STRATEGIC ACTION PLAN

Harney Basin Wetlands Collaborative

Harney Basin Wetlands Collaborative, a working group of High Desert Partnership, utilizes collaboration to integrate social, economic and ecological values to support wetlands, streams, flood-irrigated meadows, emergent marshes and other wetland types of the Harney Basin.

HARNEY BASIN Wetlands COLLABORATIVE

HIGH DESERT Partnership

October 2023

PHOTOS BY BRANDON MCMULLEN

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1. Executive Summary

The Harney Basin Wetlands Collaborative (HBWC) was formed in 2011, as a collaborative effort to improve the aquatic health and sustainability of Malheur Lake, and the wild flood-irrigated wet meadows across the Harney Basin. Since 2011 the collaborative has expanded their vision and now is working to integrate social, economic and ecological values to support wetlands, streams, flood-irrigated meadows, emergent marshes and other wetland types of the Harney Basin. These ecosystems support abundant bird and wildlife populations and the thriving agricultural economy capable of meeting ecological, community, and economic needs of this critical stop on the Pacific Flyway. HBWC is working to restore and enhance healthy lands and water while nurturing a rural way of life that supports and values wetland conservation in the Harney Basin.

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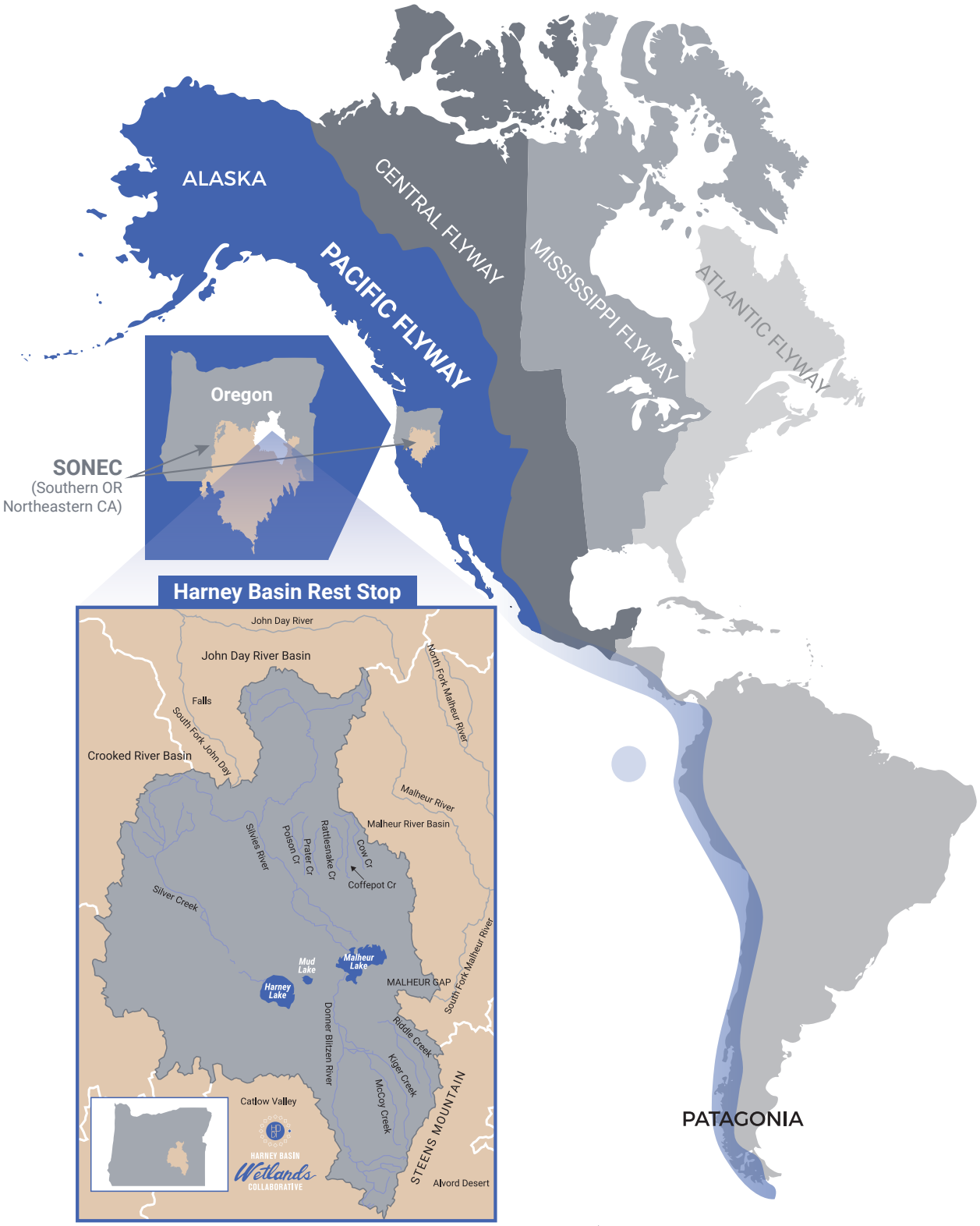
ECOLOGICAL PRIORITIES: GREAT WONDER OF THE WEST

Every year, millions of birds on the Pacific Flyway use the Harney Basin as a rest stop on their spring and fall migratory journeys.An estimated 70 percent of migratory birds—including over 6 million waterbirds—annually pass through the Southern Oregon Northeast California (SONEC) region, which includes the Harney Basin wetlands. Considered one of the most significant flyways in North America, birds come to rest and refuel, using both land and water in all parts of the basin, with large concentrations converging on the Malheur National Wildlife Refuge (MNWR) which encompasses Malheur Lake within its boundaries. Outside of the MNWR private flood-irrigated wet meadow ranch lands provide critical habitat for this important bird migration. Traditional flood irrigation practices that spread shallow water across the Harney Basin's hay meadows every spring create conditions that mimic historical flood regimes that support migrating and breeding birds. These private working lands are one of the cornerstones of Harney County, supporting families and feeding the local economy. In the central part of the Pacific Flyway, which includes the Harney Basin, private land comprises 75% of the wetland habitat. Beyond the importance of the wetlands for migratory birds, the wetlands of the Harney Basin support significant resident populations of waterbirds and other bird species.

The United States is split up into four flyways that run north and south. They are the Pacific, Central, Mississippi and Atlantic flyways. The Pacific Flyway stretches from the Arctic to the coast of Mexico and from the Rocky Mountains to the Pacific Ocean. From north to south it is more than 4,000 miles long, and in some places, it is more than 1,000 miles wide. About 70 percent of migratory birds—including over 6 million waterbirds—annually pass through the Southern Oregon Northeast California (SONEC) region of the flyway, which includes the Harney Basin wetlands where large concentrations of birds rest and refuel along the way.



CONSERVATION CONTEXT: BUT THE BASIN IS UNDER STRESS

The Harney Basin is dominated by public lands in the uplands with National Forest lands in the headwaters of Silvies River, Silver Creek, and smaller streams draining the Northeastern side of the basin and Bureau of Land Management ownership dominating the lower elevations of the Silver Creek drainage and the Donner und Blitzen drainage. MNWR encompasses some 187,000 acres that includes Malheur and Harney Lakes and surrounding wetlands of the lower Blitzen River. Private lands are located in the Harney Valley between the foothills and the lakes and in relatively flat areas along most of the streams. The flood-irrigated wet meadows of the Harney Basin are a vital economic component to the Harney County ranching community (18.37% County employment).

Major threat factors in the Harney Basin include:

- Invasive common carp (Cyprinus carpio) in Malheur Lake and tributary streams that disrupt wetland vegetation (both submerged and emergent) establishment.
- Invasive grass species such as reed canary grass (Phalaris arundinacea) that are expanding in flood irrigated wet meadows critical for migratory bird resting and feeding.
- Massive turbidity in Malheur Lake prevents light penetration to allow emergent and submergent plant growth.
- Climate change affecting stream runoff timing, duration and amount available for flood irrigation and lake levels.
- Legacy stream alterations from historic water management structures that include diversion structures, canals, straightened channels, riparian vegetation clearing, etc. all which alter the distribution of floodwaters and bird habitat.

VISION AND STRATEGIES: YET THERE IS HOPE

For the first time in nearly four decades Malheur Lake has a significant area of emergent vegetation. Vast areas of bulrush (Schoenoplectus acutus), cattail (Typha latifolia) and some burreed (Sparganium sp.) are now abundant in the wetlands of Malheur Lake. Results of unique climatic conditions and trial restoration efforts, the wetlands of the Harney valley are rebuilding habitat for breeding birds.

HBWC is focused on improving aquatic health for Harney and Malheur Lakes wetlands and the streams and rivers that flow into them. Across the west, historic and current water policies have divided communities, and in certain watersheds, made it near impossible to address complex water centered resources challenges. In addition to HBWC work there is also an unified Harney Basin community partnership (Harney County Community-based Water Planning) working to address the impacts of climate change and over allocation of ground and surface water rights for all water users. With increased community engagement, the understanding of the ecological science of both the Malheur Lake and flood-irrigated wetlands has increased significantly over the last few years. The impacts of varying water regimes on wetland and flood-irrigated wet meadow plant communities will be mitigated by developing and implementing on the ground restoration projects such as riverine habitat restoration, fish screens, support for flood irrigation of wet meadows on private lands critical to migratory birds, and removal of invasive species that are critical to being able to respond to changing conditions of water availability. Continued development of shared science and monitoring necessary to support this unprecedented effort. Community outreach and engagement that supports both the restoration effort and promotes local economic development (e.g. Harney Basis Migratory Bird Festival, volunteer restoration events, local programming, etc.) and ongoing support of the collaborative work.

2. Introduction

BACKGROUND/ ORIGIN

The Harney Basin wetlands are a significant part of the Closed Lakes Basin wetlands of Oregon. The wetland complex in the Harney Valley is dependent on the contributions from tributary watersheds. Many of the wetlands critical for bird migration in the spring are flood-irrigated wet meadows also used for grass hay production. Differences between the tributary watersheds influence the character and conditions of the wetlands in the Harney Basin (see Figure 1). The focus of the proposed work will be in the Silvies River wetlands, Silver Creek Wetlands, and Donner und Blitzen River wetlands with less emphasis on the northeast side tributary wetlands. At the present time the wetlands in Bear Valley and Silvies Valley are not being evaluated.

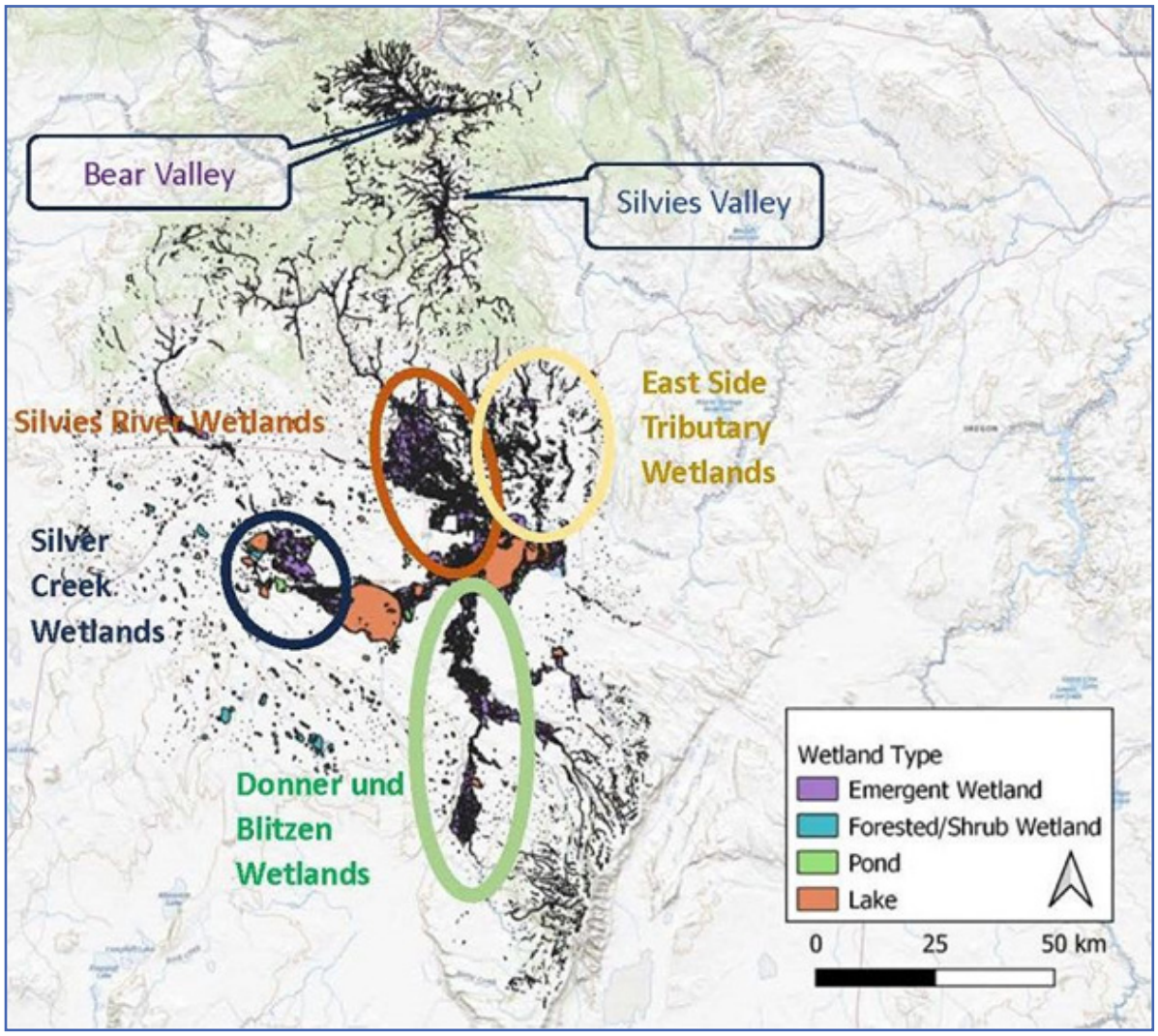


Figure 1: Wetlands of the Harney Basin showing focal areas for restoration. At the present time the wetlands in Bear Valley and Silvies Valley are not being evaluated.

