SURFACE WATER ASSOCIATED WETLANDS OF THE HARNEY BASIN

Introduction/Background

The floodplains of Silver Creek and the Silvies and Blitzen Rivers support a diversity of wetland types, many of which are dominated by emergent plants or woody vegetation such as willows (Fig. 1). *Emergent wetlands* are wetlands "characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens" (USFWS 2020). Since settlement, these wetlands, specifically in the form of flood-irrigated wet meadows, have expanded via flood irrigation systems into many historically upland habitat types (e.g., dry meadows) and today many of these wetlands are maintained by a widespread infrastructure system (USFWS 2013). At the same time, 60% of historically documented wetlands have been converted to flood-irrigated wet meadows (Fig. 2; Christy 2013). The Harney Basin Wetlands Collaborative (HBWC) is a collaborative effort to maintain the wetlands for migratory waterbirds and to support the grass hay production of the private ranches. Most wetlands in the Harney Basin are maintained by spring runoff, primarily driven by snow melt from Steens and Blue Mountains, or surface water diverted from streams, such as the Donner und Blitzen (Blitzen) or Silvies Rivers and Silver Creek.

Figure 1a.

Wetlands mapped by type from the National Wetlands Inventory (USFWS 2020).

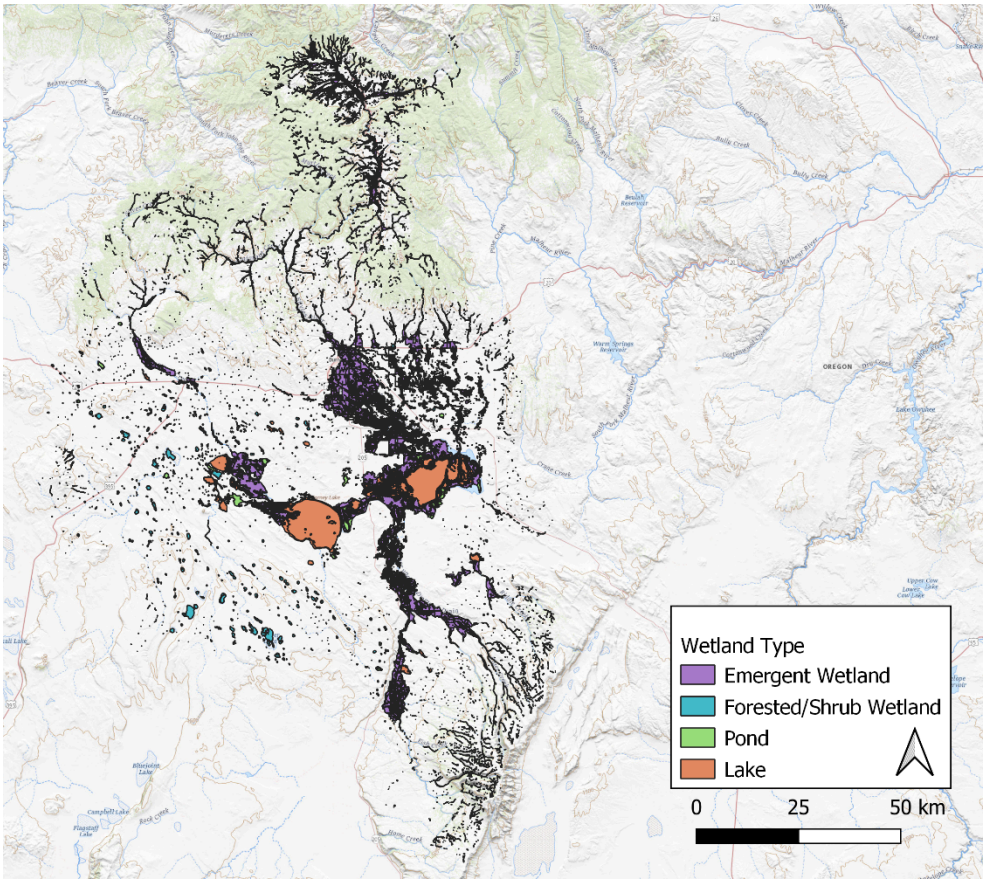
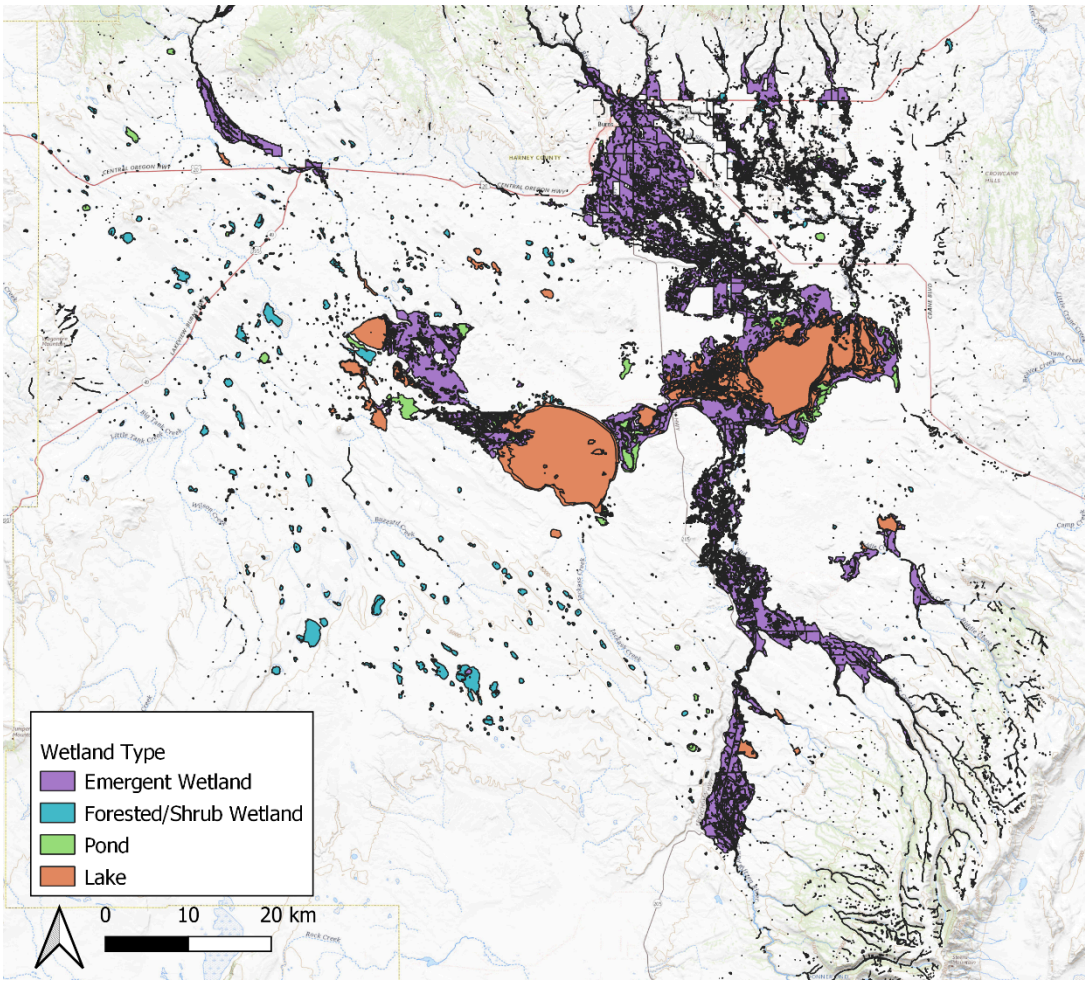


Figure 1b.

