Wetlands and flood-irrigated wet meadows - Step 3

Introduction

Kingsford & Thomas (2004) found a 90% decline in waterbird abundance and a 21% decline in species diversity in wetlands in the Lowbidgee Floodplain (Australia), after the construction of dams and irrigation diversions from the Murrumbidgee River. The dams and diversions caused in-stream flows to decrease by more than 50%, greatly limiting the amount of wetlands available to waterbirds. Reduced in-stream flows have led to similar declines in waterbird populations in the Great Basin, as freshwater wetlands decline in size and saline wetlands increase in salinity (Haig et al., 2019).

Hydrologically, Harney Basin wetlands expand and contract with interannual variability in snow pack, temperatures and water availability (Lev et al., 2012). Understanding the water needs for wetlands and flood-irrigated wet meadows, particularly in the face of a changing climate, is important for understanding water and wildlife management in the present and in the future. Climate predictions include more precipitation falling as rain instead of snow, less reliable precipitation, and rising average temperatures (Nolan & Daly, 2006). Indeed, the loss of wetlands and lake area in the Great Basin, including the Harney Basin, from 1984 to 2018 highlights the importance of wetland conservation (Donnelly et al., 2019).

Changes in seasonal temperatures and precipitation, e.g. warmer winters or increased spring rain, can have an effect (positive or negative) on breeding bird success. For example, Barn and Tree Swallows initiate nests earlier in years with warmer, wetter winters while Bank Swallows do not. This may be associated with decreased nest success in Bank Swallows as the climate shifts (Imlay, Mills Flemming, Saldanha, Wheelwright, & Leonard, 2018). Water deficits associated with decreases in precipitation (and increased drought) pose a serious problem for waterfowl, waterbirds, and other bird species, including passerines (Roberts, Burnett, Tietz, & Veloz, 2019).

Methods for determining water needs in wetlands and flood-irrigated wet meadows

Haig et al. (2019) outline methods for measuring changes in temperature and precipitation, streamflow, climate seasonality, and avian distribution data from the Breeding Bird Survey. These methods did not provide information about baseline water needs for sustaining waterbird populations, rather they provided information on how water quantity and quality had changed and how waterbird populations changed with these changes. With IWJV's wetland mapping tool, called WET (Donnelly et al., 2023), Haig et al. (2019) provides a helpful framework for considering baseline water needs for birds that

use wetlands and riparian areas in the Harney Basin. Specific efforts for determining the water needs of wetlands include personal communications with water managers at Malheur National Wildlife Refuge, Harney County climate data, and GIS information about habitat size and distribution at Malheur National Wildlife Refuge. Information from MNWR may not be applicable across the entire Groundwater Study Area, but provides a baseline from which to estimate totals for private lands.

Ultimately, while baseline water quantities and qualities are ideal metrics for understanding present and future water needs, there is not sufficient data to describe these metrics. Therefore, we will use water needs for individual species to attempt to provide qualitative descriptions of present and future water needs.

Temperature and precipitation

Temperatures across the Great Basin have increased in the past century, with a doubling of the rate of increase in the past 40 years. Summer temperatures have increased the most rapidly (Haig et al., 2019). Conversely, precipitation in the Great Basin has mostly remained stable over the past century, with a declining trend emerging within the past 40 years (Haig et al., 2019).

According to MNWR staff, 12-15 inches of snow-water equivalent at the Fish Creek SNOTEL, on Steens Mountain, provides adequate runoff for an average irrigation season (personal comm.). Runoff timing and amounts, however, depend on temperatures on Steens Mountain. In a spring where temperatures warm early and rapidly, the water tends to come off the mountain more rapidly, making maintaining flood-irrigated wet meadows and impoundments more difficult than in years where snowmelt comes off more gradually, over time (personal comm.).