The focus for restoration is different in each tributary system based on the unique hydrology and water resource conditions for each area.

PROCESS TO CREATE THIS STRATEGIC ACTION PLAN

This plan updates the 2015-2021 Strategic Action Plan for HBWC in the summer of 2023 to include information learned from wetlands studies and to align with new guidance provided by Oregon Watershed Enhancement Board (OWEB). HBWC partners have been dedicated to addressing the complex problems of the Harney Basin lakes and wetlands, a Closed Lakes Basin, since the completion of the MNWR Comprehensive Conservation Plan in 2013 (MNWR, 2013). It is rare for a group of diverse interested partners to work together on a document of this scope, but many partners have been involved in the development of this plan and have come to consensus on what is contained in the following document. High Desert Partnership took on the compilation role of the different partners' contributions to this plan.

Since the 2015-2021 SAP, the HBWC partners were awarded in 2016, Oregon Watershed Enhancement Board's (OWEB) Focused Investment Partnership (FIP) funding to support proposed conservation actions of HBWC as outlined in the 2015-2021 HBWC strategic action plan. This funding has been instrumental in considerably expanding the collaborative's understanding of the complex aquatic and wetland systems in the Harney Basin lakes and wetlands.

Some of the significant accomplishments include:

- OWEB awarded $6,347,524 in funding that leveraged $2,198,891 in matching funds for HBWC.
- Increased knowledge and understanding of the distribution and behavior of invasive carp and strategies to manage them to restore the wetlands of Malheur Lake.
- Developed a shared-science systems approach model to understand unique interactions in this important closed basin lake ecosystem that offers the collaborative a way to prioritize projects to implement and where resources can best be utilized.
- Improved the understanding of water table and plant community dynamics in flood-irrigated wet meadows with new tools for land managers to adapt to changing climatic conditions.
- Completed new irrigation infrastructures to enhance and increase best management of flood-irrigated wet meadows to promote both wildlife and agriculture.
- Built community in Harney County by engaging landowners, community groups, and partners to increase interest in and support for local conservation and a new stewardship economy that includes a youth internship program with several HBWC partners.
- Coordinated monitoring approach among multiple partners to measure progress and quantify outcomes.

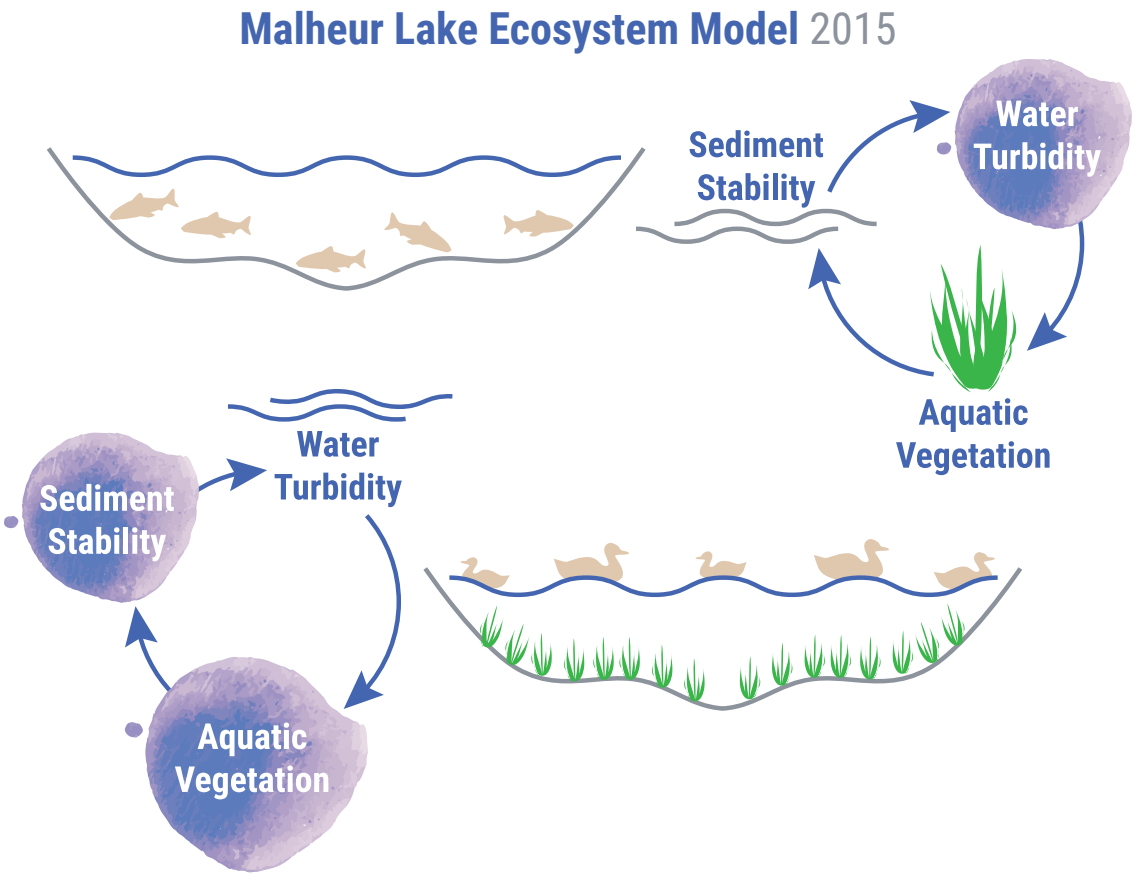
PURPOSE OF THE PLAN

The original 2015 strategic action plan for HBWC was built around the concept that Malheur Lake degraded conditions were controlled by invasive carp populations and the assumption that conservation easements were necessary to protect flood irrigated wet meadows. The updated action plan takes what has been learned about these systems and broadens the understanding of factors that affect restoration opportunities.The restoration and adaptive learning over the last decade has helped point the way for new strategies for wetland restoration in both the wetlands of Malheur Lake and flood irrigated meadows.

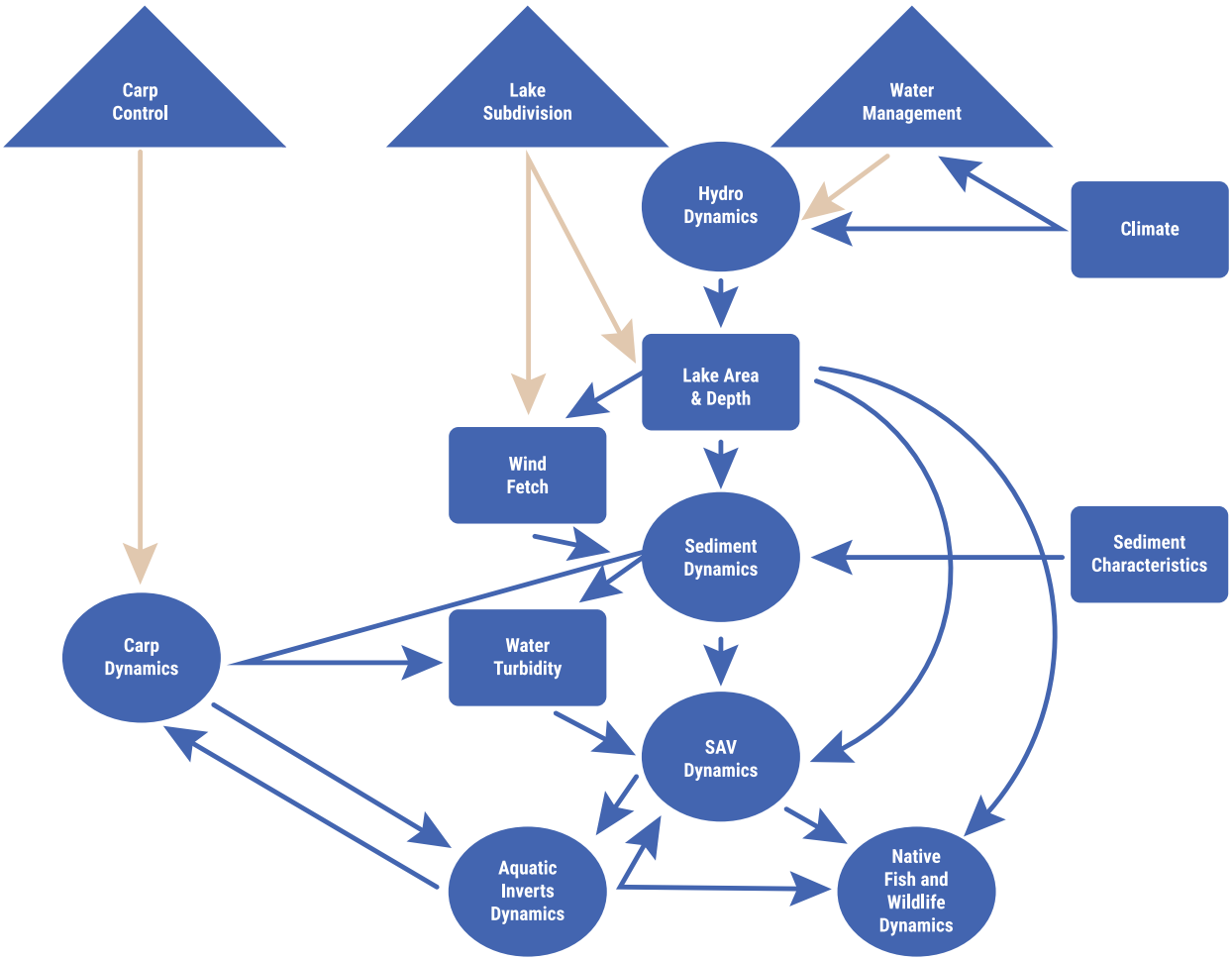
The work from the previous FIP has increased the HBWC's awareness and concern over climate driven increases in the variability of water delivery to the valley bottom floodplains and wetlands. It has also been recognized that the management of water resources is central to the maintenance and restoration opportunities for wetlands throughout the basin.

MALHEUR LAKE AND BLITZEN VALLEY WETLANDS

The in-depth study of invasive carp populations in Malheur Lake has demonstrated that the control of carp as a sole means of lake restoration is unlikely to be effective. To achieve lake restoration, more effective carp control measures must be employed, and additional complementary restoration strategies need to be explored. HBWC is utilizing a more complex systems model of Malheur Lake to better understand mechanisms beyond carp that are contributing to the current condition of the lake, undermining assumptions of the initial HBWC strategic action plan. As our understanding of the factors affecting the ecological conditions of Malheur Lake wetlands improves, a more complex set of relationships have been identified.



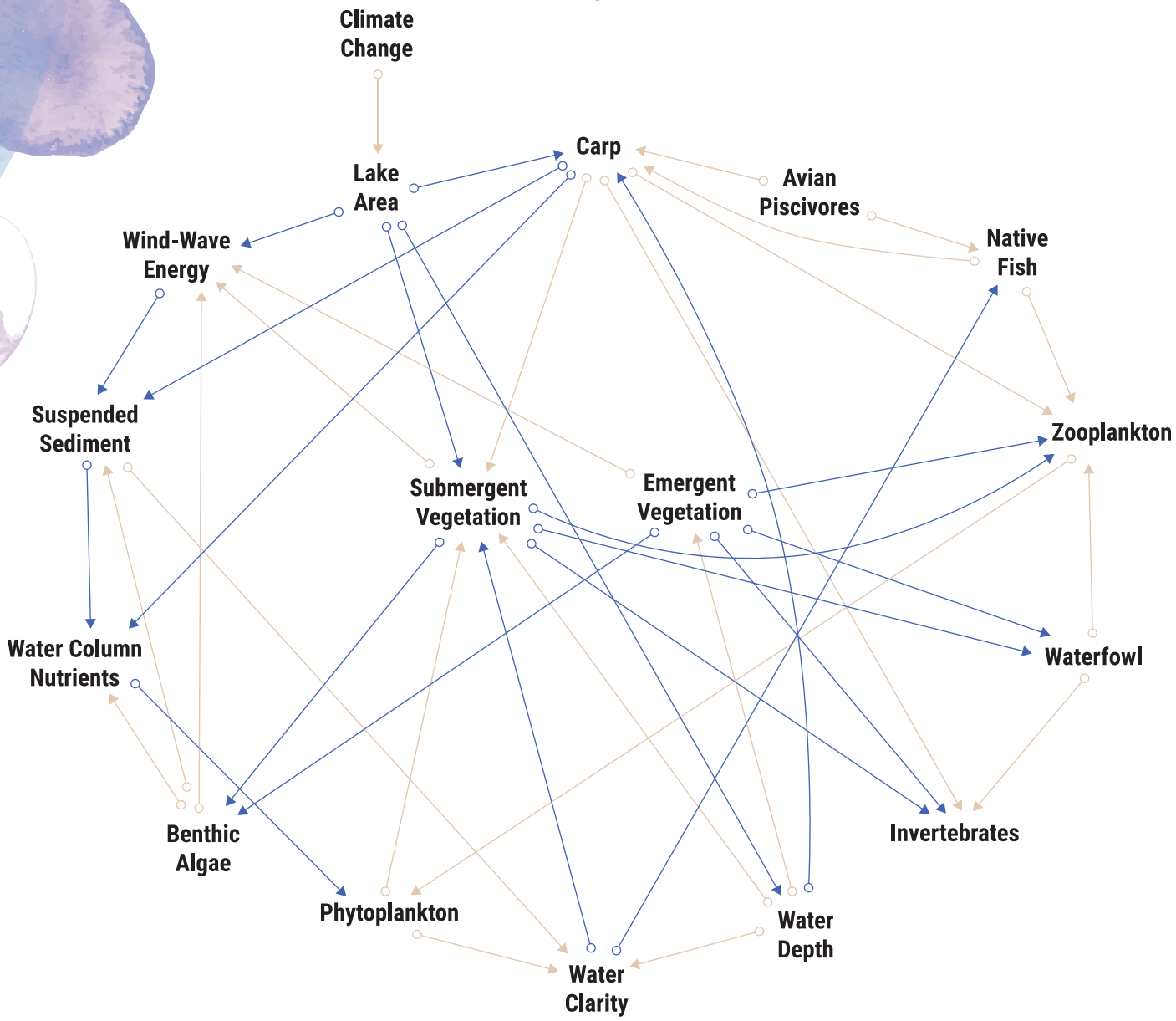
Malheur Lake Ecosystem Model 2018



The more complex systems model of Malheur Lake results from targeted research to identify opportunities to improve lake conditions. The results have helped to build a better understanding of wind-wave resuspension of sediment, river delivery of sediment, emergent vegetation limitations, phytoplankton growth, and the significant roles these factors play in maintaining the turbid state of Malheur Lake. These interdependent process-level relationships were unexplored when the MNWR Comprehensive Conservation Plan (USFWS, 2013) and the HBWC strategic action plan (HDP, 2015) were developed.