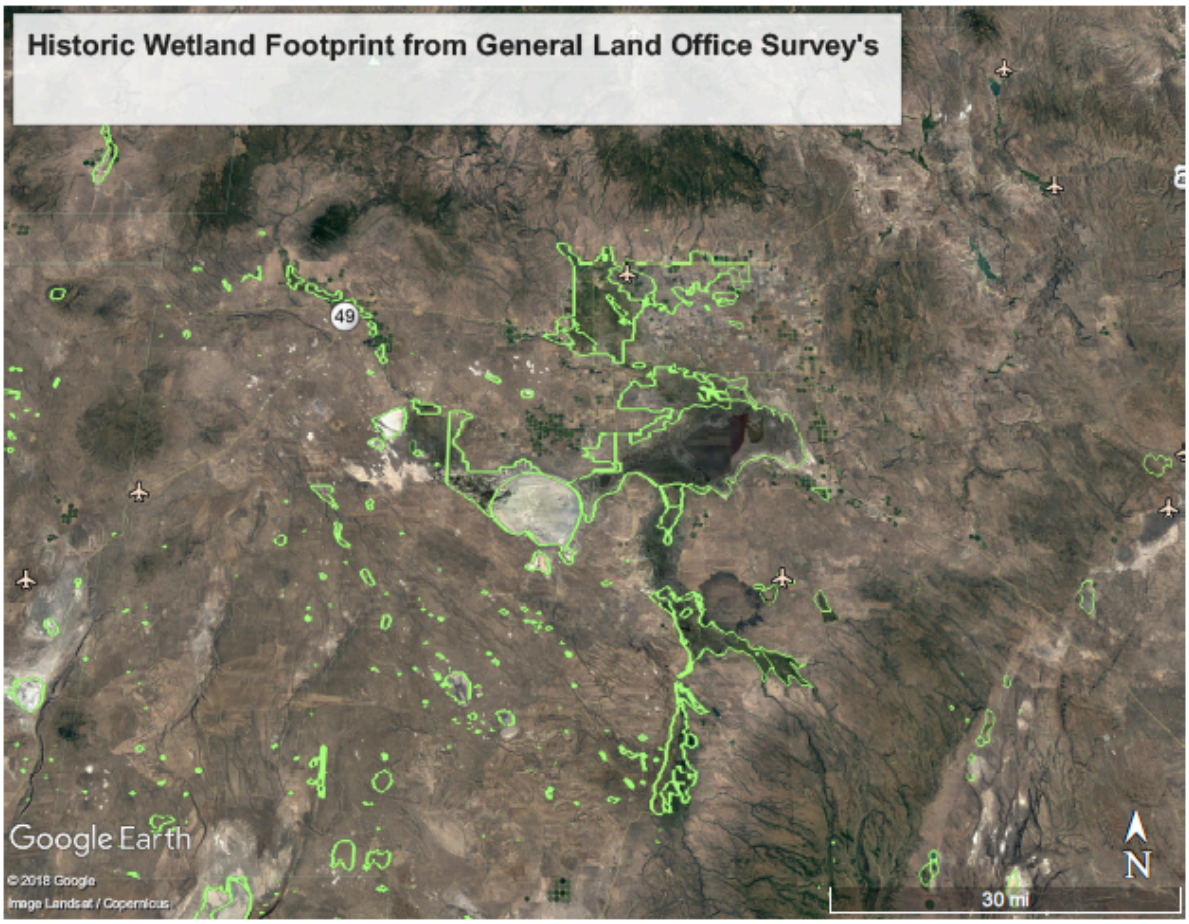
Wetlands of the Silvies Floodplain and Blitzen Valley mapped by type from the National Wetlands Inventory (USFWS 2020).



A changing climate and management of surface water affects the distribution and abundance of wetlands and flood-irrigated wet meadows throughout the basin. The Oregon Closed Basin Wetlands Conservation Plan (Lev et al. 2012) states: "Today, despite human alterations in flow patterns and timing, wetlands still expand and contract with climatic extremes, and conditions may vary greatly from one year to the next. Large areas mapped as upland in 1876-1880 is now perennially, seasonally, or irregularly flooded because of irrigation regimes." The plan characterizes the wetland dependent species of the Harney Basin as: "Three major routes of the Pacific Flyway converge at Malheur Lake. The multitude of wetland habitats on the refuge are used heavily by waterfowl and waterbirds during spring and fall migration. They also provide breeding habitat for a wide variety of species, ranging from ducks, geese, swans and sandhill cranes to shorebirds, colonial waterbirds, and songbirds."

Figure 2.

Harney Basin wetland data from the 1870 General Land Office survey (Institute for Natural Resources 2020).



Malheur National Wildlife Refuge (NWR) supports some of the highest duck nesting densities in the state, and historically supported a small population of breeding trumpeter swans (USFWS 2013). The refuge supports the largest numbers of breeding sandhill cranes under any single ownership in the state (Littlefield et al., 1994). Large breeding colonies of white-faced ibises (over 12,000 pairs), egrets, herons, cormorants, American white pelicans, gulls and terns are also present. The wetlands also support high numbers of breeding shorebirds. Harney Lake and Stinking Lake both support breeding snowy plovers, with a peak of over 400 adults counted on the refuge (Hermann et al. 1988). The significance of wetlands to the Malheur NWR is detailed in the 2013 Comprehensive Conservation Plan (USFWS 2013) for the refuge.

Conversion from flood irrigation to sprinkler irrigation represents a direct loss of spring-staging habitat resources for migratory waterfowl and waterbirds that breed in the Prairie Pothole Region and Arctic. The integrity of these habitats, as dictated by annual climatic variation,

correlates with breeding success in the north (Zarzycki et al. 2015). Conservation of the feeding and resting habitats in the Harney basin is critical for the migratory waterbirds in the Pacific Flyway. Harney Basin wet meadows comprise nearly 20% of existing flood-irrigated wet meadow habitat in Southern Oregon-Northeastern California (SONEC), a region of continental significance for migratory birds of the Pacific Flyway (IWJV 2013). The wet meadows of the SONEC have local, regional and continental significance for wetland dependent wildlife species and migratory waterfowl, waterbird, and shorebird species. The SONEC is identified as one of the areas of greatest continental significance to ducks, geese and swans in the North American Waterfowl Management Plan (IWJV 2013). The Harney basin wetlands have the greatest potential for assuring long term conservation within the SONEC because of the protected area status and the cooperative relationships developed to address current conservation issues.

Wetlands and flood-irrigated wet meadow abundance, distribution, and characteristics

Wetlands of the Harney basin are comprised of seasonally flooded wet meadows (unmanaged and irrigated wet meadows), perennial wetlands (wetland that has either surface water or wet soil year-round; naturally occurring, not human-made), ephemeral or intermittent wetlands (wetland that either has surface water or wet soil part of the year; naturally occurring, non-managed wetlands), playas/alkali flats, springs, riparian areas, and artificial open water (gravel pits, reservoirs and impoundments, sewage treatment ponds, etc.). Artificial open water is included in this section as it is commonly associated with surface water management, and/or creates habitat similar to the open water found in many Harney Basin wetlands.

Wetlands are generally characterized by wetland plant and soil composition. In the SONEC, the number of acres of wetlands, particularly flood-irrigated wet meadows is highly variable inter- and intra-annually (Donnelly et al. 2019). In the Harney Basin, wetlands cover between 6,838 (fall minimum) and 239,100 (spring maximum) acres (Lev et al. 2012; National Wetlands Inventory 2020), approximately 97,000 acres of which are surface water irrigated wetlands (i.e. wet meadows) and 142,100 acres of which are other wetland habitats; including ponds, perennial emergent wetlands, and woody riparian-type wetlands (Lev et al. 2012; National Wetlands Inventory 2020). Though naturally occurring wet meadows are an important type of seasonal wetland habitat, in this document we differentiate between seasonal wetlands and flood-irrigated wet meadows for two reasons. First, flood-irrigated wet meadows occur in both naturally occurring wet meadow habitats and in upland habitats that have been converted to wet meadows for agricultural purposes. Second, flood-irrigation tends to provide more water, over a longer period of time, than natural flooding associated with spring flush (Lev et al. 2012; Donnelly et al. 2019). It is worthwhile to note that from 1984-1999 wetlands throughout the Harney Basin declined from about 15,000 ha (mean) to approximately 6,400 hectares (mean) from 2000-2018 (Donnelly et al. 2020). At the same time, Donnelly et al. (2020) note that irrigated agricultural lands increased from 46,300 hectares to 56,900 hectares over the same period. Donnelly et al. (2020) did not separate flood-irrigated wet meadow from pivot irrigated agricultural lands, so this is not necessarily reflective of habitat available to wetland-associated bird species.

Groundwater is generally defined as water following a flow path below the unsaturated vadose zone in the soil. Groundwater exists at different depths beneath the ground surface; for

example, irrigators may be accessing much deeper groundwater, while hyporheic flow contributing to cold-water refuges in streams is often discharging from a shallow water table. Generally speaking, when talking about wetlands, groundwater as a general term refers to near-surface water. Sophocleous (2002) makes the argument that surface-water groundwater interactions are dependent upon near-surface groundwater, which is influenced by aquifer depths. Sophocleous (2002) also argues that development of aquifers (i.e. for irrigation) will eventually influence near-surface groundwater, which will affect surface expression of water in wetlands.

Seasonally flooded wet meadows

Seasonally flooded wet meadows, including unmanaged/naturally occurring and flood-irrigated wet meadows, are primarily distributed along the Silvies River floodplain, along Silver Creek/Riley in the Double O area, and along the Donner und Blitzen River at the south end of Malheur NWR. In the lowlands of the Harney Basin, seasonally flooded wet meadows are primarily dependent on springtime flood irrigation, typically with surface water. Additionally, there are some naturally flooded wet meadows in upland areas in the Silvies River watershed, on Steens Mountain, and in the Spring Creek region. There is some evidence from other high desert wet meadows that groundwater levels (including near-surface, sub-surface, and aquifers) determine how quickly water is expressed at the surface, i.e. if groundwater levels are low, flooded meadows must recharge the groundwater before pooling on the surface (Sophocleous 2002). In the Harney Basin, flood-irrigated ranchlands play an important role in basin hydrology, largely through water percolating from flooded meadows into the groundwater (Ochoa et al. 2007). An estimated 17% of applied irrigation water in the Harney Basin recharges the aquifers, which is approximately 57,300 acre-ft/yr throughout the basin (Garcia et al. 2021). Flood-irrigated meadows have also demonstrated increased late season flows and decreasing water temperatures in adjacent streams (Essaid & Caldwell 2017). Non-irrigated, upland wet meadows are discussed further in the upland palustrine wetland section.

