently,

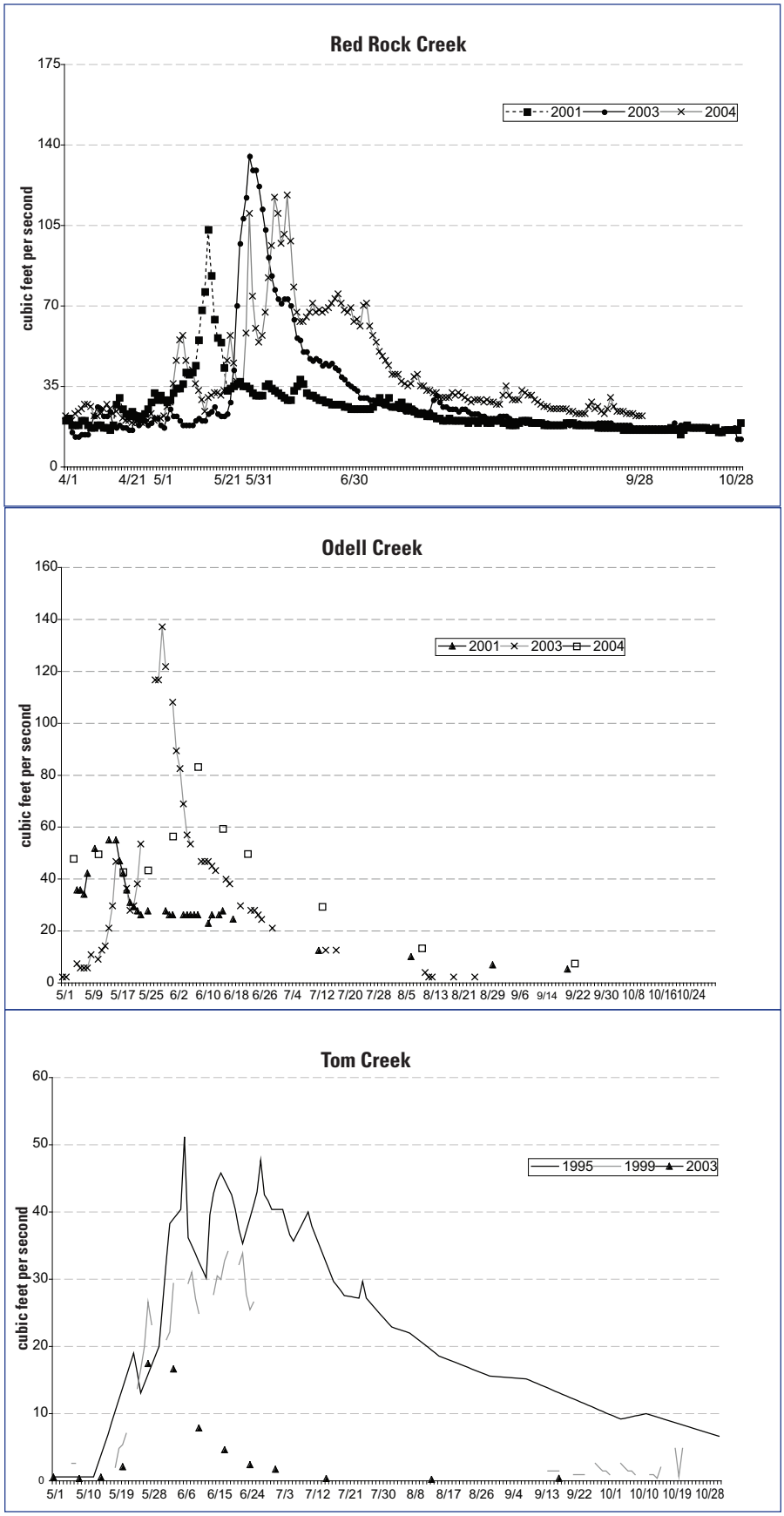


Figure 13. Representative flow rates for Red Rock, Odell, and Tom creeks at Red Rock Lakes National Wildlife Refuge. (Service data)

those facilities were allowed to deteriorate and refuge staff did not irrigate most of the areas for approximately 30 years.

In the 1960s the refuge manager and region 1 regional office engineers researched the water rights appurtenant to lands within the boundary and compiled a list of water rights (USFWS [No date). At the same time, refuge staff began to rehabilitate the existing irrigation systems. Between 1963 and 1971 stream measurement devices were installed and points of diversion were surveyed (USFWS files). There are records of measured water use for the years 1963–1971 (USFWS files).

Most of the refuge was designated as a wilderness area in 1976. There are no records of water use for irrigation after 1973. Many of the diversion structures were removed before the actual designation of wilderness (Gene Stroops, former refuge manager, personal communication).

Lower Red Rock Lake Dam

The original dam was built in 1930 by MFWP to stabilize the water level of Lower Red Rock Lake. In 1957 the Service constructed a second structure just upstream of the original dam. A dam safety inspection in 1982 found several serious problems. The Service developed a plan to rehabilitate the dam and change the operation to meet biological requirements. That plan included raising the lake's water level 2 feet for part of the year.

A new water right was needed to cover the additional storage. Anticipating objections from downstream water users whose rights were filed earlier than Red Rock Lakes rights, the Service worked with the Water Users Irrigation Company (Lima Reservoir) and East Bench Irrigation District to develop a memorandum of understanding acknowledging that the additional water to be stored was actually their water, which would be held temporarily by the refuge. In the memorandum of understanding, the Service agreed to coordinate with them about the timing of releases. Rehabilitation of the structure was completed by Ducks Unlimited in 1988.

Tucks Slough

This project was constructed in 1989 by Ducks Unlimited. Anticipating that an application for a new water right would receive objections from downstream users, the Service filed an application to change the place and purpose of use of 9.5 cubic feet per second of existing Red Rock Creek water rights from irrigation to storage. After a contested case hearing, the Montana Department of Natural Resources and Conservation (DNRC) approved the application and a permit was issued. As part of the change process, 750 acres were permanently retired from irrigation to offset the consumptive use associated with the new ponds.

Montana Statewide Water Rights Adjudication (Basin 41A)

In 1982 the Service filed use rights for 32,952 acre-feet for open-water areas and 25,979 acre-feet for marsh areas. These amounts were calculated from surface acreage multiplied by 3.3 foot average depth for open water and one foot average depth for shallow water and marsh habitat. In addition, based on the early notices of appropriation appurtenant to the acquired lands, claims were submitted for 32,073 acre-feet for irrigation of 12,829 acres and for fish and wildlife purposes. There were several other minor claims as well.

As of 2004, only 9% of basin 41A (located in the drainage area above the Clark Canyon Reservoir) has been examined in preparation for issuing a temporary preliminary decree. The Service could have waited for the state process to be completed. However, given the potential for objections alleging abandonment of irrigation rights, and little ability to protect streamflows for fish and riparian (river) purposes under state law, the Service opted to negotiate for federal reserved water rights. Negotiations began in 1984 and were discontinued in early 1986, due to personnel changes and conflicting priorities for the state and federal parties. In 1997 the state of Montana requested that negotiations be resumed. Numerous meetings, technical work, and coordination with local water users culminated in approval of the Water Rights Compact (compact) between the state of Montana and the United States of America, U.S. Fish and Wildlife Service, for the Red Rock Lakes NWR and Wilderness Area. The compact was signed by the state, the U.S. Department of the Interior and the U.S. Department of Justice in 1999. A second bill correcting errors in the consumptive use table was passed in the Montana legislature in 2001.

Technical Work

Before and during negotiations, Service hydrologists installed gauges, and refuge staff took water measurements for 3 years. Hydrologic analysis predicted high, average, and low flows for each creek and the frequency with which those flows occurred. The Service's Montana Fish and Wildlife Management Assistance Office, confirmed that the minimum streamflows (see below) identified by MFWP for Red Rock, Odell, and Tom creeks were sufficient to support Arctic grayling (Kaeding and Boltz 1999). Water rights claimed by upstream users were evaluated by DNRC to determine how much water was actually being used. In some cases, owners agreed to reduce their claims to reflect actual use. Several owners also signed management agreements describing how a refuge call for water would occur.

Major Compact Provisions

The compact includes the following major provisions:

1. Protects natural flows of all streams for wildlife habitat maintenance and enhancement, subordinate to diversion rights actually existing in 1999;
2. Maintains senior minimum streamflows of 1.4 cubic feet per second in Tom Creek, 11 cubic feet per second in Odell Creek, and 15 cubic feet per second in Red Rock Creek;
3. Recognizes the natural outlet elevation of 6607.5 feet mean sea level for Lower Red Rock Lake;
4. Confirms consumptive use rights for maintenance of refuge lakes, marshes, and ponds;
5. Confirms existing uses of 8 acre-feet for the campground spring, 8 acre-feet of groundwater for residence and headquarters use, and 1.5 cubic feet per second from Shambow Creek for irrigation of the headquarter lawn;
6. Confirms that the Service retains the right to develop an additional 8 acre-feet of groundwater for future headquarters and visitor use;
7. Allows for future diversion of 3,000 acre-feet from Odell Creek for irrigation purposes;
8. The compact specifies that there will be no changes in use for the natural and minimum flows, and that changes in consumptive use are constrained to the purposes of the refuge. Any changes must be made in accordance with applicable state law;
9. Montana DNRC imposed an administrative closure on the drainage basins above the refuge and will not issue any new ground permits >35 gallons per minute and 10 acre-feet per year. Small stock and domestic use from springs and wells are exempt from the closure;
10. The Service retains the right to object to inaccurate claims in the preliminary decree and may also petition courts for relief in the event of a conflict over water

Air Quality

Air quality is a global concern. The U.S. Environmental Protection Agency has lead responsibility for the quality of air. Through the 1990 Clean Air Act, the agency sets limits on the amount of pollutants that can be discharged into the air. Nationally, more than 170 million tons of pollution are emitted annually into the air within the United States borders, through either stationary sources (such as industrial and power plants) or mobile sources (such as automobiles, airplanes, trucks, buses, and trains). There are also natural sources of air pollution, such as fires, dust storms, volcanic activity, and other natural processes. The agency has identified six principal pollutants that are the focus of its national regulatory program: lead, carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, and particulate matter.

W. Steve Sherman/USFWS

Odell Creek north of county road.