The current Action Plan expands the scope of actions to look at the management of Malheur Lake wetlands in conjunction with the Donner und Blitzen wetland system. The channelization of the lower Blitzen River and subsequent downcutting of the stream has distributed sediment to Malheur Lake and isolated the lower river from its floodplain. The distribution of senior water rights to the Donner Und Blitzen River (hereinafter, Blitzen River) that feeds Malheur Lake wetlands are located on MNWR, which will provide some assurance that water will be provided to the Blitzen floodplain and Malheur Lake wetlands to support enhancement and restoration efforts.

Malheur Lake Ecosystem Model 2020



The Action Plan recognizes that the way in which water is managed for the MNWR affects both the flood-irrigated wetlands, ponds and Malheur Lake wetlands. The Action Plan also recognizes the effect of Silvies River management on Malheur Lake wetlands but recognizes that under current circumstances it has less effect on Malheur Lake.

HARNEY VALLEY FLOOD-IRRIGATED WETLANDS

The majority of the wetlands in the Harney Valley are maintained by spring freshet runoff from the Silvies River. Over the last nearly century and a half the floodplain of the Silvies River has been modified to spread water for flood irrigation. These flood-irrigated wet meadows have become a critical stop over area for migratory birds of the Pacific Flyway. Recognition that interplays between hydrology and water management drive the abundance and distribution of wet meadow and other wetland habitats in the Harney Basin has led to HBWC's interest in engaging with the community effort to develop a place-based water resource plan for the

Harney Basin. As recently as the later 1970s and early 1980s the meadows were a mix of native rushes, sedges, and grasses. By the 1990s the introduced species meadow foxtail (Alopercurus pratensis) was common on a wide swath of the Harney Basin. Within the last 20 years, reed canarygrass (Phalaris arundinacea) has come to dominate large areas where canopy cover can exceed 90 percent of the plant composition. These changes in plant composition are at the expense of native plant species, and in the case of reed canarygrass expansion and dominance they may also result in a reduction in quality of habitat for wildlife species (Christy, 2016). There is evidence that extended depth and duration of flooding may favor reed canarygrass. Earlier runoff could extend the duration of flooding. In this case more of a good thing (water) could have negative consequences.

Increased knowledge of working wet meadow ecology has directed HBWC's focus towards irrigation management, as dictated by seasonal hydrology. Water management decisions made by individual landowners influence meadow composition and food resource quality, for both livestock and wetland wildlife. Conversations among landowners and plant ecologists suggest a cultural shift in traditional water management is possible. Many landowners are observing the proliferation of undesired species, principally reed canarygrass. Ongoing work proposes to demonstrate a more judicious application of surface water on meadows will result in a more productive and desirable plant composition. However, judicious use of water in an agricultural landscape usually limited by water will require a solid demonstration of results to upend the cultural use of water. HBWC is working to make those demonstrations and resulting information available to landowners. Projects implemented by HBWC partners have modernized the water distribution system facilitating better management control of flood irrigation water. The Sweek Dam is one example of this.

The new Sweek Dam along the Silvies River completed fall of 2019. Photo by Jeremy Hill, jhillimages.com.

3. Partnership Members and Roles

HIGH DESERT PARTNERSHIP AND THE HARNEY BASIN WETLANDS COLLABORATIVE

In Harney County's remote Eastern Oregon landscape, there is a vastness only found in the high desert. This is where a local economy, healthy lands and water, and community wellbeing are inextricably linked. In the face of unique threats and challenges to Harney County's system of Closed Lakes Basin Wetlands, HDP's model of collaborative problem-solving respects this linkage and spurs further innovation to redefine what will best restore its landscapes while benefiting the community. The wetlands of the MNWR and the private ranch lands of the semi-arid Harney Basin are critical to migratory and resident birds of the Pacific Flyway that use the MNWR and adjacent private ranch lands. This gathering of wildlife attracts visitors from around the region, state and around the world.

Since 2005, HDP has facilitated a unique and effective collaborative decision-making process that brings diverse stakeholders to the table. What often starts over cups of coffee, leads to well thought-out solutions developed by and for the community. HDP has learned over the years how important relationships and building trust are in helping people with diverse values and perspectives work together. Currently stewarding six collaborative groups, including HBWC, HDP is addressing the economic opportunities, environmental wellbeing, and community interests that together strengthen the Harney Basin's rural way of life—something HDP hopes to continue for many generations.

The communities of Burns and Hines in the Harney Basin. Photo by Jon Black, Destination by Design.

Formed in 2011 as HDP's third collaborative, HBWC is a coalition of ranchers, conservation organizations, the Burns Paiute Tribe, government agencies, technical experts, and others focused on improving the aquatic health and sustainability of Malheur Lake and the flood-irrigated wet meadows of the Harney Basin. Its objective is to bolster the health of this wetland ecosystem, while finding solutions that also benefit the economic and social needs of the community. HBWC does this by continuing to come together through a collaborative decision-making process to address complex issues and find common ground solutions.

Harney Basin Wetlands Collaborative partners touring the basin with a final stop at the Malheur National Wildlife Refuge spring 2022.

Partners have a history of effective collaboration built upon shared experience, good working relationships, trust, and open communication. The following working agreements describe the commitments of partners to each other, the collaborative process used to conduct the work of HBWC, and implementation of HBWC's strategic action plan (Figure 4). With approval of the full collaborative, the working agreements may be revised as needed to meet the changing needs of HBWC and its partners.

HBWC operates as a collaborative made up of stakeholders and other partners with a shared commitment to HBWC's goals and its collaborative approach to implementation of the collaboratively developed strategic action plan. HDP serves as the neutral convener for the collaborative. Stakeholders include private landowners; federal, state, and local government agencies; the Burns Paiute Tribe; conservation organizations; and other individuals with a demonstrated interest in the long-term health of the Harney Basin's wetlands. Other partners contribute time, expertise, funding, and other resources in support of the partnership's efforts.

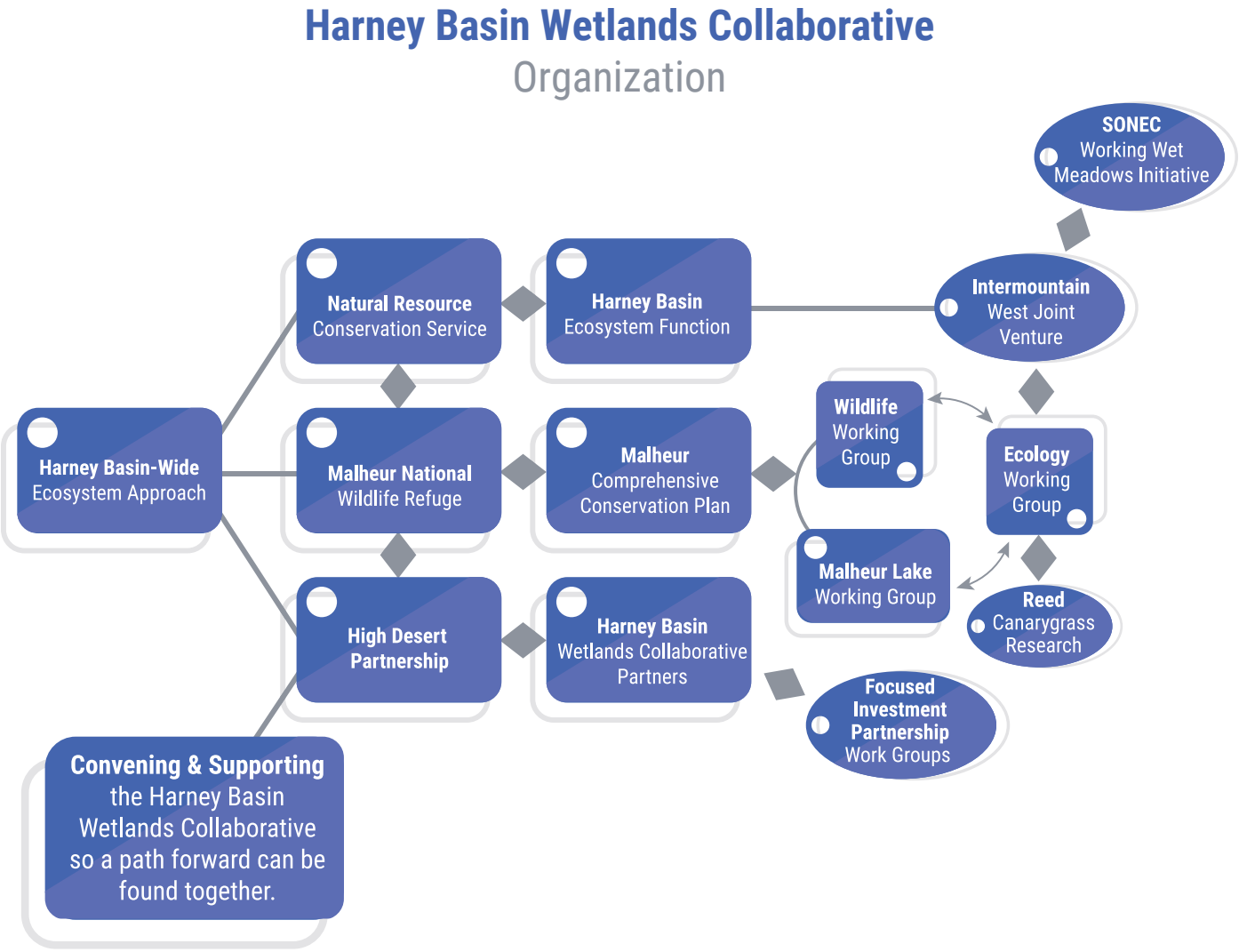


Diagram of how the Harney Basin Wetlands Collaborative operates as a collaborative partnership.

Core partners formally commit their support to HBWC by signing on to the working agreements. Other partners participate without a formal commitment but acknowledge the terms of the agreement and agree to respect the collaborative process used to advance the work of the collaborative.

HDP serves as the fiscal agent for HBWC and provides administrative and staff support for its collective work.

BACKGROUND AND PURPOSE

HBWC provides an umbrella for coordination and effective implementation of collaborative efforts to improve and maintain the ecological health of the basin's wetlands, and the social and economic values they support. A diverse set of partners works to build support for stewardship that generates long-term benefits for the human communities and native fish and wildlife of the Harney Basin. The collaborative builds upon decades of work by private landowners and MNWR.

With organizational support from HDP, the collaborative brings together a broad range of public and private partners working to achieve the following:

- Wetland systems: Sustain and improve proper functioning wetland systems and water quality in the Harney Basin.
- Malheur Lake: Implement an integrated set of strategies to restore the ecological health and functions of Malheur Lake and its associated wetland systems.
- Flood irrigation and wet meadows: Maintain and enhance traditional flood irrigation, haying, and grazing practices that sustain important seasonal wetland habitats and agricultural production.
- Adaptive management: Support adaptive management strategies to meet habitat objectives under MNWR's Comprehensive Conservation Plan and HBWC's strategic action plan.
- Stakeholder engagement support: Build support for long-term conservation of Harney Basin wetlands among stakeholders locally and beyond the basin by demonstrating the economic and social benefits of collaborative stewardship and restoration.
- National model: Establish HBWC as a nationally recognized model for public-private partnerships for landscape-scale restoration.