Seasonally flood-irrigated wet meadows cover up to 121,000 acres in the Harney Basin, including 74,000 acres of private flood-irrigated wet meadows (Petrie et al. 2011) and a range of 27,000-47,000 acres of flood-irrigated wet meadows on Malheur NWR (USFWS 2013; National Wetlands Inventory 2020). These numbers are highly variable from year-to-year dependent upon winter snowpack and spring snowmelt (IWJV, personal communication 2018). While the system remains highly variable from year-to-year, the overall trend is a reduction in wetlands, associated with climate change and agricultural uses, throughout the Intermountain West, including the Harney Basin (Donnelly et al. 2020).

The distribution of this habitat type has varied considerably over the years. Marshes, uplands, and meadows were converted to flood-irrigated wet meadows starting in the mid-to late-1800s. Conversion of upland habitat to wet meadows continued through the 1940s (Lev et al. 2012). Since the 1870 General Land Office Survey (Figure 2), 60% of historically documented wetlands have been converted to flood-irrigated wet meadows. In the northern Great Basin and SONEC, approximately 61% of these are found on irrigated private lands (Donnelly et al. 2019). In general, flood-irrigated wet meadows are hayed and baled or hayed and rake-bunched and grazed,

creating short-stubble habitat ideal for migrating waterfowl, sandhill cranes, and some shorebird species (USFWS 2013). The conversion of riparian and upland habitat has likely contributed to declines in native passerines, e.g., willow flycatcher and western meadowlark (Rockwell 2022) and reduced the amount of breeding habitat available for marsh, upland, and riparian dependent species. An increase in wet meadows has also created more nesting habitat for various shorebird and non-colonial wading birds, e.g., American avocets and greater sandhill cranes respectively, though haying operations have created documented issues with mortality of fledglings (IWJV 2013). Additionally, the duration and timing of seasonal flooding via surface-irrigation influences nesting success of greater sandhill cranes (Ivey & Dugger 2008).

Seasonal emergent marshes

Seasonal emergent marshes are found along the edges of seasonally flooded wet meadows. This habitat type is generally associated with areas that stay wet longer, e.g., irrigation ditches, swales, and former (natural) stream channels. This habitat type is most common on the southern part of Malheur NWR, and in the Double O area.

On the Refuge there are about 17,000-18,000 acres of managed seasonally flooded emergent marshes that are associated with wet meadows (USFWS 2013). Emergent marshes have increased their distribution since the late 1800s. This is due, in part to the increase in impoundments. Prescribed fire, mowing, and grazing are commonly used to control emergent marsh creep into wet meadows and open water impoundments (USFWS 2013).

Perennial mesic habitats

Perennial mesic habitats include wetlands fed by direct precipitation, surface water runoff, snowmelt and groundwater discharge, and impoundments. These areas tend to stay wet throughout the year, drying up only in drought years. Data on perennial wetlands or impoundments on private lands is lacking, though it seems likely these areas would only be found at livestock wells or ponds and modest surface water storage impoundments maintained on private land. On Malheur NWR, this habitat type is generally found in the Blitzen Valley and in the Double-O units.

On Refuge, this habitat type covers 2,200-2,800 acres (USFWS 2013), primarily in wetlands impoundments (shallow impoundments dominated by emergent vegetation) or open water impoundments (water deep enough to preclude the growth of emergent vegetation). Distribution of wetland and open water impoundments seems largely unchanged since the early 1900s. On private lands, this may not be the case, but data on acres of private land covered by perennial marshes is lacking.

Upland seasonally flooded palustrine wetlands

Wetlands of this type are found in upland and higher elevation regions of the Harney Basin. These include areas with moist soil, fed by snowmelt and surface water, such as upland playas and high-elevation marshes and meadows. These habitats are typically in productive areas found in draws, along seeps, in agricultural fields (wet meadows or pivots), and in cirques and other low-lying areas dominated by shallow soils (USFWS 2013; NRCS 2017; Donnelly & Naugle 2018).

Flood-irrigated wet meadows are discussed in the seasonally flooded wet meadow section of this document. The U.S. Department of the Interior, Bureau of Land Management (U.S. DOI 2012) describes areas in sagebrush steppe where water does or may pool seasonally as playas, also called "depressional playas" (NRCS(a) 2012; DOI 2013). The Natural Resource Conservation Service (NRCS) identifies these ecosystems as Ponded Clay and Lakebed sites (Clausnitzer 2000; NRCS(a) 2012; NRCS(b) 2012) argues that the soil and hydrology of these areas are actually more characteristic of vernal pools, and to avoid confusion with more traditional plays, we refer to these depressional playas as vernal pools in this document. Because soil characteristics of these areas classify them as wetlands, (Clausnitzer 2000) and because they're included in the National Wetlands Inventory (USFWS 2020) we include them in this document. Because the soil characteristics of vernal pools are dissimilar of lowland playa-types (Clausnitzer 2000), we separated them from the playa section of this document and include them with other seasonally wet upland habitats. Modification of these vernal pools in the Harney Basin has generally been the result of excavation for livestock watering, which frequently alters the hydrology of associated playas (Clausnitzer 2000). This excavation typically penetrates the impermeable layer, causing an alteration in hydrology, leading to a conversion from Ponded Clay to Lakebed sites (Dlugolecki 2010), changing vegetation and wildlife species associated with these sites.

As with separating vernal pool playas from lowland alkali playas, we made the decision to separate upland or high elevation meadows from flood-irrigated wet meadows. These meadows typically have different plant communities and hydro-periods/hydrology than flood-irrigated wet meadows. Many upland meadows are either part of cirque-type drainages or occur within the riparian/flood zone of creeks and rivers in the southern Malheur National Forest and on Steens Mountain. Upland grass/grasslike seasonal palustrine emergent habitat (i.e. non-shrub/tree dominated wetlands) covers 30,652 acres (Freed et al. 2022). Of this, 1,884 acres are groundwater dependent and 28,768 acres are surface-water dependent.

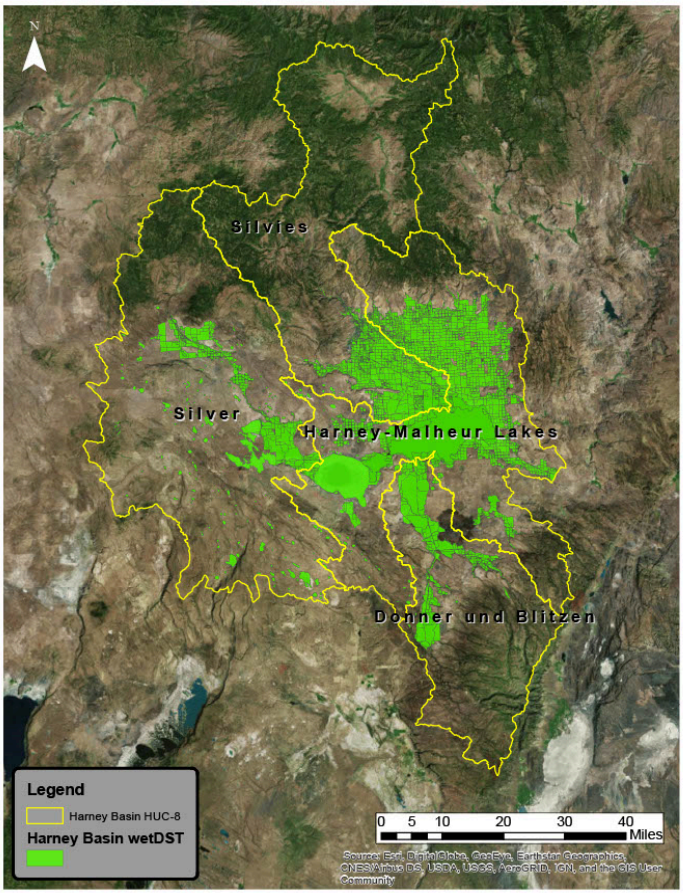
Upland mesic habitats in sagebrush steppe on Malheur NWR may be found on 14,000-15,000 acres (USFWS 2013). The National Wetland Inventory (NWI) categorizes approximately 29,000 acres of the Harney Basin as forest/shrub dominated wetlands, this includes upland mesic habitat and woody riparian areas. Of this, approximately 23,000 acres appear associated with draws and geographic depressions. From the NWI (2020) maps (Fig. 3) there is an estimated approximately 7,000 - 10,000 acres of non-woody riparian, upland mesic habitat in the Silver Creek, Silvies, and Harney-Malheur subbasins. Beyond these estimates, specific numbers on mesic areas of sagebrush steppe are difficult to find. According to the Sage-Grouse Initiatives map of mesic habitat, the Greater Harney Valley Groundwater Area of Concern provides mesic habitat in 100% of years only along ridges, draw, and seeps, and flood-irrigated meadows or pivots (Sage-Grouse Initiative 2018). This habitat type historically covered more land than it does today. Historic, landscape modification through the planting of crested wheatgrass, fire suppression, grazing, and changes in water regime associated with irrigation likely decreased the amount of upland mesic habitat (USFWS 2013; NRCS 2017).