Air quality problems in Montana are usually related to urban areas and mountainous topography, or river valleys that are sensitive to temperature inversions. Particulate matter and carbon monoxide are the air pollutants that have the greatest adverse impact on Montana's air quality. Particulate matter (PM_{10}) is a measure of tiny liquid or solid particles in the air that are respirable in the lungs. In the area of the refuge, carbon from automobiles (including all-terrain vehicles and snowmobiles) and diesel engines; soot from slash burning, forest fires, fireplaces, and wood stoves; and dust associated with windblown sand and dirt from roadways and fields may all contribute to particulate matter. The major sources of particulate matter are vehicles traveling on unpaved roads and forest fires.

The refuge has a designated Class I air quality area as defined under the Clean Air Act of 1977. Air quality in the area of the refuge is considered good, with no nearby manufacturing sites or major air pollution sources. Throughout the year, occasional widespread regional caused by large-scale forest fires located to the west (in Idaho, Oregon, Washington, and Montana) and annual agricultural burning that occurs in Idaho (just south of the Centennial Mountains) causes haze, which results in reduced visibility. The small particles and aerosols resulting from these fires are carried long distances in the air and cause haze in this remote location. In addition, concern has been raised that increased snowmobile traffic, especially on the east end of the Centennial Valley, may be contributing to reduced air quality. A wintertime study of snowmobile emissions indicated that particulate emissions from two-stroke snowmobile engines have a potential for visibility impacts in the Yellowstone National Park airshed (Sive et al. 2003). Investigations would need to be conducted to determine if air quality and visibility are being impacted by increased snowmobile use in the area.

Global Warming

The U.S. Department of the Interior issued an order in January 2001 requiring federal agencies under its direction that have land management responsibilities to consider potential climate change effects as part of long-range planning endeavors. The Department of Energy's report, "Carbon Sequestration Research and Development," concluded that ecosystem protection is important to carbon sequestration and may reduce or prevent loss of carbon currently stored in the terrestrial biosphere. The report defines carbon sequestration as "the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere."

The increase of carbon dioxide (CO^2) within the earth's atmosphere has been linked to the gradual rise in surface temperature commonly referred to as "global warming." In relation to comprehensive conservation planning for Refuge System units, carbon sequestration constitutes the primary climate-related effect to be considered in planning.

Vegetated land is a tremendous factor in carbon sequestration. Large, naturally occurring communities of plants and animals that occupy major habitats—grasslands, forests, wetlands, tundra, and desert—are effective both in preventing carbon emission and in acting as biological "scrubbers" of atmospheric CO^2.

One Service activity in particular—prescribed fire—releases CO^2 directly to the atmosphere from the biomass consumed during combustion. However, there is no net loss of carbon because new vegetation quickly germinates to replace the burned-up biomass. This vegetation sequesters an approximately equal amount of carbon as was lost to the air (Dai et al. 2006).

Several other effects of climate change may need to be considered in the future:

- Habitat available in lakes and streams for cold-water fish such as trout and salmon could be reduced.
- Climate change could reduce water resources available to refuge wetland and riparian habitats.
- Forests may change, with some plant species shifting their range northward or dying out and other trees moving in to take their place.
- Ducks and other waterfowl could lose breeding habitat because of stronger and more frequent droughts.
- Changes in the timing of migration and nesting could put some birds out of synchronization with the life cycles of their prey.

Mike Parker/USFWS

The refuge has collected weather data for over 50 years.

4.2 BIOLOGICAL RESOURCES

The following sections describe the biological resources that may be impacted by the implementation of the CCP. Biological characteristics include vegetation communities, birds, mammals, insects, reptiles, and amphibians. Unless otherwise noted, much of the following information is from unpublished Service data located in files at the refuge office.

Figure 14 displays the vegetation associations and figure 15 shows the location and composition of the various habitat types described in this section and found on the refuge, as defined by the National Vegetation Classification System (Anderson et al. 1998). Data for these figures were collected during 2005-07 by refuge staff (Newlon 2007).

Shallow Lake Wetlands

Shallow lake (lacustrine) wetland habitats are defined as >20 acres in total area and having more than 30% cover of emergent vegetation. These habitats often exhibit alternative stable states (Bayley and Prather 2003). One state is characterized by hypereutrophic conditions (frequent algal blooms and low transparency), turbid water, and pelagic (open water) phytoplankton (microscopic plants). The second state, and the current state of refuge lacustrine habitats, is characterized by clear water and submerged aquatic vegetation (SAV). Within the refuge, lacustrine wetlands cover more than 6,300 acres of habitat (USFWS 1999a) (see figure 16).

The most abundant SAV species in refuge lacustrine habitats, in order of decreasing magnitude, are Richardson's pondweed, sago pondweed, and shortspike watermilfoil (Paullin 1973); however, the abundance of SAV species is highly variable. For

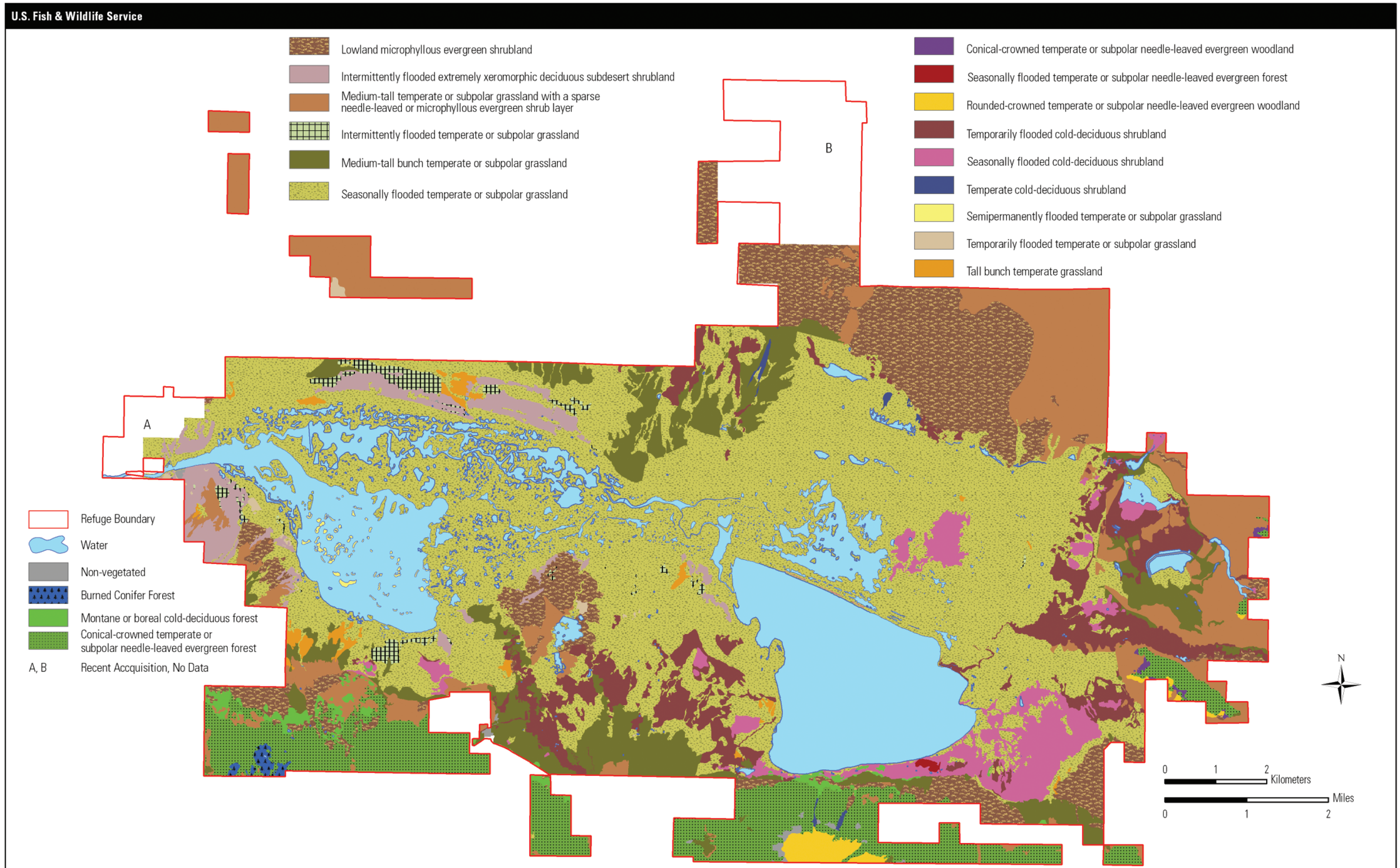


Figure 14. Vegetation classifications found in Red Rock Lakes National Wildlife Refuge.