HBWC Partners: Experience and Roles

Implementation Partner	Experience	Roles
SOVEREIGN NATION		
Burns Paiute Tribe	Supporting initiatives of wetland health that promote tribal economic and cultural goals	Funding, restoration implementation, stakeholder engagement
GOVERNMENT		
Harney County Court	Project management	Supporting projects and tracking
AGENCIES: STATE AND FEDERAL		
Natural Resources Conservation Service	National leaders in private lands soil and water conservation. Experience working with many farmers and ranchers on conservation projects	Technical Assistance, landowner contacts, cost share funding, implementer of wet meadow infrastructure improvements
Oregon Department of Fish and Wildlife	Fish and wildlife stewardship experts	Technical advice, science sharing

AGENCIES: STATE AND FEDERAL (cont.)		
Oregon Water Resources Department	Water resources management experts	Water regulations and best management practices
Oregon Watershed Enhancement Board	Watershed stewardship leaders statewide	Funding and support
United States Geological Survey	Technical assistance	Field research and publications
US Fish and Wildlife Service Malheur National Wildlife Refuge	More than a century of managing Malheur Lake	Focus on Malheur Lake Ecosystem model for management of waterbird production
USDA Agricultural Research Service	Expertise on State and Transition models and their uses in land management	Technical advice, developing shared science
ORGANIZATIONS: LOCAL & REGIONAL		
Bird Conservation Oregon	Expertise on migratory bird populations	Monitoring, fundraising
Ducks Unlimited	Private lands conservation for wetland and waterfowl habitats	Technical assistance, outreach, project design and implementation oversight
Friends of Malheur National Wildlife Refuge	Decades of supporting the mission of Malheur National Wildlife Refuge	Volunteer efforts, engaging stakeholders, educational events
Harney County Watershed Council	Providing technical expertise and funding for projects in the watershed	Landowner contact, project management, grant administration
Harney Soil & Water Conservation District	Technical assistance, project management experts	Landowner contact, project management
Intermountain West Joint Venture	Migratory bird habitat experts at Pacific Flyway scale	Science support, technical assistance, outreach
Meyer Memorial Trust	Community investment experts	Capacity funding for HDP Ecological Coordinator
Portland Audubon Society	Supporting initiatives that improve habitat for bird species	Funding, outreach, volunteer efforts
Wet Meadow Partners	Technical assistance, research, supporting initiatives to improve wetland health including outreach and education	Wetlands restoration efforts

Implementation Partner	Experience	Roles
UNIVERSITIES		
Eastern Oregon Agricultural Research Center: Oregon State University Experiment Station	Expertise on latest range and plant ecological research	Technical advice, landowner contacts
Oregon State University	Research project management	Technical assistance, publications
CONSULTANTS		
Ken Bierly	Technical knowledge on wetlands and natural resources, literature and technical reviewing	Technical assistance
Robert Warren	Theory of change expert	Technical assistance
PRIVATE LANDOWNERS		
Multiple private landowners	Land management experts	Insight, knowledge and experience as land managers and water stewards while sharing their land for research and projects
SUPPORT SERVICES		
High Desert Partnership	Relationship development, consensus, partnership building, grass roots funding	Manage funds, cultivate collaboration, project assistance, leadership, coordination and communications
Oregon Consensus	Partnership planning experts	Neutral facilitation and manage meetings

Table 1. HBWC Partnership roles and responsibilities.

4. Geographic Scope and Timeline

GEOGRAPHIC SCOPE

Restoration work focuses on the flood-irrigated wet meadows in the tributaries to the Malheur and Harney Lakes including Silver Creek, Silvies River, Blitzen River and a number of smaller tributaries to the lakes. Additional focus on riparian health of the Silvies and Blitzen Rivers and Silver Creek systems will also be considered. Wetlands within the Harney Basin are a high-priority habitat for migratory and breeding bird populations within the Pacific Flyway, as identified in the Intermountain West Joint Venture "wetland landscapes and spring migratory priority areas"

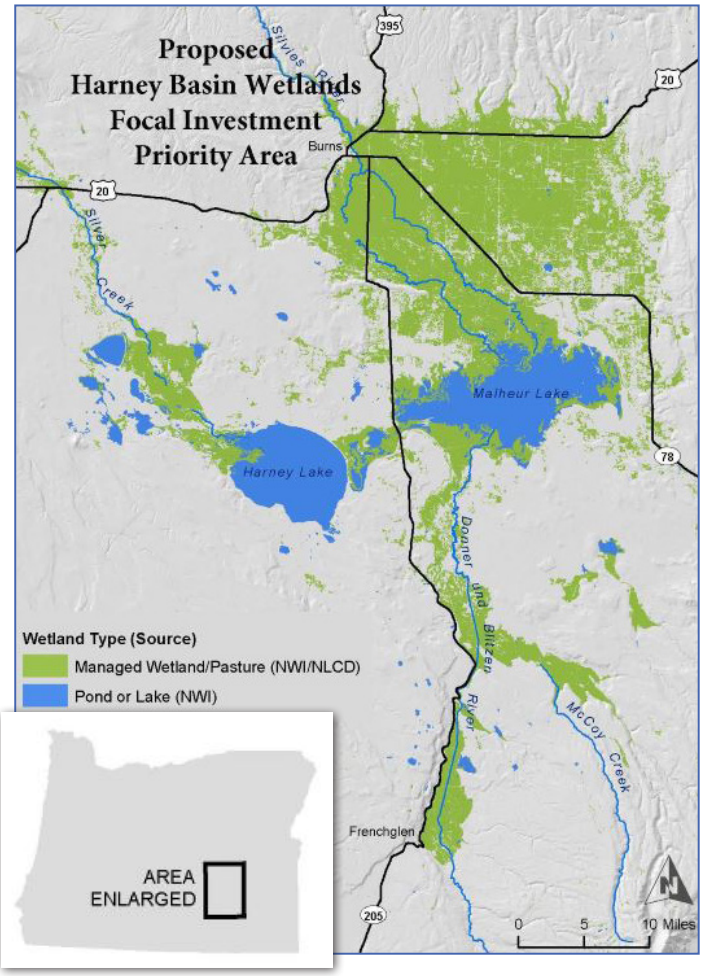


Figure 5

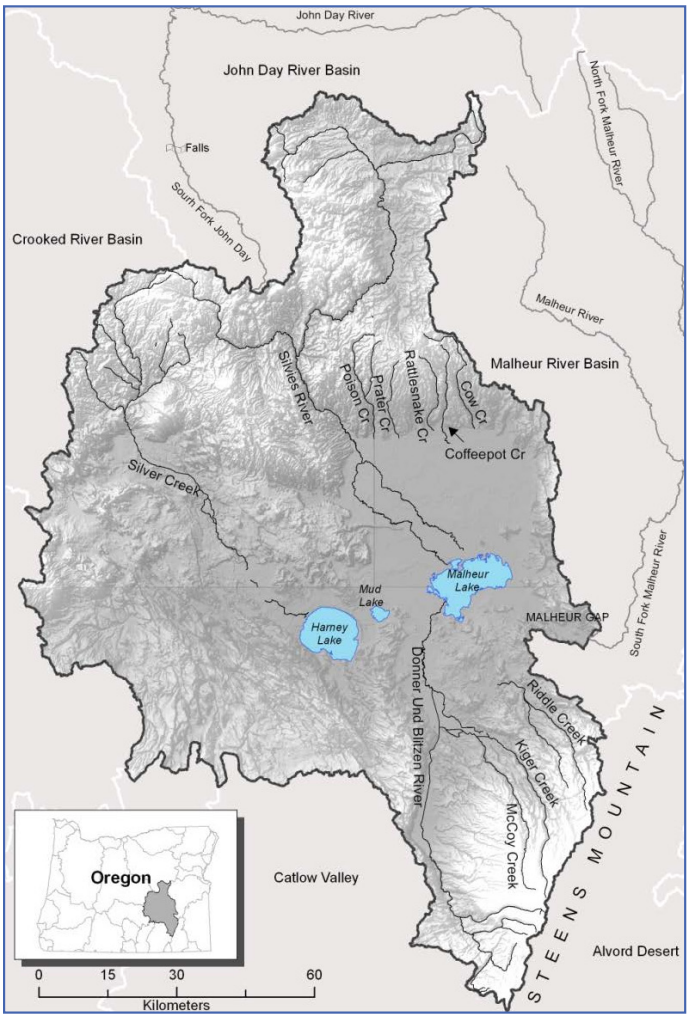


Figure 6

(Intermountain West Joint Venture Implementation Plan, 2013). The planning area is the Harney Basin catchment (Figure 6). Priority restoration areas within the planning area are focused on the Malheur-Harney Lakes and their associated wetlands (Figure 5).

The extent and distribution of flood-irrigated wet meadows and the size and spatial dynamics of Harney and Malheur Lakes, as terminal lakes, depend on annual precipitation. Timing and duration of runoff is affected by the snowpack accumulation and melt. While annual weather is unpredictable and always has been, there are increasingly variable patterns of precipitation related to climate change. Less snow and more rain has resulted in earlier spring freshet events and less late season runoff into Malheur Lake. Water management decisions affect both the extent of flood-irrigated wet meadows and the rate, duration, and timing of flooding of the floodplain meadows. Future water management decisions will need to be informed by expected changes to water supply and the limitations from changing conditions.

PLANNING TIMELINE

The strategic action plan provides a renewed 25-year vision for the Closed Lakes Basin Wetlands systems of the Harney Basin. The primary focus is the maintenance and enhancement of flood-irrigated wet meadow habitats for migratory birds, enhancement of riparian conditions for wildlife and fish, and further efforts to restore the aquatic health of Malheur Lake. Projects will be targeted for:

- Short-term (5 years)
- Mid-term (10 years)
- Long-term (25+ years)

HBWC partners recognize that as improved understanding of drivers and conditions of the Harney Basin wetlands occurs it will require recalibration of how water is managed in the basin.

5. Vision

HBWC is working to restore and enhance healthy lands and water while nurturing a rural way of life that supports and values wetland conservation in the Harney Basin. Malheur Lake and the MNWR have significance beyond the local area. This area has international significance for migratory birds and draws people from across the country.

The Harney Basin is characterized by extremely high year-to-year weather variation. Vegetation managers have had to adapt to this variability. Climate change adaptation often involves projecting future climate trajectories. In addition it has been widely recognized that irrigation infrastructure is typically old and too expensive to replace without assistance. This condition leads to inefficient use of water and conflicts over distribution. Improved infrastructure can improve management that can be aimed for optimizing both bird habitat and forage production. Flood-irrigated wet meadow conservation will ensure that there is a continued emphasis to provide flood-irrigated spring migratory bird habitat in this highly variable system through targeted conservation efforts. Management and distribution of water across the floodplain and the effects of timing, duration, and depth of water on plant communities have become crucial to providing the migratory bird habitats that will sustain the Pacific Flyway.

The HBWC defines success in the flood-irrigated wet meadows to the degree private land practices are implemented to assure the maintenance or enhancement of traditional flood-irrigation practices for the mutual benefit of forage production and migratory and breeding bird habitat. Additional outcomes include enhanced resiliency for wildlife habitat and irrigated flood meadow agricultural practices to climate change by improving infrastructure and restoring floodplain function. HBWC has supported research clarifying the potential for carp population control, studied the factors affecting plant establishment in Malheur Lake, and researched other methods to reduce the very high turbidity of the lake. Through this improved understanding and knowledge HBWC partners are now developing strategies to reverse the degraded conditions and improve restoration success.

HBWC partners are addressing a complex socio-ecological system where there are many and occasionally conflicting demands on water resources. As climate change affects water supply and availability, providing better understanding of the complex interactions of water supply, timing, and effects of that on human uses as well as ecological processes is critical in the development of management approaches that can optimize values for the community.

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6. Ecological Priorities and Goals

The Closed Lakes Basin Wetlands (OWEB Board adopted ecological priority) exist within the Southern Oregon Northeast California (SONEC) region, which is a portion of the Closed Lakes network within the northern Great Basin (Figure 7). South central and southeast Oregon have a series of wetland systems that are important for migratory birds. The Klamath, Warner Lakes, Summer Lake, and Harney Basin all have extensive wetland systems managed for migratory and resident birds. Each area is recognized by some form of wildlife habitat protection area (Klamath Basin National Wildlife Refuges, Warner Lakes Area of Critical Environmental Concern, Summer Lake State Wildlife Area, and Malheur National Wildlife Refuge). The Harney Basin is one of the largest closed lake basins. Each of the closed lake basins have natural wetland complexes along with private lands flood-irrigated wet meadows that provide habitat for migratory and resident birds while producing forage and hay for ranching operations.

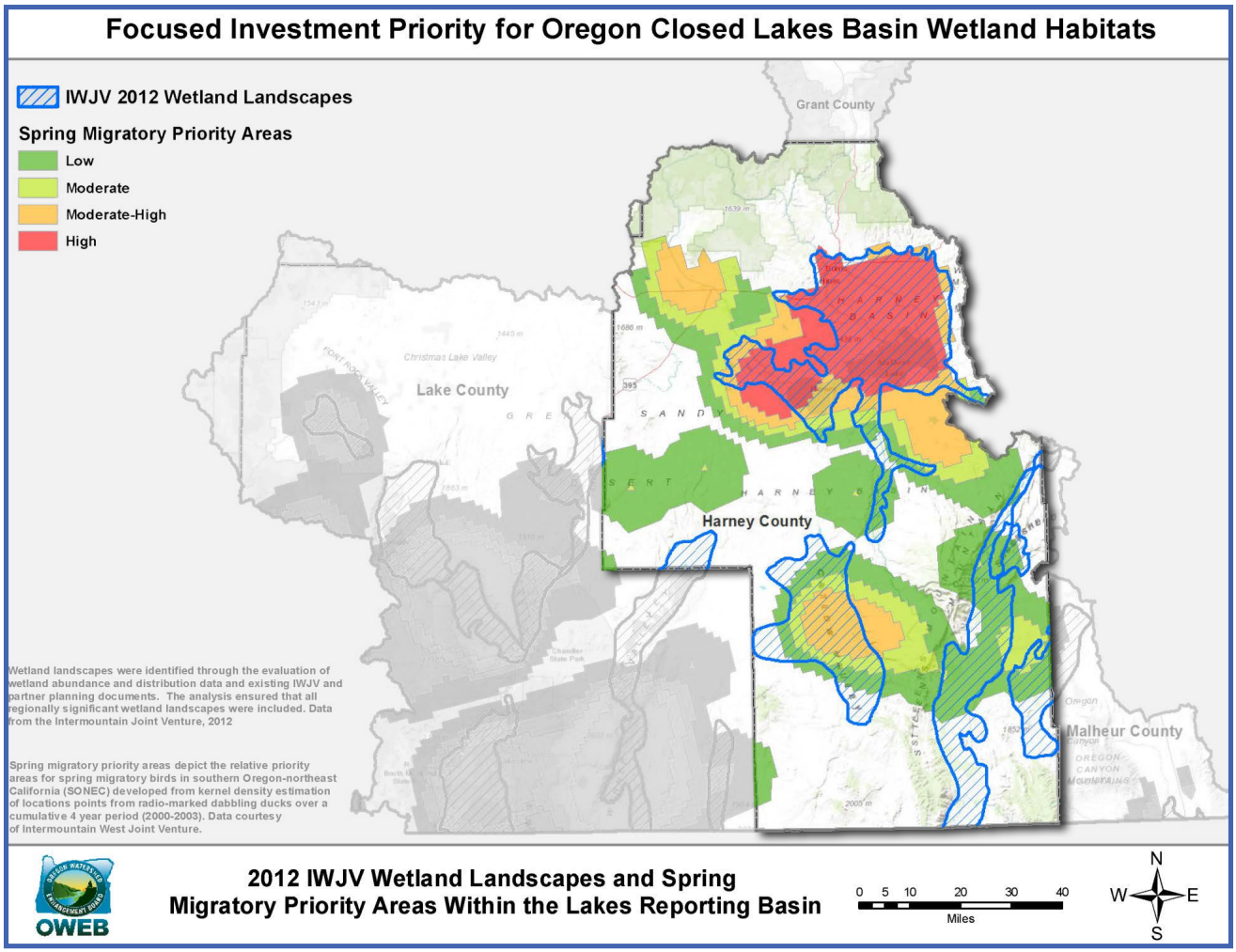

Figure 7. Spring migration wetland priority areas within the Closed Lakes Basin.