It can be hypothesized that the amount of riparian vegetation on the refuge, if maintained at the same quality and quantity found there today, would continue to be maintained through much of the Refuge, particularly along East Canal and from Diamond Swamp to Malheur Lake, with the same 12-15 inch snow/water equivalent. However, along the western part of the Refuge, where the canal is entrenched and riparian vegetation is missing or in poor condition, it will likely require more water to maintain what riparian vegetation exists. This is because entrenchment typically disconnects the water table from the riparian area. Predicted increases in temperature make it more likely that without efforts to restore connectivity between riparian areas and the canal, riparian vegetation won't persist in the long term, in areas where the streams/canals are entrenched.

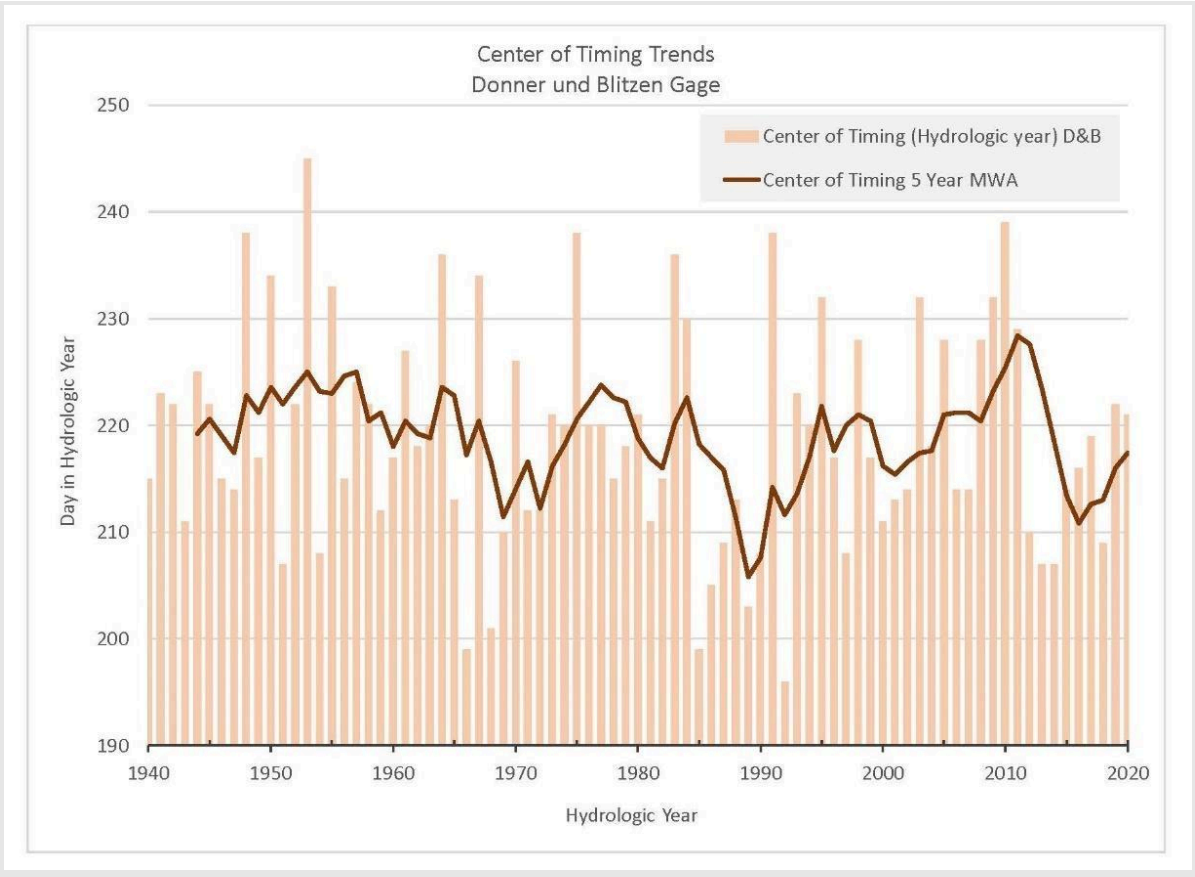
Entrenchment is caused by myriad factors. At Malheur cattle grazing, channelization, irrigation infrastructure, and removal of willow and other riparian vegetation contributed to the entrenchment of the Blitzen River (Mayer et al., 2007. In 2002, a 5-mile reach of the Blitzen was partially restored, reconnecting the river to its floodplain in much of that reach (Mayer et al., 2007). However, approximately 18-miles of the Blitzen River, from Bridge Creek to Stubblefield Canal remain entrenched and largely disconnected from the floodplain (Mayer et al., 2007).

