Western meadowlark
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Chapter 4 Biological Environment

This chapter addresses the biological resources and habitats found on the Refuge. However, it is not an exhaustive overview of all species and habitats. The chapter begins with a discussion of biological integrity (historic conditions and ecosystem function), as required under the Improvement Act. The bulk of the chapter is then focused on the presentation of pertinent background information for habitats used by each of the priority resources of concern (ROCs) and other benefitting species designated under the CCP. That background information includes descriptions, conditions, and trends of habitats and threats (stresses and sources of stress) to the habitats and/or associated ROCs. This information was used to develop goals and objectives for the CCP.

4.1 Biological Integrity, Diversity, and Environmental Health

The National Wildlife Refuge System Administration Act (as amended) requires the maintenance of the biological integrity, diversity, and environmental health (BIDEH) of the System. The BIDEH policy (601 FW 3) defines *biological integrity* as "the biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities." *Biological diversity* is defined as "the variety of life and its processes, including the variety of living organisms, the genetic differences among them, and communities and ecosystems in which they occur." Simply stated, BIDEH is represented by native fish, wildlife, plants, and their habitats as well as those environmental conditions and processes that support them. The Administration Act states that each refuge will be managed to fulfill refuge purpose(s) as well as to help fulfill the System mission. We strive to accomplish these purposes and our mission by ensuring that the biological integrity, diversity, and environmental health of Malheur Refuge is maintained and enhanced.

The Refuge System policy on BIDEH (601 FW 3) also provides guidance on consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on the refuges and in associated ecosystems, that represents BIDEH on each refuge.

4.1.1 Overview

Throughout this document, the concept of a healthy system (either aquatic or terrestrial) is the goal or direction the Refuge wishes to take in habitat management. The Refuge defines a healthy system as a landscape, land unit, or habitat in which natural ecological processes function in concert to permit an area to be productive and have a fundamentally dynamic nature. These interacting processes result in a mosaic of communities that are resilient to disturbances but that change over time along the ecological continuum defined by the Ecology Work Group (Appendix L). This result ensures balance, appropriate niches, or natural variation necessary for the wide array of potential wildlife species that could use the area. The refuge goal of restoring or maintaining the resiliency of this system and understanding the importance of all the components or needs of wildlife (migration, production, and maintenance habitat) ensures the richness necessary to maintain a healthy system, provide for the wide diversity of wildlife that use the area, and allow the area to buffer or absorb impacts from major disturbances.

Malheur National Wildlife Refuge is composed of three very distinct environments, each including a diversity of native habitats and landscapes. The core of the Refuge is dominated by a shallow lake basin and encompasses Harney, Mud, and Malheur lakes. This 103,799-acre area covers 56 percent of refuge lands. The Blitzen Valley, a broad corridor (64,215 acres) to the south of the lake basin, is divided along its entire length by the Blitzen River and associated riparian habitat. The valley covers

34 percent of the Refuge and provides most of the water feeding the central lake basin. The Double-O is a broad valley basin which covers 10 percent (19,198 acres) of refuge lands. Intermittent water from the Silver Creek watershed flows through this management area and drains into Harney Lake (see Chapter 3). Together, these three environments result in a diversity of habitats, which support more than 415 species of birds, mammals, fish, reptiles, and amphibians.

4.1.2 Wildlife and Habitat Conditions and Changes Since 1800

The Harney Basin ecosystem, of which the Refuge is a part, has undergone dramatic alteration over the past 200 years. Three of the most discernible changes are

- changes in Harney Basin lake and river hydrology due to diversion dam and irrigation operations;
- changes to species composition (decline and loss of native species and influx of non-native and invasive species) into the system; and
- conversion of basin habitats to agricultural and ranching lands (including diking and irrigation).

Many of the habitat changes and the spread of non-native and invasive species were underway long before the Refuge was established. This section discusses the connection between these landscape-level changes and the current vegetation and wildlife on the land and waters managed by the Refuge. This summary is not a complete analysis of all factors related to changes in native vegetation, fish, and wildlife. Much of the information presented here is based on staff knowledge of the area.

Historic Description of Habitat and Wildlife

Historically the Blitzen and Double-O valleys, along with the lake basin located within the refuge boundary, had a much different appearance than they do today. Wigand's work (Wigand 1987) on the vegetation and water table history of Diamond Pond, located in the Diamond Craters, illustrates the constant flux and change in water levels which prevailed in the area prehistorically. Between 1400 and 900 B.P., increased grass pollen signified greater effective moisture resulting in deeper water with abundant pondweed (*Potamogeton* sp.). Increased greasewood and saltbush pollen around 500 B.P. provide evidence of drought conditions. Widgeongrass (*Ruppia* sp.) seeds and pollen and the presence of bivalve mollusk (*Musculium* sp.) shells indicate shallow brackish water. Abundant juniper and grass pollen samples indicate moister conditions from 300 to 150 B.P. Numerous hornwort fruits (*Ceratophyllum* sp.) indicate deeper, freshened water during this period. The last cycle, sampled from the mid-1880s, showed another climate change with sagebrush re-expansion and increased sedge (*Scirpus* sp.) macrofossils indicating shallower water.

Fur trapper Peter Skene Ogden's journal of 1826 describes the lakes portion of the Harney Basin as swampy country with flat terrain and rivers flowing into two lakes with no outlet (see Section 5.1.2). Eli Cooley's diary of 1845 (Cooley and Cooley 2004) describes the vegetation along the lower Silvies River as plenty of grass and willow. As their wagon train moved west along the north side of Malheur Lake, cutting across the end of Wright's Point and camping by Harney Lake, the habitat was described as plenty of grass, no wood, and some sage. As they moved upstream along Silver Creek before crossing it and turning west, the area was again defined as having plenty of grass and willow.

The 1853 journal of wagon train emigrant Benjamin Owen labeled the lower Blitzen River as a deep miry stream. They had trouble finding a suitable ford and had to travel over 5 miles (in the vicinity of

Rattlesnake Butte) upstream to secure a safe crossing for their wagons and livestock (Beckham 1995).

The Wallen party of 1859 moved through the basin on the north side of Malheur Lake and described the area as follows: "the country is a beautiful level valley, covered with luxuriant growth of bunch grass, wild pea vines, and red clover, interspersed with fields of camas on a rich soil abundantly watered by numerous mountain streams …. This wide savannah or grassy meadow section is abundant; pronghorm, deer, elk, and several species of grouse, prairie chickens, ducks and geese, etc." (Beckham 1995).

Langston provides a historical perspective of habitat conditions before substantial alterations by settlers in her book entitled *Where Land & Water Meet: a Western Landscape Transformed* (Langston 2003). She states that when Peter French first arrived in the Blitzen Valley in the early 1870s, he found "a water world: a maze of streams, channels, wetlands, bogs, alkaline lakes, and lush riparian meadows—all fed by waters from the Blitzen River." She also documents that in a 1935 radio talk show, William L. Finley stated, "Peter French … wandered into what is now known as the Blitzen Valley, a wide flat plain watered by a fine stream, green with wide meadows of luxuriant grasses, interspersed with thickets of willow, and with great areas of swampy ground and shallow ponds." Moreover, tule marshes characterized extremely wet areas surrounding the P Ranch at the southern end of the Blitzen Valley. In fact, French noted that his livestock took cover in tules during extreme winter weather (Langston 2003).

Documentation of vegetation prior to Euro-American settlement is sketchy, existing only in the form of broad-sweeping descriptions caught in diaries and correspondence. Nevertheless, combining these references with soils information and comparisons with similar systems within the Northern Great Basin suggests that the area hosted a complex, heterogeneous mixture of plant species ranging from cattails and bulrushes in permanent marshes to dryland grasses, forbs, and shrubs in highland areas with rushes, sedges, and wetland grasses appearing along moisture gradients.

Changes to Harney Basin Hydrology, Wildlife, and Habitats Since 1850

Although people were present in Harney Basin prior to the 1850s, human influences were probably limited to minimal impacts by Northern Paiutes, fur-trapping expeditions, and settlers moving by wagon train through the area. Beckham's (1995) document on the historical appearance and uses of the Donner und Blitzen River from its headwaters to the confluence with Malheur Lake shows the trend of changes that have occurred throughout the basin over time.

In the 1870s stockmen poured into the rangelands of the Harney Basin claiming all the primary water sources and thus dominating the surrounding lands. Meanwhile, the State of Oregon was accepting applications to purchase tracts of swamplands and in the 1880's began issuing deeds. Peter French and other cattlemen acquired control of these deeds throughout the basin. This initiated an ambitious period of irrigations projects, first in the Blitzen River Valley but soon expanding to other waterways in the basin. Water was diverted into canals and ditches, flooding out sagebrush and inducing the growth of meadow grasses. This heavy irrigation had dramatic effect on basin landscapes, affecting not only uplands, but wetlands and the lakes. Giles French wrote of Peter French's irrigation projects: "His irrigation projects of themselves held water of Malheur Lake at a lower level, causing more dry land between the water and the meander line" (French 1964).

The Blitzen River has undergone significant alterations since the late 1800s. The construction of an intensive irrigation system, including seven diversion dams and a vast network of ditches, dikes, and ponds, was initiated under the management of Peter French and reached its peak during the CCC era following the Great Depression. The channelization of approximately 17.5 miles of the Blitzen River between Bridge Creek and Busse Dam also took place prior to Federal acquisition in 1935. Human activity in its various forms has disrupted the natural hydrology of historic river meanders and smaller braided tributaries; however, the ability to move irrigation water around the Blitzen Valley via canals and ditches has expanded wetland habitats that would not otherwise exist.

Changes to Species Composition: Irrigation and livestock grazing have had a profound impact on basin habitats and wildlife. Native grasses and forbs are not adapted to heavy grazing pressure or extended irrigation and have become susceptible to the spread of exotic plant species in many areas. Non-native pasture and forage grasses were also introduced. These grasses had a competitive advantage over native species under heavy grazing or irrigation pressure and thus altered many plant communities. Increased and improved irrigation around riparian areas permitted reed canarygrass to invade and largely replace the native understory plant community. Today, areas within irrigated meadows are dominated by creeping wildrye, orchardgrass, timothy, smooth brome, Nebraska sedge, meadow foxtail, and reed canarygrass. Creeping wildrye and Nebraska sedge are native species, but the remainder have been introduced to the area and did not occur before European settlement. These two factors were the beginning of the decline of wildlife species tied to upland or riparian habitats such as the yellow-breasted chat, willow flycatcher, meadowlark, and bobolink. On the other hand, grazing may have benefited other wildlife species such as greater sandhill cranes, horned larks, and snow geese. The positioning of wetlands, pasture, and croplands may have actually helped sustain populations of waterfowl and other birds that prefer short, nutritious grass.

Interruption of ecological function on the Blitzen River, Silvies River, and Silver Creek also had a profound impact on fish species. Channelization destroyed habitat complexity on large reaches of these waterways and is believed to have reduced the abundance of fish species. Barriers prevented or delayed migratory fish patterns and isolated portions of some populations. Altered water parameters such as water quality have pushed some species such as mountain whitefish to the least disturbed stretches of these streams. The increase in human disturbance has also naturally led to the introduction of exotic species such as sunfish, bluegills, large-mouth bass, and bullheads.

Conversion of Basin Habitats to Agricultural and Ranching Lands: At the close of the 1800s and the beginning of the new century, homesteaders moved onto lands below the Malheur Lake meander line, leading to conflict between ranchers and these new immigrants. During this time, heavy use was made of the lake bottom by large and small ranching operations for grazing, haying, and crops. During the same time frame, women's millinery fashions created a major market for plume hunters, who decimated populations of herons and egrets on Malheur Lake.

It was in this altered environment that Malheur National Wildlife Refuge was established in 1908. As a result of the outrage over the decimation of colonial nesting birds on Malheur Lake, President Theodore Roosevelt set aside unclaimed government lands encompassed by Malheur, Mud, and Harney lakes.

4.1.3 History of Refuge Management

As discussed in Chapter 1, the purposes of the Refuge primarily pertain to the perpetuation of breeding birds, migratory birds, and other wildlife.

Malheur Refuge lies in the shrub-steppe association of the Basin and Range Province of Oregon (Bailey et al. 1994) and hosts a significant portion of riparian and floodplain habitats (wet meadows and marshes) that are under-represented and degraded throughout this ecoregion. It is one of the oldest and most important migratory bird refuges in the Refuge System. It has long been recognized for its contribution to the Pacific Flyway as a major and essential feeding and resting location for Pacific Flyway birds migrating between the northern breeding grounds and wintering areas to the south. It is also an important breeding ground for wetland-dependent migratory birds.

The maintenance and enhancement of wetland systems occurring within the Refuge contributes not only to management for refuge purposes but also to biological integrity at multiple landscape levels. On the larger landscape scale, it is important to migratory birds on the Pacific Flyway. At the local scale, the area is significant because of native wetland and riparian plant communities and their value to resident wildlife. At the same time, the Service recognizes that wetland management should be balanced with the habitat requirements of native fishes (redband trout) and the need to improve water quality.

After the Refuge was established the Refuge remained unstaffed until 1911, when State game wardens were assigned to enforce State hunting and trapping laws. It was not until 1915 that data were finally compiled about lake levels and bird populations. Considerable time was spent banding waterfowl after 1920, and these records were used to determine bird population trends on the lakes.

In the 1930s, drought had a profound effect on the basin; with decreased flows from rivers and streams, lake levels shrank. Without a fence around the Refuge, the sole refuge employee spent considerable time keeping adjacent landowners from using refuge lands for agricultural purposes. Resolution to this issue came in 1935 when the Blitzen Valley was added to the Refuge. Acquisition of water rights for the Blitzen River allowed the release of water to the lakes that had previously been kept behind ranch dams.

William Finley described the Blitzen Valley and lake condition at that time as

> a wide flat plain watered by a fine stream, green with wide meadows of luxuriant grasses, interspersed with thickets of willow, and with great areas of swampy ground and shallow ponds. … Within the boundaries of this refuge such favorite waterfowl as Canada geese, Mallards, Pintails, Gadwall, Redheads, Ruddy Ducks and Cinnamon Teal nest and rear their young by the thousands, while during the fall and spring migrations myriads of northern-bred ducks and geese find a haven of refuge on Malheur Lake and in the swamps of the Blitzen Valley where natural food is abundant. Not only are ducks and geese found here but the great American egret, the White-faced Glossy Ibis, and the Black-necked Stilt…. Herons, bitterns, coots, grebes, and great colonies of California and Ring-billed gulls, Forester Terns, Black Terns and other marsh-loving birds held interest of the visitor. … Of upland game and song birds there is an unusual population. Sage hens stalk about the sagebrush covered slopes, and the California or Valley Quail scurry under the tickets. The introduced Hungarian Partridge and the Ring-necked Pheasant find the climatic conditions here to their liking. … Although birds, both in number of species and the number of individuals, form the greatest of the wildlife population, the visitor can find a large number of beaver along the Blitzen River.