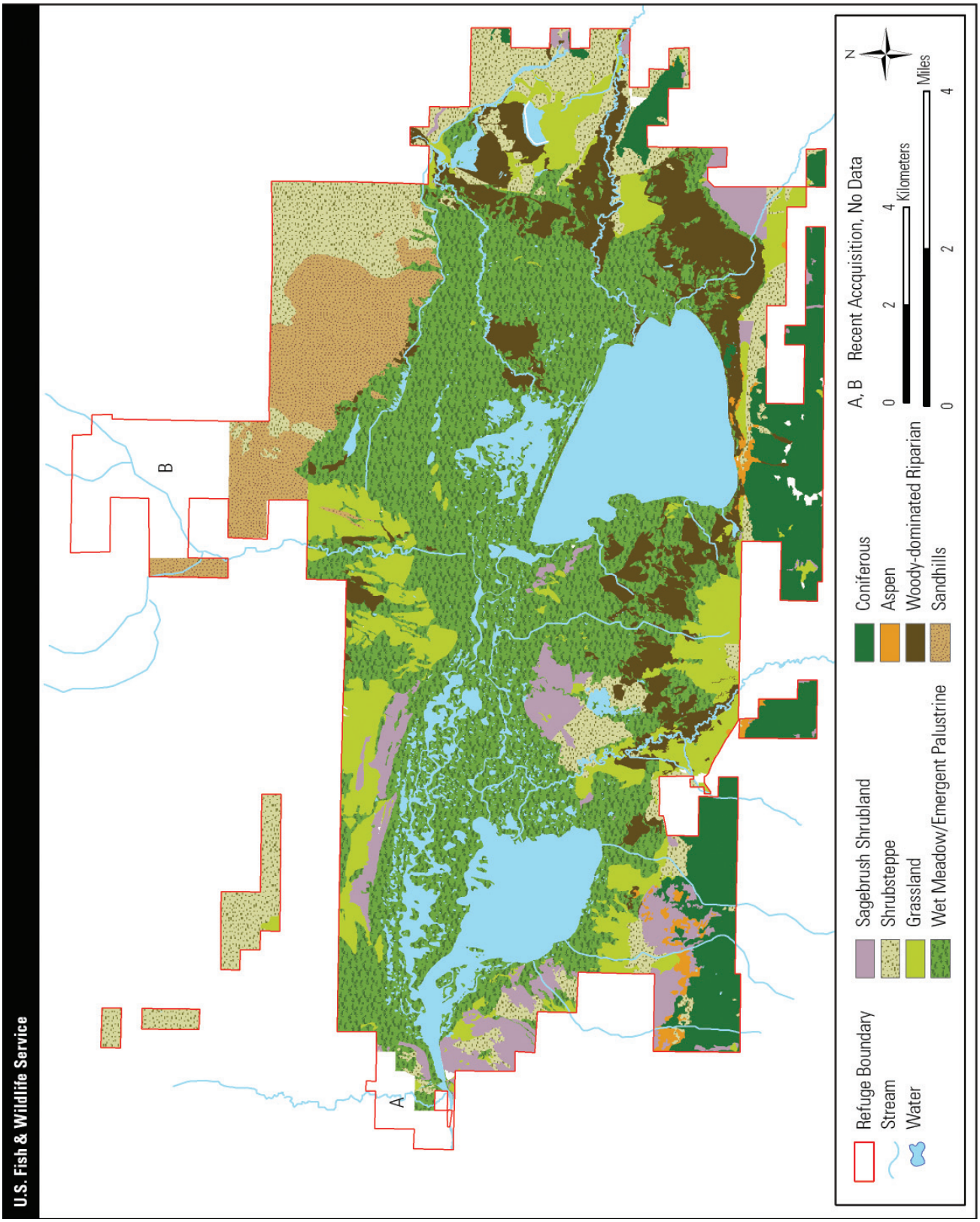


Figure 15. Habitat types found in Red Rock Lakes National Wildlife Refuge.

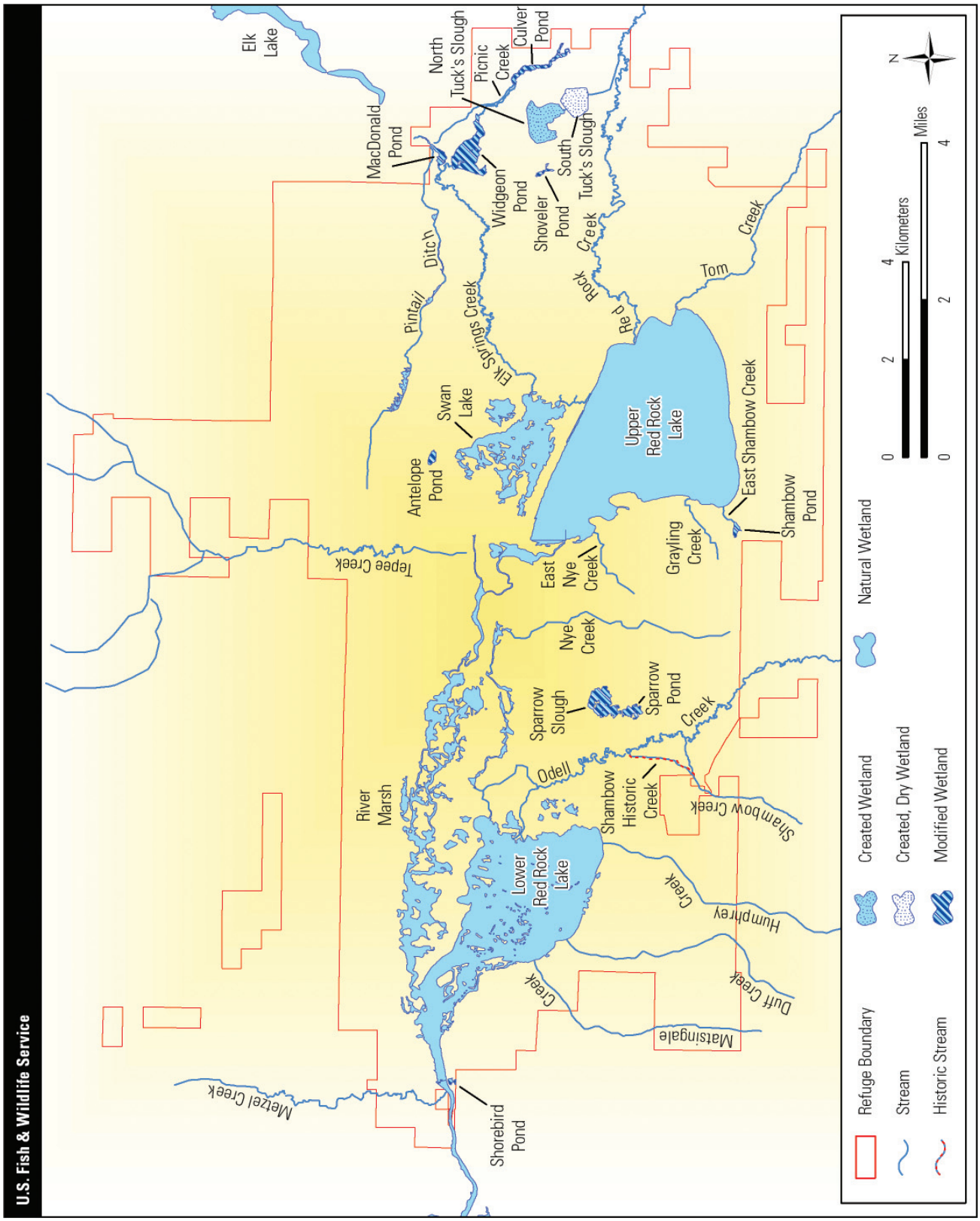


Figure 16. Wetland types found in Red Rock Lakes National Wildlife Refuge.

example, the abundance of shortspike watermilfoil in Lower Red Rock Lake has varied in abundance from <2% of species composition in 1955–56 (Beed 1957) to nearly 60% in 2002 (USFWS 2004). Canadian waterweed comprised nearly 40% of the SAV community in Lower Red Rock Lake during 1955–56 (Beed 1957) but was reduced to trace amounts by 2002 (USFWS 2004). Confounding the shifts in Lower Red Rock Lake SAV communities are the series of water control structures built at the lake's outflow beginning in 1930.

Although many factors determine the distribution of plant species within lacustrine habitats, water depth is perhaps the most significant. Water depths of refuge lacustrine habitats typically do not exceed 7 feet, with the exception of Widgeon Pond. At the greatest water depths experienced on the refuge, SAV may be sparse, especially in more turbid waters. SAV species that can be found at depths >2.5 feet include whitestem, flatstem, and sheathed pondweeds, Canadian waterweed, coon's tail, and star duckweed. At shallower water depths (<2.5 feet), sago, Richardson's, Fries, small, and fineleaf pondweeds, shortspike watermilfoil, common stonewort, longbeak buttercup, quillworts, wapato, and slender niad are common. Emergent vegetation in refuge lacustrine habitats is dominated by hardstem bulrush islands within Lower Red Rock Lake (more than 50 acres). Beaked sedge and broadleaf cattail can also be found on these islands. Within Swan Lake and River Marsh, islands of beaked sedge are prevalent. Rush, spike rush, American sloughgrass, smartweed, and common mare's-tail commonly germinate on exposed mud flats during low-water years.

Characteristic Wildlife

Native fishes found in lacustrine habitats include Arctic grayling, Westslope cutthroat trout, burbot, white sucker, longnose sucker, and mottled sculpin. Of these species, Arctic grayling and Westslope cutthroat trout have been listed as species of concern by the state of Montana. However, Westslope cutthroat trout in Upper Red Rock Lake are primarily hybrids with Yellowstone cutthroat trout and rainbow trout (Mogen 1996). Nonnative fishes introduced to refuge lacustrine habitats include Yellowstone cutthroat trout, rainbow trout, and brook trout. Yellowstone cutthroat trout are considered a species of concern by the state of Montana within its native habitat, primarily the Yellowstone River and tributaries.

Waterbird species use lacustrine habitats on the refuge primarily for foraging, with the exception of nesting that occurs within the bulrush islands of Lower Red Rock Lake. Species nesting in these islands include trumpeter swan, canvasback, redhead, lesser scaup, coot, grebes (pied-billed, western, Clark's, red-necked, eared, and horned), Franklin's gull, Forster's tern, white-faced ibis, double-crested cormorant, and great blue and black-crowned night herons. Marsh wrens and yellow-headed blackbirds are also common nesters on the bulrush islands. American white pelicans are commonly seen on the refuge, although no breeding colony exists.

Mammals common to lacustrine habitats include muskrat, mink, and river otter. Additionally, little brown bats commonly forage over lacustrine habitats at night. Blotched tiger salamander is the primary amphibian of these habitats.

Seasonally-Flooded Wetlands

Seasonally-flooded (palustrine) emergent wetlands are typically inundated each spring and dominated by persistent emergent vegetation, often on peat-forming soils. The frequency and duration of flooding is highly variable and a major determinant of vegetation communities in this dynamic habitat. Soil characteristics (physical and chemical) are also important. More than 9,000 acres of the refuge are palustrine emergent wetlands (USFWS 1999a).

Relatively homogenous stands of beaked sedge represent over 80% of palustrine emergent wetlands on the refuge. These extensive areas of seasonally flooded sedge are largely associated with Upper Red Rock, Lower Red Rock, and Swan lakes and River Marsh. Moving upslope, much of the sedge-dominated habitat is rung by the second most common palustrine emergent wetland vegetation on the refuge, Baltic rush. As noted for lacustrine habitats, other emergent vegetation species often germinate on exposed mud flats during low-water years. These include spike rush, American sloughgrass, smartweed, and common mare's-tail.

Characteristic Wildlife

Palustrine emergent wetlands provide extensive habitat for breeding migratory waterbirds. Species known to nest in this habitat include trumpeter swan, canvasback, redhead, lesser scaup, ruddy duck, mallard, northern shoveler, blue-winged and cinnamon teal, gadwall, northern pintail, coot, sandhill crane, Wilson's snipe, sora, Virginia rail, American avocet, marsh wren, and northern harrier. Other birds common to palustrine habitats, but which typically nest in drier areas, include willet, Wilson's phalarope, spotted sandpiper, and killdeer.

Mammal species common to palustrine emergent habitats on the refuge include meadow and montane voles, muskrat, and mink. Striped skunk, coyote, and red fox also commonly forage in these habitats. These habitats also support all of the amphibian and reptile species that occur on the refuge: western toad, boreal chorus and Columbia spotted frogs; blotched tiger salamander; and western terrestrial garter snake.