Much of the Silvies River, particularly as it leaves the forest, runs through private property. The NRCS has worked with irrigators to do riparian restoration some parts of the Silvies Floodplain, though the full extent of riparian vegetation in the Silvies Watershed is largely unknown. Ultimately, without a better understanding of the quantity and quality of riparian vegetation on the landscape, it is difficult to understand the relationship between temperature, precipitation, and riparian areas particularly under future climate scenarios.

Climate seasonality and depth to water

As precipitation has shifted from snow to rain (with warming temperatures), streamflows have peaked earlier in the year, with earlier and more prominent declines in water availability (Haig et al. 2019). Additionally, earlier and more dramatic spring warming causes even normal snowpacks to melt at faster rates, creating a higher likelihood of flooding and erosion of streams, canals, and other irrigation infrastructure (Figure 1).

Figure 1. Center of timing of water by year in Donner und Blitzen River



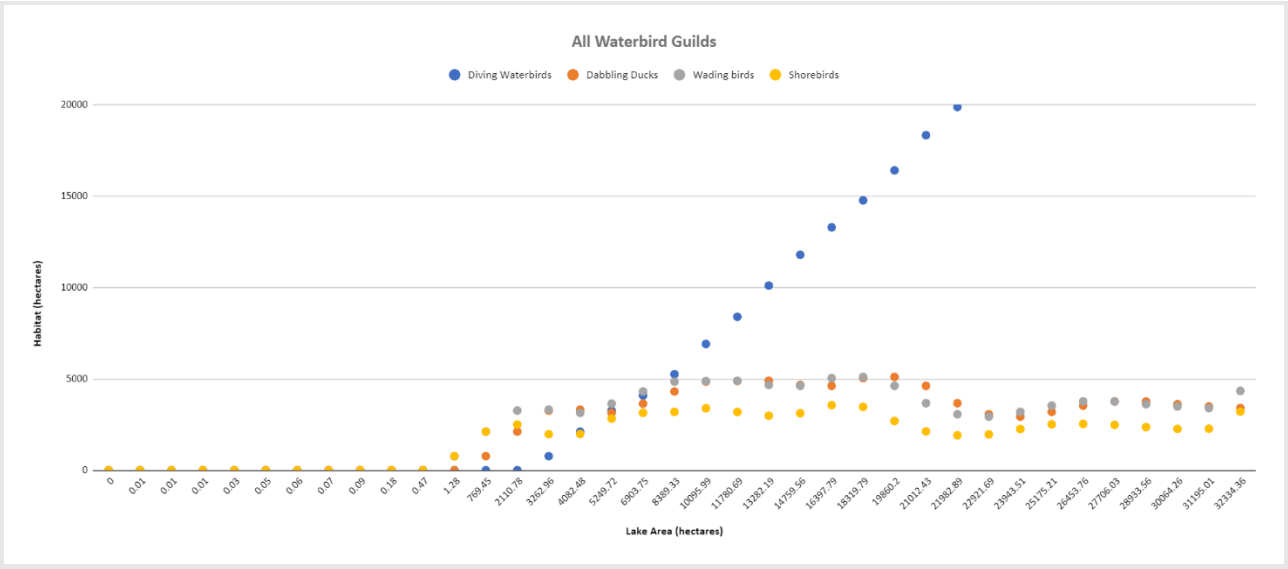
Climatic shifts in temperature and precipitation, including in the winter before migratory birds arrive on their breeding grounds, can influence phenology and nest productivity in bird species, e.g. swallows (Imlay, et al. 2018). This is, in part, because the timing of insect-hatch follows water and warming patterns, potentially causing insects to hatch before insectivorous birds arrive at their breeding grounds (Imlay, et al. 2018). Additionally, in dry ecoregions, such as the high desert of Eastern Oregon, bird species tend to be more negatively affected by an increasing climate water deficit (Roberts, et al. 2019).