Closed Lakes Basin flood-irrigated wet meadows are ecologically unique high desert wetlands that provide critical habitat for numerous migratory and resident bird species, as well as other wildlife. This region is recognized internationally for its important migratory bird habitat. Oregon's Closed Lakes Basin Wetlands are a significant portion of the greater SONEC complex of wetlands that are critical to the millions of birds traveling along the Pacific Flyway each year.

The SONEC region's geography and habitat has been defined by the Intermountain West Joint Venture (IWJV) and in the federal North American Waterfowl Management Plan (NAWMP). The IWJV recognizes the SONEC region as one of two top priority areas in the Intermountain West for wetland-dependent birds and it is one of the IWJV's highest priority landscapes for conservation for several reasons. It is a rich mosaic of wetlands, flood-irrigated wet meadows, and irrigated pasturelands that provide critical migration and breeding habitat for a myriad of North American bird species. These wetland complexes are an important part of the intercontinental Pacific Flyway. Within the SONEC region, 75% of wetland habitat is located on private lands, most of which is managed as flood-irrigated hay and pastureland.

The main ecological priority is to maintain the Closed Lake Basin wetlands unique chain of desert oases that, as an integrated network, provide a critical corridor of habitat and food for waterbirds throughout the seasons. Closed Lake Basin wetland habitats include shallow lakes and marshes, flood-irrigated wet meadows, and irrigated pasturelands. A recent analysis shows Malheur Lake as being affected by climate and human water use (Donnelly et al., 2020). MNWR and other sites within the Harney Basin are critical for seasonal recreation which also feeds Harney County's economy each year. The U.S. Fish and Wildlife Service has documented over 65,000 annual visitors to the MNWR alone—a renowned destination for avid birders and outdoor recreationists.

Many ranching businesses are reliant on the ecological health of flood-irrigated wet meadows as a critical part of their operation for the forage that they provide. Finally, the unfolding impacts of climate change may lead to a change in timing and reduction in overall water availability. This is of concern as it is yet unknown how water scarcity will further alter the natural hydrologic regime across these sensitive habitats. This concern, in tandem with water resource issues in other important areas of the SONEC wetland complex, lend added urgency to the importance of conservation efforts concerning this unique habitat and its relationship with the area's water resources.

CONSERVATION GOALS

The HBWC is pursuing a series of interrelated ecological goals:

1. By 2030, the wetlands of the Blitzen valley and Malheur Lake will be managed to optimize the habitat for all stages of migratory and resident birds and other wildlife.
2. By 2030, all flood irrigators have had the opportunity to learn about management opportunities for differing water conditions and the ecological outcomes from different management options.
3. By 2050, the private landowner irrigators in the Silvies River, Silver Creek, and other tributary stream systems optimize available water to maintain wet meadow habitats for birds and forage production using tools developed by the HBWC.
4. By 2050, the flood irrigation infrastructure of the Harney Valley is modernized and optimizes the distribution of water received annually from the Silvies River, Silver Creek, and other tributary streams.
5. By 2050, priority stream reaches of tributary streams have restored riparian conditions reducing stream heating in the Silvies River, Blitzen River, Silver Creek and other tributary streams.
6. By 2050, an integrated management program maintains carp populations at a low level sufficient to maintain significant areas of emergent and submergent vegetation in the wetlands of Malheur Lake.

The Harney Basin has been recognized by the Oregon Department of Fish and Wildlife (ODFW) as having a concentration of areas important for conservation. Recognized as Conservation Opportunity Area (COA) 187 (Harney-Malheur Area) by ODFW, this is an important area for the protection of several special habitats and many focal species. Four other COAs, Bear Valley (COA 177), Upper Silvies River (COA 178), Rattlesnake Creek-Calamity Creek (COA 181), and Silver Creek (COA 175) are also recognized for the importance of their wetland systems.

Malheur Lake and Blitzen wetlands are clearly an outstanding bird migration site recognized as early as 1908 for protection. MNWR provides a diverse concentration of birds that follow the Pacific Flyway. Thousands of birders from around the world come to Harney County each year to visit MNWR and take part in the migratory spectacle. According to eBird MNWR Headquarters has the highest bird count in Oregon, with MNWR (general) in second. The Malheur Lake area has 3 of the top 20 highest all-time bird lists on eBird.

The wet meadow system in the Silvies River floodplain is also an **Audubon Important Bird Area**. As described by the Audubon Society of Portland: “The Silvies River Floodplain is an area of flood-irrigated meadows and hay lands between Burns, Oregon and Malheur Lake. The Silvies River area was historically a shallow, slow moving river system of sloughs and swales interspersed with meadows. In wet years, the flooding banks of the Silvies River creates an extensive wetland system in the valley.”

Shrub dominated riparian areas thread through the flood-irrigated wet meadows creating structural diversity and providing significant habitat for swallows and other summer residents, winter residents, or migrant birds. Species of continental importance in the **Partners in Flight North American Landbird Conservation Plan** include the Willow Flycatcher, Calliope Hummingbird, Red-naped Sapsucker, Lewis’s Woodpecker, Willow Flycatcher, Brewer’s Sparrow, and Green-tailed Towhee.

KEY HABITAT THREATS TO THE HARNEY BASIN

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- Invasive common carp populations that could damage the recently established emergent and submergent wetland vegetation in Malheur Lake.
- Expansion of reed canary grass and other non-native grass species that affect the habitat quality of flood irrigated wet meadows.
- Changed water availability from changing climate and water management structures and that are either in poor repair or designed for different flow conditions.
- High levels of turbidity in Malheur Lake from both internal and external sources.

Sandhill Cranes utilizing the flood irrigated wet meadows of the Silvies River Floodplain near Burns, OR. Photo by Brandon McMullen.

7. Conservation Context

BIOPHYSICAL

The Harney Basin is the northern extension of the Northern Basin and Range ecoregion, bounded on the north by the Blue Mountains and to the south by Steens Mountain. The Harney Basin is a closed lakes basin that has no external surface drainage. The lowest point of the basin is Harney Lake, a terminal lake that loses water through evaporation.

- **GEOLOGICAL SETTING.** The Harney Basin is a depositional basin composed of alluvial deposits from the Silvies, Silver Creek, and Blitzen River systems. Also, lacustrine deposits from Pleistocene Lake Malheur. All the rocks in and near the Harney Lake and Malheur Lakes are of Pliocene or younger age and include ashfall and ash flow tuffs and tuffaceous sedimentary rocks, interstratified basalt flows, local accumulations of basaltic eruptive material, and broad expanses of several different kinds of Pleistocene and Recent surficial sediments (groundwater study Advisory Committee presentation March 19, 2019).
- **GROUNDWATER OVER-APPROPRIATION.** In the eight years since the development of HBWC's first strategic action plan, Harney County has learned of the significant over- appropriation of groundwater in the basin. Recent hydrogeological studies identified aquifers, groundwater conditions and the groundwater budget (OWRD-USGS, 2021). The information presented to the groundwater study advisory committee indicates the basin is out of balance for groundwater by about 110,000 acre feet/ year (Gingerich et al., 2022). A community-based integrated water plan is being developed and is led by a HBWC partner: the Harney County Watershed Council in cooperation with Harney County Court. The significant over appropriation of groundwater has been recognized as a key area of concern and strategies are being developed with local solutions to address the use of the area's limited groundwater resources. The water plan will also address surface water resources and representatives of HBWC are actively participating to ensure lake and wetland conservation investments to date are recognized during plan development. The allocation and distribution of surface water could have a significant effect on flood irrigated wet meadow systems and the size and fluctuation of Malheur Lake.

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- **ECOREGIONAL CONTEXT.** Malheur Lake and the Silvies Floodplain are in the High Desert Wetlands portion of the Northern Basin and Range ecoregion. The High Desert Wetlands are described as: "The nearly level High Desert Wetlands ecoregion consists of high desert lakes and surrounding wetlands that provide critical habitat for nesting and migratory birds and associated upland birds and mammals. Elevation varies from 4,000 to 5,200 feet (1,219 to 1,646 m). The fine-textured soils are poorly drained, and basins collect water seasonally. Although water levels fluctuate from year to year, lakes and wetlands in this region hold water more consistently than on the course, better drained soils of the Pluvial Lake Basins. Sedges, rushes, black greasewood, tufted hairgrass, mat muhly, meadow barley, creeping wildrye, and Nevada bluegrass occur in wetter areas. Drier areas support basin big sagebrush, Wyoming big sagebrush, silver sagebrush, bluebunch wheatgrass, basin wildrye, Idaho fescue, Thurber's needlegrass, and cheatgrass (an invasive species). The region covers 1,651 square miles

(4,276 km2) in Oregon, including the MNWR and land surrounding Malheur Lake, as well as several other wetland systems."

- **TERRESTRIAL AND AQUATIC ECOSYSTEMS AND SUPPORTED SPECIES.** As described in Ecological Priorities and Goals within this document, the wetlands of the Harney Basin are a critical resource for a multitude of migratory and breeding avian species. Along with the waterbirds, the wetlands complex is important to small mammals, amphibians and reptiles and the streams are important for cold water fish (primarily redband trout). Groundwater-dependent ecosystems include a number of invertebrates unique to the springs and other groundwater dependent habitats in the basin.

SOCIAL

Harney County has a population of around 7,300 people with the median age of 46. It is a predominantly white Caucasian population (87% white and about 3% American Indian). Home ownership in the area is around 70% and the median property value is about $112,000.

Harney County is the tenth largest county in the U.S. in terms of land mass, at 10,226 square miles with just 7,300 people. This vast landscape is made up of 75% public lands managed by various government agencies.

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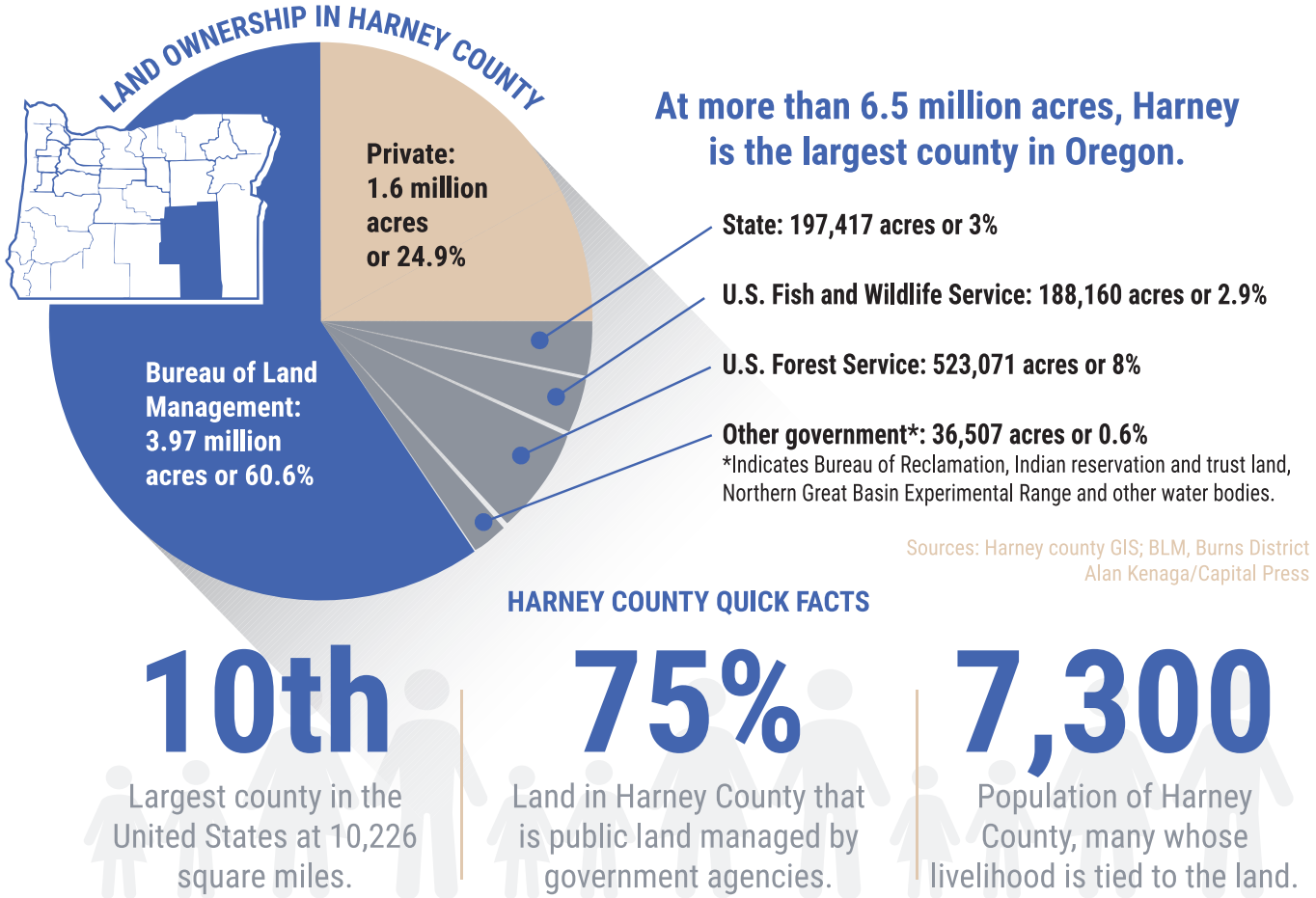


HARNEY COUNTY QUICK FACTS

10th
Largest county in the United States at 10,226 square miles.