Shrub-dominated Wetlands

Soils in these habitats range from poorly drained peat or muck meadows to saline to calcareous. The refuge has three major wetland shrub communities: shrubby cinquefoil dominated, low-statured willow dominated, and tall-statured willow dominated.

Shrubby Cinquefoil

The shrubby cinquefoil community is dominated by this low-statured (<2 feet in height) shrub with low to moderate (10%–60%) canopy cover. Topography in these wetlands is often hummocky. The surface is saturated into early summer, but the water table typically drops by mid- to late summer. Dominant graminoids include Baltic rush, tufted hairgrass, clustered field sedge, and mat muhly. Forbs are diverse and may be abundant with up to 35% cover. Common forb species include meadow zizia, weak groundsel, pleated gentian, meadow thistle, and wild chives. Dandelion, Rocky Mountain iris, and Kentucky bluegrass may be common to abundant in stands that have been heavily impacted by grazing.

Low-statured Willow

Low-statured willow habitats on the refuge are dominated by the low (<3 feet in height) Wolf's willow. Willow canopy cover is typically moderate to high (30%–80%). Soils are generally histosols, entisols, or mollisols (Hansen et al. 1995). This habitat occurs on both subirrigated flats and adjacent to low-gradient streams. Generally, this habitat remains saturated until late summer. Other shrubs present include bog birch and diamondleaf willow. The understory is a dense graminoid layer dominated by beaked sedge, Baltic rush, and tufted hairgrass. Forb cover is low and slender cinquefoil, northern bedstraw, and largeleaf avens are common.

Tall-statured Willow

Tall-statured willow habitats are dominated by Booth's and Geyer willows, with Booth's willow having higher canopy cover. Total willow canopy cover ranges from 10%–30%. On the refuge, these habitats are found along streams as well as in an extensive willow fen (an area of low, flat, marshy land) in the southeastern portion of the refuge. Along streams, soils are generally from alluvium, whereas willow fen soils are derived from peat. These sites generally remain saturated throughout the growing season. The understory is dominated by graminoids, typically tufted hairgrass, northern reedgrass, and various sedge species. Forbs are diverse but often have low canopy cover (10%–20%). Common forb species include largeleaf avens, wild chives, fringed willow herb, slender cinquefoil, elephanthead lousewort, and false lily of the valley.

Steve Sherman/USFWS

Wilsons phalarope.

In all three shrub-dominated habitats, disturbed areas typically also have smooth brome, Kentucky bluegrass, and Canada thistle.

Characteristic Wildlife

Shrub-dominated wetlands on the refuge support a diverse breeding bird community. According to refuge surveys, the most common species include yellow warbler, song sparrow, common yellowthroat, white-crowned and Lincoln's sparrows. Common mammal species include moose, elk, white-tailed deer, striped skunk, meadow and montane voles, and long-tailed weasel. Amphibian and reptile species observed include western terrestrial garter snake, western toad, boreal chorus and Columbia spotted frogs, and blotched tiger salamander. Native fishes found in refuge creeks include Arctic grayling, Westslope cutthroat trout, mountain whitefish, white sucker, longnose sucker, and mottled sculpin. Nonnative fishes include brook trout, rainbow trout, and Yellowstone cutthroat trout.

Wet Meadows

Wet meadow habitat occurs over 7,000 acres of the refuge. Topography of wet meadows on the refuge varies from level to undulating or hummocky. Soils are poorly drained loam, sandy loam, or clay. These habitats are dominated by a dense layer of graminoids (sedges, rushes, and grasses) with low to moderate forb diversity and low forb canopy cover. These areas are flooded early in the growing season, but soils are dry by midsummer. Dominant graminoids include Baltic rush, clustered field sedge, and mat muhly. Tufted hairgrass is common on more mesic sites, whereas basin wildrye,

Sandberg bluegrass, and meadow and foxtail barley are common on drier or more alkaline sites. Forb coverage and diversity varies with moisture gradient and level of disturbance, mainly grazing. Native forbs in more mesic portions of this habitat include northern bedstraw, darkthroat shooting star, pleated gentian, meadow zizia, meadow thistle, slender thelypody, hooded lady's tresses, weak groundsel, and hookedspur violet. Rocky Mountain iris, common dandelion, and Kentucky bluegrass are common in areas influenced by grazing. Bare ground is rare. The amount of residual cover is variable depending upon the species composition and subsequent vegetative growth of the previous growing season. Differences in species composition and moisture gradients result in a mosaic of relatively short (<1 foot in height) and relatively tall (>2 feet in height) vegetation. On average, vegetation is <20 inches in height by late summer.

Montane wet meadows undergo a rapid wet/dry cycle, with complete inundation in the spring and early summer followed by two to three months of little to no precipitation. Groundwater flow, surface runoff, and spring/early summer precipitation are important water sources for these habitats (Windell et al. 1986). Hydrologic cycles in these habitats are strongly influenced by snowpack, and water table levels can undergo extreme fluctuations both within a single growing season and annually (Svejcar and Riegel 1998). Variation in the depth to water table has a strong influence on plant species distribution (Allen-Diaz 1991, Castelli et al. 2000, Dwire et al. 2006). Soil characteristics are also important drivers of plant species composition and distribution, in particular the soil redox potential (Dwire et al. 2006). Soil redox potential is the ability of the soil to gain or lose electrons. When soils are inundated with water, pore spaces in the soil are depleted of oxygen, and an anaerobic soil layer develops. The soil redox potential varies temporally and spatially and is strongly tied to water table depth (Castelli et al. 2000). The composition and distribution of plant species reflects, in part, their tolerance of these anaerobic conditions.

The majority of wet meadow habitats on the refuge are grazed by cattle 1 out of every 3 years. Cattle typically arrive in mid-July and remain until mid- to late September. Nonnative plants, including smooth brome, Canada thistle, and Kentucky bluegrass, have invaded portions of this habitat, particularly areas that were historically-hayed. Prescribed fire has been used to reduce cover of smooth brome.

Characteristic Wildlife

Wet meadow habitats on the refuge support a diverse breeding bird community, including long-billed curlew, willet, sandhill crane, northern harrier, short-eared owl, Savannah sparrow, and western meadowlark. Common mammal species include pronghorn, coyote, striped skunk, meadow and montane voles, long-tailed weasel, and American badger. Amphibian and reptile species observed include western toad, boreal chorus and Columbia spotted frogs, blotched tiger salamander, and western terrestrial garter snake.

Shrub-steppe and Grasslands

Upland shrub-steppe habitats, or habitats where both shrubs and grasses share dominance, occur on over 9,200 acres of the refuge. Several shrub-steppe habitats occur on the refuge, with areas dominated by threetip sagebrush. These habitats typically have <20% sagebrush canopy cover. Threetip sagebrush is very localized in Montana, occurring only in the extreme southwestern portion of the state. This species typically occurs on gentle alluvial slopes or benches with moderately deep soils (Mueggler and Stewart 1980). Other common species include green rabbitbrush, fringed sagewort, and spineless horsebrush. Bunchgrasses dominate the understory with an average of 70% cover. Idaho fescue, needle and thread, and prairie junegrass are the most common bunchgrass species. Typically, <10% of the soil is bare. Forb cover and diversity are low with silvery lupine, spiny phlox, sticky geranium, rosy pussytoes, old man's whiskers, and common yarrow being the most common. Mountain big sagebrush shrub lands occur on the southern edge of the refuge on the foothills of the Centennial Mountains, as well as within snowmelt drainages and north-facing aspects. Again, grasses are the most common plant form in the understory with Idaho fescue, basin wildrye, western needlegrass, and nodding brome being the most common. Forb coverage and diversity are moderate with sticky geranium, flax, and slender cinquefoil being common. Basin big sagebrush shrub lands occur only within the Centennial Sandhills (see "Centennial Sandhills" on the following page). Two shrub-steppe habitats, mountain silver sagebrush and greasewood, are considered wetland habitats. Silver sagebrush shrub lands occur on alluvial fans on the refuge and typically have <20% sagebrush canopy cover. Idaho fescue, basin wildrye, and western wheatgrass are the dominant understory species. Greasewood shrub lands also occupy alluvial fans on saline or alkaline soils. Most examples occur on the north and south sides of Lower Red Rock Lake. Grasses dominate the understory and include basin wildrye, western wheatgrass, Nuttall's alkaligrass, inland saltgrass, and Sandberg bluegrass.

Grasslands on the refuge occur primarily north of Lower Red Rock Lake and make up over 2,000 acres. The bunchgrass, Idaho fescue, has by far the most coverage at over 1,500 acres. On more alkaline soils, basin wildrye, Nuttall's alkaligrass, and Sandberg bluegrass are common. Forb coverage and diversity is variable depending upon soil moisture and type. Silvery lupine, rosy pussytoes, and common yarrow are the most widely occurring forbs.

Soil type is the primary determinant of vegetation distribution. Secondarily, fire and herbivory are important drivers of sagebrush and grassland structure, composition, and seral stage. High-intensity fires can result in replacement of sagebrush species by subdominant shrubs such as green rabbitbrush, rubber rabbitbrush, and spineless horsebrush. With heavy grazing by livestock during the growing season, native bunchgrasses associated with Idaho fescue-dominated grasslands can be reduced or replaced by nonnative rhizomatous grasses such as smooth brome and Kentucky bluegrass.

Grassland and shrub-steppe communities on the refuge are relatively intact and contiguous. The largest disturbance to these habitats resulted from seeding of nonnative forage for hay production, which occurred before refuge ownership. These haying operations resulted in the replacement of native vegetation with nonnative, rhizomatous grasses, particularly smooth brome, Kentucky bluegrass, and meadow foxtail. Other invasive species, including cheatgrass, Canada thistle, and common tansy, occur in localized patches throughout these communities.

Characteristic Wildlife

Grassland and shrub-steppe habitats provide important nesting habitat for numerous migratory land birds, waterbirds, and raptors. These habitats also provide critical calving/fawning grounds for native ungulates and support a relatively intact predator and prey community. The value of these habitats to wildlife is enhanced by their relatively unfragmented character. Common birds of shrub-steppe and grassland habitats include Brewer's sparrow, vesper sparrow, western meadowlark, Savannah sparrow, long-billed curlew, greater sage-grouse, and short-eared owl. Mammal species occurring in this habitat include white-tailed jackrabbit, coyote, badger, red fox, pronghorn, elk, mule deer, and Wyoming ground squirrel. Gray wolves have also been observed in these habitats. Amphibian and reptile species include western terrestrial garter snake, blotched tiger salamander, and boreal chorus frog.