Nationwide waterfowl numbers had declined so rapidly because of widespread drought that Federal funds were allotted to restore breeding and feeding areas. Malheur Lake was given high priority, and thus began the era of the Civilian Conservation Corps and major refuge restoration projects. Projects included the construction of Refuge Headquarters, boundary fences, dikes (to better conserve water for both the lakes and valley), canals (to carry water to favored feeding grounds), and roads (to better patrol the area). The water delivery system within the Blitzen River Valley was developed or enhanced to provide water for new wetlands (Boca, Benson, Knox, Wright, and Buena Vista ponds).

Although most of the projects were considered very beneficial to restoring water to the lakes and wetlands, some of the projects continued the disruption of the natural hydrological processes in the basin, such as replacement of five wooden diversion dams with concrete diversion dams, which included fish ladders. In addition, when some projects were combined with other human impacts, such as grazing and irrigations practices, whole plant communities were altered. The Refuge developed a cropland management program to provide carbohydrate-rich crops for fall migrants, particularly waterfowl and cranes.

The 1940s and 1950s saw the next major change to Harney Basin ecology and impacts to the Refuge, with the introduction of common carp to the Silvies River. Carp spread throughout the system in a very short period of time and altered wetland systems by uprooting submergent and emergent vegetation, increasing turbidity, and exposing wetlands to wind and wave erosion. This had a tremendous impact on the number of birds using Malheur Lake, particularly waterfowl and other wetland nesting and feeding species. Intermittent attempts to eradicate carp were carried out in 1955, 1961, 1968, and periodically since then. Control efforts showed positive results for one to two years after treatment until population dynamics re-established carp in treated areas.

Other management activities during this period saw the third major addition to the Refuge with the purchase of the Double-O Unit to provide habitat for shorebirds, waterbirds, and waterfowl. Grazing was used as a management tool to maintain short-grass habitat for waterfowl, cranes, and other grasslands nesting species. Rainbow trout were introduced into Krumbo Reservoir (constructed in the mid-1950s), and trumpeter swans were reintroduced to the Refuge.

In the 1970s, the Refuge shifted its management direction to bring activities in line with new Service directives by developing a refuge land use plan for habitat management. This called for a shift in management actions by reducing the amount of cattle grazing on the Refuge and providing other tools to maintain short grass or meadow habitat. Management actions to control exotic and invasive species were initiated. Formal survey procedure and protocols were developed to monitor habitat and wildlife. All these changes were part of a move to support greater conservation of resources under new national policies.

Higher-than-normal precipitation levels in the 1980s resulted in extensive flooding throughout the basin and the subsequent destruction of infrastructure and habitat. With the high water and the deleterious effects of carp on Malheur Lake, conditions were in place to accelerate destruction of Malheur Lake ecology. Wind, waves, and ice scoured the lake substrate, creating a shallow uniform lake bottom in which sediments never settled and emergent and submergent vegetation became mostly absent from the central portion of Malheur Lake. With the loss of emergent vegetation, the muskrat population on the lake was drastically reduced and to date has not recovered. Refuge staff was also charged with developing a master plan for the Refuge.

As quickly as the water rose in the 1980s, the lake rapidly diminished in the early 1990s, with watering covering just a few thousand acres in the center of the lake. This shift sharply curtailed wildlife use of the lake. From the 1990s onward, the Refuge continued to repair the damage to habitats and infrastructure and provide for wildlife needs in the Blitzen Valley while waiting for increased precipitation events to restore water to Malheur Lake.

Fish passage, screening, and fish traps became an important issue trying to ensure passage of Great Basin redband trout over the dams on the river while preventing movement of carp through the system. The concrete fish ladders in operation since the dams were constructed were retrofitted with new denil-style fish passage structures. Screens were placed on a number of diversion canals and ditches to prevent entrainment of native fishes and decrease spawning areas for invasive carp in fields, ponds, and ditches. Fish traps were manufactured and fitted at the top of the fish ladders to sort carp from the native fish moving upstream on migration. Fish screens were installed on the diversion of the East Canal. A fish screen and passage structure was installed on the Blitzen River at the West Canal diversion to prevent entrainment of fish into the irrigation ditch and permit passage of fish up and down the mainstem of the Blitzen River. Research conducted by Matt Anderson concluded that fish passage and screening on the Blitzen River was not optimal for the native redband trout (Anderson 2009). Therefore, ODFW recommended that new fish ladders be installed. In 2009, construction of three new fish ladders and screens was started to improve fish passage and screening and was complete in 2012.

The Refuge put a greater emphasis on controlling exotic and invasive species as infestations increased in size. Fire became a more active management tool for enhancing wetland, meadows, and grassland habitats through the removal of decadent growth, reduction in fuel loads, and setting back undesired vegetation. With degradation of the lake ecosystem, an emphasis was placed on maintaining water on wetlands units and meadows for as long as possible to maximize production for all species of waterfowl, cranes, and other birds that use these habitats. This had the desired outcome, and production has been sustained at very high levels. However, maintaining water on these habitats has also provided ideal conditions for water-tolerant plant species and a competitive advantage to the exclusion of other species, resulting in dense monotypic stands of emergent vegetation and encroachments into meadow habitats.

Restoration efforts focused on riparian and riverine habitats. Canals and ditches were fenced to reduce erosion from cattle and to provide an opportunity for re-establishment of riparian plants. The upper Blitzen River was the site of a restoration project in which inverted rock weirs were staggered over a 5- mile length of river between the P Ranch and the confluence of the river with Bridge Creek. The restoration project was intended to create in-stream and riparian habitats, reconnect the river to the floodplain, and raise the level of the deeply incised river. Assessments of the effect and success of this project are still being conducted.

4.1.4 Changes in Species Composition of Wildlife Populations after Refuge Establishment

Hydrologic Changes that Led to Altered Habitats

It can be hypothesized that the greatest difference between plant community conditions prior to Euro-American settlement and current conditions can be directly correlated with the extent and availability of water. Prior to hydrological modifications (ditches, dams, and the channelization of 17.5 miles of the Blitzen River, as well as the rerouting and damming of Silver Creek in the Double-O Unit),

concentrations of plants would have been dependent on the level of flooding that occurred in conjunction with topographic features. Beckham (1995) believes that the Blitzen Valley once hosted a much higher percentage of upland and meadow plant communities, such as basin big sagebrush, bluebunch wheatgrass, and basin wildrye, than exist today.

After settlement, some uplands and meadows were leveled to maximize efficiency of flood irrigation, which was provided by a complex system of diversion dams and ditches, and to facilitate the production of grain and grasses. Under current refuge management an emphasis on extended irrigation in these areas provides ideal conditions for water-tolerant plant species, and some sites have become dominated by such species as cattails, phragmites, and reed canarygrass. However, extended irrigation has also encouraged the re-establishment of woody riparian species, such as willow, to some of its historic range.

Although historic numbers for waterfowl in the Blitzen Valley and Double-O are not available, it is likely that construction of the water-delivery systems and the managed impoundments and wet meadows in these irrigated units led to increased numbers of breeding waterfowl, cranes, and shorebirds. However, this benefit to waterfowl could not compensate for the loss of quality waterfowl habitat in Malheur and Mud lakes because of invasive carp.

When refuge grain fields were abundant, use of the valley by migrant geese and ducks was very high with peaks in the hundred-thousands. However, as the grain fields were converted back to irrigated meadows, high use by migrants diminished.

Gabrielson and Jewett (1940) stated that the greater sandhill crane was rapidly disappearing from Oregon in the late 1930s and estimated that the remaining flock numbered only about 100 pairs in the Blitzen Valley and east of Steens Mountain. The Blitzen Valley was a stronghold for crane survival during the era of unregulated market hunting. By the late 1990s, the refuge crane population had increased to 245 pairs (Ivey and Herziger 2000). Migrant crane use of refuge grain fields increased over time as populations recovered from unregulated hunting and peaked in the early 1980s at approximately 3,500. However, during the flood years of the mid-1980s and the subsequent droughts in 1988 and 1992, refuge grain crops were poor, and fall crane use declined to less than 10 percent of the peak and has remained low.

While nesting colonial waterbirds were historically abundant in Malheur Lake, there is no evidence that colonial waterbirds were nesting in the Blitzen Valley or Double-O units before refuge acquisition and subsequent development of large impoundments. Today, managed impoundments support substantial numbers (numbering in the thousands in good years) of nesting white-faced ibis, Franklin’s gulls, and eared grebes.

It is likely that changes to the Blitzen River hydrology have caused significant declines in the carrying capacity of the river for native fishes, mollusks, and other aquatic species. Development of the irrigation system contributed to lower water quality (primarily water temperature) and eliminated connectivity between many braided channels in the valley, significantly reducing aquatic and riverine habitat diversity and availability for aquatic fauna. This loss of extensive riverine habitat may also have had a major impact on local beaver populations.

Influx of Exotic and Invasive Species

Exotic plants and animal invasions are a serious threat to the biological integrity of the Refuge. Invasive plant species displace native vegetation, alter the composition and structure of vegetation communities, affect food webs, and modify ecosystem processes (Olson 1999). Ultimately, invasive plant and animal species can result in considerable impacts to native wildlife. Common carp are believed to have had the largest impact to habitat and wildlife, causing reduced migratory bird use of the Refuge.

Exotic Plants in Riparian and Wetland Systems: Exotic invasive plants that have proliferated in riparian and wetland areas include perennial pepperweed, reed canarygrass, Canada thistle, and Russian olive. Common reed is also present on a much smaller scale in some wetland units. All of these species displace native plant communities and reduce the habitat values for many wildlife species. For example, reed canarygrass forms tall, dense, almost impenetrable stands, which have almost no value for nesting birds and other wildlife.

Exotic Species in Aquatic Systems: The Harney Basin supports fish mirroring the native fishes of the Columbia River with a few species absent or undetected, before they disappeared. (As noted in Chapter 3, the basin was connected thousands of years ago to the Columbia River drainage.) Since Euro-American settlement, a variety of warm-water fish species have been introduced to the basin to increase the diversity and quality of recreational angling. Many of these introduced fish prey on native species and/or compete with them for food resources. Common carp were introduced into the Silvies River in the 1920s and invaded Malheur Lake in the late 1940s, becoming a noticeable problem in the early 1950s. Their presence has resulted in devastation of aquatic plant and invertebrate communities, reduced water quality, and increased turbidity, and they have caused a large reduction in waterfowl use and production on the lake (Ivey et al. 1998). Carp have also spread or have the potential to spread to most of the aquatic systems of the Blitzen Valley and the Silver Creek drainages. A small established population of bullfrogs located at the south end of the Blitzen Valley could threaten the Refuge's population of Columbia spotted frog by predation, loss of habitat, and food resources.

A number of non-native fish have been recorded in various surveys on the Refuge. These fish include common carp, rainbow trout (*Oncorhynchus mykiss*), mosquito fish (*Gambusia affinis*), yellow bullhead (*Ictalurus natalis*), brown bullhead (*Ictalurus nebulosus*), black bullhead (*Ameiurus melas*), largemouth bass (*Micropterus salmoides*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), white crappie (*Pomoxis annularis*), and yellow perch (*Perca flavescens*).

Exotic Plants in Upland Systems: Major invasive weeds that have invaded refuge upland habitats include perennial pepperweed, Russian knapweed, and whitetop. These species occupy a large percentage of lowland shrub communities and have replaced native grasslands and forbs, which are important to native animals, such as small mammals. More recently, medusahead has invaded shrub lands on the southernmost portion of the Refuge (approximately 30 acres).

Control Efforts: An IPM approach is used, which includes a variety of tools such as mechanical/physical control methods, cultural control methods, biological control, pesticides, habitat restoration, and protocols preventing new introductions (see Appendix G, Integrated Pest Management Plan). Control efforts are planned annually, and Pesticide Use Proposals (PUPs) are submitted to regional and/or national IPM coordinators for approval.

Mechanical, physical, biological, and chemical methods have been used to combat invasive plants in a variety of habitats. Biological methods have included prescribed use of cattle and sheep grazing and prescribed burning. Insects introduced for biological control include thistle stem gall flies, thistle beetles, and thistle weevils for Canada thistle. Considerable progress has been made with infestations of Russian olive around Malheur Lake, using burning, grazing, and chemical control.

Much effort has focused on controlling carp. Annual wetland management plans prescribe drawdowns of impoundments to kill carp; traps have been placed in major dams to prevent their migration upstream; various types of netting techniques have been used for removal and population assessments and electroshocking has been used to remove them from some areas. Rotenone, a piscicide, has been used to supplement other measures of carp control. Several large-scale rotenone projects were conducted on the Refuge during years when lake levels were low and such treatments were deemed cost-effective. These treatments resulted in temporary increases in waterfowl use before the carp population rebounded.

4.2 Priority Resources of Concern

A key step in biological planning involves selection of priority ROCs (sometimes called conservation targets in other planning methodologies). These priority ROCs framed the development of the CCP's goals and objectives for wildlife and habitat.

4.2.1 Selection Process

Resources of concern, as recommended under the Service's Habitat Management Planning policy (620 FW 1), include:

> all plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), System mission, or international, national, regional, State, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect "migrating waterfowl and shorebirds." Federal or State threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts (620 FW 1.4G).

Negative features of the landscape, such as invasive plants, may demand a large part of the refuge management effort but are not designated as resources of concern.

To identify these resources, the team reviewed numerous plans and assessments that have been completed (see Section 1.7). A large list of species, species groups, and habitats were identified (see Appendix E, Biological Resources of Concern list). The list was then narrowed to a shorter list of priority ROCs.

The main criteria for selection of the priority ROCs included the following requirements drawn from the document *Identifying Refuge Resources of Concern and Management Priorities: A Handbook* (USFWS 2008a):

- Reflective of the Refuge's establishing purposes and the Refuge System mission

- Species that may be used as an indicator of the health of one the main natural habitat types found at the Refuge
- Recommended as a conservation priority in the Wildlife and Habitat Management Review (USFWS 2008a)
- Federally or State listed, candidate for listing, or species of concern

Other criteria that were used in section of the resources of concern included the following:

- Species groups and/or refuge features of special management concern
- Species contributing to the biological diversity, integrity and environmental health of the ecosystem
- Species where it is feasible to estimate population size (needed for future monitoring and adaptive management)

Early in the planning process, the planning team invited extended team members to assist in identifying priority species for the Refuge (see Appendix I for names of team members). A number of different species were recommended by the participants in this collaborative workshop. The list was refined to 21 priority species for the Refuge and consists of canvasback, sago pondweed, northern shoveler, tui chub, white pelican, eared grebe, redhead, ruddy duck, yellow-headed blackbird, greater sandhill crane, bobolink, cinnamon teal, willow flycatcher, yellow warbler, redband trout, snowy plover, gadwall, mallard, sage thrasher, loggerhead shrike, and sage sparrow. Each species in discussed in more detail by habitat below.