75%
Land in Harney County that is public land managed by government agencies.

7,300
Population of Harney County, many whose livelihood is tied to the land.

In HDP's view the culture of rural Harney County is one of self-reliance, determination, resilience, volunteerism, and taking care of each other. It is also a culture where a local landowner might say: "Oh, I've only been here 40 years or so", which is a sign of the respect given to those who come from families who have resided in the area for generations working on and caring for the land. There is a common sentiment among locals that "we can do this together" despite differences and fiercely held independence. As a community that has weathered hard times in the past, there is a resilient spirit deeply embedded in Harney County's rural culture that brings determination and optimism to new challenges.

It is also a place where landowners who manage their own lands understand the choices and decisions they make have an impact on the community as a whole. It is this rural culture that has made working together such an effective tool for solving problems in Harney County. As Peter Walker shares in his book Sagebrush Collaboration, "In a nation staggering to find its center of gravity, Harney County proved the power of a community that knows how to work together."

ECONOMIC

Among Oregon's most sparsely populated rural counties, Harney County faces common economic challenges because it is a community strongly tethered to its ranching, logging, and mining past. Developing new economic opportunities that maintain the natural balance and integrity of the landscape continues to be a major challenge. Agriculture and ranching have been a steady backbone of the local economy for generations. The expansion of groundwater irrigated agriculture has contributed to accelerated groundwater depletion that limits future growth and development. There is also a shift in generational interests where young farmers and ranchers are no longer guaranteed to take over their family business because they seek other career paths or leave the area for opportunities elsewhere.

Like so many rural Oregon communities, Harney County was once home to a booming timber industry. But rising costs, increasing regulation, and a range of other factors have completely eroded this industry over the years. The final closure of the Louisiana Pacific lumber mill in 2007 led to employment and income shortfalls for which no large-scale or single-source replacement has been found. These factors and others have led to the classification of Harney County as one of Oregon's "Top Five Distressed Counties" by Business Oregon. While the number of jobs in Oregon has grown more than 74% in the last 40 years, they have fallen significantly in Harney County, where there are 10% fewer living-wage jobs in the region now versus in 1976 (Oregon Office of Economic Analysis, 1976-2016). Harney County's unemployment rate at 13.1% is almost double the state rate of 6.8%. At the current time agriculture amounts to nearly 25-30% of the employment in the County. The Agricultural Census of 2017 shows cattle and hay production as the dominant agricultural producers in the area. The public sector is a primary employer accounting for some 39% of the jobs in Harney County. Bird viewing in the basin accounts for some 79 jobs and some $9,200,000 annually to the County (Bair et al., 2021).

OPPORTUNITY
STEWARDSHIP ECONOMY

Over the last 20 or more years, there have been outstanding advances in **Harney County** toward implementing environmentally-sound, ecologically based ecosystem management throughout the region using a collaborative model. There also has been a shift in Harney County to embrace grassroots economic development strategies and BizHarney Opportunity Collaborative, an economic collaborative convened by HDP,

is building on this interest by intentionally developing pathways for entrepreneurs and small businesses within the natural resources restoration and conservation sector. Opportunities are ripe as Harney County is uniquely located to capitalize on the area's land-based economy and multiple collaborative efforts are coming together to solve these complex issues.

HISTORICAL

For more than ten thousand years, people have inhabited the Harney Basin and lived off its wetlands. The Wadatika people (Wada eaters) have used the lake and surrounding areas for food, medicine, shelter, and spiritual centering for their people. The Burns Paiute Tribal Council recognized "the spiritual and cultural importance of Malheur Lake and its current and historic shoreline to the Burns Paiute Tribe, and that these locations hold invaluable, irreplaceable, and endangered aspects of our cultural heritage" in Resolution 2016-01. The Burns Paiute Tribal Council also recognizes Malheur Lake and its current and historic shoreline, watershed, and viewshed as traditional cultural properties each with numerous sacred loci including historic and contemporary spiritual quest sites, sacred sites, and other important cultural sites. Figure 8 shows the traditional territory of the Burns Paiute tribe in the Harney Basin area.

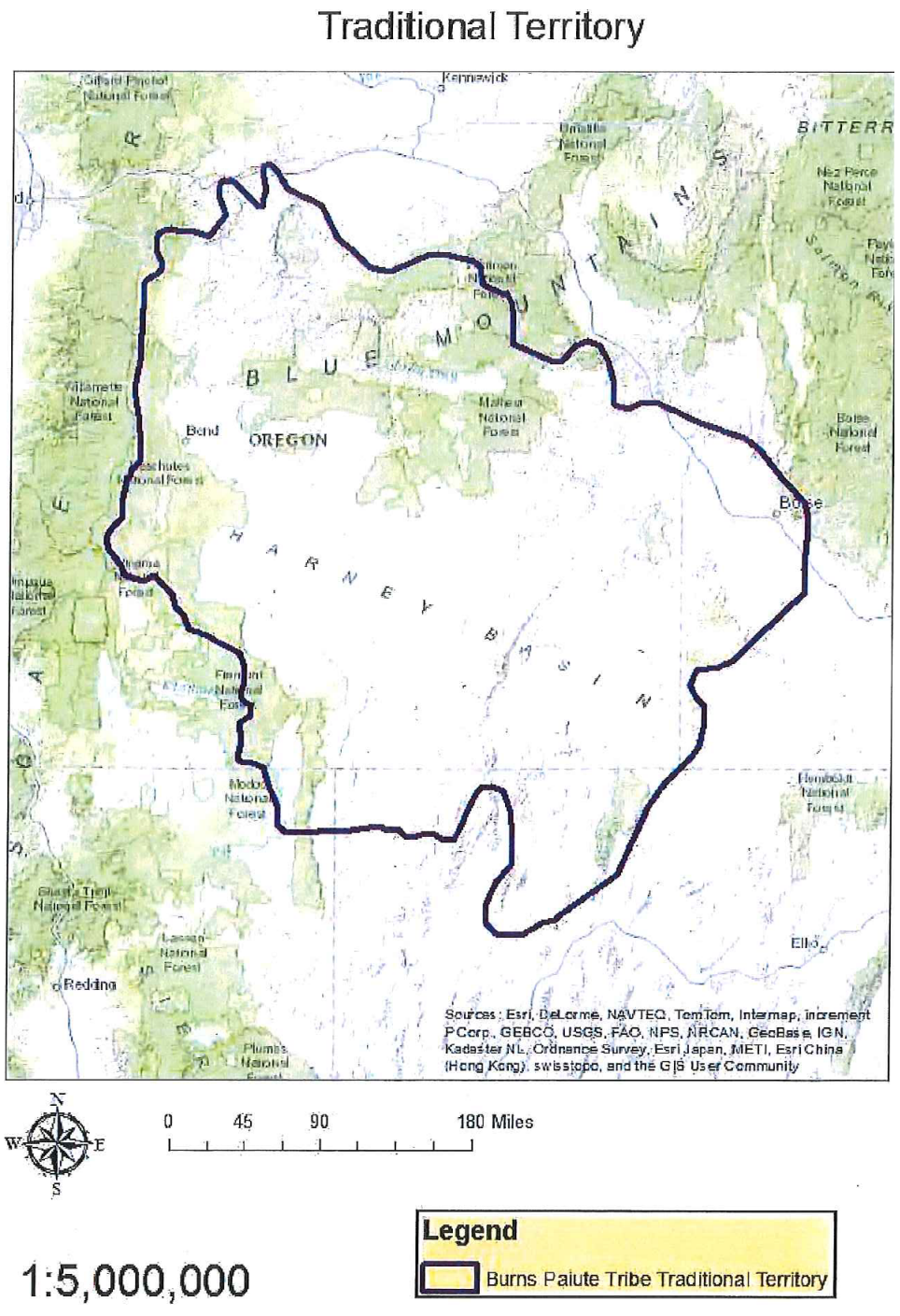
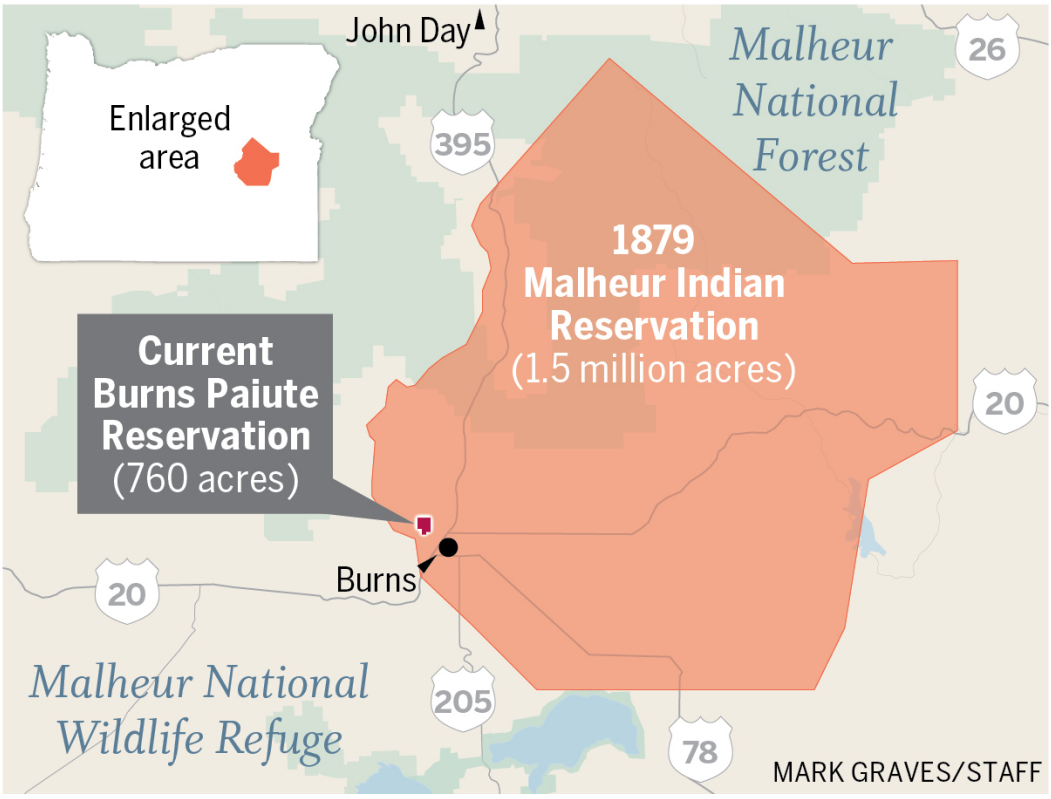


Figure 8. Burns Paiute traditional area Map for the Harney basin region.

In 1872, President Ulysses S. Grant created the Malheur Indian Reservation by executive order. Over time the reservation was reduced and eliminated in 1879. Some 11,000 acres of allotted land are owned by individual tribal members and the Burns Paiute Tribe purchased a 760-acre site near Burns in 1935. The Tribe was identified as a federally recognized tribe by executive order in 1972 and the lands purchased earlier were recognized as reservation lands.

Malheur Indian Reservation: Then and now

The Malheur Indian Reservation once covered nearly 1.5 million acres of land in Harney, Grant and Malheur counties. Today, the Burns Paiute Tribe's reservation consists of just 760 acres on the outskirts of Burns.



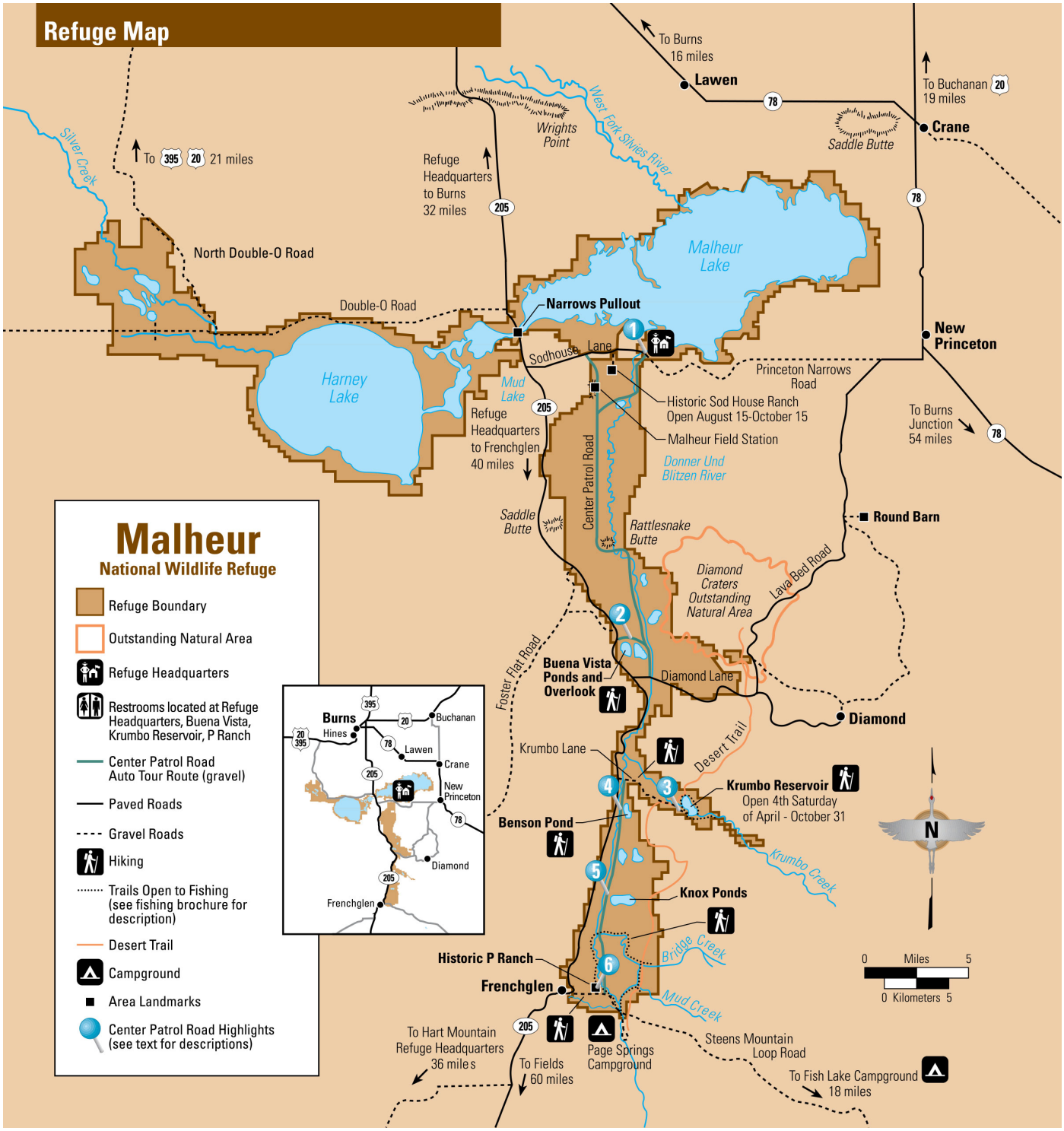
Sources: Bureau of Indian Affairs; U.S. Interior Department.