Playas and associated alkaline wetlands

Playas are geologically low, flat areas of desert basins which are hydrated by precipitation and local surface water drainage. "Lowland playas" are typically unvegetated or have remnant vegetation (i.e. dead greasewood) from eras when conditions on such playas were different (Clausnitzer 2001). "Upland playas" are typically vegetated and provide important upland mesic habitat, including a diversity of plants and insects (U.S. DOI 2012; Clausnitzer 2001). We discuss "upland playas" further in the upland mesic habitat section of this document. Playa soils are typically characterized by an impermeable soil lens. Playas are generally too alkaline to grow vegetation, though some grasses, forbs, and shrubs have adapted to high saline levels and can be found along the higher, boundary areas of playas and in associated alkaline wetlands. Saline lakes and associated with playas provide habitat for brine shrimp and brine flies, important food sources for breeding and migrating shorebird and waterbird species (Haig et al. 2019). In periods of high water, the influx of freshwater can temporarily produce aquatic plant species, creating alkaline wetlands, but these species are generally short-lived. Fluctuations in water levels tend to change salinity (low water increases salinity, high water decreases salinity) of playa associated lakes, impacting brine shrimp and brine fly productivity, thus impacting food availability for breeding and migrating birds. Playa habitat is distributed throughout the Harney Basin, though is most common in the Double-O, Harney, and Mud Lake area of Malheur NWR (Lev et al. 2012; USFWS 2013).

Figure 3.

Spring wetland and flood-irrigated wet meadow availability for migratory birds (IWJV, 2019).



Historically playas make up 5-14% of wetland habitat in the Harney Basin. On Malheur NWR, there are 29,000 acres of playa, on average. According to the Malheur NWR Comprehensive Conservation Plan, playas on the Refuge are believed to be largely intact and remain unaltered (USFWS 2013). However, diversions from Silver Creek have likely directly contributed to the decline in water availability and expression in Harney Lake. Diversions from the Silvies River, which no longer flows to Malheur Lake in most years, have potentially affected Malheur Lake's size, which in turn may have affected water delivery from Malheur Lake to Harney Lake in high water years. Human disruption of water supply and off-road all-terrain vehicles are the largest risk to playa habitat. The USGS Groundwater Study indicates a shift in the low point of groundwater

from Harney Lake north to areas of extensive groundwater pumping. The potential effects of this groundwater shift, on surface water availability at Harney Lake are currently unknown, though may be contributing to perpetually low water levels in Harney Lake. According to the USGS Groundwater Study, groundwater pumping upgradient from the playas in the Double O are likely to have a negative impact on the springs that feed the playas, decreasing water availability to spring-fed playas such as Stinking Lake.

Wetland Woody Riparian areas

Woody riparian habitat occurs along canals, rivers, streams, and previously active sloughs in the Harney-Malheur Lakes, the Donner und Blitzen, Silvies River, and Silver Creek Subbasins. Willow-dominated riparian habitat also grows along irrigated meadows throughout the southern Blitzen Valley, and along wet meadows and wetlands in the northern Blitzen Valley and in the Double-O unit of the Refuge (Lev et al. 2012; USFWS 2013).

Pre-European settlement, riparian areas associated with wetlands were likely more abundant than they are today. This is due in part to the channelization and incision of streams and the removal of willow and other woody riparian vegetation associated with irrigation and livestock grazing. However, in some areas of Malheur NWR, where grazing pressure was removed in the 1970s, and where connectivity with the groundwater and floodplains exists, riparian areas have restablished (USFWS 2013). Historically, the distribution of willow stands on the landscape would have shifted as water levels changed from year-to-year, and the Silvies River, Silver Creek, and Donner und Blitzen River shifted across the landscape. Throughout the four subbasins, there are 29,663 acres of woody riparian habitat, mostly located along rivers and streams at higher elevations in the basin. It is not clear how many acres of woody riparian vegetation in the area are directly associated with wetlands, though there has likely been a decline in this habitat type associated with overgrazing, intentional removal of woody plants from wet meadows, channelization of water for irrigation, and conversion of wetlands to flood-irrigated wet meadows (USFWS 2013).

Historic and present distribution and characteristics of plant and bird species associated with wetlands in the Harney Basin

For a table of focal/umbrella species, see Appendix 1. For a description of data gaps associated with wetlands and flood-irrigated wet meadows, see the *Data Gaps* section below. Littlefield (1990) complied information on the birds of Malheur National Wildlife Refuge. Littlefield's descriptions of species abundance, seasonal occurrence, and habitat uses gives a good start on the historical bird uses of the Refuge.

Seasonally flooded wet meadows plant and bird species

Irrigation-based hydrologic regimes and livestock grazing have changed the composition and distribution of basin habitats and wildlife. Nonnative pasture and forage grasses have been introduced and altered many plant communities. The altered hydrology and loss of variability has permitted the spread of invasive plant species, largely replacing the native meadow plant communities (Lev et al 2012).

Wet meadows covered in water for longer durations of time, or at greater depths support populations of sedges, rushes, arrow-grass, Nevada bluegrass, western yarrow, slender cinquefoil, large-leafed avens, and fringed willow-herb. Bobolinks, greater sandhill cranes, and cinnamon teal serve as indicator species for wet meadow habitat. Other species that use this habitat type include nesting long-billed curlew, wilson's snipe, and other shorebirds; and foraging waterfowl, white-faced ibis, deer, pronghorn, and the occasional elk. Small mammals that live in these meadows are an important food source for raptors (USFWS 2013).

Since 2014, savannah sparrow abundance has remained unchanged while bobolink abundance in wet meadows has increased and western meadowlark populations have declined over that same period (Rockwell and Stephens 2020). Analysis by IWJV (Donnelly et al., 2019) of the seasonal availability of fall and spring flooded habitats shows significant area of wetlands available for migratory birds (Fig. 3 & 4). Wetland availability during the fall migratory period is greatly decreased from spring wetland availability, particularly in the Silver Creek and Silvies River subbasins (Fig. 5). Across SONEC, 60-70% of flooded wetland habitats in the spring are found on private lands. In the fall, flooding is much reduced and less predictable, and flooded acres are nearly equivalent on public and private lands. Reduced wet acres in the fall creates a habitat bottleneck for wetland dependent birds during fall migration in SONEC (Donnelly et al. 2019).

Seasonally flooded emergent marshes

Submergent plants include bladderwort, pondweeds, duckweeds, and waterweeds. Emergent plants include bulrushes, cattails, sedges, and rushes. Key species include yellow-headed blackbird and greater sandhill crane. Other species that depend on emergent marshes include ducks, rails, bitterns, terns, coots, marsh wrens, blackbird species, and common yellowthroats (USFWS 2013). According to data collected by birders in Harney County, greater sandhill crane and yellow-headed blackbird populations have not changed significantly since 2014 (eBird 2022).

Perennial mesic habitats

Emergent plant species include bulrushes, cattails, sedges, rushes, and spike rushes. Wildlife that use perennial wetlands and impoundments include trumpeter swans, waterfowl (particularly ducks with broods), white-faced ibis, grebes, Franklin's gulls, muskrats, redside shiners, and tui chub. Key species for this habitat type include eared grebes, redheads, and ruddy ducks. In high water years, redhead use of Malheur NWR increases, as does the number of young produced (USFWS 2013).

Upland seasonally flooded palustrine wetlands

Plants species that dominate this habitat type vary throughout the Harney Basin. Mesic regions of sagebrush steppe include low sagebrush, balsamroot, western yarrow, phlox, locoweed, bottlebrush squirreltail,

Figure 4.

Spring vs Fall total acres of wetlands and flood-irrigated wet meadows in the Donner und Blitzen and Harney-Malheur Lake Subbasins. (Donnelly et al., 2019).

bluebunch wheatgrass, Idaho fescue, needle-and-thread grass, and other native grasses. Obligate wildlife includes greater sage-grouse, sage thrasher, sage and brewer's sparrows. Other wildlife common to this habitat type include badger, black-tailed jackrabbit, and Townsend's and gold-mantled ground squirrel. An umbrella species for this habitat type is the sage thrasher.