4.2.2 Relationship of Priority Resources of Concern to Habitat Goals and Objectives

Wildlife habitat goals and objectives were designed directly around the habitat requirements of the priority ROCs. Goals were written for priority ROC habitats. Objectives were developed from the habitat requirements of priority ROC species.

To develop objectives, the team followed the process outlined in the document *Identifying Resources of Concern and Management Priorities for a Refuge: A Handbook* (USFWS 2008a). For each priority ROC, the team identified the ecological attributes of habitats that are necessary to meet the ROC's life history requirements, and are therefore, critical to sustain the long-term viability of the ROC and other benefitting species. Ecological attributes of habitats include parameters such as vegetation structure, species composition, age class or seral stage, patch size and/or contiguity with other habitats, hydrologic regime, absence of human disturbance, and natural disturbance events (e.g., flooding, fire). These attributes, when described in measurable terms, provide specific habitat targets that strongly correlate with the ability of a habitat to support priority species, and by extension, other benefitting species. For most attributes, the team developed "desired" conditions that were based partly on scientific literature review and partly on the team's professional judgment. These desired conditions for specific attributes were used to help design measurable habitat-based objectives, as presented in Chapter 2.

Limiting factors were also considered in developing objectives. A limiting factor is a threat to, or an impairment or degradation of, the natural processes responsible for creating and maintaining plant and animal communities. In developing objectives and strategies, the team gave priority to mitigating or abating limiting factors that presented high risk to ROCs. In many cases, limiting factors occur on

a regional or landscape scale and are beyond the control of the individual refuge. Therefore, objectives and strategies may seek to mimic, rather that restore, natural processes. For example, mowing and/or grazing may be used to maintain a desirable vegetation structure, when restoring native grassland communities may be impractical.

4.3 Major Habitat Types on Malheur Refuge

4.3.1 Lacustrine (lakes)

Overview

Malheur Lake: One of the largest inland marshes in the United States, Malheur Lake may vary dramatically in size (from 500 to 110,000 acres) but generally fluctuates about 2 feet during the calendar year and upon average covers approximately 37,500 acres, or 20 percent of the total refuge acreage. On the basis of water depth, water chemistry, and vegetation, it is classified as an Inland Deep Fresh Marsh (Shaw and Fredine 1956). The lake is described in great detail in Duebbert (1969). It receives water from the Blitzen and Silvies rivers, fills from the center, then flows east and finally to the west, and then connects with Mud Lake. Water supply is predominantly influenced by snowpack on Steens Mountain to the south and the Blue Mountains to the north.

The western section of Malheur Lake is a series of natural ponds separated by a network of low dune islands and peninsulas. The center section, the deepest area of the lake, is predominantly open water with some hardstem bulrush stands near the mouth of tributaries. The eastern section tends to be more alkaline and lacks tall emergent vegetation.

Common emergent species in Malheur Lake include hardstem bulrush, cattail, burreed, Baltic rush, and various sedges. The largest stands of hardstem bulrush are at the mouths of both rivers and typically support mixed colonies of ibises, egrets, Franklin's gulls, and western grebes. The lake contains extensive areas of open, aquatic bed habitat supporting submergent plants such as sago pondweed, water milfoil, horned pondweed, coontail, small and leafy pondweed, white water buttercup, bladderwort, and widgeon grass.

Harney and Mud Lakes: Harney Lake has a bottom elevation about 8 feet lower than Malheur Lake and is deeper than Malheur Lake when it is full. However, Harney Lake dries up completely during dry periods, shifting from a hypersaline lake to a dry salt flat (Dugas 1996). Water often enters Harney Lake through Silver Creek. Harney Lake is too saline to support emergent vegetation.

Regional Distribution, Condition, and Trends of this Habitat Type

These types of aquatic systems are thinly scattered throughout the Great Basin.

The large invasive carp population in Malheur and Mud lakes and in the Blitzen and Silvies rivers has severely compromised submerged aquatic vegetation (e.g., sago pondweed); therefore, the lakes do not adequately support refuge purposes. Historically, Malheur Lake was a key staging area for canvasbacks and tundra swans in the Pacific Flyway. As a consequence of declining habitat quality, these and other waterfowl no longer stage in significant numbers on the lake except during years following major carp control efforts. Waterfowl production is less than 10 percent of its potential on the lake because of carp. There were high numbers of canvasbacks using Malheur Lake during the

falls of 1993 and 1994, after drought conditions and a carp control project in 1992; duck production was estimated to be over 100,000 produced per year on Malheur Lake before the carp invasion (Cornely 1982). During the 1980s, high water levels eliminated most emergent vegetation in Malheur Lake, causing a significant number of colonial birds to abandon nesting on Malheur Lake and shift to flooded private lands to the north. The large stands of hardstem bulrush that were present before the 1980s flood have not recovered. Historically, Mud Lake had an extensive bulrush community used by nesting canvasbacks; however, with low water levels there are minimal bulrush stands present on the lake.

Malheur Lake also supports a diverse community of other exotic fish species, and they likely have an adverse effect on the native species in the system. Other invasive aquatic species, such as quagga and zebra mussels, are not present but could arrive in the lake system in the future, with huge potential for negative effects on the natural biological integrity of the lakes and adjacent wetlands.

When Harney Lake is full and less saline, it supports extensive stands of wigeongrass and high numbers of waterfowl. At higher salinities, it supports an abundance of brine shrimp and brine flies, important food sources for many birds.

Key Species Supported

The primary wildlife value of the refuge lakes includes their importance as foraging sites for migrating waterfowl, waterbirds, and shorebirds and as nesting habitat for colonial nesting waterbirds and diving ducks. Canvasbacks and tundra swans are particularly abundant when sago pondweed is abundant in the lakes, and many other dabbling and diving ducks are also supported in large numbers. Very high numbers of nesting colonial birds use the lake when habitat conditions are favorable, including white-faced ibis; American white pelican; great and snowy egrets; herons; Franklin's, California, and ring-billed gulls; Caspian and Forster's terns; and western, Clark's, and eared grebes. Total colonial waterbird nests have at times exceeded 10,000 when the lakes reach optimal conditions. Migrant shorebirds use the lakes extensively, when natural fluctuating water cycles expose mudflats. The lakes are also very important to molting geese and ducks as the expansive open water provides them security from predators. Malheur Lake supports over 10,000 molting ducks in good years, and some of the mallards molting there have been documented as birds that nested in California. Occasionally, when Harney Lake is full, it supports well over 300,000 migrating ducks foraging on extensive beds of wigeongrass.

The emergent vegetation in the lakes also once supported most of the Refuge's population of muskrats and also supported many beaver and mink.

The lakes are very important in preserving the life-history diversity of redband trout in the Harney Basin. A portion of the population migrates to the lower Blitzen River and also Malheur Lake during high water years. Migrations expand resources available to redband trout and allow expression of diverse life histories (Anderson 2009). Native tui chubs are also abundant in the lakes when water conditions are favorable, and they too are likely limited by other exotic fishes in the system. Historically, large numbers of native suckers were reported spawning in Sodhouse Spring (Bendire 1875-1876) and they were likely once abundant in the lakes. Priority ROCs for this habitat type are presented in Table 4-1 and include canvasback, northern shoveler, tui chub, and American white pelicans.

Table 4-1. Selected Priority Resources of Concern Lacustrine Habitats

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Canvasback	Concentrate in large numbers in lakes and open marshes heavily vegetated with beds of sago pondweed (Mowbray 2002). Nesting requirements similar to redheads.	Migration and breeding	Tundra swan, geese, ducks, coots, grebes, fish, muskrat
Northern shoveler	Prefer margins of open shallow wetlands usually with submergent vegetation and associated nearby grasslands, sagebrush, or rangelands for nesting. Prefer grass cover for nesting from 0 to 2 feet (0.6 m) in height, 295 feet (>90 m) from water (Dubowy 1996).	Breeding and foraging	Teal, shorebirds, herons, egrets, other wading birds, blackbirds
Tui chub	Inhabit small streams to lakes, prefers areas of shallow water with heavy vegetation for spawning, 3 feet (1 m). Diet of invertebrates, plant material, algae, plankton (Bird 1975; Knopf and Kennedy 1981).	Spawning and foraging	Redband trout, cormorant, marsh and wading birds, mergansers, other native fish species
White pelican	Inhabit marshes and open water areas such as lakes and nesting on isolated, flat, low-lying islands with sparse interspersed vegetation adjacent to bare soil (Evans and Knopf 1993). Foraging in shallow water ≤37 feet (11.4 m) and prey dominated by small to medium sizes 1-27 inches (2.5-68.6 cm) (Finholt and Anderson 1995; McMahon and Evans 1991).	Breeding and foraging	Geese, ducks, herons, egrets, rails, white-faced ibis, coot, shorebirds, yellow-headed and other blackbirds, marsh wren, common yellowthroat, black tern, muskrat, mink

Refuge Management Activities

There is little direct management of the lakes. The primary management activity on Malheur Lake has been periodic carp control using rotenone when lake levels were low. A riprap barrier with screened culverts has been installed at the Narrows Bridge on Highway 205 to slow carp movements between Malheur and Mud lakes. In the 1950s dikes were constructed between dunes in the Cole Island Dike area to span the lake north to south, while other smaller dikes were constructed to keep water out of private lands north of the lake, but these dikes were destroyed during the flood of the 1980s and are no longer functional.

4.3.2 Riverine

Overview

The major areas of riverine habitat on the Refuge are the Blitzen River and its tributaries. Ideal riverine conditions exist when hydrologic floodplains are intact and when waterways support riparian communities that provide shade to maintain cooler water temperatures and are appropriate to stream channel type. A fully functional river or stream exhibits balanced pool-riffle-glide ratios depending on slope and substrate due to the lack of fine sediments covering large section of river reaches. In such a waterway, water turbidity is typically low with an appropriate level of sediment storage, which buffers against the sediment loading of critical rearing pools and spawning gravels for native fishes. Boulders, undercut banks, logs, and vegetation provide ample hiding cover for native fishes and other aquatic species. Eddies and other slow-current areas contain abundant populations of various aquatic invertebrates. Low turbidity also allows a variety of native aquatic vegetation to establish and propagate in suitable microniches.

On the Refuge, the highest quality riverine habitat occurs at the south end of the Refuge in the unchannelized reaches of the Blitzen River and in the major tributary streams (Mud, Bridge, and Krumbo creeks). Although artificial, the East Canal from Page Dam to Bridge Creek provides attributes of riverine habitat and is in better condition than much of the Blitzen system. Below the confluence of Bridge Creek, the river channel is deeply incised and does not support floodplain hydrology or riparian vegetation and is poor quality habitat for native fish. The river suffers from poor water quality with high sediment and nutrient loading and, in summer, warm temperatures (see Chapter 3).

Silver Creek in the Double-O Unit is disconnected above the Refuge by Moon Reservoir dam and no longer has a natural channel until it reaches the boundary between the East Freeman and Martha Lake fields where the channel is re-established. Riverine habitat conditions are very poor, as flows are intermittent and the lower channel is artificially maintained by the diversion of spring water.

Regional Distribution, Condition, and Trends

A portion of lower Bridge Creek and 17.5 miles of the Blitzen River were channelized early in the 20th century prior to refuge acquisition, resulting in degraded riverine conditions through much of this portion of the Blitzen Valley. In some reaches, channel incision has lowered water tables enough to allow sagebrush to grow along the river. Development of the irrigation system, including six active irrigation dams, further modified riverine hydrology and caused significant reduction of riverine habitats as floodplain connectivity was disrupted and natural riverine function was reduced.

Much of the degradation of refuge water quality may be the result of historic overgrazing by livestock and the condition of upstream rangelands. It appears these factors still contribute to silt loading and high stream temperatures due to the slow recovery of riparian habitat in affected areas. Since restrictions on livestock grazing were implemented in the 1970s, riparian habitat associated with the riverine system has recovered in the south Blitzen Valley, but remains poor elsewhere.

Channelization and overgrazing have increased incision of the Blitzen River, compromised in-stream habitat diversity, and diminished the system’s ability to disperse energy during high flow events. Channelization has also led to the loss of the functionality of most floodplains on the Refuge, and the associated channel incisions have reduced adjacent water tables and limited recovery of riparian

vegetation. The presence of invasive carp likely has a significant impact in reducing the carrying capacity of the riverine system for native species. Altered hydrology and passage impediments have also influenced water and habitat conditions and access by redband trout.

Key Species Supported

Riverine habitats are prime habitat for redband trout, other native fishes, and native mollusks. This habitat is also important to Oregon spotted frogs, mergansers, belted kingfishers, river otters, and mink. Redband trout is the sole priority ROC species under this habitat type, and more information about this species is listed below in Table 4-2.

Table 4-2. Riverine Habitat Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Redband trout	Native fish habitat for redband trout: stream shading (>80%), bank cover (no bare soil), bank stability (<5% eroding), channel stability (<1% channel movement), fine sediment <2 mm (<10%), cover (>50% of channel (Zoellick and Cade 2006); percent late summer pools (25%-75%), mean annual base flow (>45% of annual flow) (Raleigh et al. 1984).	Year-round	Native suckers, sculpins, dace, whitefish, mollusks, river otter, beaver

Refuge Management Activities

Within the past two decades, the refuge staff has focused on improving fish passage through refuge dams and screening irrigation diversions to minimize loss of fish via irrigation diversion. Considerable effort has been applied to enhance stream-side riparian habitat in Bridge and Mud creeks and along the southern reach of the Blitzen River through plantings. Inverted weirs were installed in this reach of the river to raise the water table and increase habitat diversity in the natural channel. These projects are still being monitored to assess their effectiveness.

4.3.3 Woody Riparian

Overview

The Refuge hosts a variety of riparian habitat along the Blitzen River and its tributaries, along ditches and canals, along remnant traces of previously active sloughs in the Blitzen Valley, and in a few patches in the Double-O Unit. Riparian habitat encompasses 800 to 1,000 acres. Although many plant associations are found within this habitat type, the principal woody species include willows, cottonwoods, alder, redosier dogwood, Wood's rose, golden currant, common snowberry, Lewis' mock orange, water birch, and alder. Herbaceous groundcover is characterized by Nebraska sedge, yellow monkey-flower, Northwest cinquefoil, American speedwell, wooly sedge, slender-beaked

sedge, meadow barley, tufted hairgrass, western yarrow, and Baltic rush. The south Blitzen Valley also supports extensive stands of willow associated with irrigated meadows, and these stands are very important for riparian landbirds. Smaller stands of willow are associated with wet meadows and seasonal wetlands in the north Blitzen Valley and the Double-O.