Centennial Sandhills

The Centennial Sandhills (sandhills) cover the northeastern portion of the Centennial Valley and make up over 3,500 acres of refuge habitat. This is 44% of the 7,907 total acres that occur in the valley. These well-vegetated, relatively stable sand dunes are in various states of activity. The western dunes, located outside of the refuge boundary, are the most active and topographically varied, whereas those on refuge lands to the east are well stabilized with less topographic relief. Soils in the sandhills are highly erodible, well-drained, and sandy. Vegetative communities in these sandhills occur nowhere else in Montana (Lesica and Cooper 1999). Basin big sagebrush is the dominant shrub with 5%–40% canopy cover. Such dominance of basin big sagebrush is rare in Montana (Morris et al. 1976). Threetip sagebrush, rubber rabbitbrush, green rabbitbrush, and spineless horsebrush are other common shrubs. Bunchgrass canopy cover ranges from 5%–90% with needle-and-thread dominant and Idaho fescue codominant in some portions. Other common grasses include prairie junegrass, Sandberg's bluegrass, and thickspike wheatgrass. Forbs have 5%–45 % cover and moderate to high diversity. Hoary tansyaster, silvery lupine, granite prickly phlox, buckwheat, silverleaf phacelia, tarragon, slimflower scurfpea, and brittle pricklypear are common. Ten to 70% of the soil surface is bare sand, although the nonnative pale madwort is common in some portions of the sandhills, subsequently reducing the amount of bare sand. Several rare plant species are found in areas of open sand in early seral portions of this habitat. Two species are critically imperiled (painted milkvetch and sand wildrye), and one species (Fendler cat's-eye) is imperiled in Montana due to limited range and habitat in the state. The status of a fourth species, pale evening primrose, is currently under review by the network of Natural Heritage Programs. The sandhills contain several unique vegetation associations, one of which, the threetip sagebrush and needle-and-thread grass vegetation association, is critically imperiled globally (MTNHP 2002).

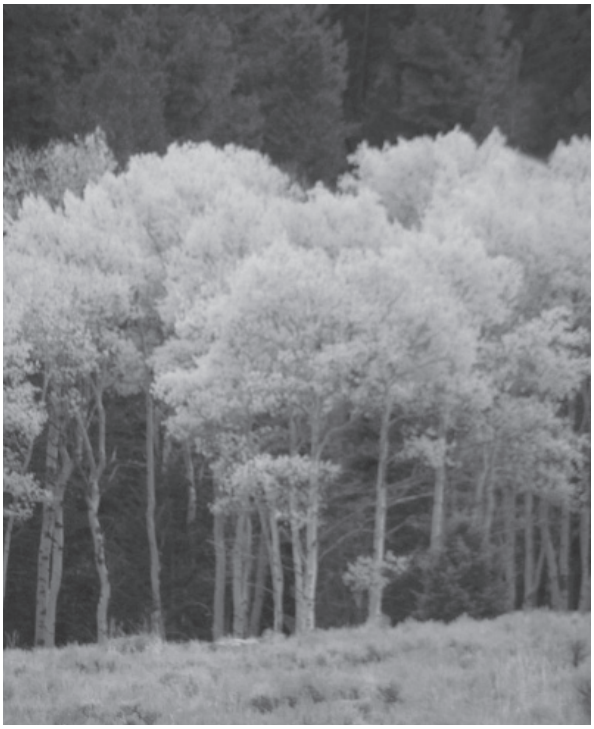
Characteristic Wildlife

The Centennial Sandhills support several sagebrush obligate breeding birds, including Brewer's sparrow and sage thrasher. Greater sage-grouse use the sandhills from early spring through fall; early refuge records show how grouse migrated to lower elevations for winter, including the western Centennial Valley and Camas Flats in Idaho. Other common breeding species include vesper sparrow, western meadowlark, long-billed curlew, and willet. Mammal species observed in the sandhills include four mammal species of concern in Montana: Preble's shrew, black-tailed jackrabbit, pygmy rabbit, and Great Basin pocket mouse (Hendricks and Roedel 2001). Other common mammals include white-tailed jackrabbit, coyote, badger, red fox, pronghorn, elk, mule deer, Wyoming ground squirrel, northern pocket gopher, and several shrew species. Gray wolf has also been observed in this habitat. Amphibian and reptile species observed in the sandhills include western terrestrial garter snake, blotched tiger salamander, and boreal chorus frog. Several invertebrate species have been observed in the sandhills, including four species of tiger beetle and several butterfly species including Rocky Mountain parnassian, sooty hairstreak, and the common branded skipper (Hendricks and Roedel 2001).

Aspen Woodlands and Forests

Aspen communities on the refuge occur as relatively small patches located within wetlands in the southeastern portion of the refuge near Upper Red Rock Lake, within mixed stands of aspen and conifer, and as larger patches on the fringe of Douglas-fir forests on the southern edge of the refuge. These larger patches are typically associated with old earthflows and landslides on the northern flank of the Centennial Range. The vegetation in these communities is variable, ranging from two-layered quaking aspen overstory and grassland understory communities (quaking aspen and mountain brome, quaking aspen and pinegrass) to multilayered quaking aspen and tall forb; and quaking aspen and tall willow vegetation associations. The upper elevation limit for aspen within the Centennial Valley is about 8,500 feet.

Reproduction in these aspen communities is most likely vegetative via root suckering, forming clonal (genetically identical) stands. Aspen are shade intolerant and regeneration cannot occur under a dense tree canopy (Jones and Debyle 1985). Historically, many of these stands were maintained through disturbances, such as fire, that removed the overstory and promoted root suckering. Large-scale declines of aspen across the western United States have been widely distributed, likely caused by a combination of factors, including global climate change, high levels of ungulate herbivory, and conifer encroachment due to fire suppression (Brown et al. 2006).



Mike Parker/USFWS

There is minimal aspen habitat within the refuge boundary.

Recent work suggests that aspen loss at the scale of the Greater Yellowstone ecosystem has averaged 10% in the last 50 years—much less than previous studies have suggested (Brown et al. 2006). Much local variability exists in changes in aspen extent, likely based on biophysical setting and climatic conditions (Brown et al. 2006). In the Centennial Mountains of Idaho, vegetation models show a 75% decline in aspen coverage since the mid-1800s (Gallant et al. 2003). A 45% decline in coverage of aspen and mixed aspen/conifer stands over the past 50 years was estimated in the Gravelly Mountains of southwestern Montana (Wirth et al. 1996). A recent study conducted on the refuge found successful aspen regeneration throughout the twentieth century along the sagebrush-grassland and forest ecotone (transition zone between two different plant communities) (Sankey et al. 2006). Preliminary results of a second study conducted in the Centennial Valley show some aspen expansion, but most sites exhibited loss of aspen due to conifer encroachment (Korb et al. 2008). Fire suppression has likely promoted the encroachment of Douglas-fir into aspen stands, potentially reducing their extent. Surveys conducted by The Nature Conservancy showed that where aspen are successfully regenerating, aspen stems are undergoing moderate to heavy browsing by elk and moose, with few stems growing above browse height.

Characteristic Wildlife

Aspen is often considered a keystone species, and aspen habitats, aside from riparian corridors, are the most biologically diverse habitats in the Rocky Mountains (Dobkin et al. 1995). Several bird species breed in aspen woodlands more than in any other habitat (Dobkin et al.1995, Finch and Reynolds 1987, Turchi et al. 1995, Winternitz 1980), and some species may be aspen obligates (species which must occupy a certain niche or behave in a certain way in order to survive) (Finch and Reynolds 1987, Turchi et al. 1995). Aspen habitats are particularly important to cavity-nesting birds such as woodpeckers (Dobkin et al. 1995, Martin et al. 2004). The susceptibility of aspen to fungal heartrot creates ideal conditions for cavity excavation, creating nesting and roosting sites for several bird and mammal species (Dobkin et al. 1995). Bird species that breed in aspen habitats on the refuge include red-naped sapsucker, northern flicker, hairy woodpecker, American three-toed woodpecker, American kestrel, tree swallow, house wren, ruffed grouse, warbling vireo, lazuli bunting, western tanager, and great gray owl. Aspen stands on the refuge also provide valuable browse for native ungulates (moose, elk, and mule deer). Gray wolves have also been observed in these areas. Amphibian and reptile species include western toad, boreal chorus and Columbia spotted frogs, and western terrestrial garter snake.

Coniferous Woodlands and Forests

Coniferous woodlands (evergreen trees having <60% canopy cover) and forests (evergreen trees having >60% canopy cover) cover over 3,500 acres on the refuge. The primary natural disturbance in these habitats is fire. Several sawmills operated in the Centennial Valley during the early 1900s, but the extent of logging that occurred in the area that is now part of the refuge is unknown.

At the forest and grassland ecotone, open woodlands dominated by Douglas-fir occur. Understory vegetation is dominated by mountain big and threetip sagebrush, bunchgrasses, bluebunch wheatgrass, and Idaho fescue. Historically, these woodlands underwent frequent (annual to every few years), low-severity fires, which killed sapling and small-diameter trees and maintained the open tree canopy. Since settlement of the Centennial Valley, fires in these woodlands have been actively suppressed because most homes and other buildings occur in this habitat. Cattle grazing occurs in these woodlands, reducing fine grassy fuels. As a result, tree densities have increased and forests have expanded into the adjacent sagebrush/grassland habitat (Heyerdahl et al. 2006, Korb 2005, Sankey et al. 2006).

Open woodlands (tree canopy cover <60%) of limber pine are found on mostly south- and southwest-facing slopes. The ground is mostly bare and gravelly and understory vegetation is sparse. Scattered common juniper and bluebunch wheatgrass are the most common understory species although their coverage is typically <10%. Fire is infrequent due to the lack of fuels. Trees in these sites may be several hundred years old (Cooper 1999).

Coniferous forests flank the north-facing slopes of the Centennial Mountains, ranging in elevation from 6,700 to 9,600 feet. Common tree species include Douglas-fir, subalpine fir, lodgepole pine, Engelmann spruce, whitebark pine, and limber pine. Shrubs make up a minor component of the vegetative community with mountain snowberry and white spiraea. The undergrowth can be sparse depending upon tree canopy cover. The forb understory can be diverse, but no species are particularly common except heartleaf arnica, timber milkvetch, and western showy aster. Western meadowrue, showy aster, northern valerian, and mountain sweet-cicely are common forbs on more mesic sites. In more open forests, the understory is dominated by graminoids, with Geyer's sedge and pinegrass being most common.