Table 1. Donner and Blitzen

Time Periods	1984	1990	1995	2000	2005	2010
Spring Acres	4169.367	4611.32	7259.028	1936.392	1266.366	2616.88
Fall Acres	1033.779	1797.966	4741.503	911.8853	661.1973	2073.871

Figure 1. Donner and Blitzen

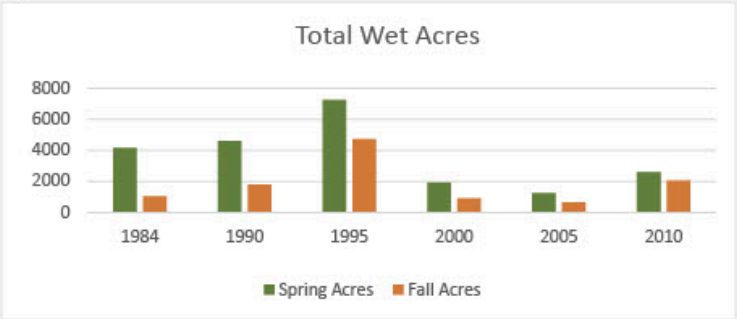
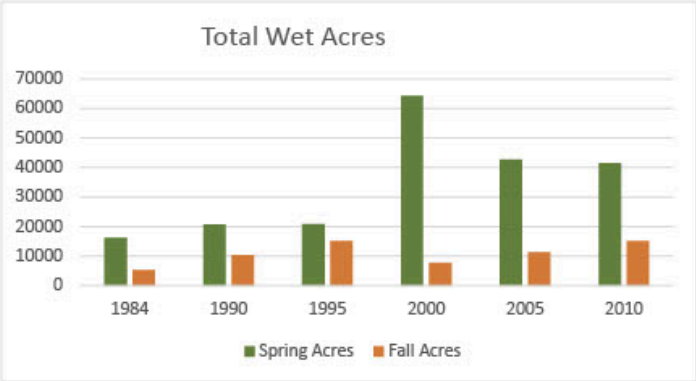


Table 2. Harney-Malhuer Lakes

Time Periods	1984	1990	1995	2000	2005	2010
Spring Acres	16195.62	20659.45	20938.08	64188.79	42665.85	41536.82
Fall Acres	5264.374	10436.08	15021.03	7648.774	11305.1	15088.93

Figure 2. Harney-Malhuer Lakes



Community scientist reports of sage thrasher indicate a general upward population trend in the Harney Basin (eBird, 2022), though Partners in Flight (2021) indicates a long-term downward population trend in Bird Conservation Region (BCR) 9, which extends from the Great Basin north into south British Columbia. Predicted relative abundance for sage thrasher indicate high abundance levels in associated upland habitats in this region (Donnelly et al. 2017). It should be noted that there is little quantifiable data about sagebrush steppe mesic habitat in the Harney Basin and there is no literature about these habitats and their connection, or lack thereof, to groundwater (Foster, personal comm.).

In upland wet meadows in the Silvies River watershed, are largely dominated by sedge species. These meadows have been affected by heavy grazing by elk and livestock and by alteration of hydrology through the construction of channels and ditches for irrigation (Dwire et al. 2017). Wet basins (i.e. fens), swales, springs, and other low-lying flooded areas are

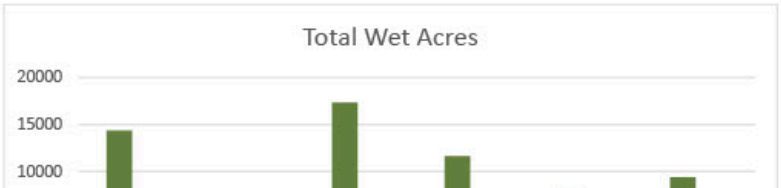
Figure 5.

Spring and fall total acres of wetlands and flood-irrigated wet meadows in the Silver Creek and Silvies River Subbasins (Donnelley, et al., 2019).

Table 3. Silver

Time Periods	1984	1990	1995	2000	2005	2010
Spring Acres	14367.47	3770.634	17324.47	11619.87	7464.237	9350.404
Fall Acres	687.5307	1779.011	1279.738	655.4072	942.3385	1437.196

Figure 3. Silver



commonly dominated by bulrush species and other rushes (Crowe and Clausnitzer 1997). Several sagebrush species can be found associated with mesic habitats in trough-like basins and broad, flat valleys (Crowe and Clausnitzer 1997). Broad valley bottoms can be important for greater sandhill cranes and were historically important for upland sandpipers. Springs are important for various forest nesting bird species and moist meadows interspersed with tree stands are associated with many passerine species.

On Steens Mountain, there are many rare plant species associated with vernal pools, wet meadows, and other seasonally flooded palustrine emergent habitat (Mansfield 1995). These upland wet meadows are dominated by rushes, sedges, and native grasses and have largely been modified by livestock grazing (NRCS(c) 2012). Upland mesic sites on Steens Mountain can be important for various passerine species, including horned lark, several sparrow species, and black rosy-finches (along seeps and edges of snow fields in rocky soils).

Playas and associated alkaline wetlands

Due to the high levels of salt and alkali deposits, few plants grow on playas. Scattered, salt or alkali tolerant plants, including greasewood, salt grass, saltbrush, rabbitbrush, and silver sagebrush. Brine shrimp and brine flies are common macroinvertebrate species in playas that provide critical food resources to birds, including high numbers of migrant shorebirds (e.g. Wilson's phalarope and American avocet), northern shovelers, ruddy ducks, gulls, and eared grebes (USFWS 2013). Brine shrimp and brine flies are also an important food source for breeding snowy plover, an umbrella species for playa habitat. The abundance of brine shrimp and brine flies depends on the amount of water available in playas and alkali lakes. Low water years create hyper saline conditions in playa associated lakes, decreasing brine shrimp and brine fly populations, reducing habitat for breeding and migrating shorebirds, including snowy plover.

Data from the 1980s to 1990s shows a downward trend in snowy plover populations at Harney and Mud Lakes. This trend seems to correlate with decreases in water availability in the 1990s, after high water years of the 1980s. The current population of breeding snowy plovers in the Harney Basin appears to have declined since the 1990s but may be stable over the past three years. More data is necessary to understand population trends (USFWS, historic records).

Wetland woody riparian areas

Riparian plants include several willow species, Wood's rose, golden currant, common snowberry, Lewis' mock orange, sedge species, Northwest cinquefoil, yellow monkey-flower, meadow barley, tufted hairgrass, Baltic rush, western yarrow, and American speedwell. Yellow Warblers, Yellow-breasted Chat, and Willow Flycatchers are indicator species for riparian areas throughout the area of concern. Other species that use willow thickets associated with wetlands include Lazuli Bunting, Song Sparrow, Eastern Kingbird, skunks, and weasel. This habitat type also provides important stopover habitat for migrating warblers, vireos, and other passerine species.

Since 2014, yellow warbler abundance has remained steady and willow flycatcher numbers have declined (Rockwell and Stephens 2020).

Assessment of stressors and limiting factors that affect wetlands in the Harney Basin

Potential Stressors

There are a number of factors adversely affecting wet meadow and wetland habitats in the Harney Basin. Annual variability in precipitation has significant effects on wetland habitat availability. Donnely et al. (2020) identified long-term declining trends in wetland availability in the Great Basin associated with climate change and agricultural water use. Projected changes in future precipitation associated with climate change will likely further exacerbate annual wetland habitat availability (Haig et al. 2019). While woody and non-woody riparian plants are adapted to variability in water levels and can survive periods of drought, extended drought associated with climate change may decrease the likelihood of wetland plants recovering during subsequent wet periods (Sandi et al. 2020). Currently, surface water quantities are enough to flood meadows to ecologically beneficial levels for spring migrating dabbling ducks (IWJV 2013). However, in the next 50 years it is unknown how water levels will change. It is possible there will be a similar number of acres of flood-irrigated meadows, distributed in a different way across the landscape. For example, along the upper Silvies River, alteration of wet meadow systems using beaver dam alternatives (Davee et al. 2017) have increased potential surface water-related stressors in the lower Silvies. Donnelly et al. (2020) identified a nearly 50% decline in closed basin wetlands in the Northern Great Basin over 34 years (1984-2018) as a result of increased aridity attributed to climate change and human water use for irrigation. This study indicated a 56%, or 8,605 a, reduction in wetlands in the Harney Basin.

Other potential stressors include water availability and timing (including ensuring adequate water supply to the Refuge), spread of non-native invasive plants and animals (e.g. reed canarygrass, common carp), dilapidated infrastructure creating an inability to continue flood irrigation practices, splitting of large ranches to smaller ranchettes, loss of institutional knowledge of how to manage water systems (i.e. flood irrigation), declining groundwater levels altering surface water expression (Barlow and Leake 2012), inefficient irrigation water delivery (i.e. old infrastructure that causes water loss through leakage or increased evaporation) and application systems (e.g. high elevation vs low elevation sprinklers on pivots), fire suppression increasing emergent plant and shrub density, and altered fire regimes (more frequent fires) associated with cheatgrass invasion (Lev et al. 2012; USFWS 2013; NRCS 2017). Between 1995 and 2010, there was a 43% reduction in flood-irrigation and 210% increase in sprinkler irrigation within the Southern Oregon Northeastern California (SONEC) (USGS). Sprinkler irrigation has increased dramatically across SONEC largely due to pivot installation in upland areas, with some conversions from surface irrigation to sprinkler irrigation. Conversion from flood-irrigation to sprinkler irrigation has occurred on a small scale in the Silver Creek drainage (near Riley). There is some risk of this trend continuing in the Harney Basin.