Regional Distribution, Condition, and Trends

Since major reductions in livestock grazing occurred during the 1970s, riparian habitats have increased and expanded, especially in the south Blitzen Valley. The condition of riparian habitat is generally good. There is much diversity in the plant communities along the Blitzen River, its tributaries, and the East Canal. In other portions of the Refuge, diverting water for irrigation or incision of stream banks has lowered the water table, and this has prevented riparian species from re-establishing.

Threats to riparian habitat on the Refuge include invasion by non-native plants, such as reed canarygrass, water hemlock, Russian olive, and perennial pepperweed; river channelization; lowered groundwater table; and water quality impairments. Grazing by trespassing livestock occasionally occurs and can be damaging to the structure of riparian habitat.

Key Species Supported

There are 97 native landbird species considered by the Partners in Flight plan to be associated with riparian habitat in the Columbia Plateau (Altman & Holmes 2000). This plan lists several species as "dependent," including western wood peewee, Bullock's oriole, willow flycatcher, yellow-breasted chat, yellow-billed cuckoo, and yellow warbler. The same species, including lazuli bunting and excluding western wood peewee, are considered focal species under the plan.

Common refuge breeding bird species using this habitat include song sparrow, willow flycatcher yellow warbler, American robin, eastern kingbird, and black-billed magpie. Also present, but less common, are long-eared owl, black-headed grosbeak, yellow-breasted chat, cedar waxwing, and lazuli bunting. Many other warblers, vireos, and sparrows use this habitat type during migration. Riparian areas are very important to beaver, porcupine, and mule deer (especially in winter) and are used as cover by raccoons, striped skunks, and weasels. Montane voles and jumping mice are also closely associated with this habitat. The priority ROC species under this habitat type include willow flycatcher and yellow warbler and more information about these species is listed below in Table 4-3.

Table 4-3. Woody Riparian Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Willow flycatcher	Inhabit thickets of willow, cottonwood, dogwood, and other shrubs along river corridors or waterways through the broad valley. Shrub layer cover >40%-80% of native shrubs more than 3 feet (1 m) tall; canopy tree	Breeding and foraging	Yellow-billed cuckoo, black-headed grosbeak, long-eared owl, yellow-breasted chat, song sparrow, eastern kingbird, skunk, weasel

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
	cover <30% (Altman and Holmes 2000; Sedgwick 2000).		
Yellow warbler	Found in riparian and wet deciduous thickets dominated by willow, alder, dogwood, and other early successional species. Mean territory 0.14-0.29 ha, nest height of 1.6-6.5 feet (0.5-2.0 m) located in dense stands (Knopf and Sedgwick 1992; Lowther et al. 1999).	Breeding and foraging	Yellow-billed cuckoo, black-headed grosbeak, long-eared owl, yellow-breasted chat, song sparrow, eastern kingbird, skunk, weasel

Refuge Management Activities

Historically, willows, other shrubs, and trees were mechanically and chemically removed to maximize wet meadow forage for livestock. This practice ended in 1972, and grazing and haying activities were also excluded from stream banks to protect riparian habitat. A 400-foot ungrazed corridor along the Blitzen River and a 200-foot corridor for other streams were established as a standard in the Blitzen Valley Management Plan (USFWS 1990). Selective burning, grazing, haying, or mechanical disturbance may be used to reinvigorate decadent riparian stands. Many riparian areas have been excluded from livestock grazing by implementing hay-only management practices or through the use of protective fencing.

Refuge riparian habitat has been managed for structure, patch size, and patch distribution or spacing of woody clumps within a specified area to meet life-history needs of migratory landbirds, including willow flycatchers and yellow warblers (USFWS 1990).

4.3.4 Palustrine Emergent (Seasonally flooded wet meadows)

Overview

Meadows are influenced by water depths and the timing of irrigation. On the Refuge, they are seasonally flooded and managed artificially by irrigation. The largest areas of meadow habitats are located in the southern Blitzen Valley, where much of the valley is flat and water supplies are more dependable. Meadows in the northern half of the Blitzen Valley and in the Double-O Unit tend to be drier and less extensive; however, they are widely dispersed throughout these managed units of the Refuge. The Blitzen Valley and Double-O currently supports approximately 20,000 to 25,000 acres of meadow habitats. Water conditions in meadows range from subirrigated up to 1 foot in depth. Drier sites are typically dominated by creeping wildrye or saltgrass, while wetter areas tend to be dominated by sedges such as woolly sedge, Nebraska sedge, and slender-beaked sedge. Other native

species include Baltic rush, arrow-grass, Nevada bluegrass, western yarrow, slender cinquefoil, large-leafed avens, and fringed willow-herb.

Regional Distribution, Condition, and Trends

Beginning in the 1870s, uplands, marshes, and irrigated meadows in the Blitzen Valley and Double-O were converted to wet meadows to provide forage for livestock. Further development of the irrigation system in the Blitzen Valley by the CCC led to further habitat conversions in the 1940s. Acreage numbers for meadow habitats have remained relatively stable since these earlier conversions.

The largest threats to the biological integrity of meadows are invasive plant species. Reed canarygrass poses the greatest threat and has already degraded extensive areas of meadow habitat in the Blitzen Valley. Reed canarygrass stands are very poor wildlife habitat. Limited water supplies are another threat to maintenance of meadows. If water supplies are reduced by global warming in the future, the Refuge will need to be strategic about how it uses and delivers water to important meadow habitat.

Key Species Supported

The primary importance of meadows is to provide nesting cover for ground-nesting birds. Cover provided by drier meadow sites serves nesting cinnamon teal, northern shovelers and northern pintail. Short vegetation in meadows provides habitat for nesting bobolinks and shorebirds, such as Wilson's snipe, Wilson's phalarope, American avocets, and black-necked stilts. Other nesting species are numerous (e.g., mallard, gadwall, short-eared owl, western meadowlark, long-billed curlew). Meadows also serve as foraging sites for territorial greater sandhill cranes, Canada geese, waterfowl, white-faced ibises, and other waterbirds. Meadows support large numbers of montane voles and other small mammals, which are important prey for raptors and mammalian predators (e.g., weasels and coyotes). Deer, pronghorn, and occasionally elk graze in refuge meadow habitats. Priority ROC species for this habitat type are listed below in Table 4-4.

Table 4-4. Palustrine Emergent (seasonally flooded wet meadow) Priority Resources of Concern Species

Focal Species	Habitat Type	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Cinnamon teal	Palustrine emergent (seasonally flooded wet meadow)	Use seasonal and semipermanent freshwater marsh nesting near water in low dense perennial vegetation composed of rushes, grasses, and various forbs interspersed with willows, rabbitbrush, and greasewood. Emergent layer cover with a height of 11-35 inches (28-90 cm); grass layer cover with a height of <4 inches (10 cm); water depth 5.5-58.5 cm)	Breeding and foraging	Mallard, northern harrier, northern shoveler, northern pintail, short-eared owl

Focal Species	Habitat Type	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
		(Thorne and Zwauk 1993).		
Greater sandhill crane	Palustrine emergent, (seasonally flooded marsh associated with wet meadow)	Found in isolated, open, wet marshy meadows dominated by grasses, sedges, and rushes surrounded by shrubs. Shrub/emergent cover <30%; grass cover layer 40%-50%; forb cover layer 10%-20% (Mullins and Bizeau 1978; Stone 2009).	Breeding and foraging	Shrike, teals, gadwall, meadowlark, common yellowthroat, Savannah sparrow, blackbirds, voles, mice, nesting shorebirds
Bobolink	Palustrine emergent, (seasonally flooded marsh associated with wet meadow)	Breed in subirrigated meadow composed of grasses and large forbs. Dependent on annual growth of grass cover layer 50%-70%, up to 3 feet (1 m) tall; 10%-20% forbs; bare ground <20% (Dechant et al. 1999; Moskwik and O'Connell 2006; Wittenberger 1978).	Breeding and foraging	Shrike, teals, gadwall, meadowlark, common yellowthroat, Savannah sparrow, blackbirds, voles, mice, nesting shorebirds

Refuge Management Activities

During spring irrigation, wet meadows are sheet flooded (subirrigated to 5 inches of standing water). To provide habitat for breeding greater sandhill cranes, Canada geese, and early nesting mallards, irrigation will commence by March 15 for a majority of wet meadow habitat. Fall irrigation of some meadow areas may be desirable to achieve other habitat goals. Irrigation water is maintained in meadows through early August for crane broods, except when drawdowns are necessary to repair facilities or accomplish other habitat management projects (e.g., mowing).

Meadows are managed to provide two habitat structure objectives: to provide dense nesting cover for ground-nesting birds, and to provide short stubble for early green-up as forage for early nesting birds such as waterfowl and cranes and as short-cover nesting sites for shorebirds. To achieve the second objective, meadows are treated by mowing the vegetation in late summer and removing it as hay or through rake-bunch grazing.

4.3.5 Palustrine Emergent (seasonally flooded marsh associated with wet meadows)

Overview

This habitat type, measuring approximately 17,000 to 18,000 acres, exists within a mosaic of wet meadow and open water areas. Emergent marshes are found throughout the southern Blitzen Valley, become less extensive north of Buena Vista, and occur in the southern half of the Double-O Unit. Common emergent plant species include burreed, bulrushes, cattails, sedges, rushes, and spike rushes. Refuge emergent marshes are dominated by hardstem bulrush, cattails, or broad-fruited burreed. These emergents typically tolerate fluctuations in water availability ranging from 3 feet (1 m) above to 4-5 inches (10-12 cm) below the soil surface. Submergent plants such as pondweeds, bladderworts, waterweeds, and duckweeds occur in adjacent deeper open water (aquatic beds) areas. Willow species can occur along elevated ecotones along marsh perimeters.

Regional Distribution, Condition, and Trends

The greatest challenge associated with this habitat is maintaining an adequate prescribed fire cycle to remove excess litter, create open water areas, and generally make it more conducive to use by wildlife (e.g., nesting cranes and mallards). The two prevalent invasive species within emergent marshes are common reed and hybrid cattail. Some emergent stands in the Blitzen Valley (i.e., common cattail) have expanded and encroached into adjacent wet meadow and open water areas in the past decade, reducing habitat values for some nesting birds.

Common reed and hybrid cattails have the potential to displace significant areas of marsh plant community types that are more valuable for nesting birds.

Key Species Supported

Wildlife species associated with these marsh habitats include sandhill cranes, trumpeter swans, overwater nesting ducks (diving ducks and mallards), rails, bitterns, black and Forster's terns, coots, marsh wrens, common yellowthroats, and yellow-headed and red-winged blackbirds. Marshes provide foraging, resting, pairing, and nesting habitat for these species. Emergent vegetation in marshes provides escape cover for broods of numerous species, particularly late-season nesters such as gadwall, redhead, and grebes. The priority ROC species under this habitat type are listed below in Table 4-5 and include yellow-headed blackbirds and greater sandhill cranes.

Table 4-5. Palustrine Emergent (seasonally flooded marsh associated with wet meadow) Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Yellow-headed blackbird	Found in a variety of wetland areas but in this region prefers seasonal wetland with dense emergent vegetation over standing water. Favor vegetation around 23 inches (60 cm) in height, a mean stem density of 80-104/yd², over 11-22	Breeding and foraging	Bitterns, mallards, other waterfowl, sora, other rails and marsh birds, other blackbirds, willets, snipe, other shorebirds, swallows

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
	inches (28-57 cm) of water (Twedt and Crawford 1995).		
Greater sandhill crane	Prefer coarse, emergent vegetation predominately hardstem bulrush, cattail, and burreed with an average water depth of 7 inches (18.0 cm) (Littlefield 1995; Tacha et al. 1992) for nesting.	Nesting	Bitterns, mallards, other waterfowl, sora, other rails and marsh birds, other blackbirds, willets, snipe, other shorebirds, swallows

Refuge Management Activities

The maintenance of existing emergent communities is artificial, requiring extensive infrastructure and active water diversion. Tools such as burning, mowing, disking, and using herbicides have been used to enhance this habitat type. Herbicides are occasionally used to control invasive species within this community.

4.3.6 Palustrine Open Water/Emergent (semipermanently flooded wetland impoundments)

Overview

This habitat type, measuring between 2,200 and 2,800 acres, is primarily provided in wetland impoundments in the Blitzen Valley and Double-O units. Palustrine open water habitats are semi permanently flooded at depths that preclude the development of extensive stands of emergent vegetation. Extensive areas of emergents occur in larger impoundments. The aquatic beds of these impoundments support submerged and floating plants including common and greater duckweed; Canadian waterweed; coontail; water milfoil; common bladderwort; white water crowfoot; and sago, longleaf, and small pondweeds. Emergent plants occupy shallow areas within and alongside of open water communities and include bulrushes, cattails, sedges, rushes, and spike rushes.

Regional Distribution, Condition, and Trends

Most refuge impoundments are in good condition and meet the goal of providing hemi-marsh conditions (approximately half marsh and half open water); however, a few are overgrown with emergent vegetation and lack diversity and extent of open water. These are typically sites that have poor water control or that have undergone changes in hydrology.

Palustrine systems are threatened by a number of factors. Invasive species such as carp and reed canarygrass reduce their wildlife values. Aging infrastructure and management of vegetation within the water delivery system poses challenges in ensuring reliable and consistent water supplies.

Key Species Supported

These impoundments are the primary habitat for breeding and foraging of the Refuge's population of trumpeter swans. The impoundments provide brood water for late-nesting ducks, such as redheads

and gadwalls, and provide overwater nesting substrate for a large variety of wetland birds, including Canada geese, diving ducks, mallards, American coots, rails, grebes, and colonial species such as white-faced ibises and Franklin's gulls. They also provide foraging habitat for migrating waterfowl and serve as night roosts for staging sandhill cranes and Canada geese. They serve migrant shorebirds when they are being flooded or drawn down and provide very shallow or moist mudflats.

Muskrats use the emergent marsh component of this habitat for their lodges. Their lodges are also used by mink, which hunt muskrats and wetland birds in the marshes. Raccoons also forage in these areas.

The priority ROC species for this habitat type are listed in Table 4-6 and consist of eared grebes, redhead ducks, and ruddy ducks.