Douglas-fir dominates the tree canopy at elevations up to 8,200 feet. Historically, these relatively mesic lower-elevation forests experienced mixed-severity fires; supporting both frequent (years to decades) low-severity fires, which typically killed individual or small clumps of small-diameter trees, and infrequent (one to many centuries), high-severity crown fires, which killed large areas (thousands of acres) of canopy trees (Korb 2005, Schoennagel et al. 2004). Accordingly, the fire systems in these forests are the most complex and least understood of the major fire systems of Rocky Mountain forests. A complex interaction of both fuels and climate affect the frequency, severity, and size of fires under mixed-severity fire systems (Schoennagel et al. 2004). Historic fire suppression efforts in these forests were likely few due to their remoteness; thus, current conditions in these forests are likely to be within their historic range of variability.

Above 7,200 feet, moist, high-elevation forests are dominated by subalpine fir, Engelmann spruce, and lodgepole pine. These forests experience infrequent (one to many centuries), high-severity, stand-replacing crown fires (Schoennagel et al. 2004), and the thin bark of these tree species make them easily killed by fire. Tree density is high in these forests and tree canopy typically exceeds 70%, thus undergrowth vegetation is sparse and fuels are few.

A small (19 acres) seasonally flooded Engelmann spruce forest exists on the south shore of Upper Red Rock Lake. Soils within this association typically remain wet well into the growing season. Old growth Engelmann spruce dominates the canopy. The understory is dominated by a moderate cover of field horsetail and a dense layer of moss. Other forbs include arrowleaf ragwort, starry false lily of the valley, and claspleaf twistedstalk. This forest type is rare in southwest Montana.

Characteristic Wildlife

Birds of coniferous forests and woodlands on the refuge include northern goshawk, bald eagle, great-horned owl, dusky grouse, Clark's nutcracker, gray jay, Steller's jay, hairy woodpecker, olive-sided flycatcher, hermit thrush, ruby-crowned kinglet, mountain chickadee, brown creeper, yellow-rumped warbler, dark-eyed junco, western tanager, pine siskin, and Cassin's finch. Mammal species that inhabit coniferous forests on the refuge include elk, mule deer, moose, black bear, grizzly bear, wolverine, mountain lion, lynx, marten, short-tailed weasel, golden-mantled ground squirrel, yellow-bellied marmot, and red tree squirrel. Gray wolves have also been observed in these areas. Amphibians and reptiles of these habitats include western toad, boreal chorus and Columbia spotted frogs, and western terrestrial garter snake.

4.3 CULTURAL RESOURCES

Due to its unique location offering access to wetland and mountain ecotones, Red Rock Lakes National Wildlife Refuge has likely supported native people for the last 12,000 years. The area has abundant natural springs and game along with stone suitable

for tool manufacture, including obsidian, ignimbrite, cherts, and Quadrant quartzite. The east to west trending valley and low pass over the Continental Divide would also have been a natural travel route. Because of deep winter snow, it is likely that summer use by prehistoric peoples was more common (Taylor 1991).

Little excavation work has been conducted near the refuge so models for understanding the lifeways of native peoples are not well formed. Being situated at the Continental Divide, Red Rocks Lakes National Wildlife Refuge borrows from both the Basin Plateau Model and Plains Model. In the Basin Plateau model, artifacts and other technologies are similar to the region west of the refuge. While in Plains model, the cultures are archaeologically similar to the plains to the east. According to a major survey of federal lands in the Centennial Valley conducted by the Bureau of Land Management, prehistoric people inhabited promontories along the Red Rock River and in the forested timberline along south slopes. Springs at the base of the slopes, near the valley floor, have also been documented to be important locations for prehistoric people.

The valley has several prehistoric sites recorded as part of reviews for federal projects. The most important of these (24BE279) is located near a spring on the refuge. This site is a multicomponent prehistoric living floor with at least three components. The researchers observed indications of hearths with charcoal, bone and obsidian artifacts suggesting the site is largely intact. Artifacts observed at the site that are of known time period include: Folsum (10,500 BP), Hannah (3,000 BP) and Late Prehistoric period (500 AD to 1800 AD) documenting that the site has potential to yield information concerning adaptation to the area from Paleo-Indian to historic times.

Osborn Russell, a trapper who visited the area in 1835 noted the presence of the Blackfeet tribe. Russell followed a well established trail that was recorded by Lewis and Clark in their 1805 visit to the area. The trail follows the Blacktail drainage and crosses the Centennial Valley. In 1938 Julian Steward noted the presence of Shoshone in the Centennial Valley although, by this time, it is difficult to discern whether this area was part of their aboriginal homelands.

In 1876, in honor of the nation's 100th birthday, the valley was named Centennial Valley by Ms. William Orr (Beaverhead County History Book Association 1990). Reports of abundant waterfowl, fish, game, water and feed for livestock spurred homesteading efforts. Between 1876 and 1892, development within the refuge went from one cabin to 21 ranches and cabins, including a post office, which was the seed for present day Lakeview. This growth was spurred by the Utah and Northern Railway linking Monida to Idaho and Utah in 1880 and to Butte in 1881 (Ferrel et al. 1981). A stage route linking Monida with West Yellowstone also influenced development, including that at Culver Springs and Shambow Pond. An article published in August 1902, reported, "the Monida and Yellowstone stage line has carried over 12,000 passengers to Yellowstone National Park this season and are having all they can handle every day" (Beaverhead County History Book Association 1990). Hunting clubs were also established on the shores of Upper and Lower Red Rock lakes.

Transportation route development elsewhere, drought, long winters, and great distances to market made life difficult in the Centennial Valley. By the Great Depression of the 1930s, few remained in the valley. Many sold their land back to the Federal Resettlement Administration during the 1930s. The refuge supports several historic homesteads left by the early Anglo settlers including the Shambow, Buck, and Hanson Homesteads.

In 1935, the Bureau of Biological Survey (a precursor to the U.S. Fish and Wildlife Service) sent Basyl Kercheval to conduct an evaluation of the area's natural resources in which he suggested these lands should become a migratory bird refuge. The tremendous natural resources and impacts of unregulated hunting and collecting of waterfowl, especially trumpeter swans, helped spur the establishment of Red Rock Lakes National Wildlife Refuge. He stated, "The economic situation is grave. A large part of the land is mortgaged. Taxes are delinquent in many cases. Livestock in very [*sic*] instance is mortgaged to various agencies for feed. It is conceded by every one that the Red Rock Lakes area has been the foremost breeding, nesting and resting place for migratory waterfowl with the state of Montana" (Project of the Bureau of Biological Survey 1935). Soon after, on April 22, 1935, President Franklin D. Roosevelt established the Red Rock Lakes Migratory Waterfowl Refuge (renamed Red Rock Lakes National Wildlife Refuge on July 19, 1961).

The refuge was critical in protecting the last know trumpeter swan population in the world. Long before the refuge was established, concern for the trumpeter swan was apparent as noted in a letter to the Dillon Tribune on August 21, 1895; "It is wicked the way the young swan are being caught at the

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One of several pre-establishment duck hunting clubs.

Red Rock Lakes. A man from Lima has made three trips and we are told by good authority he got from 25 to 30 young ones to sell. This ought to be put a stop to or we will soon have none of the sacred birds on our lakes" (Beaverhead County History Book Association 1990).

The Works Progress Administration constructed the original shop/office, barn, residence, oil storage shed, and fire tower in 1936 and 1938. All of the buildings have undergone some modifications with the office having major changes over the years. Although several other buildings and structures have been added to the headquarters site, it is still considered eligible for inclusion into the National Register of Historic Places.

A comprehensive cultural resource inventory has not been completed. Only site-specific inventories for project areas or buildings have been done. The area is rich in cultural resources, and a comprehensive inventory would help the refuge in protecting these sites.

4.4 SPECIAL MANAGEMENT AREAS

Wilderness Designation

Congress designated 32,350 acres of the refuge as the Red Rock Lakes wilderness area in 1976 (figure 17). The wilderness is one of 71 such areas managed by the U.S. Fish and Wildlife Service. In 1964, Congress passed and the president signed the Wilderness Act, which established the National Wilderness Preservation System. The legislation set aside certain federal lands as wilderness areas. Four federal agencies of the United States government administer the National Wilderness Preservation System, which includes 702 designated areas and more than 107 million acres. Wilderness, as defined by the Wilderness Act, is untrammeled (free of human's control), undeveloped, and natural and offers outstanding opportunities for solitude and primitive recreation. The Refuge System manages refuge wilderness to secure an enduring resource of wilderness and to accomplish refuge purposes in a way that preserves wilderness character. People value wilderness for its wildlife, scenery, clean air and water, opportunities for solitude, and a sense of connection with nature. Wilderness policy permits hunting, fishing, wildlife observation, wildlife photography, environmental education, interpretation, hiking, backpacking, cross-country skiing, canoeing, and kayaking on national wildlife refuges where these activities are deemed compatible with the purposes of the refuge.

Wilderness Review

A wilderness review is the process used to determine whether to recommend Service lands or waters to Congress for designation as wilderness. The Service is required to conduct a wilderness review for each refuge as part of the CCP process. Land or waters that meet the minimum criteria for wilderness are identified in a CCP and further evaluated to determine whether they merit recommendation for inclusion in the Wilderness System. To be designated a wilderness area, lands must meet certain criteria as outlined in the *Wilderness Act of 1964*:

- generally appears to have been affected primarily by the forces of nature, with the imprint of human work substantially unnoticeable.
- has outstanding opportunities for solitude or primitive and unconfined type of recreation.
- has at least 5,000 acres of land or is of sufficient size to make practicable its preservation and use in an unimpaired condition.
- may also contain ecological, geological, or other features of scientific, educational, scenic, or historic value.

As stated earlier, 32,350 acres of the refuge are already designated as wilderness. This encompasses over 68% of the refuge. The planning team examined other portions of the refuge for inclusion into the wilderness area. Expanding this wilderness area into other portions of the refuge would make management and enhancement of the refuge difficult. This could result in a net loss of habitat and continued spread of invasive plants. The planning team is not recommending any further additions or expansions to this existing wilderness boundary.

National Natural Landmark

The National Natural Landmarks Program was established in 1962 by the Secretary of the Interior "to identify and preserve natural areas that best illustrate the biological and geological character of the United States, enhance the scientific and educational values of preserved areas, strengthen public appreciation of natural history, and foster a greater concern for the conservation of the nation's natural heritage" (36CFR62.1(b)). It is the only natural areas program of national scope that identifies and recognizes the best examples of biological and geological features in both public and private ownership. To date, there are about 600 sites designated as National Natural Landmarks.