Current climate models for Oregon Closed Basins show mean diurnal temperature shifts over the next 50 years of 0.25-0.75 Degrees C. This includes a predicted 50 year increase in minimum temperature in the coldest months of more than 2 degree C (Veloz & Kim, 2019). Warm season temperatures are predicted to increase by more than 3 degrees C. Precipitation is predicted to increase slightly in wet months and decrease slightly in dry months (Veloz & Kim, 2019).

Habitat area (acres) and water depth

In the San Joaquin Valley, CA Safran, et al. (1997) found that water depths for foraging shorebirds and waterfowl varied interspecifically, with sandpipers foraging in water < 5cm deep, dowitchers and avocets foraged in water 5-10 cm deep, Green-winged Teal foraged in water 10-15 cm deep, and other dabblers foraged at water depths > 20 cm. In the Sacramento Valley, winter shorebird abundance peaked at seasonally flooded meadows between 40 and 95 ha. Percent open water and percent emergent vegetation appeared to also influence bird use of seasonally flooded wetlands, with most waterbird species foraging in higher densities in flooded, unvegetated habitats (Isola, Colwell, Taft, & Safran, 2000).

Figure 2. All Waterbird Guild use of marshes by habitat availability and lake/marsh size.



Waterbird presence and density was also correlated to water depth in the Grassland Ecological Area of Merced, CA, though shorebird and some dabbling duck species presence and density did not (Colwell & Taft, 2000). Green-winged Teal and Northern Pintail appeared associated with shallower wetlands, while Gadwall appeared associated with deeper water, as did diving duck species (e.g. Ruddy Duck). Larger and more topographically diverse wetlands appeared to influence community composition (number of waterbird species). Lastly, the distribution of these habitats is particularly important for breeding birds. For example, Gadwall forage and raise ducklings in wetlands with abundant emergent vegetation but need adjacent upland shrubs and grassy areas for nesting. White-faced Ibis benefit from flood-irrigated wet meadows adjacent to intact semi-permanent marsh for foraging and nesting (respectively). Donnelly et al. (2022), found that over the past 40 years there has been a marked loss of functional wetlands, with the largest loss occurring as semi-permanent wetlands shift to temporary or seasonal wetlands.

Seasonal habitat needs and climate change

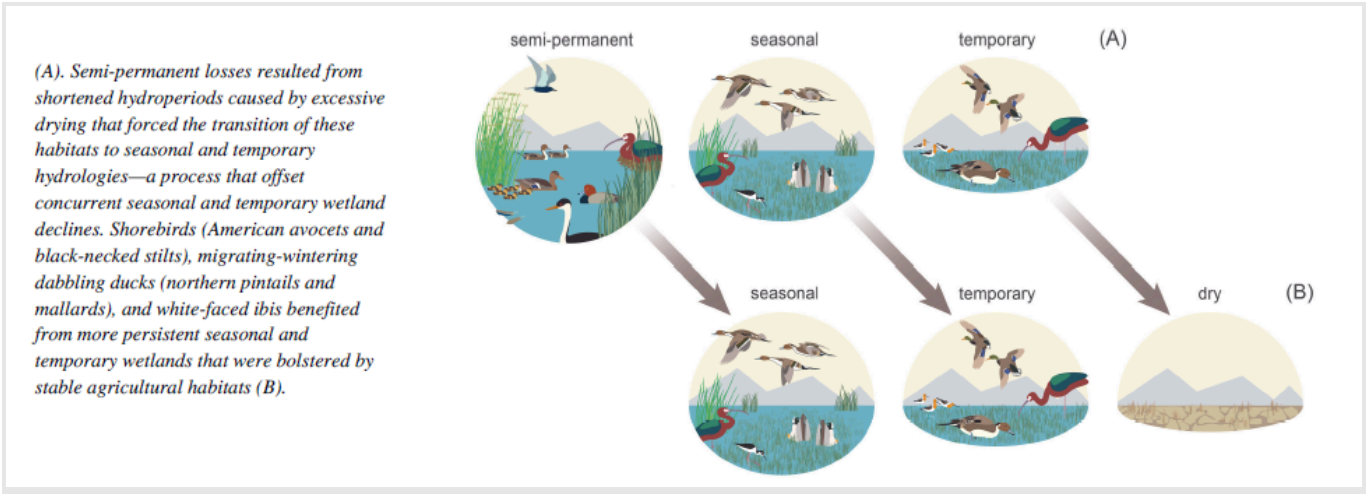
Many bird guilds and species depend on wetlands at some point in their life cycle. For these species, there are several important considerations: water depth, plant composition, salinity, and timing (seasonality). Because species needs vary considerably with life cycle stage, and between species, it can be difficult to categorize the amount of water necessary to support the diversity of guilds and species that use wetlands throughout their life cycle. In this section, we will describe what we know about species water needs depending on time of year. We will also attempt to forecast the effects of climate change based on current climate change data.