Declining groundwater levels in the Harney Basin are likely impacting spring discharge that maintain wetlands in parts of the basin. This is because wetlands are often associated with shallow groundwater tables or direct spring discharge to support obligate wetland vegetation (Stevens et al. 2021), so alterations to groundwater hydrology can affect wetlands (Aldous and Bach 2014). Wherever there is surface water, it is in constant interaction with groundwater based on pressure differences (Barlow and Leake 2012). Changes to groundwater hydrology affect streams, wetlands, and lakes and changes to surface water hydrology affect groundwater.

Data Gaps

Current information about specific species, particularly non-game species outside of the Refuge, is difficult to come by. Historic, baseline, data are available through agency biologists, though there is little published data for the Harney Basin. There are Community Science databases, e.g., eBird, and "expected distribution" maps available from ODFW via the Compass website. Some efforts are being made to collect information about vegetation in flood-irrigated wet meadows on and off Refuge, though this data is not publicly available yet. Additionally, a Community Science project inventorying birds in the Silvies Floodplain (Project IBiS) is ongoing. This effort includes six flood-irrigated sites associated with work being done by the Harney Basin Wetlands Collaborative. From 2019-2021, volunteers identified 129 species using the flood-irrigated wet meadows at some point in their life cycle (Wicks, personal comm.). Information about specific focal species using the Silvies Floodplain will be available in fall of 2023. While these efforts will help fill some data gaps, there is a general need for better understanding of floral and faunal communities, and the relationships between these communities, surface water, and groundwater throughout the Harney Basin.

There are also data gaps regarding wetland distribution, particularly for wetlands other than flood irrigated wet meadows. We lack data regarding how the declining groundwater levels have and will affect wetlands throughout the basin. There are ongoing efforts through the HBWC to fill some of these gaps.

Socioeconomic Impacts

Natural wetlands, such as the marshes and playas on the Malheur NWR, and flood-irrigated meadows provide stopover habitat for migrating waterfowl and waterbirds. This habitat is increasingly important along the Pacific Flyway as wetland-type habitat declines associated with climate change or development continue to occur. The large concentration of birds in the Silvies Floodplain draws in birders from all corners of Oregon and the U.S (79% and 21%, respectively; Carver 2013), creating an important source of revenue for businesses in the Harney Basin. In 2011, 892,000 people (resident and non-resident) participated in observing wild birds in Oregon (U.S. DOI and U.S. Census Bureau 2011). Of these, 424,000 traveled away from home to observe birds, including to the Harney Basin.

The most recent hunting, fishing, and wildlife-related recreation report for Oregon is from 2011. In 2011, wildlife observers spent $1.7 billion on observing wildlife in 2011. An estimated 63.7% of wildlife observers were watching birds. Assuming 63.7% of expenses for wildlife watching were paid by birders, this means birders spent nearly $1.1 billion on travel, equipment, etc. in Oregon in 2011. Approximately $307 million of this was spent on travel. Though Harney County is not ranked first in terms of number of species, it is largely considered one of the most visited non-urban or suburban birding hubs in Oregon (eBird 2022). In population size, Harney Country ranks 31st out of 36, meaning there are five counties with fewer people than Harney County. However, in number of checklists submitted Harney County ranks 9th out of 36 counties (with >53,000 checklists submitted). Because several of the eight counties with higher numbers of checklists have large population centers with birders who travel shorter distances (i.e. do not have to stay overnight), we can assume the distribution of travel spending is skewed toward more rural counties with destinations that require overnight stays, such as to Malheur NWR. If we assume birders spend travel money evenly across all counties of Oregon, we would estimate that as of 2011 birders spend more than $8 million in Harney County each year.

In 2016, the USFWS estimated that nationwide the total number of birders declined by approximately 1.5 million birders from 2011 (Carver 2013; Carver 2019). The economic value was estimated to drop by approximately $1.8 billion. In this same time period, travel expenditures declined by approximately $4.5 billion and expenditures on equipment increased by approximately $2.8 billion (Carver 2013; Carver 2019). While we don't have specific data for Oregon from 2016, approximately 17% of birders nationwide are in Pacific States. If these birders spent 17% of the nationwide travel expenditure, they would have spent approximately $1.7 billion in 2016. Averaged among the five Pacific states (Washington, Oregon, California, Alaska, and Hawaii) travel expenses are estimated at $350 million per state. If this total was average across Oregon counties, travel expenditures in Harney County would have totaled approximately $9.7 million in 2016 (Carver 2019).

While we don't have exact numbers on birders visiting the Harney Basin, visitor data from the Friends of Malheur National Wildlife Refuge Nature Store, at Malheur NWR indicates that visitation to the Refuge is increasing. In 2020, during the COVID pandemic, the Harney Basin saw an estimated 300% increase in visitation (Bureau of Land Management, personal communication).

References

Adjei, Zola Yaa Apoakwaa, Mackayla J. Thyfault, and Gustavious Paul Williams. 2015. Exploring Emergent Vegetation Time-History at Malheur Lake, Oregon Using Remote Sensing. Natural Resources 6:553-565.

Avian Knowledge Network. 2009. Avian Knowledge Network: An online database of bird distribution and abundance. Ithaca, New York. www.avianknowledge.net (Accessed: 15, October 2019).

Barlow, P.M., and S.A. Leake. 2012. Streamflow depletion by wells–understanding and managing the effects of groundwater pumping on streamflow. U.S. Geological Survey Circular 1376, 84 p. https://pubs.usgs.gov/circ/1376/ .

Clausnitzer, David. 2000. Hydric Soils in Eastern Oregon Temporary Pools. [Doctoral dissertation, Oregon State University.] Scholars Arcive@OSU, Graduate Thesis or Dissertation. https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/1z40kw62p. (Accessed: 20 November, 2022)

Carver, E. 2009. Birding in the United States: A demographic and economic analysis addendum to the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. *U.S. Fish and Wildlife Publications,* Division of Economics. 2006-4

Carver, E. 2013. Birding in the United States: A demographic and economic analysis addendum to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. *U.S. Fish and Wildlife Publications*, Division of Economics. 2011-1

Carver, E. 2019. Birding in the United States: A demographic and economic analysis addendum to the 2016 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. *U.S. Fish and Wildlife Publications,* Division of Economics. 2016-2

Craver, Daniel Robert. 2010. Influence of Wetland Landscape Structure on Duck Nest Success at Malheur National Wildlife Refuge, Oregon. Geography Masters Research Papers. 9.48 p.Miller, Jordan W. 2012. Geographic Information System Techniques for the Mapping of Access Routes, Habitat Suitability & Variations in the Distributions of Common Carp (Cyprinus carpio) Throughout Malheur National Wildlife Refuge. M.S. thesis University of Wisconsin-River Falls. 50p.

Crowe, E.A. and R.R. Clausnitzer, 1997. Mid-Montane Wetland Plant Associations of the Malheur, Umatilla and Wallowa-Whitman National Forests. USDA Forest Service R6-NR-ECOL-TP22-97, Portland, Oregon.

Davee, Rachael; Gosnell, Hannah; Charnley, Susan. 2019. Using beaver dam analogues for fish and wildlife recovery on public and private rangelands in eastern Oregon. Res. Pap. PNW-RP-612. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 29 p.

Dlugolecki, L. 2010. A Characterization of Seasonal Pools in Central Oregon's High Desert. [Masters Thesis, Oregon State University]. Scholar Archive@OSU. https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/7d278z126. (Accessed: 28 November, 2022)

Donnelly, J.P., D.E. Naugle, C.A. Haugen, and J.D. Maestas. 2016. Public lands and private waters: scarce mesic resources structure land tenure and sage-grouse distributions. Ecosphere. 7(1):1-15.

Donnelly, J. P., J. D. Tack, K. E. Doherty, D. E. Naugle, B. W. Allred, and V. J. Dreitz. 2017. Extending Conifer Removal and Landscape Protection Strategies from Sage-grouse to Songbirds, a Range-Wide Assessment. Rangeland Ecology & Management 70:95–105. http://dx.doi.org/10.1016/j.rama.2016.10.009

Donnelly, J.P., D.E. Naugle, et. al. 2018. Seasonal drought in North America's sagebrush biome structures dynamic mesic resources for sage-grouse. Ecology & Evolution 8:12492-12505.

Donnelly, J. P., D. E. Naugle, D. P. Collins, B. D. Dugger, B. W. Allred, and Tack Jason D Dreitz Victoria. 2019. Synchronizing conservation to seasonal wetland hydrology and waterbird migration in semi-arid landscapes. Ecosphere 10(6):1-12.

Donnelly, J. P., King, S. L., Silverman, N. L., Collins, D. P., Carrera‐Gonzalez, E. M., Lafón‐Terrazas, A., & Moore, J. N. (2020). Climate and human water use diminish wetland networks supporting continental waterbird migration. *Global change biology*, *26*(4), 2042-2059.

Dwire, K.A., Mellmann-Brown, S., and Gurrieri, J.T. 2017. Potential effects of climate change on riparian areas, wetlands. And groundwater-dependent ecosystems in the Blue Mountains, Oregon, USA. *Climate Services.* http://dx.doi.org/10.1016/j.cliser.201710.002 (Accessed: 23 November, 2022)

Essaid, Hedeff I., and Rodney R. Caldwell. "Evaluating the impact of irrigation on surface water–groundwater interaction and stream temperature in an agricultural watershed." *Science of the total environment* 599 (2017): 581-596.