Portions of the Red Rock Lakes National Wildlife Refuge were designated as a National Natural Landmark in May 1976. Designation was granted because the refuge contains a "series of relatively undisturbed, high-altitude ecosystem types, representative of pre-settlement conditions in this region including various wetland types as well as upland meadows and forests." The evaluation also commented on the outstanding waterfowl production that occurs on the refuge, as well as the occurrence of several "uncommon species" at the time of

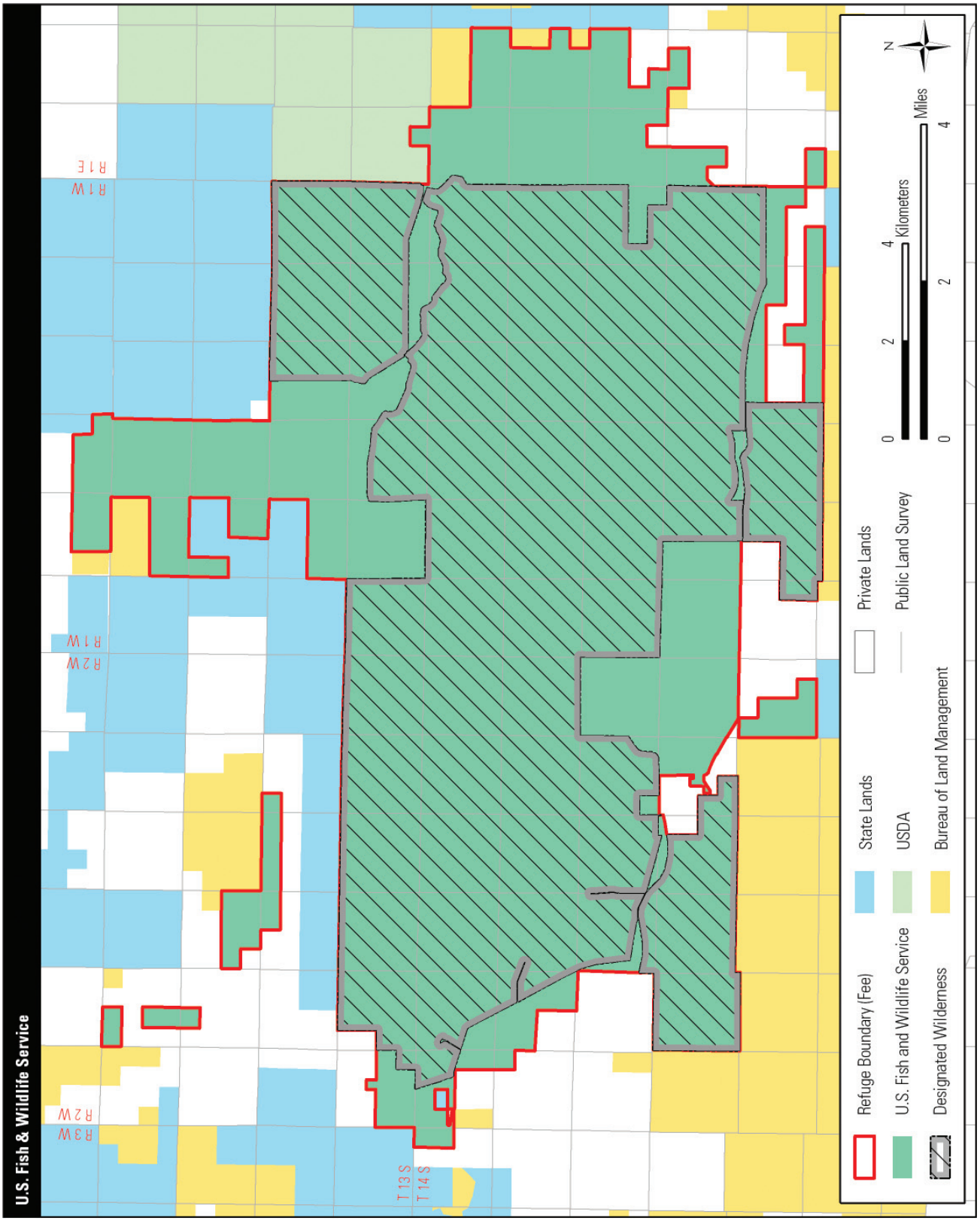

Figure 17. Designated wilderness within the acquisition boundary of Red Rock Lakes National Wildlife Refuge.

designation (some of the uncommon species include peregrine falcon and bald and golden eagles).

Research Natural Area

Research Natural Areas are part of a national network of reserved areas under various ownerships where natural processes are allowed to predominate and which are preserved for the primary purpose of research and education.

The U.S. Fish and Wildlife Service administratively designates research natural areas on refuges. Currently, there are 210 research natural areas on national wildlife refuges. Research natural areas have these objectives:

- to help in the preservation of examples of all significant natural ecosystems for comparison with those influenced by man.
- to provide educational and research areas for scientists to study the ecology, successional trends, and other aspects of the natural environment.
- to serve as gene pools and preserves for rare and endangered species of plants and animals.

On Red Rock Lakes National Wildlife Refuge, the Douglas-fir forest that occurs on Sheep Mountain was designated a research natural area. The entire research natural area is 85 acres in size.

Important Bird Area

The American Bird Conservancy's Important Bird Area Program concentrates on identifying and documenting the top important bird sites throughout all 50 states. For a site to be designated as an Important Bird Area (IBA), it must, during at least some part of the year, contain critical habitat that supports (1) significant numbers of an endangered or threatened species such as piping plover, red-cockaded woodpecker, or Kirtland's warbler; (2) a watch list species such as black rail, cerculean warbler, or Henslow's sparrow; (3) a species with a limited range such as tricolored blackbird, yellow-billed magpie, or brown-capped rosy-finch; or (4) a significantly large concentration of breeding, migrating, or wintering birds, including waterfowl, seabirds, wading birds, raptors, or land birds.

Red Rock Lakes National Wildlife Refuge received designation as an Important Bird Area by the American Bird Conservancy in July 2001. More than 230 species of birds have been documented on the refuge, which is well known for its breeding trumpeter swans and other wetland species. An estimated 2,000 pairs of Franklin's gulls nest here, as do more than 200 pairs of white-faced ibises. A pair of peregrine falcons and three pairs of bald eagles have nested on the refuge for many years. Thirteen species of breeders are of global (long-billed curlew, olive-sided flycatcher, Cassin's finch) or continental (trumpeter swan, bald eagle, northern harrier, Swainson's hawk, peregrine falcon, Wilson's phalarope, short-eared owl, Williamson's sapsucker, red-naped sapsucker, and willow flycatcher) conservation concern. Numerical data is unavailable for most of these species but trumpeter swan surveys document that numbers exceed threshold values to classify the refuge as an IBA of continental significance.

4.5 VISITOR SERVICES

Visitors to Red Rock Lakes National Wildlife Refuge enjoy a variety of activities, including priority visitor services such as hunting, fishing, wildlife observation, wildlife photography, wildlife interpretation, and environmental education.

The annual number of visits to the refuge is around 12,000. This estimate is loosely based on visitors entering the visitor contact station, campground sign-in sheets, and general observation. The small visitor contact station, housed with administrative offices, is open Monday through Friday. Information, regulations, and universally accessible restrooms are available.

The refuge has a general brochure that contains a refuge map, describes the refuge and its management, identifies habitats and common wildlife, lists recreational activities, and cites regulations. Two other leaflets provide information for visitors who are hunting or observing birds. These two leaflets are produced by the refuge and do not meet Service standards. Brochures are generally available at the visitor contact station, Upper Lake and River Marsh campgrounds, and at kiosks located at headquarters, the east side of the refuge, and on Elk Lake Road.

Hunting

Various forms of hunting are allowed in selected units of the refuge. Hunting seasons can start as early as August for archery seasons and generally go through the end of November. Species hunted include elk, white-tailed deer, mule deer, moose, pronghorn, ducks, coots, and geese.. Certain areas are closed to hunting to provide resting and feeding habitat for migratory birds, to protect refuge facilities, and to separate user groups. The limited moose hunting (currently an average of 11 permits annually) on the refuge is confined to the willow fen area (southeast corner of the refuge) and begins later than the state regulations. Boat launches are provided on Lower Lake for waterfowl hunters.

Fishing

Fishing primarily focuses on three introduced trout species (rainbow, brook, and Yellowstone cutthroat). Native sport fish species include Arctic grayling, mountain whitefish, and Westslope cutthroat

trout, although the latter has hybridized with the introduced Yellowstone cutthroat. The Arctic grayling and Westslope cutthroat are both species of special management concern. Fishing generally follows state regulations, with some areas closed to fishing seasonally or year-round. Fishing is allowed on Red Rock, Odell, and Elk Springs creeks, and Culver, MacDonald, and Widgeon ponds.

Wildlife Observation and Photography

Wildlife observation and photography is the most popular visitor service on the refuge. Most visitors view wildlife from the public roads and refuge campgrounds. There are two designated hiking trails, but no auto tour route or overlook. Foot travel is permitted throughout the refuge, and visitors are encouraged to take a hike into the wilderness. Boat launches are provided at Upper Lake and River Marsh campgrounds and Lower Red Rock Lake to allow visitors to explore the refuge and the wildlife by canoe or kayak during certain times of the year.

Environmental Education, Outreach, and Interpretation

Staff-led environmental education, outreach, and interpretation programs are very limited, with refuge staff conducting talks or tours on an "as-needed" basis. Due to the refuge's distance from local schools (minimum 45 miles, one way) and remote location, there is minimal contact with students in the surrounding communities. Visitors may explore the refuge independently and are provided some interpretation of refuge resources through informative panels in kiosks located at the headquarters, Upper Lake campground, east entrance, and along Elk Lake Road. There are also displays, interpretive panels, and maps in the visitor contact area in the headquarters office. Interpretive panels are also located at Shambow Pond and the sandhills.

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Upper Lake campground.

Camping

Due to its remote location, the refuge provides two campgrounds for visitors to participate in wildlife-dependent recreational activities on and off the refuge. River Marsh campground is located at Lower Red Rock Lake and the other campground is at Upper Red Rock Lake. Both are primitive sites with toilets, fire rings, and some picnic tables. Water is only available at Upper Lake campground. One campsite at the Upper Lake campground is universally accessible, but the outhouses are not.

4.6 SOCIOECONOMIC ENVIRONMENT

A socioeconomic study prepared by BBC Consulting (2007) is the source for the information in this section.