Wetlands cover approximately 153,000 acres of the Harney Basin. These wetlands support migrating and breeding populations of waterfowl, waterbirds, shorebirds, passerines, and various grebe and rail species. The diversity of wetland types, and species using them, necessitates the quantification and preservation of the suite of wetland types. In order to sustain wetlands in the Blitzen Valley at MNWR 12-15" snow/water equivalent is necessary at the Silvies SNOTEL station, located on Steens Mountain at 6990 feet elevation, (personal comm. with irrigation manager at MNWR). In an optimal year, approximately 363,300 acre feet of water is permitted to flood-irrigate approximately 121,100 acres (in the Silver Creek, Silvies, and Blitzen drainages) of flood-irrigated wet meadows, 73,900 acres private and 47,200 at MNWR. This is not an accurate number for minimums, nor for understanding breeding season water needs, but it does provide good information about optimal year water use for spring irrigation.

In creating a water budget for the Blitzen Valley at MNWR, Mayer, et al. (2007) found a range of 1.3 to 1.7 acre ft/acre of consumptive use of water for the irrigation season. The largest amount of water for irrigation is used in May and June, primarily for irrigating the 29,500 acres of wet meadows and fields, though water is moved to 6,500 acres of open water impoundments and other wetland types as part of flood-irrigating or in wet years (Mayer, et al., 2007). One important note is that the amount of water diverted to irrigate the 36,000 acres of wet meadow, wetland, and open water in the Blitzen Valley may be higher than 1.3-1.7 acre ft/acre as some water that is diverted isn't used consumptively (Mayer, et al., 2007). If these numbers hold across the Harney Basin, we can estimate that during spring irrigation season we need 198,900 – 260,100 acre ft of water to maintain flood-irrigated wet meadows and temporary, seasonal, and semi-permanent wetlands and impoundments across the Harney Basin.

The combined effects of climate change and agricultural uses are likely to continue diminishing wetlands and lakes in the Harney Basin (Donnelly et al., 2019). From 1984-2018, lake area in the Harney Basin declines by 59%, wetland area declined by 56%, and peripheral wetlands (those wetlands fed by groundwater or that are located adjacent to larger lake/wetland systems) declines by 81% (Donnelly et al., 2019). Donnelly, et al. (2019) identified irrigated agriculture and increasing evaporative demands as the main drivers of wetland and lake loss in the Great Basin, including in the Harney Basin. Layered in this wetland loss, however, is the large-scale ecological conversion of semi-permanent wetlands to seasonal wetlands, of seasonal wetlands to temporary wetlands, and the drying of historically temporary wetlands (Donnelly et al., 2022).

Figure 3. Functional wetland declines disproportionately affect waterbirds associated with semi-permanent wetlands



(A). Semi-permanent losses resulted from shortened hydroperiods caused by excessive drying that forced the transition of these habitats to seasonal and temporary hydrologies—a process that offset concurrent seasonal and temporary wetland declines. Shorebirds (American avocets and black-necked stilts), migrating-wintering dabbling ducks (northern pintails and mallards), and white-faced ibis benefited from more persistent seasonal and temporary wetlands that were bolstered by stable agricultural habitats (B).