Fink, D., T. Auer, A. Johnston, M. Strimas-Mackey, S. Ligocki, O. Robinson, W. Hochachka, L. Jaromczyk, A. Rodewald, C. Wood, I. Davies, A. Spencer. 2022. eBird Status and Trends, Data Version: 2021; Released: 2022. Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/ebirdst.2021

Freed, Z., Schindel, M., Ruffing, C., and S. Scott. 2022. Oregon Atlas of Groundwater-Dependent Ecosystems. 129 p. The Nature Conservancy. Arlington, VA.

Garcia, C.A., Corson-Dosch, N.T., Beamer, J.P., Gingerich, S.B., Grondin, G.H., Overstreet, B.T., Haynes, J.V., and Hoskinson, M.D. (2021). Hydrologic budget of the Harney Basin groundwater system, southeastern Oregon. U.S. Geological Survey Scientific Investigations Report 2021-5128, 144 p. https://doi.org/10.3133/sir20215128.

Haig, S. M., Murphy, S. P., Matthews, J. H., Arismendi, I., & Safeeq, M. (2019). Climate-altered wetlands challenge waterbird use and migratory connectivity in arid landscapes. *Scientific reports*, *9*(1), 1-10.

Herman, S. G., J. B. Bulger and J. B. Buchanan. 1988. The snowy plover in southeastern Oregon and western Nevada. Journal of Field Ornithology 59:13-21.

Intermountain West Joint Venture. 2013. Implementation Plan – Strengthening Science and Partnership. Intermountain West Join Venture, Missoula, MT.

Ivey, Gary L. and Bruce D. Dugger. 2008. Factors Influencing Nest Success of Greater Sandhill Cranes at Malheur National Wildlife Refuge, Oregon. Waterbirds 31(1): 52-61.Esquivel, Robert A. 2018. Aquatic Health Basin-Wide Baseline Monitoring Report 2016-2018. Project Number 216-8202-1279 Harney Basin Wetlands Initiative. 33p.

Langston, N. 2003. Where Land and Water Meet: a Western Landscape Transformed. University of Washington Press, Seattle. 230 pp.

Lev, Esther, John Bauer, and John A. Christy. 2012. Oregon Closed Lakes Basin Wetland Conservation Plan. Report to U.S. Environmental Protection Agency. 45 p.

Littlefield, Carroll D. 1995. Demographics of a Declining Flock Of Greater Sandhill Cranes in Oregon. Wilson Bull. 107(4):667-674.

Littlefield, Carroll D., Mark A. Stern and Ronald W. Schlorff. Summer Distribution, Status, and Trends of Greater Sandhill Crane Populations in Oregon and California. Northwestern Naturalist 75(1):1-10.

Mansfield, D. (1996). The unique botany of Steens Mountain: The rare and endemic plants. *Kalmiopsis*, *5*, 10-17.

North American Waterfowl Management Plan Committee.. 2012 "North American Waterfowl Management Plan 2012: people conserving waterfowl and wetlands. US Department of the Interior, US Fish and Wildlife Service, Washington, DC, USA; Environment Canada." *Canadian Wildlife Service, Ottawa, Ontario, Canada*.

Natural Resource Conservation Service (a). 2012. Ecological Site Description R023XY200OR: Ponded Clay. https://edit.jornada.nmsu.edu/catalogs/esd/023X/R023XY200OR (Accessed: 20 November, 2022)

Natural Resource Conservation Service (b). 2012. Ecological Site Description R023XY100OR: Lakebed. https://edit.jornada.nmsu.edu/catalogs/esd/023X/R023XY100OR (Accessed: 20 November, 2022)

Natural Resource Conservation Service (c). 2012. Ecological Site Description R023XY416OR: Wet Meadow. https://edit.jornada.nmsu.edu/services/descriptions/esd/023X/R023XY416OR.pdf (Accessed: 20 November, 2022)

Natural Resource Conservation Service. 2017. Mesic Habitat Conservation Planning Guide. https://www.sagegrouseinitiative.com/wp-content/uploads/2017/04/Mesic_Habitat_Conservation_Planning_Guide1.pdf Accessed 15, October 2019.

Ochoa, C.G., Fernald, A.G., Guldan, S.J. and Shukla, M.K. 2007. Deep percolation and its effects on shallow groundwater level rise following flood irrigation. *Transactions of the ASABE*, *50*(1), pp.73-81.

Partners in Flight. 2021. Avian Conservation Assessment Database, version 2021. http://pif.birdconservancy.org/ACAD (Accessed: 28 November, 2022)

Petrie M, Brasher MG, Soulliere GJ, Tirpak TM, Pool DB, Reker RR. 2011. Guidelines for establishing Joint Venture waterfowl population abundance objectives. North American Waterfowl

Management Plan Science Support Team Report 2011-01 (see Supplemental Material, Reference S8, http://dx.doi.org/10.3996/062012-JFWM054.S8).

Rockwell, S. M. 2022. Conservation strategy for landbirds in sagebrush-steppe and riparian habitats of eastern Oregon and Washington. Version 2.0. Prepared for Oregon-Washington Partners in Flight, Bureau of Land Management, and U.S. Forest Service. Klamath Bird Observatory, Ashland, OR.

Rockwell, S.M. and Stephens, J. L. 2020. Bird community composition and select species trends in managed wet meadow and woody riparian habitats within Unit 12 at the Malheur National Wildlife Refuge. Klamath Bird Observatory, Report No. KBO-2020-0008.

Sandi, S.G., Rodríguez, J.F., Saintilan, N., Wen, L., Kuczera, G., Riccardi, G.A., & Saco, P.M. (2020). Resilience to drought of dryland wetlands threatened by climate change. *Scientific Reports, 10*.

Sophocleous, M. (2002). Environmental implications of intensive groundwater use with special regard to streams and wetlands. *Intensive use of groundwater: challenges and opportunities. CRC Press, Boca Raton, Louisiana*, 93-112.

U.S. Department of the Interior, Bureau of Land Management. 2013. Sage-Grouse Playa Management Environmental Assessment. Prineville District, Prineville, OR. Available at: http://www.blm.gov/or/districts/prineville/plans/index.php. (Accessed: 28 November, 2022)

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

U.S. Fish and Wildlife Service. 2013. Malheur National Wildlife Refuge final comprehensive conservation plan and environmental impact statement. Malheur National Wildlife Refuge, Princeton, OR.

Zarzycki, C.M., C. Jablonowski, D.R. Thatcher, M.A. Taylor. 2015. Effects of localized grid refinement on general circulation and climatology in the Community Atmosphere Model. *Journal of Climatology*, 28(7): 2777-2803. doi:10.1175/JCLI-D-14-00599.1.

Appendix 1

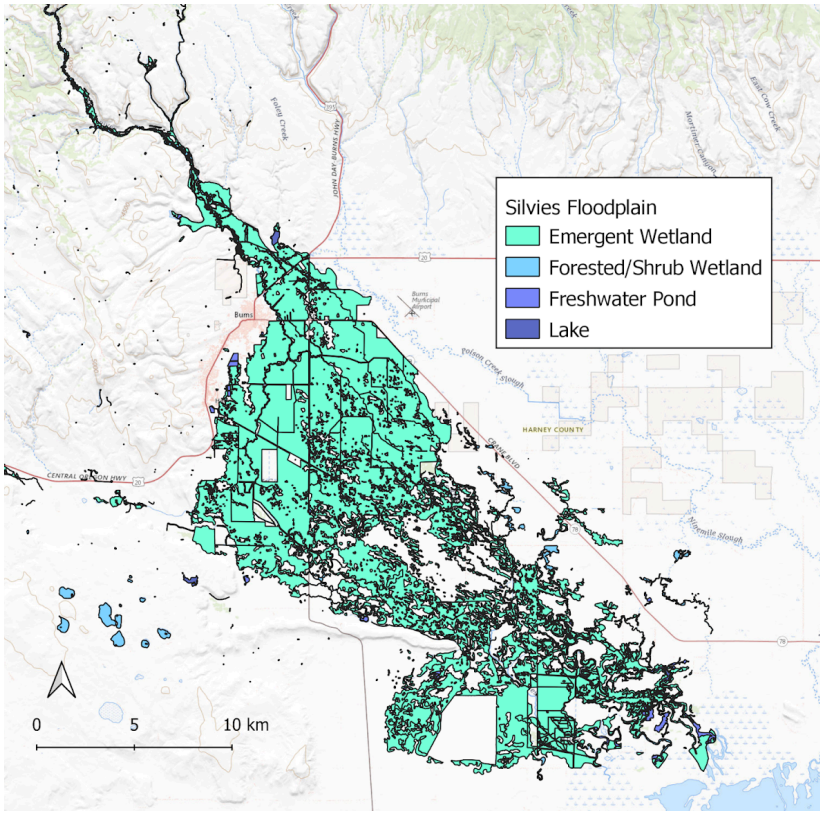
Focal bird species by habitat type.