Fur trappers came through the Harney Basin in the 1820s, taking beaver from the Silvies River and other streams in the basin. Beavers were mostly trapped out of these areas by the 1830's. Settlers passed through the area headed to the Willamette Valley in the 1840s-1860s. Army exploration of the area in the 1860s led to the establishment of army outposts (forts) in the area, and along with settlers, led to the provocation of hostilities with the native people. Large ranch interests from California came north to use the summer ranges found in the Harney Basin. Ranches were established where flood irrigated wet meadows from spring flooding provided abundant forage. Early water management included spreading the spring water to as much land as possible (Langston, 2003).

Homesteaders began moving into the basin in the 1870s. The MNWR was established in 1908 and incrementally added to its present size of 187,757 acres around Malheur and Harney Lakes.

MALHEUR LAKE AND BLITZEN VALLEY WETLANDS

The Blitzen River currently provides most of the water for Malheur Lake. A rough hydrological model has shown that the previous year lake level and the runoff from the Blitzen River are good predictors for the lake level of Malheur Lake. As the Donner und Blitzen River comes off Steens Mountain near Page Springs it spreads out across an alluvial fan and forms a wetland complex that is managed as a part of the MNWR. Currently there is a review of the management approaches to provide appropriate habitat for focal species such as sandhill crane and bobolink by water and vegetation management for the reach from Page Springs



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to Krumbo Bridge. Approximately 17.5 miles of the Blitzen River between Bridge Creek and Busse Dam has been channelized, which has led to downcutting and transporting sediment to Malheur Lake wetlands. Flow to Malheur Lake is dominated by snowmelt runoff and requires a minimum flow of 25 cfs in the lower river.

Malheur Lake is a large (≈ 19,600 ha), shallow (avg. depth ≈ 0.76 m; max depth ≈ 1.52 m), polymictic, terminal wetland (endorheic basin) system with two major freshwater inputs, the Silvies and Blitzen Rivers; (Miller, 2012; Williams et al., 2014). Malheur Lake is located within the MNWR, which is managed by the U.S. Fish and Wildlife Service. Malheur Lake was once one of the largest freshwater marshes in North America, serving as an important transitional area for migratory duck and geese species, breeding area for numerous shorebird species, and habitat for resident species (Duebbert, 1969; Cornely, 1982; MNWR, 2012). Typically, the aquatic ecosystem of Malheur Lake is highly turbid, with a lack of submergent and limited extent of emergent vegetation, high levels of nutrients and suspended sediments in the water column, and diminished fish assemblage dominated by the non-native benthivorous common carp.

HBWC utilized systems modeling to investigate the non-native carp population, management options, and potential effectiveness of reducing the population (Pearson er al., 2020). The results demonstrated that restoration actions in the form of carp control solely targeting the adult life stage (commercial harvest) will likely be insufficient at suppressing and maintaining the carp population below the desired 50 kg/ha (hypothesized to be the threshold at which waterfowl productivity would increase via the recovery of lake clarity and aquatic vegetation; Vilizzi et al. 2015). The difficulty in changing the lake conditions by carp harvest alone is due to the carp population exhibiting compensatory density dependence, in which demographic rates shift in response to population densities (Pearson 2020, Pearson et al. 2019, Weber et al., 2016; Rose et al., 2001). This means that as carp are harvested, their reproduction increases making population control difficult by harvest alone. These simulations demonstrated that management actions directed at suppressing the carp populations should target multiple life-stages to overcome these compensatory responses. Furthermore, modeling also demonstrated that the highly variable environment of Malheur Lake (lake level fluctuations) is likely a significant factor affecting the carp population with lower lake levels reducing the population and higher levels resulting in higher carp populations. This affects the ability for managers to impose mortality rates via removal efforts.

The results of the Malheur Lake system modeling suggest that lake fluctuations driven by environmental variability drive the carp population in Malheur Lake, with lake level fluctuations responsible for the carp

biomass naturally falling below the critical threshold (50 kg/ha ≈ 17% of the year). While continuing adult harvest during low water years alone is insufficient to eliminate carp, other strategies are possible. Preventing carp access to the Blitzen River through the deployment of an electronic barrier could reduce survival during low water years and drastically reduce reproduction in the lower Blitzen River which has historically been the only place with successful reproduction during drought. The barrier would not only restrict movement to the carp's preferred breeding and low water refugia but would also be used as a trap to capture and remove carp with an automated system that drastically reduces fish biologist's labor and time.

Malheur Lake has maintained the turbid state during the last 30+ years, and recent study and modeling efforts have demonstrated that wind-wave resuspension (Figure 11) would likely maintain the turbid state (Figure 12) in the absence of carp. For instance, the modeling demonstrated that wind-wave resuspension is driven by both physical and environmental factors (i.e., water depth, wind fetch, and wind speed; Figure 13), and therefore, restoration treatments such as wave reduction barriers could be used to decrease the overall suspended sediment concentration and increase light in the water column. A more recent study has documented the sediment contribution from the Blitzen River (Smith and Wood, 2023). Collectively these results reinforce the notion that future restoration actions in Malheur Lake must be more broadly focused (i.e., systems perspective). It is recognized that there are alternative stable states for shallow lakes and understanding the conditions that move conditions towards clear water or turbid water will improve management decisions (Scheffer et al., 1993; Janssen et al., 2014; Williams, 2005).

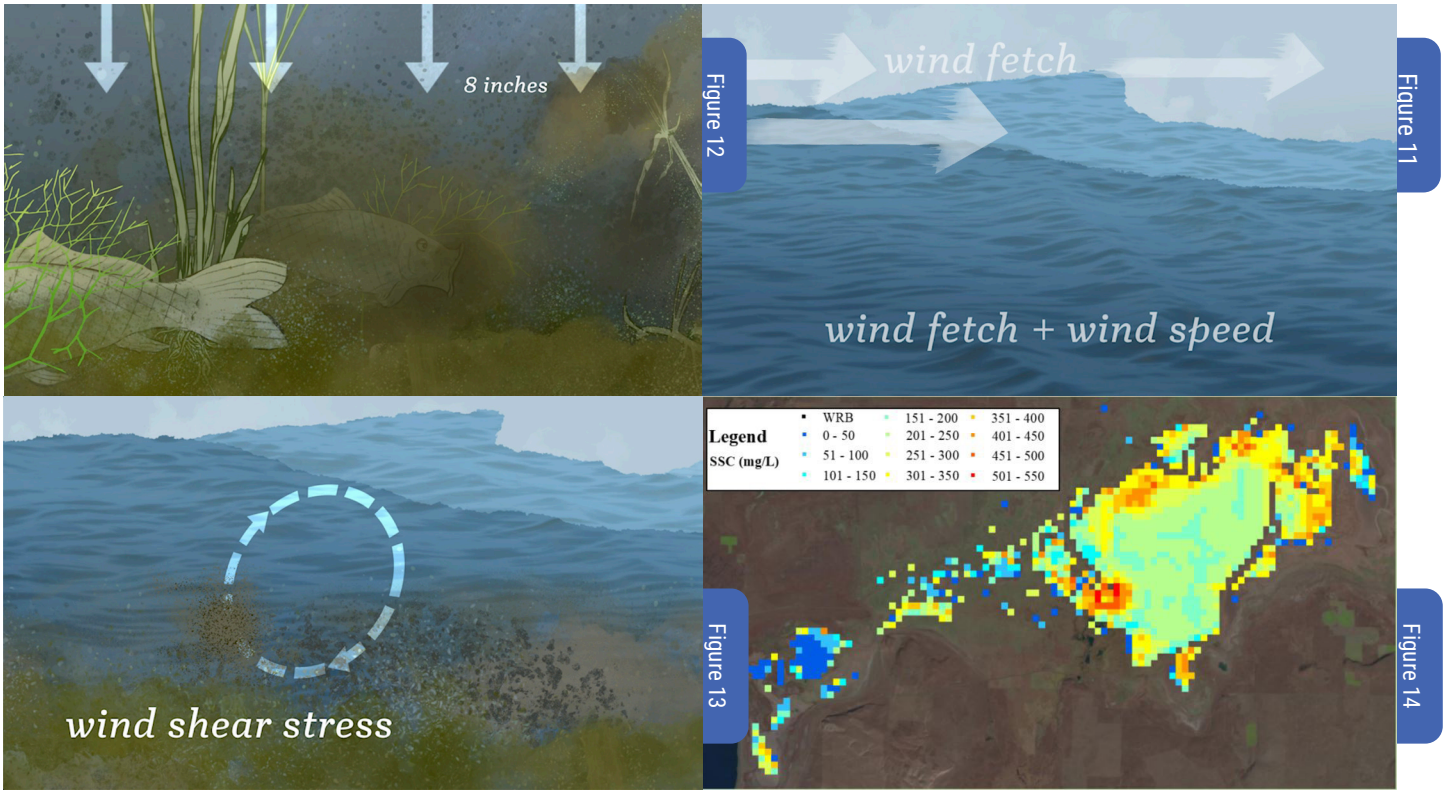

Figure 11: A visual demonstration of wind fetch and wind speed. Figure 12: A visual demonstration of a turbid water column, in which suspended sediment resuspended by the activity and mode of feeding by the carp and the wind-wave resuspension. This image also shows how the photosynthetic active radiation is extinguished within 8 inches (20 cm) of the water column. Figure 13: A visual demonstration of wind shear stress. Wind shear stress is the energy exerted at the sediment water interface. As the wind shear stress increases, more sediment is suspended into the water column. Figure 14: A wind-wave resuspension model output demonstrating the average suspended sediment concentration (SSC; mg/L) for each cell throughout Malheur Lake.

Recognizing that there are alternative stable conditions of clear water or turbid water, the presence and or absence of aquatic macrophytes is the main driver that stabilizes either of the states (clear/turbid) in perpetuity. For instance, aquatic macrophytes reduce wind driven sediment resuspension (Figure 13) via shortening the effective wind fetch (Figure 11) and settling the sediment which subsequently reduces internal phosphorus loading and promotes the establishment of benthic algae (Horppila et al., 2013; Zhang et al., 2013). The establishment of benthic algae further removes nutrients from the water column and decreases the susceptibility of sediment to wind resuspension (Zhang et al., 2013). The source of the sediments that make up the turbid load of the lake is unknown at this time. There appears to be sediment from the lower Blitzen River resulting from the historic channel straightening. There is also significant lake sediments and decayed organic materials from the dead emergent vegetation in the lake bottom.

Furthermore, aquatic macrophytes provide structural habitat for zooplankton, increasing their negative effect (predation) on the phytoplankton biomass (Figure 13), which further increases water clarity (Timms & Moss, 1984). Lastly, aquatic macrophytes take up nutrients available in the water column, release allelopathic chemicals, and oxidize sediment, all of which decrease the amount of phosphorous available to phytoplankton, further reducing phytoplankton biomass and increasing water clarity (Wium-Andersenet al., 1982; Carpenter et al., 1983; Ozimek et al., 1993; Williams, 2005). In the context of Malheur Lake restoration, aquatic macrophytes, while generally described for their benefit as habitat to residential and migratory bird species (i.e., material, food, shelter, etc.), also act as a system stabilizing mechanism that is crucial for the establishment and maintenance of the clear state (Pearson 2020).

Aquatic macrophytes have generally been identified as an important system stabilizer, emergent vegetation may have specific importance to Malheur Lake. For instance, emergent vegetation (e.g., bulrush, cattail, etc.) can act to dissipate wave energy in shallow lakes, decreasing the winds forces and limiting resuspension of bottom sediments. The rigid stems of emergent vegetation dissipates the effective turbulence and lowers the frequency of resuspension events (Horppila et al., 2013). Emergent vegetation has also been shown to have a large effect on reducing internal phosphorus loading, with emergent vegetation decreasing loading by 26 mg/m2/d (Horppila & Nurminen, 2005). Carp have not been demonstrated to have a deleterious effect on emergent vegetation. Many studies have demonstrated the negative effect carp have on submergent vegetation both directly and indirectly (Crivelli, 1983; Lougheed et al., 1998; Miller & Crowl, 2006; Matsuzaki et al., 2007; Weber & Brown, 2009). Unlike submergent vegetation that is adversely affected by carp, emergent vegetation should be able to persist even in the presence of carp and dissipate wind energy and potentially promote favorable growing conditions for submergent vegetation during years coupled with carp management treatments(Pearson et al 2021).These findings led us to conduct a historical review of the MNWR literature, demonstrating that emergent vegetation once occupied 40% to 53.9% of the surface area in the two main units of Malheur Lake (west and central units respectively; Deubbert, 1969; Spencer, 1994). During the 1980's Malheur Lake increased to a lake area of ≈ 51,500 ha (average lake area = 19,200 ha) with a max depth of ≈ 4.4 m (avg max depth = 1.26 m), exceeding all previously instrumented recordings (Hostetler & Bartlein, 1990). These floods inundated the previously robust emergent vegetation stands for an extended period under depths at which they were not able to survive. Once the flooding subsided, Malheur Lake was devoid of emergent vegetation except for a narrow area around the lake. It has been hypothesized that the loss of emergent vegetation, specifically the rooted structures that act to secure the sediment is why Malheur Lake is now highly susceptible to wind resuspension (Hamilton et al., 1986; Spencer, 1994; MNWR, 2012).