Spring migration

Spring migration brings an inundation of waterfowl, shorebirds, and passerines through the Harney Basin. Many waterfowl and shorebird species use the Harney Basin as a staging area before they continue their journey north to their breeding grounds. This includes thousands of Snow and Ross's Geese in the flood-irrigated wet meadows of the Silvies floodplain and hundreds of plovers, dunlin, and other shorebird species. The Intermountain West Joint Venture (IWJV) has shown that there is a connection between forage quality in the SONEC (including the Harney Basin) and breeding success in Northern Pintail (Intermountain West Joint Venture, 2013). IWJV estimated that 100% of forage needs of dabbling ducks migrating through the Malheur Subregion in the spring can be met by 7,000 acres of private flood-irrigated wet meadows. There are an estimated 15,300 acres of private flood-irrigated wet meadows in the Malheur Subregion, indicating that more than 100% of energy needs are being met (Fig. 4) for the duration of spring migration (IWJV, 2013).

Figure 4. IWJV estimates that more than 100% of energy needs for spring migrating dabbling ducks are met on private lands in the Harney Basin.

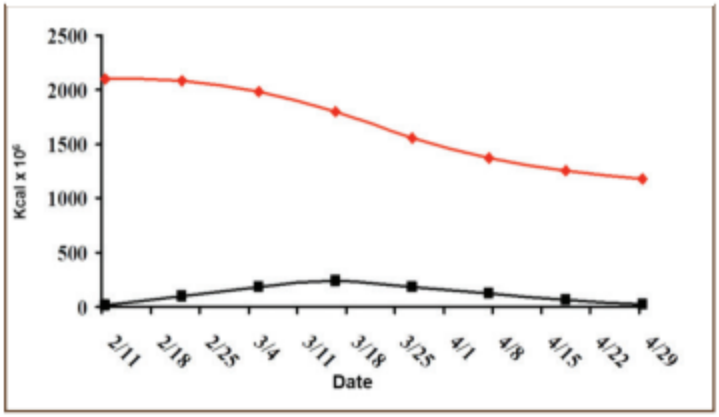


Figure 18 Food energy (red) provided by flood-irrigated habitats vs. dabbling duck energy demand (black) during spring in the Malheur subregion of SONEC.

Approximately 60-70% of wetlands flooded in the spring are on private land (Donnelly et al., 2019b). Though the abundance of public flooded wetlands is less than private lands, timing of wetland flooding is more reliable on public lands (Donnelly et al., 2019b).

Spring runoff and flood irrigation are highly dependent on melting winter snowpack. As precipitation shifts from predominantly snow to rain, water availability peaks and declines earlier (Haig et al., 2019). Thus, spring migrants, such as the thousands of Snow and Ross's Geese that stopover in the Harney Basin, may find more variable conditions in the wetlands and flood-irrigated wet meadows of the Harney Basin. Currently, there is little information available about quantities of water required to maintain spring wet meadow habitat for geese, shorebirds, and other waterbirds. Suffice it to say, if water from snowpack and winter rains peaks earlier in the spring it may reduce the amount of early spring aquatic invertebrates available for migrating birds, largely through flooding. Conversely, it is possible that longer durations of flooding could result in larger invertebrate populations, though peak

depth of flooding would potentially negatively impact accessibility of prey for many shorebird and waterbird species.

Ultimately, this could result in a mis-timing of food supply that could have impacts on breeding success for spring migrants, once they arrive on their breeding grounds. Additionally, if there is less winter precipitation, or more water diverted for storage projects, this could reduce the amount of spring forage available for migratory birds. For example, in the Sacramento Valley peak shorebird habitat is often available after the peak of shorebird migration (May and April, respectively), creating a mis-timing of critical habitat (Schaffer-Smith et al., 2018). It is important to understand not only what percentage of time inundation occurs in Harney Basin wetlands, but how often optimal habitat is created for migrating birds (other than dabbling ducks), including the duration of optimal habitat and how this correlates with migratory bird peak numbers in the Harney Basin.

Understanding relationships between bird use of wet meadows, water timing, depth, etc is important for understanding how climate change and future water availability will affect spring migrants.