SPECIES	HABITAT	TIME-OF-YEAR
Bobolink	Flood-irrigated wet meadow	Breeding
Greater Sandhill Crane	Flood-irrigated wet meadow	Migration
	Seasonal emergent marsh	Breeding
Redhead	Perennial mesic habitat	Breeding
Ruddy Duck	Perennial mesic habitat	Breeding
Sage Thrasher	Upland mesic habitat	Breeding
Snowy Plover	Playas	Migration and breeding
Willow Flycatcher	Woody riparian	Breeding
Yellow-headed Blackbird	Seasonal emergent marshes	Breeding
Yellow Warbler	Woody riparian	Breeding

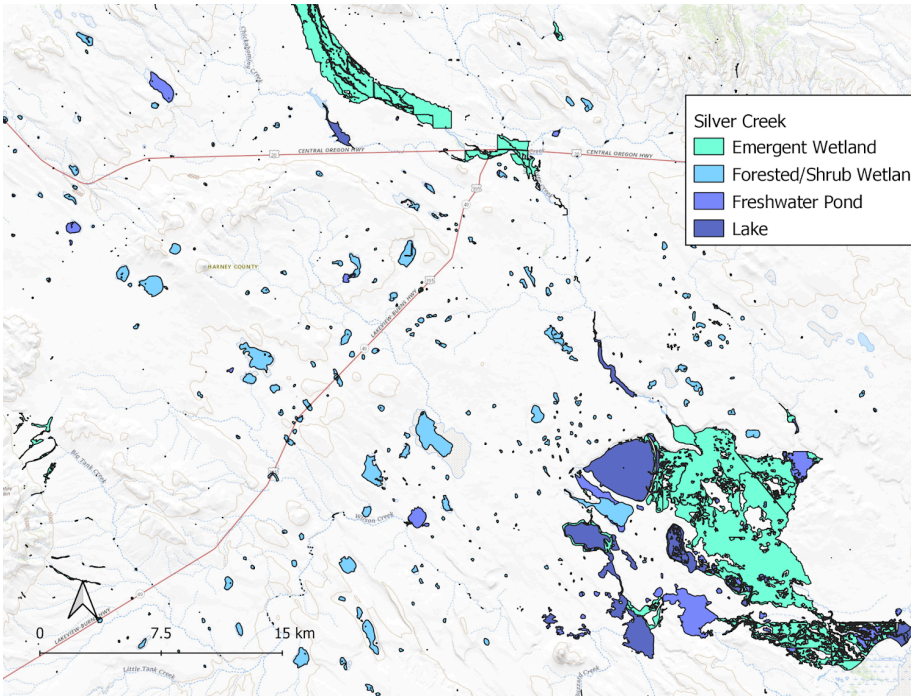
Appendix 2

Distribution of wetlands by subbasin (National Wetlands Inventory, 2020)

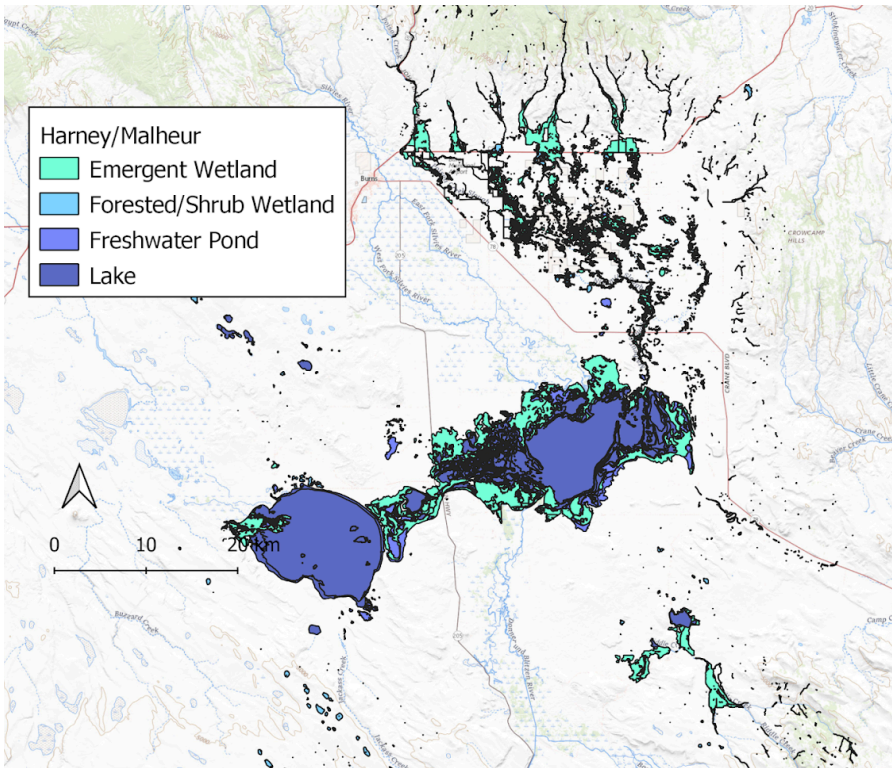
Silvies



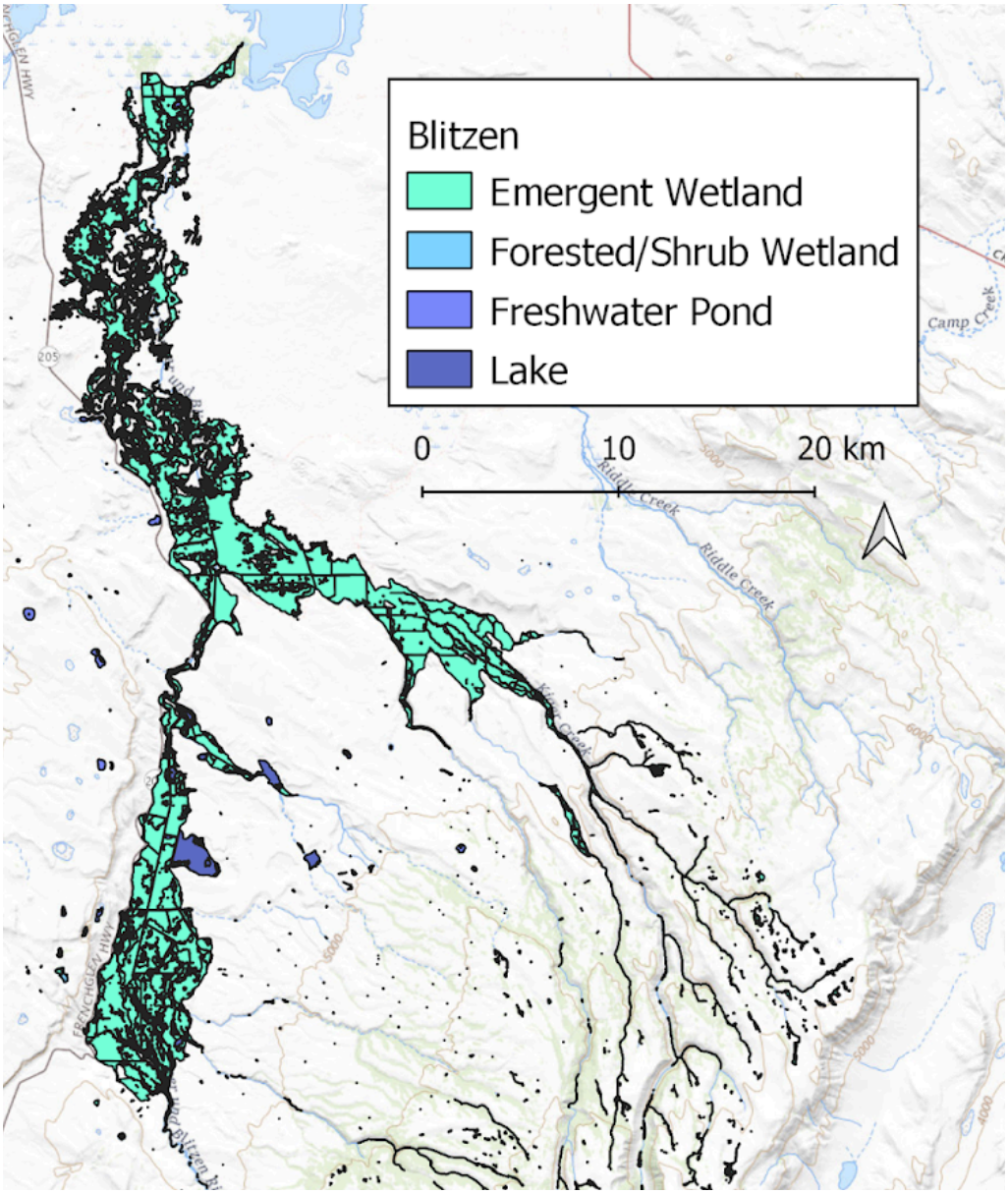
Silver Creek



Harney/Malheur



Blitzen


Blitzen
Emergent Wetland
Forested/Shrub Wetland
Freshwater Pond
Lake
0
10
20 km
Riddle Creek
Riddle Creek
Camp Creek