Table 4-6. Palustrine Open Water/Emergent (semipermanently flooded wetland impoundments) Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Eared grebe	Inhabit large fresh open water marshes and prefer to nest in waters with abundant and diverse submergent aquatic beds and periphery emergent vegetation and 10 feet (3 m) deep. 60:40 to 70:30 ratio of open water to emergent vegetation with a stem density 8-144 stems/yd², open water areas with submergent vegetation covering 40%-70% of area dominated by sago pondweed (Cullen et al. 1999; Dechant et al. 2002).	Breeding and foraging	Swans, geese, ducks, herons, egrets, rails, ibis, coot, yellow-headed and other blackbirds, swamp sparrow, marsh wren, common yellowthroat, black tern, muskrat, mink
Redhead	Inhabit permanently or semipermanent palustrine wetlands, water depth 8-39 inches (20-100 cm) (interspersed open water pockets 1.7-2.5/yd²; emergent stem density bulrush 350-450 stems/yd² or cattails 32-52 stems/yd² (Custer 1993; Low 1945; Woodin and Michot 2002).	Brooding	White pelican, egrets, herons, mergansers, grebes, cormorants, rails, ducks, coot, marsh wren, black tern, red-winged and yellow-headed blackbirds, muskrat
Ruddy duck	Inhabit large open water areas with submergent vegetation during foraging but use dense emergent vegetation >35 inches (91 cm) in height for breeding. Prefer stems density 88-200/yd² with a water depth of 16-24 inches (42-61 cm) (Bura 2002).	Breeding and foraging	Swans, geese, ducks, herons, egrets, rails, ibis, coot, yellow-headed and other blackbirds, swamp sparrow, marsh wren, common yellowthroat, black tern, muskrat, mink

Refuge Management Activities

With the exception of small natural depressions next to springs (e.g., Double-O Spring), the palustrine community has been maintained through active and intensive management. Emergents within impoundments are managed to maintain a hemi-marsh condition. Tools such as burning, mowing, disking, and using herbicides have been used to reduce extensive stands of emergents. Occasional drawdowns oxidize nutrients and consolidate substrates to facilitate the germination of submergent vegetation, such as sago pondweed. When pond bottoms are exposed production of smartweed and other desirable native colonizers is higher after reflooding, especially in mudflats in shallow benches. Periodic drawdowns are occasionally used to remove carp from impoundments. When impoundments cannot be totally dried up, rotenone, netting, and electroshocking have been used to remove invasive carp.

4.3.7 Dry Meadow

Overview

Dry meadows are influenced by water depths and the timing of irrigation through the availability of subirrigation. Standing water is typically not found within these plant communities. The largest areas of dry meadow habitats are located in the northern Double-O and scattered throughout the Blitzen Valley where gradual shifts in elevation facilitate the presence of this habitat type, which lies between wet meadows and sagebrush lowland/salt desert scrub. The Blitzen Valley and Double-O currently supports approximately 4,500 to 5,500 acres of dry meadow habitats. Dry meadow habitats are typically subirrigated but may be temporarily inundated during flood events. Shallow depth to water table makes these areas largely uninhabitable by woody upland vegetation such as basin big sagebrush and greasewood. Sites are typically dominated by creeping wildrye, Nevada bluegrass, bluejoint, or saltgrass. Other native species include western yarrow, slender cinquefoil, and lanceleaf goldenweed.

Regional Distribution, Condition, and Trends

Depth to water table is a driving factor influencing the presence of dry meadow communities. Water management within wet meadows and emergent marshes impact outlying water tables, and these impacts cause this habitat type to either expand or contract. In areas near prevailing ecotones between dry meadows and sagebrush lowland/salt desert scrub habitats, upland shrub invasion has occurred. This habitat is highly susceptible to invasion by perennial pepperweed.

The largest threat to the biological integrity of dry meadows is invasive plants (either upland shrubs or noxious weeds). Fire suppression over the last century has favored the expansion of shrub communities into this habitat, and the prolific availability of weed seed throughout the Refuge proves difficult to manage.

Key Species Supported

The primary importance of dry meadows is to provide nesting cover for ground nesting birds such as cinnamon teal, bobolink, gadwall, and mallard. These communities are also significant for the western meadowlark, a species that uses this habitat type for breeding and foraging. The latter species is the priority ROC species for this habitat type and more information about it is listed in Table 4-7.

Table 4-7. Dry Meadow Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Western meadowlark	Prefer open country with meadows and fields with good grass and litter cover and little or no woody layer. Grass layer 20%-80%, forb layer 1%-17%, mean thatch layer of 16%, bare ground ≤10% (Dechant et al. 2002; Greer 2009; Lanyon 1994)	Breeding and foraging	Savannah sparrow, vesper sparrow, horned lark, blackbirds, sandhill crane, northern harrier, curlew

Refuge Management Activities

Active management within dry meadows consists mainly of weed control and the stimulation of nesting cover via occasional disturbance (prescribed fire, haying, rake-bunch grazing). Water management of adjacent habitats does influence these plant communities by raising or lowering the prevailing water table.

4.3.8 Salt Desert Scrub

Overview

Salt desert scrub occurs in barren alkali flats or alkaline valley bottomlands, and occupies 40,000 acres of the Refuge. This community is most abundant in alkaline areas around the Double-O Unit, Harney Lake, and Mud Lake but also occurs in portions of the Blitzen Valley and along the east end of Malheur Lake where soil alkalinity is high. Infrequent inundation of outer playa areas or wind erosion from these playas distributes salts to nearby low-lying areas, causing elevations in alkalinity and pH, which favor this community association. The plant community for this habitat type consists of widely spaced shrubs with dense patches of rhizomatous grasses, as well as low densities of other annual and perennial grasses and succulent forbs. Dominant species are black greasewood and inland saltgrass, but shortspine horsebrush, fourwing saltbush, bud sage, green and gray rabbitbrush, alkali sacaton, alkali cordgrass, and alkali bluegrass are often present. Mat muhly and Sandberg's bluegrass may be present in mosaics which exhibit more moderate conditions (lower pH.).

Regional Distribution, Condition, and Trends

These upland sites also experience moderate to heavy grazing by livestock during the winter, and this probably reduced the resiliency of this community to resist invasive plants. Perennial pepperweed has significantly encroached in these areas at lower elevations and has replaced vast areas of native vegetation. Rabbitbrush tends to be invasive in some sites after burning.

Livestock grazing may compromise plant species diversity within this community type. There is no wildlife benefit to grazing in these uplands. Perennial pepperweed has invaded vast areas of this habitat in the Blitzen Valley and to a lesser degree in the Double-O Unit.

Key Species Supported

This community is preferred for nesting by loggerhead shrikes, which use the thorny shrubs to impale their prey. Similar to the sagebrush lowland community this habitat is important as nesting cover for ground-nesting birds, such as mallards, gadwalls, and short-eared owls when in proximity to water. Nesting birds primarily rely on tall grass and forb components. A variety of landbirds also breed here, including sage thrashers, Brewer's sparrows, black-throated sparrows, sage sparrows, Brewer's blackbirds, and western meadowlarks. Many mammalian species use these communities including American badgers, weasels, black-tailed jackrabbits, cottontails, Townsend's and northern pocket gophers, and deer mouse. They are typical denning sites for coyotes and are also frequented by bobcats. They also get used regularly by mule deer and pronghorn. The priority ROC species under this habitat type is loggerhead shrike, and more information about this species is listed below in Table 4-8.

Table 4-8. Salt Desert Shrub Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Loggerhead shrike	Found in open gentle terrain with low density of shrubs (particularly sagebrush) mixed with low and sparse grasses such as saltgrass. Shrub layer cover 5%-15%, grass layer cover 50%-70% <10 inches (25 cm) tall (Pampush and Anthony 1993; Paton and Dalton 1994).	Breeding and foraging	Sage sparrow, sage thrasher, vesper sparrow, snakes, shrews, lizards

Refuge Management Activities

Although this habitat type was historically intensively grazed, in more recent years cattle have been excluded from grazing in this habitat type on the Refuge. Prescribed burning is periodically used in these sites to set back succession and composition over the short term, but these communities often do not contain enough continuous fuels to accomplish a complete burn, so the result is a mosaic burning pattern.

4.3.9 Sagebrush Lowland

Overview

These upland habitats occur in elevated basin bottomlands with deep silty or sandy soils along stream channels in valley bottoms and flats. Lowland sagebrush habitat is found on 4,300 to 4,500 acres of the Refuge. Structurally, these habitats are composed of widely spaced medium-tall to tall shrubs (1.5-6 feet) with an understory of perennial bunchgrasses. Basin big sagebrush, Wyoming big sagebrush, rabbitbrush, and basin wildrye are dominant features in this habitat type. These habitats occur in upland areas on the valley floors of the Blitzen Valley and Double-O units. The fire frequency in these habitats ranges from 10 to 25 years (ODFW 2006).

Regional Distribution, Condition, and Trends

Historically, this habitat was probably more abundant in the Blitzen Valley. As the development of the irrigation system changed the water regime, it likely also changed the composition of plant communities on lower-elevation upland sites. However, most of the loss of upland habitat due to development of irrigation more likely occurred in the meadow areas dominated by creeping wildrye/Nevada bluegrass communities throughout the Blitzen River Valley. These communities have developed along the incised river and stream channels and along the edges of some refuge canals and dikes.

Before the reduction of grazing in the 1970s, these upland sites were moderately to heavily grazed by cattle during the winter, with cattle use extending into early spring, for over 30 years. This use degraded these sites and likely changed a number of plant community characteristics.

Invasive plants, such as cheatgrass, have degraded this community and have altered the natural fire regime by allowing more frequent fire-return intervals. Perennial pepperweed has significantly encroached in these areas at lower elevations and has replaced vast areas of native vegetation. Rabbitbrush tends to proliferate in some sites after burning.

Weed invasions are the biggest threats to this habitat type. There is no wildlife benefit to grazing in these uplands. Grazing by trespassing livestock can be an issue.

Key Species Supported

A primary value of this upland community is as dense nesting cover for ground-nesting birds, such as mallards, gadwalls, and short-eared owls. These birds primarily rely on tall grass and forb components. A variety of landbirds also breed here, including California quail (*Callipepla californica*), sage thrashers, Brewer's sparrows, Brewer's blackbirds, and western meadowlarks. Many mammalian species also use these communities, including American badgers, weasels, black-tailed jackrabbits, cottontails, potentially pygmy rabbits, Townsend's and northern pocket gophers, least chipmunk, bushy-tailed and desert woodrats, northern grasshopper mouse, deer mouse, and sagebrush vole. These habitats are typical denning sites for coyotes and are also frequented by bobcats. They also get used by mule deer, pronghorn, and elk and provide good hiding cover for these species. The priority ROC species under this habitat type consist of gadwall and mallard. More information about these species is listed below in Table 4-9.

Table 4-9. Sagebrush Lowland Priority Resources of Concern Species

Focal Species	Habitat Type	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Gadwall	Sagebrush lowland	Prefer islands of brushy habitat with Great Basin wildrye, or tall grass or forb component in proximity to open water. Shrub layer cover <10%; herbaceous veg. cover 10%-20%, 9-13 inches (25-35 cm) tall, within 147 feet (45 m) of	Nesting	Short-eared owl, mallard, western meadowlark, sage thrasher

Focal Species	Habitat Type	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
		open water (Leschack et al. 1997; Sousa 1985).		
Mallard	Sagebrush lowland	Nesting in dense cover scattered shrub lands surrounded by water for brooding (Drilling et al. 2002). Nests are generally equal to or less than 164 yards (150 m) from water (Dzus and Clark 1997).	Early season nesting and brood water	Short-eared owl, gadwall, song sparrows

Refuge Management Activities

The primary management activities in these upland communities are weed control and prescribed burning to reinvigorate basin wildrye for dense nesting cover for ducks.

4.3.10 Sagebrush Steppe

Overview

This community includes 14,000 to 15,000 acres on the Refuge and is dominated by shrubs with an understory of various bunchgrass and forb species found within interspaces. It can be found above greasewood/lowland sagebrush communities on various aspects, slopes, and soil types. It occurs around the fringe of the Blitzen Valley at higher elevations, at several locations in the Double-O Unit, and along the south side of Harney Lake. Plant species include Wyoming and low sagebrush, bluebunch wheatgrass, Sandberg's bluegrass, bottlebrush squirreltail, Idaho fescue, needle-and-thread, Thurber's needlegrass, western yarrow, arrowleaf balsamroot, and various locoweed and phlox species. A gradient in soil depth determines whether Wyoming big sagebrush or low sagebrush dominates a site. Low sagebrush sites typically host higher densities of forbs due to higher concentrations of available soil moisture due to shallow, rocky conditions. These communities depend on natural fire cycles or equivalent disturbance to maintain a balance between shrub, grass, and forb components. A lack of disturbance lends itself to high shrub densities with sparse vegetation in the interspaces.

Regional Distribution, Condition, and Trends

Originally, upland habitats were composed of native shrubs, bunchgrasses, and forbs. Most of the former native vegetation has been severely altered by historical land use, including intensive livestock grazing, reduced burning frequency, and cultivation. Large areas of shrub-steppe have been seeded to crested wheatgrass or as part of former "fire restoration" activities.

Invasive plants, such as medusahead and cheatgrass, are major threats to the remaining shrub-steppe areas of the Refuge. Medusahead is capable of outcompeting native grasses and forbs in the understory. An altered fire regime resulting in more frequent fire return intervals due to the volatility

of cheatgrass can limit recovery of sagebrush species in these communities, and wildfire can exacerbate these invasions.

Key Species Supported

Examples of obligate shrub-steppe species include sage-grouse, Brewer's sparrow, sage sparrow, and sage thrasher. Likely because of the elevation, condition and fragmentation of refuge shrub-steppe, only very limited use by sage-grouse has been observed. Historically the area also supported sharp-tailed grouse (*Tympanuchus phasianellus*), which were last documented in southeastern Oregon in 1940. Many other birds occur in shrub-steppe but are not as dependent on sagebrush. Examples of these include burrowing owl (*Athene cunicularia*), lark sparrow (*Chondestes grammacus*), vesper sparrow, horned lark, loggerhead shrike, long-billed curlew, and western meadowlark.

Mule deer, pronghorn, and occasionally elk use these areas, which are within their winter range. Coyotes, bobcats, and badgers are common in these areas, and mountain lions are rarer, but present. The black-tailed jackrabbit, Nuttall's cottontail, least chipmunk, Townsend's and golden-mantled ground squirrels, and northern and Townsend's pocket gophers are locally abundant in shrub step.

A variety of reptiles use shrub-steppe habitat, including sagebrush, fence and side-blotched lizards; western rattlesnakes; racers; gopher snakes; and common garter snakes. Amphibians are represented by spade-foot toads.