Playas, wetlands, and mudflats are important for spring migrating shorebirds, in particular Black-bellied Plover and Marbled Godwit. In 2019, a slightly above average snowpack, combined with a rush of spring snowmelt associated with rapidly warming temperatures early in the spring and spring rains, Malheur Lake had no mudflat available for shorebirds. Migrating shorebirds instead depended on shallow waters in the lake margins and other wetlands and wet meadows for stopover habitat. Unfortunately, shorebird migration in the Harney Basin, including important stopover areas, isn't well-understood (Robinson & Warnock, 2019). Because playa habitats and mudflats are generally not managed (for) it is difficult to understand how much water (surface and groundwater) is required to maintain this habitat type today, and how much water will be required into the future. Suffice it to say, this is another area that requires more data to fully understand.

Breeding birds

As with spring migrants, water availability and seasonality, are related to nest success in breeding birds. As temperatures warm earlier and water levels decline earlier, some breeding bird species may experience population changes. For example, Bank Swallows (*Riparia riparia*) appear to be declining throughout their range. It is hypothesized that this is associated with a mis-timing in insect availability associated with changes in temperatures and precipitation, i.e. insects are hatching earlier in

the spring, reducing food availability later in the nesting season (Imlay, Mills Flemming, Saldanha, Wheelwright, & Leonard, 2018). Conversely, Tree Swallows (*Tachycineta bicolor*) have shifted their phenology, arriving on breeding grounds earlier. Because of this, their reproductive success appears less affected by changing climate and precipitation. Both of these swallow species breed in riparian areas and wetlands. While there aren't direct correlations between habitat requirements of these swallow species and other wetland nesting birds, climate models show that changes in hydrology are likely to cause declines/range shifts in other passerines and grassland birds that breed in the Harney Basin, e.g. Bobolinks (*Dolichonyx oryzivorus)* and Sandhill Cranes (*Antigone canadensis*), respectively (Audubon, 2019).

This mis-timing, or hydroperiod shift, is also predicted to impact breeding waterbirds. Donnelly, et al. (2022) found that while many lakes and wetlands physically exist on the landscape still, they are functionally disappearing. Many lakes and wetlands are drying up sooner and more often than in documented history. These shifts in hydroperiod will increasingly result in colony abandonment by colonial nesting waterbirds, such as White-faced Ibis, and nest failure or reduced recruitment in species such as Greater Sandhill Cranes (Ivey, 2008; Gerber, et al., 2015). Additionally, saline-lake dependent breeding birds, for example interior populations of Western Snowy Plover, may be faced with decreasing prey availability as shrinking lakes increase salinity and cause declines in brine shrimp and brine flies (Haig, et al. 2019; Donnelly, et al. 2022). Brine fly and shrimp populations at Malheur NWR are currently largest at Stinking Lake, though Harney Lake has had water for a prolonged period in 2023 which could create good conditions for brine shrimp and brine fly populations at Harney Lake. In years where Harney Lake is largely dry, there are small populations of brine flies at the springs on the eastern side of Harney Lake.

There are no current estimates of riparian habitat in the Harney Basin. Because of this, it is difficult to estimate how much water is needed to maintain this habitat type on the landscape. The potential implications for Harney Basin bird communities are unknown, but a large percentage of breeding passerine bird species in the basin depend on woody riparian habitat for the breeding season. Willow-dominated woody riparian areas are maintained through adequate connectivity to streams and subsurface flow (i.e. groundwater), both for sustaining existing willow communities and for expanding communities (Dwire, et al., 2017). As smooth brome (an invasive dryland grass) becomes more common in the Harney Basin, there is some possibility that smooth brome could move into herbaceous riparian areas if the riparian areas are disconnected from streamflow and groundwater. In addition to an

unknown quantity of riparian habitat in the Harney Basin, the condition/quality of this habitat is largely unknown.