Red Rock Lakes National Wildlife Refuge is open to the public and offers hunting, fishing, and wildlife observation and photography. These recreational opportunities attract outside visitors and bring in dollars to the community. The refuge primarily draws visitors from nearby Henry's Lake in Idaho, but some come from Yellowstone National Park to the east. Ancillary visitor activity, such as spending on food, gasoline, and overnight lodging in the local area, provides local businesses with supplemental income and increases the local tax base. Management decisions regarding visitor services, expansion of services, and habitat improvement measures may either increase or decrease visitation to the refuge and thus affect the amount of visitor spending in the local economy.

Study Area

Red Rock Lakes National Wildlife Refuge is located in Beaverhead County in southwestern Montana, near the Idaho border. The study area also includes neighboring Madison and Gallatin counties as well as Fremont County, Idaho, because they are in close proximity to the refuge and could potentially be affected by management decisions. Gallatin County is different than the other counties because it has a much greater population and larger urban centers located far from the refuge; however, it is included in the study area because the city of West Yellowstone, located in the southern arm of the county near the refuge, serves as a base for overnight accommodation and commercial activity among visitors to the refuge. Fremont County in Idaho is also included because many visitors to the refuge stay in the area surrounding Henry's Lake and towns to the south.

Population and Demographics

The estimated 2005 population of the four-county study area was almost 106,500. Due to the large urban center of Bozeman and surrounding communities, Gallatin County is by far the most populous county in the region, with a population of

78,200 in 2005; followed by Fremont County, Idaho (12,200); Beaverhead County, Montana (8,800); and Madison County, Montana (7,300). The population of the study area grew by over 26% between 1990 and 2000 from 75,800 to 95,700. The population of Montana grew by 13% from 800,000 to 900,000 over the same period. Future growth rates for the study area and the state overall are expected to follow historical trends.

About 32% of the population in 1990 was between 35 and 64 years old, while that same demographic constituted 37% of the population in 2000. Gallatin County, with a large student population, and Fremont County, Idaho, have younger populations, with a median age of 32 in 2000, compared to a median age of 39 in Beaverhead County, and 43 in Madison County.

Employment

Employment in the four-county study area grew significantly between 2001 and 2005, from 43,000 to 50,800, an increase of 18%. Gallatin County had by far the largest workforce with 42,102 employees, followed by Beaverhead County (3,380); Fremont County, Idaho (2,890); and Madison County (2,390). Estimates from 2005 calculated the unemployment rate for Fremont County at 3.9%, Beaverhead County at 3.4%, Madison County at 3.1%, and Gallatin County at 2.8%. These compare favorably to a statewide unemployment level of 4% in Montana and Idaho.

The study area primarily employs individuals in retail trade, accommodations and food services, and educational services. Retail establishments employed 15% of the workforce, while accommodation and food services,and educational services each employed 14% of the workforce. The agricultural industry in the study area is small, employing only 2% of the workforce.

This data is largely driven by the large workforce of Gallatin County. When Beaverhead, Madison, and Fremont (Idaho) counties are examined alone, significantly greater proportions of the workforce are employed in agriculture (6.8%) and public administration (13.5%), and a significantly smaller proportion of the workforce is employed in educational services (9.4%).

Current Conditions

Red Rock Lakes National Wildlife Refuge affects the local economy through the visitor spending it generates and the employment it supports. The refuge currently supports five full-time permanent employees.

The refuge sees approximately 12,000 visitor days annually, of which an estimated 85%, or 10,200 visitor days, are not from the local area. Considering that expenditures can vary greatly among campers, lodgers, and passers-by, it is estimated that on average, a visitor to the refuge will spend $25 in the local area per day, for an annual total of about $260,000.

4.7 OPERATIONS

Staffing

Red Rock Lakes National Wildlife Refuge has been managed as a "stand alone" refuge since its establishment in 1935. Over the past 70 years, there have been a wide variety of staffing levels. In fiscal year 2007, the refuge was provided base funding for one full-time permanent refuge manager (GS-12), one full-time permanent assistant refuge manager (GS-11), one full-time permanent biologist (GS-11), one full-time permanent maintenance worker (WG-08), and one full-time permanent administrative assistant (GS-7) (table 5). In recent years, the refuge has used grants and other "soft" funding sources in order to hire seasonal staff (such as seasonal biological technicians) and cover the cost of volunteer services. Over the past 5 years, seasonal staffing levels have varied depending on the amount of funding acquired through "soft" funding sources. Seasonal staff have been essential for collecting biological data, maintaining equipment and facilities (for example, signs, buildings, and fences), and orienting and educating refuge visitors. The hiring of seasonal staff has been invaluable to accomplishing biological and visitor service goals each year.

Staff located at the refuge headquarters are responsible for Red Rock Lakes National Wildlife Refuge as well as the Centennial Valley Conservation Easement program (see "Centennial Valley Conservation Easement" on following page).

Table 5. Current base funded staff at Red Rock Lakes National Wildlife Refuge, Montana.

Staff Group	*Position*
Management	Refuge manager, GS-12, assistant refuge manager, GS-11
Biology	Wildlife biologist, GS-9/11
Administration	Administrative assistant, GS-7
Maintenance	Maintenance worker, WG-8
Total Salaries and Benefits = $309,365	

Facilities

The refuge used the Works Progress Administration (WPA) between 1936 and 1938 to build one log home, one log administrative and maintenance building (since converted solely to an administrative and visitor contact station), two log storage barns, and

one metal fire tower. The refuge has since added several structures to help with management and operation activities. These additional structures include three 3-bedroom residences, one 4-bedroom bunkhouse, one metal maintenance shop, three vehicle and equipment storage structures, one trailer pad, and one 2-bedroom cabin. These structures were obtained through land acquisitions or built by the refuge staff.

The infrastructure for these buildings includes two wells (supplying potable water to the residences, administrative building, bunkhouses, and maintenance shop) and six operational septic systems. The refuge also has an operable cistern that draws water from Shambow Creek. This was the main source of water for the residences until 1956 when a well was established. The cistern now serves as a back-up water supply system and is used occasionally by the refuge staff. The cistern was also used to supply water to the surrounding town of Lakeview. The current year-round population of Lakeview is between five and 15, including the refuge staff and their families.

There are several unused log buildings and structures that were obtained through various land acquisitions. Several of these serve as reminders of the homesteading era (for example, the Buck and Hanson homesteads), and the Compañeros house is eligible for listing under the National Historic Preservation Act.

There are numerous water control structures, diversion ditches, culverts, and cattle guards (of various ages and condition) located throughout the refuge. There are approximately 12 miles of public and service roads maintained by the refuge staff and 23 miles of county-maintained roads that bisect the refuge. The South Valley Road (also known as Red Rock Pass Road) is maintained during the winter only from Monida, Montana, to the refuge headquarters. Depending on local weather conditions, this road can be impassable for several days to months at a time during the late fall, winter, and early springtime periods. No other county roads are maintained during the winter months.

Centennial Valley Conservation Easement and Land Acquisition Program

Most valleys and foothills in the Greater Yellowstone Area and near the Centennial Valley are being developed or subdivided to provide homes for people wanting to live in more rural settings. During the 1960s, demographers documented that for the first time in American history, higher proportions of people were leaving cities for parts rural than were making the return trip (Fuguitt 1985). "Exurbanization" accelerated in the 1990s, drawing people still further out into the rural west. In the 1990s, the West's "beachfront property"—rural lands adjacent to national parks and forests—were the fastest growing areas (Rudzitis 1996). In the Greater Yellowstone area, fully one-third of all private lands have already been subdivided for development, with a majority of new lots locating outside existing towns (Harting and Glick 1994). In Gallatin County, 17,000 acres of farmland were subdivided between 1993 and 1999 alone. Madison Valley recorded 16,000 acres subdivided into 685 lots between 1994 and 1998—most of this into 20-acre "ranchettes" (Johnson 1999). Even in counties with slow growth rates, loss of agricultural land continues. The state of Montana, as a whole, is consuming land four times faster than the population growth rate (U.S. Census Bureau 1999).

The Centennial Valley, in which the refuge lies, remains biologically intact and has not been converted to housing developments. Almost 100,000 acres in the Centennial Valley are privately owned, and the majority of this land remains as large working ranches. The Service recognized the opportunity to partner and compensate these landowers for keeping their lands intact and in 2001 the Service approved the Centennial Valley Conservation Easement Program. An approved acquisition boundary was determined at that time. Since this program began, the refuge has acquired perpetual conservation easements on 20,219 acres from nine landowners (see figure 6, page 19). There are approximately 20,000 acres of additional ranch lands in the Centennial Valley protected by perpetual easements acquired by nongovernmental organization. Given the current trends of low cattle prices and a strong market for scenic western properties, the remaining unprotected Centennial Valley ranches may be vulnerable to sale and subdivision for development.

To achieve Service goals for fish, wildlife, and habitats (including providing large tracts of unfragmented habitats), the Service will pursue acquisition or protection, or both, of inholdings from willing sellers within the approved refuge and Centennial Valley conservation easement boundaries using both fee title and perpetual conservation easements (USFWS 2001). Key areas to acquire and protect include, but are not limited to

- lands that protect and augment existing large tracts of undeveloped and unfragmented habitats (for example, Centennial livestock);
- lands that would protect wetland or riparian habitats, or both (such as those along Red Rock Creek);
- lands that would protect source waters into the refuge to maintain or improve water quality and quantity of the refuge's wetland habitats (such as Alaska Basin and Red Rock Creek) (Note: the reach of Red Rock Creek through the area known as Alaska Basin is the largest input of water into the refuge remaining unprotected. It is key spawning habitat for Arctic grayling and

arguably the most important input of water into the refuge's wetland complex).

Staff located at the refuge headquarters are responsible for the Red Rock Lakes National Wildlife Refuge and for managing and monitoring lands protected under the Centennial Valley Conservation Easement program (see preceding page). No additional staff or operational funding was added to the refuge when the conservation easement program was established in 2001.

Partnerships

The refuge has a history of fostering partnerships that help the refuge accomplish its mission and goals. The refuge actively sought and fostered partnerships with organizations and individuals with whom a common goal was shared. These partners include county, state, and federal agencies; nongovernmental organizations and conservation groups; schools, colleges, and universities; and local landowners and private citizens. Private lands and significant acres of federal and state lands surround the refuge. These neighboring landowners and agencies have been and will continue to be partners in achieving the refuge's vision in the Centennial Valley, while sharing ideas and resources

The refuge's partners have assisted in wildlife and habitat management, visitor services and recreational opportunities, land protection and acquisition, fire protection, law enforcement, and community outreach. Several of these relationships have developed into formalized partnerships with written agreements or memorandums of understanding, while others remain more informal.