The priority ROC species for this habitat type is the sage thrasher, and more information about this species is listed below in Table 4-10.

Table 4-10. Sagebrush Steppe Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Sage thrasher	Found in open terrain with a high density of sagebrush and large contiguous tracts. Shrub layer cover 5%-25%, 31 inches (>80 cm) in height; other shrub cover <10%; herbaceous cover 5%-20%; tract size >39 acres (16 ha) (Altman and Holmes 2000; Reynolds et al. 1999).	Breeding and foraging	Sage sparrow, sage-grouse, long-billed curlew, ground squirrel, mule deer, pronghorn

Refuge Management Activities

To provide green winter browse for wintering Canada geese, crested wheatgrass seedings have been treated with livestock grazing to provide short stubble. Otherwise, cattle have been excluded from most of these sites on the Refuge. Research on restoring crested wheatgrass areas to more native shrub-steppe communities is being conducted in conjunction with the Eastern Oregon Agricultural Research Center (USDA Agricultural Research Service).

4.3.11 Dune

Overview

Dune habitat on the Refuge is located adjacent to playa basins and is characterized by open sand ridges with widely spaced shrubs, grasses, and forbs. Created by wind erosion off nearby dry playa bottoms (i.e., Stinking and Harney lakes), dune shrub communities are made up of shortspine horsebrush, fourwing saltbush, bud sage, green and gray rabbitbrush, and black greasewood. Grasses include Indian ricegrass, needle-and-thread, bottlebrush squirreltail, and alkali sacaton. Forbs include tufted evening primrose, Paiute suncup, Geyer's milkvetch, sharpleaf penstemon, and various lupines. Dunes cover about 6,300 acres on the Refuge and are primarily located on the east side of Harney Lake and as islands on Malheur Lake.

Regional Distribution, Condition, and Trends

Possibly because of harsh conditions, constantly shifting sand and specific adaptations of the plants that inhabit these sites, this habitat has fewer invasive weed issues than other upland types on the Refuge. Some invasive weeds, such as Russian thistle, are present, but their extent is very limited. The dunes are unstable and slowly shift over time. We have no trend data for the dunes but consider them basically pristine and unique habitat on the Refuge.

Dunes are susceptible to invasion by exotic weeds such as *Halogeton*, povertyweed, and Russian thistle. These plants could change the dynamics of sand movement in the dunes and lead to increased stability, which would change the natural vegetation patterns on the dunes and compromise their integrity. Grazing by trespassing livestock occasionally occurs as well as use by trespassing all-terrain vehicle riders. Both of these are a significant threat to the stability of the dunes.

Key Species Supported

Vertebrate wildlife associated with dunes are dependent on the associated vegetation and include many small mammals, including black-tailed jackrabbits, western cottontails, kangaroo rats, dusky-footed woodrats, and deer mice. Occasionally mule deer use the dunes to forage and seek cover. Shrub-steppe nesting birds such as sage thrashers, sage sparrows, and black-throated sparrows nest in the associated brush. Reptiles such as western fence lizards, side-blotched lizards, short horned lizards, and Pacific rattlesnakes frequent the dunes and some likely lay their eggs there. During high water periods, the sandy shorelines are used by foraging shorebirds. The priority ROC species under this habitat type is the sage sparrow, and more information about this species is listed below in Table 4-11.

Table 4-11. Dune Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Sage sparrow	Prefer large patches of contiguous sagebrush; semi-open, evenly spaced shrub habitat with big sagebrush and rabbitbrush as part of the community component. Shrub layer cover 10%-25% with a height of >19 inches (50 cm); herbaceous layer	Breeding and foraging	Sage thrasher, sage-grouse, loggerhead shrike, badger

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
	cover >10%; open ground >10% (Altman and Holmes 2000; Martin and Carlson 1998).		

Refuge Management Activities

Dune habitats have received no direct management as these area lie within the RNA and proposed wilderness boundary for Harney Lake. Natural ecological factors continue to shape the dune terrain, without any significant human influences. The primary management objective is protection from trespassing livestock and people.

4.3.12 Playa

Overview

Refuge playa habitats are located primarily in Harney Lake (a 40,000-acre playa when dry) and the Double-O. Stinking Lake is the second-largest refuge playa and is spring-fed and isolated from other surface hydrology. Total average refuge acres of playa habitats are approximately 29,000. During low-water periods, there are large playa areas in Mud Lake and a few along the east side of Malheur Lake. The flat playa surfaces that appear during drier periods are periodically flooded but generally too alkaline to support vegetation. They are bare or scattered with dead vegetation killed by floodwaters of the 1980s (Dugas 1996), and these unique habitats are often intermixed with saltgrass or desert salt-scrub communities. Evaporation of closed basin water during dry periods results in high levels of alkalinity and associated pH. During high-water events, the alkaline water is diluted, stimulating the temporary production of aquatic species. Playa soils are typically very deep and poorly drained. Virtually no vascular plants reside within Harney and Stinking lakes, with the exception of spring areas where steady freshwater inflows modify water chemistry.

Regional Distribution, Condition, and Trends

Generally, refuge playa habitats are in pristine condition with these communities least impacted by human actions or changed by environmental conditions. A few playas in the Double-O have been bisected by roads. Harney Lake is a designated Research Natural Area and wilderness study area, and has been protected for those values. Stinking Lake is designated as a Research Natural Area.

When dry, playas are popular for off-road all-terrain vehicle use, which can cause soil compaction and erosion, reducing their resiliency and allowing soils to blow away. With access on the Refuge restricted, this is mostly a limited trespassing issue. Disruption of natural water supplies from local runoff by road construction or drainage systems could reduce the flood frequency and the wildlife value of playa habitats.

Key Species Supported

Playas systems are rich in invertebrates, such as brine flies and brine shrimp. They support breeding snowy plovers and occasionally American avocets and black-necked stilts. Harney Lake is the most

important breeding site for snowy plovers in the Harney Basin and has supported over 400 breeders. When these habitats develop standing water, large numbers of waterfowl have been observed using the sites. Because they are rich in invertebrates, playas attract high numbers of migrant shorebirds when they are wet. When brine shrimp are abundant, the Refuge's playas receive high use by Wilson's and northern phalaropes, northern shovelers, ruddy ducks, gulls, and eared grebes. Peaks of over 15,000 phalaropes have been counted at Stinking Lake. The priority ROC species under this habitat type is the snowy plover, and more information about this species is listed below in Table 4-12.

Table 4-12. Playa Priority Resources of Concern Species

Focal Species	Habitat Structure and Attributes	Life History Requirements	Other Benefiting Species
Snowy Plover	Found in barren or sparsely vegetated alkaline or saline lakes, playas, and flats. Bare ground with little vegetation of any kind; nests are usually <0.8 mile from water; water levels for foraging are from 0-1 inch (0-2 cm) deep (Page et al. 1985; Page et al. 1995).	Breeding and foraging	Phalaropes, eared grebe, northern shoveler, ruddy duck, shorebirds

Refuge Management Activities

These systems generally do not require any management other than protecting them from trespassing and off-road vehicle use.

4.3.13 Cropland

Overview

Croplands are maintained on the Refuge to provide forage for fall-staging sandhill cranes and waterfowl. Grain fields are present at scattered locations in the Blitzen Valley. In the past two decades, refuge maintenance staff have planted and irrigated these fields. Winter wheat and spring barley are the primary crops planted, which are rotated among about 300 acres of grain fields. These fields are left unharvested for wildlife use.

Grain crops are occasionally planted in bottoms of refuge impoundments as part of the drawdown cycle to reinvigorate wetland nutrients.

Regional Distribution, Condition, and Trends

Historically, a much higher percentage of the Blitzen Valley was managed as grain fields. Grain crops were extensive in the late 1930s through the 1950s to support fall migrants. Many fields that are now managed as wet meadows were leveled and ditched to allow farming. Approximately 1,300 acres of grain fields were managed in the 1990s (USFWS 1990). Today about 80 acres of grain fields are managed on the Refuge.

Invasive weeds can be a threat to these lands if farming operations are terminated, with soils freshly tilled, and if the field is left idle and not restored.

Key Species Supported

Grain field farming has primarily been conducted to support fall-staging sandhill cranes. They are heavily used by cranes, Canada geese, mallards, northern pintails, and occasionally American wigeon. They are also used by mule deer, pronghorn, and upland game birds, including pheasants and California quail. Red-winged, yellow-headed, and Brewer's blackbirds, as well as a variety of sparrows, also use them.

Refuge Management Activities

Crops are maintained on an annual basis. These areas are periodically treated for invasive weeds.

4.3.14 Cold and Hot Springs

Overview

Springs occur throughout the Refuge, ranging from the southern end of the Blitzen Valley to the Double-O Unit. They provide stable, permanent sources of water for flood irrigation, pond filling, and/or maintenance, and wildlife.

Regional Distribution, Condition, and Trends

The ability of many springs to provide high quality aquatic habitat for fish and wildlife has been compromised due to the prevalence of common carp throughout the Refuge's water system. Those areas that have remained carp-free provide abundant submergent vegetation and associated invertebrates.

Key Species Supported

Springs provide habitat for a diverse assemblage of macroinvertebrates, native plants, fish, other aquatic species, and wildlife. These areas provide essential habitat for spotted frog (breeding, feeding, and winter refugia) and trumpeter swan (warm-water springs are often the only open water available during the winter).

Refuge Management Activities

Areas adjacent to cold and hot springs are treated as needed for invasive weeds.

4.3.15 Cliffs, Rimrock, and Outcroppings

Overview

Areas of steep basalt cliffs and outcroppings can be found along the sides of the Blitzen Valley and the south end of Mud and Harney lakes and in the Double-O Unit. This habitat type occurs within the refuge perimeters of the Blitzen and Double-O valleys.

Regional Distribution, Condition, and Trends

Frequent wildfires have reduced the quality of vegetation occurring on and near cliff areas. The trend for the condition of these habitats is generally stable. Some sites have been modified in the past for use as sources of gravel and rock.

Invasive weeds are a threat to the integrity of habitat surrounding cliffs and talus areas as they reduce the value of the sites for foraging wildlife. Disturbance of nesting raptors is an issue and human trespass needs to be minimized during the nesting period.

Key Species Supported

These areas provide nesting habitat for cliff dwelling birds, as well as various reptiles and are particularly important for nesting raptors, including golden eagles; prairie falcons; red-tailed hawks; and great-horned, screech, barn, and long-eared owls. Historically, they supported nesting peregrine falcons and they will likely soon reoccupy such refuge sites based on upward population trends and available habitat. These areas are used by mule deer, bighorn sheep, black-tailed jackrabbit, Nuttall's cottontail, yellow-bellied marmots, golden-mantled ground squirrels, and bushy-tailed and desert woodrats. Many lizard and snake species are associated with this habitat type and some of the sites support rattlesnake hibernacula, especially in the Double-O Unit.

Refuge Management Activities

These systems generally do not require any management other than protecting them from trespassing.

4.4 Major Species Groups

4.4.1 Migratory and Resident Birds

Waterfowl

The Refuge supports several priority waterfowl species that are highlighted in the North American Waterfowl Management Plan (North American Waterfowl Management Plan Committee 1998). Species present that are identified as "high" priority in the plan and which use the Refuge are tule greater white-fronted goose, northern pintail, mallard, and lesser scaup. Most of the refuge use for these high-priority species is provided during migration periods. However, substantial numbers of mallards nest on the Refuge with some nesting by pintail and lesser scaup. Additionally, "other" priority waterfowl species identified in the plan use the Refuge or the area surrounding the Refuge, including Pacific greater white-fronted goose, Wrangel Island snow goose, wood duck, redhead, canvasback, ring-necked duck, and American wigeon. Most refuge use is migratory, but breeding pairs of wigeon, canvasback, ring-necked, and redhead ducks are observed each year. The Refuge also supports a breeding Rocky Mountain population of trumpeter swans, which are a priority for the Pacific Flyway.

Use of the Refuge is substantial for many of these waterfowl species and varies with habitat conditions. A comparison of peak refuge counts, conducted in the 1980s and 1990s during spring and fall migration, with annual the Pacific Flyway midwinter population indices shows that the Refuge supported up to the following percentages for each species:

- 66 percent of the white goose (snow and Ross's) population (spring 1996)
- 63 percent of the American wigeon population (fall 1993)
- 48 percent of the tundra swan population (in fall 1980 after carp control on Malheur Lake)
- 40 percent of the American green-winged teal population (fall 1993)
- 24 percent of the ruddy duck population (spring 1995)
- 22 percent of the northern shoveler population (fall 1993)
- 10 percent of the northern pintail population (spring 1996)
- 5 percent of the mallard population (fall 1996)

Additionally, refuge counts for both redheads and canvasbacks exceeded the Pacific Flyway midwinter indices (328 percent for redheads in fall 1992 and 148 percent for canvasbacks in fall 1995). However, it should be noted that the midwinter counts do not include Mexico, where substantial numbers of redheads and canvasbacks winter.

Tule and Pacific greater white-fronted geese, snow geese, and Ross's geese use the Refuge, primarily during migration. Tule geese primarily use the marshy areas on the north side of Malheur Lake in the fall, while white geese and Pacific white-front geese use the area more extensively in the spring. They use the lakes for night roosting and forage in irrigated meadows on the Refuge in the north Blitzen Valley and Double-O. However, it should be noted that the majority of these birds forage off-refuge on the Silvies River floodplain. Large numbers of western Canada geese winter here.

Breeding waterfowl most commonly found on the Refuge include western Canada geese, cinnamon teal, mallard, gadwall, redhead, northern shoveler, northern pintail, American wigeon, canvasback, and ruddy duck. Several other species breed here but in much lower densities. A small flock of resident trumpeter swans use the Refuge year-round and nest in the Blitzen Valley.

Waterfowl annual production has declined from production numbers of over 100,000 birds to between 50,000 and 60,000 annually by the 1980s (Cornely, 1982). A precipitous decline occurred in the early 1950s which was strongly suspected to be correlated with expanding carp populations and degradation of Malheur Lake aquatic habitats. Waterfowl production has rebounded from the lows of the 1960s but still remains less than half of historic production levels (Cornely, 1982). Information on production in the last decade is incomplete.

Waterbirds

Thirty different species of waterbirds occur on the Refuge. The Refuge supports several colonial waterbird species identified as priority species in the Intermountain West Waterbird Conservation Plan (Ivey and Herziger 2006), including greater sandhill cranes, western and Clark's grebes, American white pelicans, California gulls, and Forster's terns.

Greater sandhill cranes are also listed as a sensitive species in Oregon. Malheur supports the highest number of breeding greater sandhill cranes of any refuge in the western United States. A statewide pair survey in 2000 found 245 pairs on the Refuge, 21 percent of the Oregon population (Ivey and Herziger 2000).