It can be assumed that intact stream channels that have stream connectivity with the riparian areas and floodplain are important for predicting quality riparian habitat. While quality is a less precise description than area we know that for Willow Flycatchers, for example, quality riparian habitat has a high density of willows, with some openings. Willow Flycatchers are Harney Basin focal species and a riparian bird with declining populations that are predicted to shrink to a small remnant population with climate change. In areas where connectivity between rivers or streams and their riparian areas is intermittent and only early in the spring, riparian habitat tends to shift to shrub species more tolerant of drier conditions (Dwire, Mellmann-Brown, and Gurrieri, 2017). At lower elevations, this would likely change willow-dominated riparian areas to areas of sparse and/or low growing Wood's rose, golden currant, and other trees and shrubs that do not provide habitat for Willow Flycatchers (Sedgwick, 2020). Indeed, in the Southwest as desert riparian areas lose connectivity to groundwater and/or streamflow Merritt and Bateman (2012) predict changes in riparian species composition and a reduction in bird diversity and richness. Quality riparian bird habitat in their study was highly associated with tree cover, including *Salix gooddingii*, which we don't have in the Harney Basin, though we do have native willow species that grow in a similar form.

Unfortunately, there are few if any data available about current water regimes and reproductive success for breeding birds in the Harney Basin. Because of this, it isn't clear that current water regimes are providing sufficient quality habitat to maintain existing breeding bird populations. Some species that depend on wetlands in the Harney Basin currently are declining in numbers, and several are predicted to experience moderate to extreme population declines under future climate scenarios, this includes many riparian and grassland dependent bird species, including willow flycatcher and western meadowlark, respectively (Veloz & Kim, 2019). While the correlation between modeled changes in precipitation, temperature, and bird populations don't show the pathway by which climate change will negatively affect grassland, riparian, and wetland bird populations, it is likely these changes are associated with changes in water availability and hydroperiod.

It seems important to note that while Sagebrush Steppe is not an aquatic ecosystem, species that depend on sagebrush steppe are predicted to be particularly affected by climate change. Not all models agree on individual species response to climate change (e.g. Loggerhead Shrike are predicted to decline by Veloz and Kim (2019) and to remain stable by Aububon (2019)). However, this may be

related to the already low numbers of some species. A species that are already below 1 on an abundance index, e.g. Loggerhead Shrike, (Veloz & Kim 2019) would likely appear stable into the future because they are already uncommon.

Fall migration and staging

Fall migration differs from spring migration in that populations of migrating birds tend to be larger, in part because of the number of offspring that were produced (and survived to adulthood) in a given year. Fall migration is a relatively under-studied phenomenon, particularly compared with spring migration. Shorebird and waterfowl diversity during fall migration tends to vary greatly from spring migration, with no to few Ross's or Snow Geese and Lesser Sandhill Cranes migrating through the Harney Basin in the fall.

Currently, efforts to remove water from flood-irrigated wet meadows, in order to dry out vegetation for haying, starts in May or June (depending on the year). This correlates to declining water availability in-stream. As wetland availability declines, the importance of upland playas, saline and freshwater lakes, springs, and other semi-permanent and permanent wetlands increases. As temperatures and precipitation in the driest and warmest quarters of the year decrease, waterbird community composition becomes less diverse, shifting toward upland dependent waterbird species, e.g. Black-necked Stilt, Long-billed Curlew, etc. (Haig, et al., 2019).

Because wetland availability is typically lower in the fall than in spring, predictability of wetland availability is important. In the spring, flooded wetlands on private lands outnumber those flooded on public lands. In the fall, the number of acres of flood wetlands on private lands is roughly equal to the number on public lands. However, timing of flooding is more reliable (i.e. water is more predictably available during peak migration) in wetlands on public lands (Donnelly et al., 2019b). In Kansas, there were no relationships between marshbirds and fall migration habitat use at the landscape level (Wilson, Jensen, & Schultheis, 2018). At the microhabitat level, Sora were more associated with areas with greater water cover and depth, and marshbirds in general showed association with denser vegetation and more water. Thus, most fields that are flooded in spring and hayed in summer will provide good habitat for spring migrants and breeding birds but will be less likely to provide good habitat for fall migrating marshbirds.

References

Donnelly, Patrick. Wetland Evaluation Tool (WET). Intermountain West Joint Venture. Available at: https://iwjv.org/solution-based-science/wet/ (accessed July 19, 2023).