Comparing peak refuge counts of nesting waterbirds with population estimates for the Great Basin bird conservation region, most colonial waterbird numbers peak counts exceeded 10 percent of regional populations. The Refuge supported

- 20,500 breeding white-faced ibises (35 percent of regional population in 1998);
- 7,782 breeding western and Clark's grebes (50 percent of the regional population in 1983);
- 4,090 breeding American white pelicans (15 percent of the regional population in 1988); and
- 1,730 breeding great egrets (77 percent of the regional population in 1983).

The Refuge also supports high numbers of breeding Franklin's gulls in good water years. The Refuge also supports very high numbers of sora, Virginia rails, American coots, and American bitterns.

Nesting populations fluctuate annually and quite dramatically depending on water levels and habitat conditions. Populations have disappeared during drought conditions and then rebounded with rising water levels. Populations such as white pelican (nesting on Malheur and Harney Lakes and in the Blitzen Valley) have moved as habitat conditions changed.

Shorebirds

The Refuge provides vital habitat for a wide variety of shorebirds. Twenty-seven shorebird species are found on the Refuge during different seasons of the year. The most common migrant species are the western sandpiper, long-billed dowitcher, Wilson phalarope, American avocet, and common snipe. From 1990 to 1995, the Refuge participated in the Pacific Flyway Project (Ivey et al. 1995), a study coordinated by Point Reyes Bird Observatory. Shorebird numbers were counted each spring and fall when the migrating shorebirds were using the Refuge as a stopover site (Figure 4-1). Total peak numbers exceeded 20,000 individuals during migration. Using peak numbers of shorebirds counted along the Pacific coast as estimates of Pacific Flyway populations (Page et al. 1999), refuge uses were as follows: the western sandpiper peak was <0.5 percent of the Pacific Flyway population, the long-billed dowitcher peak was 4.4 percent, and the American avocet peak was 10.8 percent.

Malheur, Mud, Harney, and Stinking lakes provide most of the shorebird habitat on the Refuge and within the Harney Basin. Other important shorebird habitat on the Refuge can be found in the Double-O and Blitzen Valley units. Stinking Lake is an especially important shorebird use area. For example, Littlefield and Paullin (1976) documented 8,300 Wilson's phalaropes and 10,000 American avocets there on August 21, 1975. These birds were likely attracted to crustaceans and brine flies, which are abundant when saline playa lakes are at low levels and salts are concentrated. Breeding snowy plovers use Harney Lake and other refuge playas, and the Refuge supports over 400 breeding adults in good years.

Raptors

Twenty-three species of raptors have been recorded on the Refuge. The recorded species consist of osprey, bald eagle, northern harrier, sharp-shinned hawk, cooper's hawk, northern goshawk, red-shouldered hawk, Swainson's hawk, red-tailed hawk, rough-legged hawk, golden eagle, American kestrel, merlin, peregrine falcon, prairie falcon, barn owl, flammulated owl, western screech-owl, great horned owl, burrowing owl, long-eared owl, short-eared owl, and northern saw-whet owl.

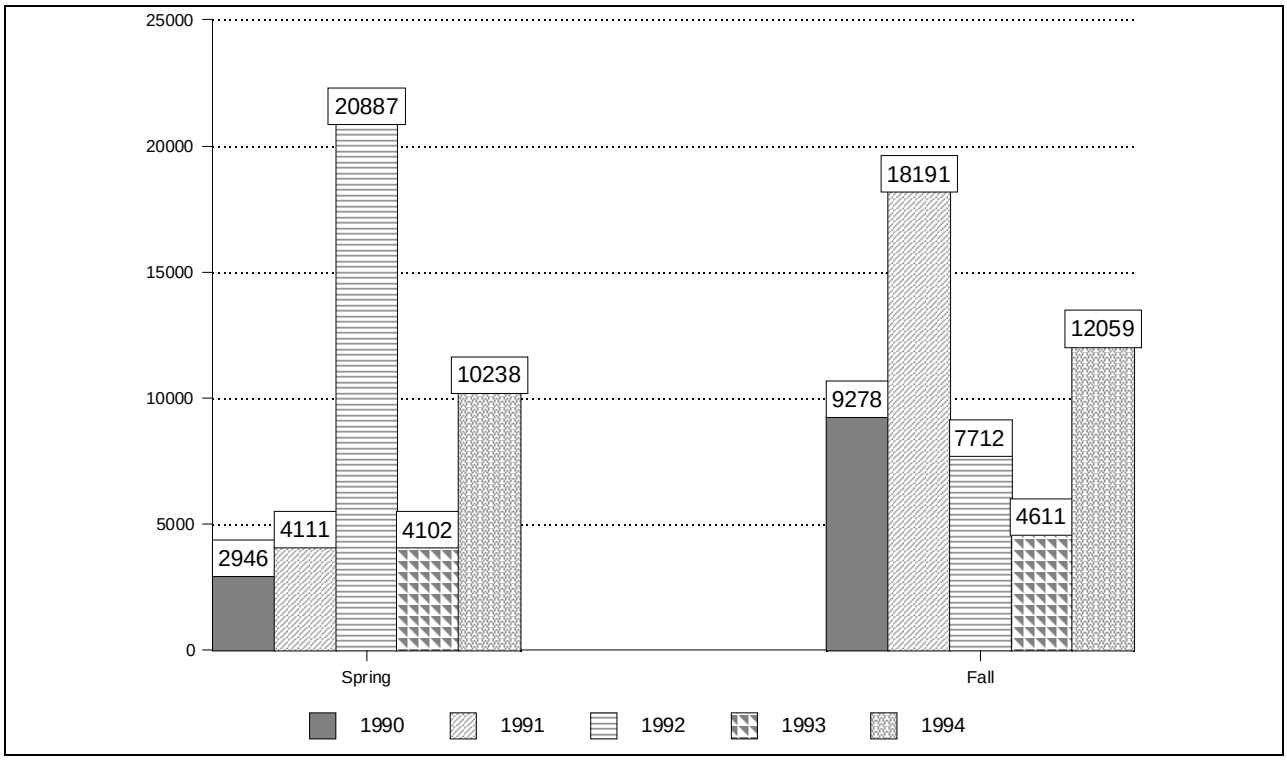

Figure 4-1. Total shorebird numbers from counts conducted at Malheur National Wildlife Refuge during the Pacific Flyway Project, 1990-1994.

Passerines

The Refuge supports at least 130 species of passerines, many of them identified as priority species by the Oregon and Washington Partners in Flight (Altman and Homes 2000). Riparian-dependent priority species include willow flycatchers, yellow warblers, Bullock's orioles, and yellow-breasted chats. The Refuge also supports the largest local population of bobolinks in the western U.S. Passerine species found in the uplands include loggerhead shrike, sage sparrow, sage thrasher, black-throated sparrow, lark sparrow, and Brewer's sparrow.

Other Birds

Thirty-four species of non-passerine birds are found on the Refuge, including five species of gulls, three species of hummingbird, and seven species of woodpecker.

4.4.2 Fisheries

Native Fishes

The Harney Basin, because of historic connections with the Columbia River drainage, supports a fish fauna mirroring the native fishes of the Columbia, with a few species absent or undetected, before they disappeared. A diverse assemblage of native fishes inhabit the Refuge, including the Great Basin redband trout, bridge lip sucker, coarse scale sucker, chisel mouth, northern pikeminnow, red-sided shiner, mountain whitefish, longnose and speckled dace, and Malheur mottled sculpin. Of these species, redband trout and Malheur mottled sculpin are listed as Oregon State-sensitive species.

Non-native Fish Species

A number of non-native fish are present in the Refuge's permanent wetlands, rivers, impoundments, and lakes. Introduced fish include common carp, green sunfish, largemouth bass, rainbow trout, bluegill, yellow bullhead, brown bullhead, black bullhead, mosquito fish, yellow perch, pumpkinseed, and white crappie. Many of the introduced species were stocked by the State of Oregon for recreational fisheries. Other species invaded the Refuge during flood events.

4.4.3 Other Wildlife and Plants

Land Mammals: Fifty-eight species of mammals have been observed on the Refuge. The muskrat is the most conspicuous mammal in Malheur Lake and has an important influence on the marsh ecology. Like waterbird populations, numbers of muskrats fluctuate primarily in response to habitat conditions and, to a lesser extent, disease. The benefit of muskrats to a marsh results from their feeding and lodge-building activities. By cutting emergent vegetation for food, muskrats create an interspersed habitat more desirable for waterfowl than pure stands. Muskrat lodges provide attractive and productive nest sites for Canada geese and trumpeter swans.

Deer mice, montane voles, Great Basin pocket mice, and least chipmunks made up 91 percent of the small mammals captured between 1973 and 1975 (Feldhamer 1979). Other mammals include pronghorn, mule deer, beaver, raccoon, coyote, bobcat, mink, long-tailed weasel, bats, and black-tailed jackrabbit.

Reptiles and Amphibians: The following amphibians occur on the Refuge: long-toed salamander; great basin spadefoot, pacific tree frog, western toad, Columbia spotted frog, and bullfrog.

The following reptiles occur on the Refuge: western fence lizard, sagebrush lizard, side blotched lizard, short-horned lizard, western skink, rubber boa, racer, striped whipsnake, gopher snake, common garter snake, western terrestrial garter snake, night snake, and western rattlesnake.

The following species occur near the Refuge, but no known specimens have been collected on the Refuge: collared lizard, leopard lizard, desert horned lizard, western whiptail, and western ground snake.

Invertebrates: At least 54 species of butterflies and dragonflies occur on the Refuge. There is a great diversity of aquatic macroinvertebrates due to the diversity of aquatic habitats. No comprehensive list of these organisms exists for the Refuge.

4.5 Threatened, Endangered, and Sensitive Species

4.5.1 State or Federally Listed Species Known to Occur on the Refuge

One goal of the Refuge System is "To conserve, restore where appropriate, and enhance all species of fish, wildlife, and plants that are endangered or threatened with becoming endangered." In the policy clarifying the mission of the Refuge System, it is stated, "We protect and manage candidate and proposed species to enhance their status and help preclude the need for listing" (16 U.S.C. 1531-1543; 87 Stat. 884).

In accordance with the above, the planning team considered all species with Federal or State status in the planning process. Table 4-13 lists species that are federally endangered, threatened, or candidate species and are known to occur on or near Malheur Refuge. A discussion of the federally listed candidate species follows the table in Section 4.5.2.

A total of 19 Federal species of concern (declining or in need of conservation) are known to occur or are likely to occur on the Refuge: least bittern, white-faced ibis, black tern, ferruginous hawk, burrowing owl, yellow-breasted chat, willow flycatcher, sage-grouse, mountain quail, Lewis' woodpecker, redband trout, fringed myotis, long-legged myotis, silver-haired bat, small-footed myotis, spotted bat, Townsend's big-eared bat, Yuma myotis, and Preble's shrew. Among this group the willow flycatcher and redband trout were selected as focal species whose requirements indicating the habitat parameters that would also support a large group of other species using these areas.

Table 4-13. Federally Listed Species Known to Occur on or Adjacent to Malheur Refuge

Common Name	Scientific Name	Federal Status*	Current Occurrence on Refuge
Malheur wire-lettuce	*Stephanomeria malheurensis*	Endangered	Adjacent to Refuge
Great Basin Columbia spotted frog	*Rana luteiventris*	Candidate species	Page Springs, Mud Creek, Double-O Springs
Yellow-billed cuckoo	*Coccyzus americanus*	Candidate species	Occasional migrant according to historic records
Greater sage-grouse	*Centrocercus urophasianus*	Candidate species	Incidental and adjacent to Refuge

4.5.2 Habitat Needs, Conditions, and Trends of Federally Listed, Proposed, or Candidate Species

Malheur Wire-lettuce: This annual plant is not present on the Refuge but is located on public lands adjacent to the Refuge. It is found on top of a dry, broad hill on volcanic soil intermixed with layers of limestone. Dominant plants at the site are big sagebrush, gray rabbitbrush, green rabbitbrush, and cheatgrass. Malheur wire-lettuce may be one of the few species able to survive on and around the otherwise barren harvester ant hills at the site (USFWS 1991).

This plant is in great danger due to its small population size. Natural fluctuations in population numbers occur in response to variations in annual rainfall and spring frosts and are particularly problematic for small populations. Immediate threats include competition from cheatgrass and predation by native herbivores, such as black-tailed jackrabbits. Currently, there are no plans to introduce this species in appropriate refuge habitats. The Refuge is working closely with USFWS Ecological Services and other State and Federal agencies on the status of this plant.

Great Basin Columbia Spotted Frog: The Columbian spotted frog consists of two distinct populations: the Northern and Great Basin populations. The Refuge is believed to have a population of the Great Basin distinct population segment (DPS) of the Columbia spotted frog. The Great Basin Columbia spotted frog is designated as a Federal candidate species for listing under the Endangered

Species Act. However, the geographic distribution of the Northern and Great Basin DPS Columbia spotted frogs overlap in eastern Oregon, quite possibly on the Refuge, given the available data. The Northern Columbia spotted frog is not designated as a Federal candidate species. Sporadic monitoring of spotted frogs has occurred for over two decades on the Refuge; however, refuge-wide species distribution and genetic analyses have yet to be completed. Known populations within the northwest portion of the Refuge appear to be geographically isolated from populations approximately 25 miles south within the Blitzen River watershed.

There are numerous threats to Columbia spotted frogs (e.g., habitat destruction, fragmentation and/or degradation of wetlands, non-native predatory species, fire and fire suppression, contaminants). The habitat present on the Refuge needs to be assessed to determine water for breeding, summer habitat, and winter refugia to aid in the conservation of the species. In addition, results from the assessment will assist Refuge management and biologists to understand the distribution of Columbia spotted frogs on the Refuge, help facilitate the development of an annual egg mass monitoring protocol, and identify the role the Refuge plays in Columbia spotted frog conservation.

Yellow-billed Cuckoo: The yellow-billed cuckoo has been documented on the Refuge; however, no breeding has been recorded and cuckoo observations are considered accidental. Refuge sightings account for most of the recent sightings of the yellow-billed cuckoo in Oregon (USFWS 2008b).

The primary reason for the decline of the yellow-billed cuckoo west of the Rocky Mountains is loss of tall streamside habitat. They tend to prefer trees with extensive canopies, such as cottonwood, which are not abundant on Malheur Refuge.

Greater Sage-grouse: This species is a rare user of the Refuge, but it uses public lands adjacent to the Refuge. Occasional sighting have been documented of sage-grouse watering on the East Canal during drought years. They have also occasionally been observed foraging in meadows at the northern end of the Double-O in late summer. Other uses have not been documented.

4.6 Invasive and Nuisance Species

4.6.1 Exotic and Invasive Plant Species

Invasive plant species infect and degrade many of the aquatic and terrestrial habitats on the Refuge. Some highly invasive species (e.g., pepperweed and reed canarygrass) can produce monotypic stands that completely displace native and desirable plant communities. These native communities are essential habitat that supports high-priority species and species groups on the Refuge (e.g., migratory birds). The Refuge's overall strategy to manage invasive plants is to use an IPM approach. For IPM, mechanical, physical, biological, and chemical methods are used to control invasive plants as a basis for achieving desirable habitat conditions. Many factors affect efficacy of control efforts for invasive plants. Aerial spraying is limited because treated ditches typically cannot be charged soon after applications based upon pesticide label restrictions. For species with extensive infestations throughout the Refuge (e.g., pepperweed), the Refuge's strategy involves containment to prevent spread to uninfested areas.

There are nine species of plants found adjacent to or on the Refuge (Table 4-14) which are classified by the Oregon Department of Agriculture as noxious weeds.

Table 4-14. Oregon Department of Agriculture Noxious Weeds Found on or Adjacent to Malheur Refuge

Common Name	Scientific Name
Canada thistle	*Cirsium arvense*
Diffuse knapweed	*Centaurea diffusa*
Medusahead rye	*Taeniatherum caput-medusa*
Perennial pepperweed	*Lepidium latifolium*
Puncture vine	*Tribulus terestris*
Russian knapweed	*Acroptilon repens*
Salt cedar	*Tamarix ramosissima*
Scotch thistle	*Onopordum acanthium*
Whitetop	*Cardaria draba*

The plants listed below are of the highest priority for the Refuge and are part of invasive species management.

Perennial Pepperweed: Flooding during the mid-1980s initially spread pepperweed throughout the Refuge and adjacent private lands; subsequent drought (1988-1992) exacerbated this invasive plant problem. There are approximately 30,000 acres of perennial pepperweed infestation on the Refuge, likely because the water delivery system has spread seeds throughout the system. Pepperweed represents a significant threat to the Refuge's capability to meet refuge purposes and habitat management objectives, especially those related to migratory birds. Pepperweed infests and forms monotypic stands and displaces grass/shrub uplands, wet meadows, and riparian habitat that are used by breeding waterfowl, cranes, and landbirds. Because it infests meadows, it can jeopardize the Refuge's haying program, which provides short-grass habitat used by breeding aquatic migratory birds. Pepperweed also infests and compromises fire breaks. Moreover, areas disturbed during riparian restoration may become infested with pepperweed.

Phragmites, Reed Canarygrass, and Other Undesirable Plant Species: Plants such as these are also displacing native/desirable species in marsh/meadow complexes. Based on habitat surveys, approximately 80 percent of the 60,000 wetland and meadow acres on the Refuge are infested to some degree with invasive plants. As a result, habitat quality for breeding migratory birds is declining relative to the degree of infestations.

Russian Olive: This species spread across refuge lands around Malheur and Mud lakes during the floods of the 1980s.

4.6.2 Exotic Wildlife Species

Common carp are the most invasive and detrimental wildlife species that inhabits the Refuge. Carp first invaded the Refuge in the late 1930s or early 1940s. The Silvies River provided access to Malheur Lake, and carp migrated up the Blitzen River and invaded the wetlands of the Blitzen Valley. Carp invaded the Double-O Unit during the early 1950s when the natural sand dune barrier

separating Malheur and Mud lakes was breached and allowed water and carp from Malheur and Mud lakes to enter Harney Lake. By the early 1960s carp had successfully invaded virtually all aquatic systems within the Refuge and surrounding private lands. Before carp invaded the Refuge, duck production averaged over 111,000 ducks annually in the 1940s and peaked at 147,000 ducks in 1948. After the carp population became established, duck production has averaged less than 30,000 annually (Ivey et al. 1998). Carp compete directly with waterfowl and waterbirds for aquatic invertebrates and vegetation, and their benthic foraging causes a detrimental decrease in water quality.

A small population of bullfrogs has established at the south end of the Blitzen Valley. This invasive species could be a threat to the Oregon spotted frog population because of predation or habitat competition.

4.7 Wildlife and Habitat Research, Inventory, and Monitoring

The Refuge has a long history of strong biological monitoring and research. Many projects are collaborative efforts between the Refuge and other Service programs, agencies, nongovernmental organizations, and universities.

4.7.1 Monitoring

Table 4-15 summarizes surveys conducted by refuge biological staff in the late 1990s. Due to changes in staff and budget cuts, many of these surveys were discontinued in the last decade.

Table 4-15. Biological Surveys Conducted at Malheur Refuge during the Peak of Biological Monitoring in the Late 1990s

Survey Type	Survey Type
Mid-winter waterfowl survey (flight)	Migration waterfowl surveys (5 flights)
Muskrat house surveys	Raptor survey routes (4)
Read goose neck collars	Bald eagle roost counts
Use telemetry to scan for radio-marked waterfowl	Golden eagle nest survey
Crane pair survey	Water temperature monitoring (Hobotemps)
Goose pair survey	Monitor goose, duck and crane nest success
Predator survey	Neotropical migrant monitoring station (mist net; spring, fall)
Common raven roost surveys	Colonial waterbird surveys
North American migration count	Duck and waterbird pair survey
Dove coo count (2 routes)	Spotted frog surveys
Trumpeter swan production survey	Duck brood survey
Bobolink survey	Snowy plover survey
Upland habitat monitoring	Breeding bird survey routes (7)

Survey Type	Survey Type
Botulism monitoring	Aquatic plant surveys
Tule goose surveys	Fall crane use surveys
Fall crane survey for Pacific Flyway	2 Christmas bird counts (Sodhouse, P Ranch)

4.7.2 Refuge Research

Many research studies have been conducted at Malheur National Wildlife Refuge since the Refuge was established. Projects are listed below in chronological order and a complete copy is on file at Malheur Refuge library, summarized in the narratives or available as literature cited:

- Breeding Habits of the Canvasback, *Nyroca valisineria* (Wilson), on the Malheur National Wildlife Refuge (Erickson 1942).
- Relationship between Land-use Patterns and Waterfowl Production at Malheur National Wildlife Refuge, 1964 (Jarvis 1965).
- Breeding Biology of Greater Sandhill Cranes on Malheur National Wildlife Refuge, Oregon (Littlefield 1968; Littlefield and Ryder 1968).
- Color Marking of Greater Sandhill Cranes on Malheur Refuge, Oregon. The study is ongoing and was initiated by Carroll Littlefield in the late 1960s. The objective of this study is to color mark greater sandhill cranes and monitor their movements and life history. Marking these birds helps document effects of land use practices on cranes breeding at Malheur Refuge and assess their migration and wintering movements, annual productivity, and behavior.
- Land-use Patterns and Duck Production at Malheur National Wildlife Refuge (Jarvis and Harris 1971).
- Distribution and Survival of Mallards Banded at Malheur National Wildlife Refuge (Jarvis and Furniss 1978).
- Productivity of Greater Sandhill Cranes on Malheur National Wildlife Refuge, Oregon (Littlefield 1976).
- An Ecological Study of the Common Raven (*Corvus corax*) at Malheur NWR and its Effects on the Nesting Success of Selected Waterfowl (Stiehl 1976, 1985; Stiehl and Trautwein 1991).
- Factors Affecting the Ecology of Small Mammals on Malheur National Wildlife Refuge (Feldhamer 1977).
- Effects of Experimental Management Schemes on Production and Nesting Ecology of Ducks at Malheur National Wildlife Refuge (Clark 1977). This is a duck nesting ecology study.
- The Breeding Biology of an Isolated Bobolink Population in Oregon (Wittenberger 1978).
- Effects of Haying and Grazing on Duck Production in the Blitzen Valley (Unit 12) of Malheur National Wildlife Refuge, Oregon (Ivey 1979).
- Historical Review and Status of Colonial Nesting Birds on Malheur National Wildlife Refuge, Oregon (Thompson et al. 1979).
- Burning, Haying, Grazing, and Non-use of Flood Meadow Vegetation (Britton and Cornely 1980; Britton and Sneva 1979). This study evaluated management effects on wet meadows.
- Future Management of Malheur Lake Marsh: Recommendations of the Technical Advisory Committee (Summerfelt et al. 1980).
- Waterfowl Production at Malheur National Wildlife Refuge, 1942-1980 (Cornely 1982).

- History and Status of the Franklin's Gull on Malheur National Wildlife Refuge, Oregon (Littlefield and Thompson 1981).
- Malheur-Harney Lakes Basin Study, Oregon (Horton et al. 1983; Littlefield 1982; Paullin et al. 1977).
- Manipulation of Flood Meadow Vegetation and Observations on Small Mammal Populations (Cornely et al. 1983).
- Nesting History of Golden Eagles in Malheur-Harney Lakes Basin, Southeastern Oregon (Thompson et al. 1984).
- Habitat Definition of Nesting Birds in the Double-O Unit, Malheur National Wildlife Refuge (Foster 1985).
- Fire Ecology and Management in Plant Communities of Malheur National Wildlife Refuge Southeastern Oregon (Young 1986).
- Effects of Cattle Grazing on Passerine Birds Nesting in Riparian Habitat (Taylor 1986).
- A Summary of Trumpeter Swan Production on Malheur National Wildlife Refuge, Oregon (Cornely et al. 1985).
- Autumn Sandhill Crane Habitat Use in Southeast Oregon (Littlefield 1986).
- The Re-establishment of American White Pelican Nesting in the Malheur-Harney Lakes Basin, Oregon (Paullin et al. 1988).
- Effects of Land Management on Nesting Success of Sandhill Cranes in Oregon (Littlefield and Paullin 1990).
- Rough-legged Hawk Habitat Selection in Relation to Livestock Grazing on Malheur National Wildlife Refuge, Oregon (Littlefield et al. 1992).
- Nests and Eggs of Colonial Birds Nesting in Malheur Lake, Oregon, with Notes on DDE (Cornely et al. 1993).
- Population Trends of Small Mammals on Malheur Refuge, Oregon. This study was initiated in 1986 by Dr. David Kerley of Eastern Oregon State College at La Grande. The purpose is to monitor long-term trends in small mammal populations in Great Basin sagebrush and greasewood shrub communities. Field work only. No report.
- Environmental Contaminants and Reproductive Success of Waterfowl, Stilts, and Coots at Malheur Refuge. This study was initiated by Dr. Charles Henny, of Patuxent Wildlife Research Center, Pacific Northwest Field Station, to investigate levels of contaminants in eggs of selected wetland species and to determine if contaminants were impacting production in these species. Field work only. No report.
- Willow Flycatcher Reproductive Success, Population Dynamics, and Habitat Relationships. Jim Sedgwick of the National Ecology Research Center initiated this study in 1988. The study is designed to examine the extent and causes of variation in reproductive success and the survival, productivity, and habitat relationships of willow flycatchers at Malheur Refuge. Site tenacity, as related to reproductive success and habitat quality, predation, parasitism by brown-headed cowbirds, and environmental (habitat) correlates of reproductive success receive special attention. Field work only. No report.
- Recovery of Vegetation at Malheur Lake Following Extensive Flooding (Spencer 1994).
- Overview of Shorebird Abundance and Distribution in Wetlands of the Pacific Coast of the Contiguous United States. From 1990 to 1995, refuge staff participated in the Pacific Flyway project, a study coordinated by Point Reyes Bird Observatory (see Page et al. 1999). One count of Malheur, Mud, and Harney lakes was conducted each spring and fall using airboats.
- Archaeological and Geomorphic Investigations of Prehistoric Sites on Malheur Lake. This study, conducted by Intermountain Research of Silver City, Nevada, examines the

relationship of archaeological sites and the geomorphic processes that have shaped the landforms on Malheur, Mud, and Harney lakes. (Raven and Elston 1992)

- A Radio-telemetry Study to Identify Sandhill Crane Colt Mortality Factors. In 1991, a radio-telemetry study was initiated by Gary Ivey to determine causes of crane colt mortality. This study continued through 1998 to provide data for better management of sandhill cranes on the Refuge. Field work only. No report.
- Breeding Biology of Eared Grebes at Malheur National Wildlife Refuge. This study was conducted by Dr. Wendy Hill of Lafayette College in Pennsylvania. She studied two eared grebe colonies, one at Boca Lake and the other near the mouth of the Blitzen River in Malheur Lake. (Hill et al. 1997).
- Use of Integrated Pest Management to Restore Meadows Infested with Perennial Pepperweed at Malheur National Wildlife Refuge (Kilbride et al. 1997).
- Roaring Springs Ranch Riparian Bird Monitoring. A study to determine occurrence and abundance of riparian-dependent songbirds was initiated by refuge biologists on Roaring Springs Ranch. The Ranch signed a cooperative agreement with the Refuge and BLM regarding grazing practices along streams on their property and adjacent Federal land. This study was designed to monitor bird species during the breeding season to note changes in bird populations as the riparian zone along these creeks recovers.
- Eastern Kingbird Study. From 2001 to 2010, Malheur Refuge has been the site of eastern kingbird studies that have shown a decline in the Malheur Refuge's kingbird population along with an increase in the population of American crows. Field work only. No report.
- Establishing Native Plants in Crested Wheatgrass Stands Using Successional Management (Fansler and Mangold 2007). Field work only. No report.
- Factors Influencing Nest Success of Greater Sandhill Cranes at Malheur National Wildlife Refuge, Oregon (Ivey and Dugger 2008)
- Geomorphic History and Current Channel Condition of the Donner und Blitzen River, Malheur National Wildlife Refuge, Oregon (Salant et al. 2010).
- Migratory Behavior and Passage of Redband Trout (*Oncorhynchus mykiss*) in the Donner und Blitzen River, Oregon (Anderson 2009).

4.8 Paleontological Resources

Paleontological resources, also known as fossils, are the remains or traces of prehistoric plant and animal life that are found in the geologic formations in which they were originally buried. At Malheur Refuge fossils are found within volcanic ash deposits on the Refuge dating from the Pleistocene epoch (2.6 million to 11,700 years ago). Fossilized remains (vertebrae) of a camel-like species have been recovered from the site. The site may also contain additional fauna and flora, but other than a cursory examination by a paleontologist from the John Fossil Beds National Monument, there has not been any scientific investigation of the site. The site has regional importance as it encompasses a period of geologic time that has not been found elsewhere in eastern Oregon. Paleontological resources are considered to be nonrenewable, sensitive, scientific, and educational resources and are protected by the Paleontological Resource Preservation Act (P.L. 111-011 2009).

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