CHANGE IN MALHEUR LAKE IS OCCURING


Malheur Lake summer 2021 in the midst of drought.

During the low water years of 2021-22 the lake was reduced to approximately 2000 acres of sheetwater. The low water conditions were ideal for germination of cattails, bulrush and other facultative plants. To further facilitate survival of these seedlings the vast majority of carp either died due to shallow water or were removed by electroshocking. The resulting establishment of thousands of acres of emergent vegetation provided significant restoration to waterbird habitat for Malheur Lake. During the winter of 2022-23 there was a large snowpack and water from both the Blitzen and Silivies Rivers refilled the dry lake to an optimal area of about 25,000 acres. Although there was a large portion of the center of the Lake that contained some turbidity, much of the rest of the lake had clear water and vast areas of submergent vegetation among the submergent vegetation. Many thousands of acres of emergent growth including dense patches of bulrush, cattails and bur-reeds established by seed in the previous years expanded vegetatively.


Malheur Lake thriving with vegetation providing food for hundreds of thousands of birds.

As predicted, with significant expansion of emergent vegetation, the number of birds nesting during spring, summer and fall of 2023 increased significantly. Turbidity in the middle of the lake was much lower than previous years, however this allowed sunlight to enter the water column causing

An underwater scene from Malheur Lake of Horned Pondweed and other healthy, thriving underwater vegetation. Photos by Conrad Gowell.

algae including potentially toxic blue-green algae to take advantage of the lake's eutrophic condition and bloom in portions of the lake. Algae blooms are occuring in areas where there is not emergent or submergent vegetation utilizing those nutrients.

The decrease in carp, increase in vegetation growth and clear water is an exciting window into what Malheur Lake wetlands could look like in the future. From these successes, the partners wish to push forward with actions to maintain and build on the restoration of the wetland system to increase the area of emergent vegetation and clear water. If there ever was a time to push the lake into ecological change from a turbid to clear state we are as close as we have ever been.

Recent research on the factors affecting emergent vegetation establishment (Boos, 2023) help to identify restoration approaches. The research documents that there is an abundant seed bank in the lake sediments. The work also explores the effectiveness of windbreaks and other protection measures to assist in emergent plant establishment. A lot was learned about how soil moves and builds up behind structure during dry years and how we might be able to take advantage of that to create future lake bottom topographic heterogeneity.

An emergent vegetation plot at Malheur Lake.

With broad scale establishment of emergent vegetation over the past two years, the challenge is to maintain and enhance the active spread of marsh conditions in Malheur Lake.

Evaluation of the sediment source from the Blitzen River and management of flood irrigation and pond management on the Blitzen floodplain will need to consider the effect of floodplain management on Malheur Lake wetlands.

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Flood irrigated wet meadow in the Harney Basin provide habitat for resident and migratory birds as well as hay for local cattle ranches. Photo by Brandon McMullen.

FLOOD-IRRIGATED WET MEADOWS

In the original 2015-2021 strategic action plan for HBWC conservation targets for spring migratory bird habitat were established based on North American Waterfowl Management Plan population targets for northern pintail in the SONEC region in combination with U.S. Geological Survey bioenergetics modeling to calculate habitat acres needed to support the target population. It was estimated through these modeling efforts and field studies that evaluated the foraging value of flood-irrigated habitats, that a minimum of 10,300 acres of Harney Basin flood-irrigated wet meadow habitat is necessary to support target populations for this species. Currently the minimum acreage is met but maintaining and enhancing acres is a high priority.

Looking at the Harney Valley wetlands in a broader perspective, the maintenance and management of flood-irrigated wetlands has importance beyond the needs for a single species. Under a changing climate regime it is important to develop management approaches to optimize the available runoff for wet meadow habitats for birds and forage production. There are wet meadow habitats in nearly all of the streams that enter the Harney Valley. Most of the lower reaches of the tributary streams have been altered to facilitate flood irrigation for cattle fodder which has expanded spring wet meadow habitat that provides invertebrate and other food for migrating birds.

During spring migration, the Silvies River floodplain supports high numbers of migrant waterfowl. A study conducted by the USFWS in the late 1970s and early 1980s found that 56 percent of the waterfowl use in the Harney Basin occurred on the private lands of the floodplain during the spring. Scientists from the U.S. Geological Survey have documented the importance of such flood-irrigated areas in southeastern Oregon and northeastern California; these areas support about 80 percent of the Pacific Flyway Northern Pintails during spring migration (Miller et al. 2010). More recently, the dependence of spring migrating dabbling ducks moving through the Oregon SONEC was further reinforced by tracking migration stopovers of Cinnamon Teal (Mackell et al., 2021).

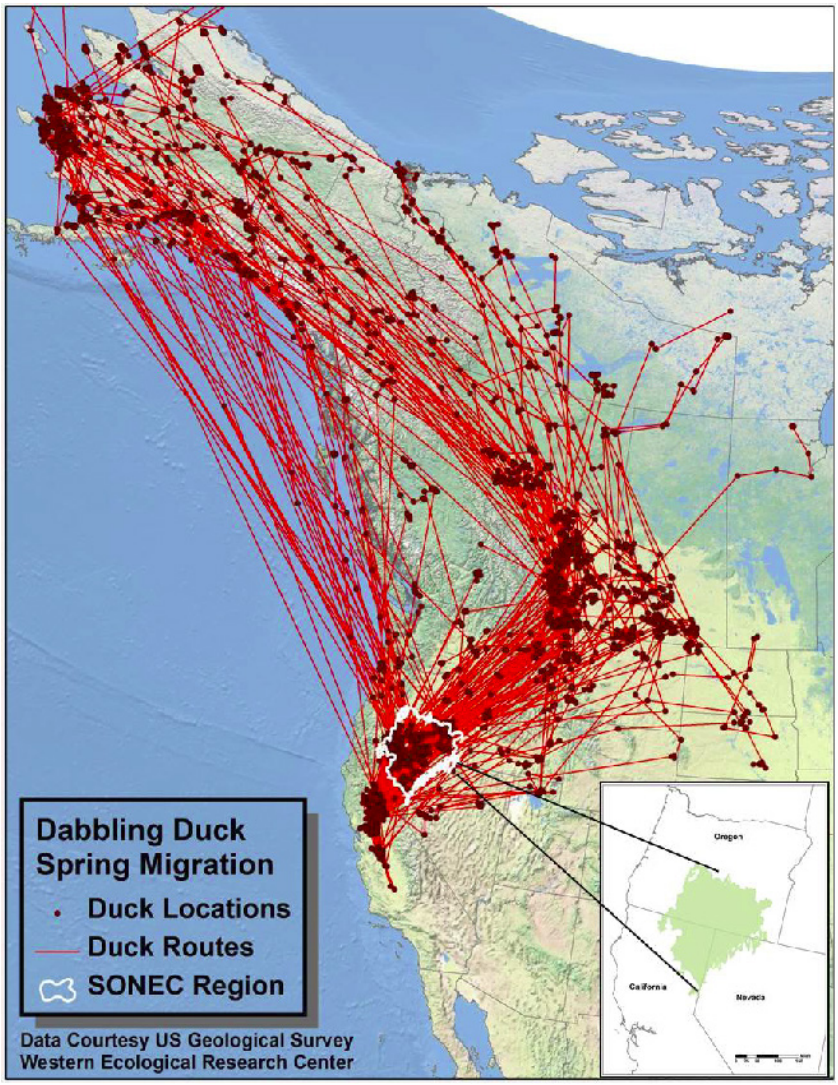

Figure 15. Spring migration routes by strategy category of adult female Northern Pintails PTT-tagged in the northern Central Valley of California during December-January and tracked annually through August each year 2000-2003 (Michael R. Miller, 2005).

Northern Pintails, as well as most other waterfowl, saw a sharp decline in numbers in the late 1970's and early 1980's. Urbanization and changes in agricultural practices throughout the continent created a habitat deficit. This deficit in conjunction with continent wide drought conditions in the 1970's and 1980's led to the sudden decline of these migratory birds. While there has been a recovery of numbers, the threats remain with changing climate and irrigation conversion. Emerging research is demonstrating a strong correlation between Northern Great Basin snowpack and breeding success in the northern prairies, presumably a function of snowmelt and resources made available on seasonal flood-irrigated wet meadows.

Within the Pacific Flyway management region, there are 14 areas of concern named in the NAWMP. The intermountain west contains six of these regions (NAWMP, 2018). IWJV named the Great Salt Lake and the SONEC regions as their two top priorities in their 2013 plan. It is estimated that about 50% of the Northern Pintail continental population uses the Pacific Flyway. Of those birds, approximately 70% (1/3 of the continental population) pass through the SONEC region before heading north either following the Rockies or west of the Cascades (Fleskes and Gregory, 2010; Figure 6). It is the food resources in the flood-irrigated pasture and hay land that keeps these birds returning annually (Beatty et al., 2014).

More recent evaluations of wetland change in the southern Oregon, Nevada and eastern California areas have further documented the importance of privately managed wetlands (Donnelly et al., 2019). The authors conclude: "Patterns indicate privately owned flood-irrigated hay meadows, first settled in the late 1800s for their persistent water resources (Sauder, 1989), remain a major driver of habitat abundance seasonally. Hay meadow sites were unique in that they were confined to riparian floodplains and lowlands." Today, 61% of snowpack driven wetlands occur on privately owned agricultural lands, and of all irrigated lands only 7% provide this critical wetland value (Donnelly et al., 2020). The flood-irrigated wet meadows of the Harney Basin are part of this 7% irrigated agriculture footprint. The large percentage of that footprint that falls under private ownership is part of what makes conservation efforts of wet meadow habitats so complex from a socioeconomic standpoint.

A tool to evaluate the hydroperiod of wetlands at a scale has been developed using Landsat imagery that can be used to connect plot data with basin scale patterns. Past HBWC efforts to document the plant communities that exist in flood-irrigated wet meadows, and the bird populations that utilize them, can now be evaluated through the lens of seasonal water persistence on the landscape to link surface water presence, plant communities, and wildlife use.

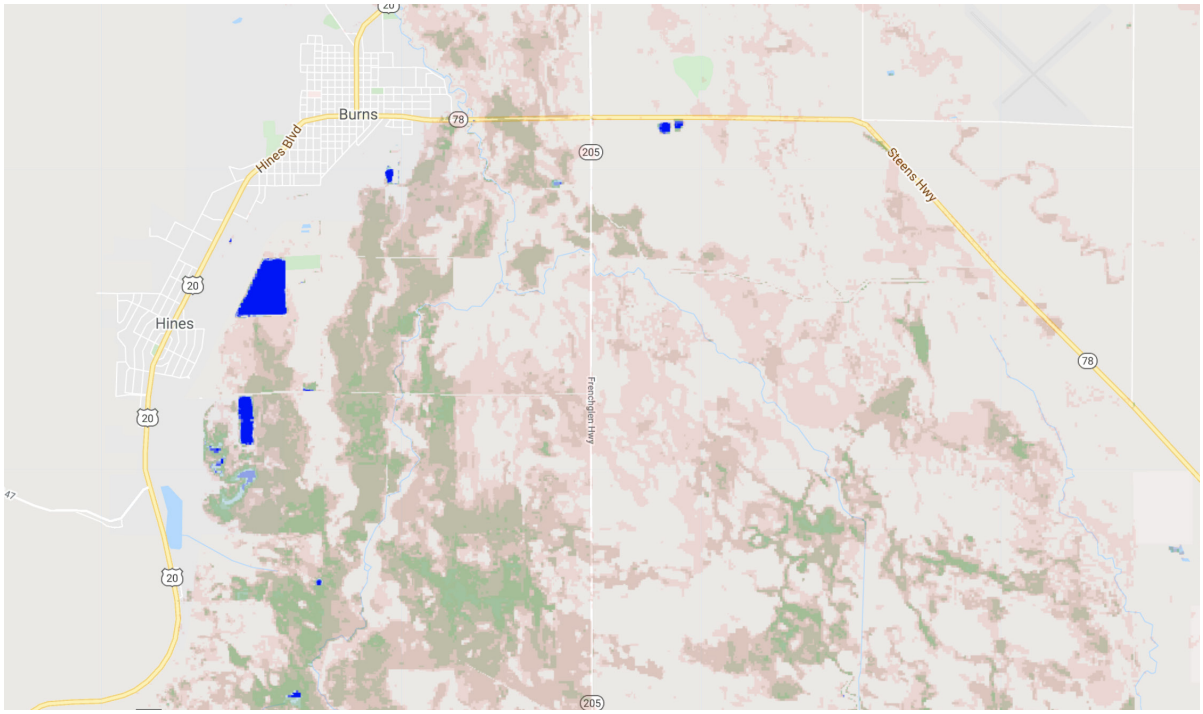

Figure 16 & 17. Hydroperiod data is being used to help with land management. This is one example of some data showing the hydroperiods on the Silvies River floodplain. Mean 2015-2019. Pink-temporary (flood=<2months); green-seasonal (flood>2 and =<7months); blue-semi-perm wetlands(flooded>7months). Provided by Patrick Donnelly 2020.

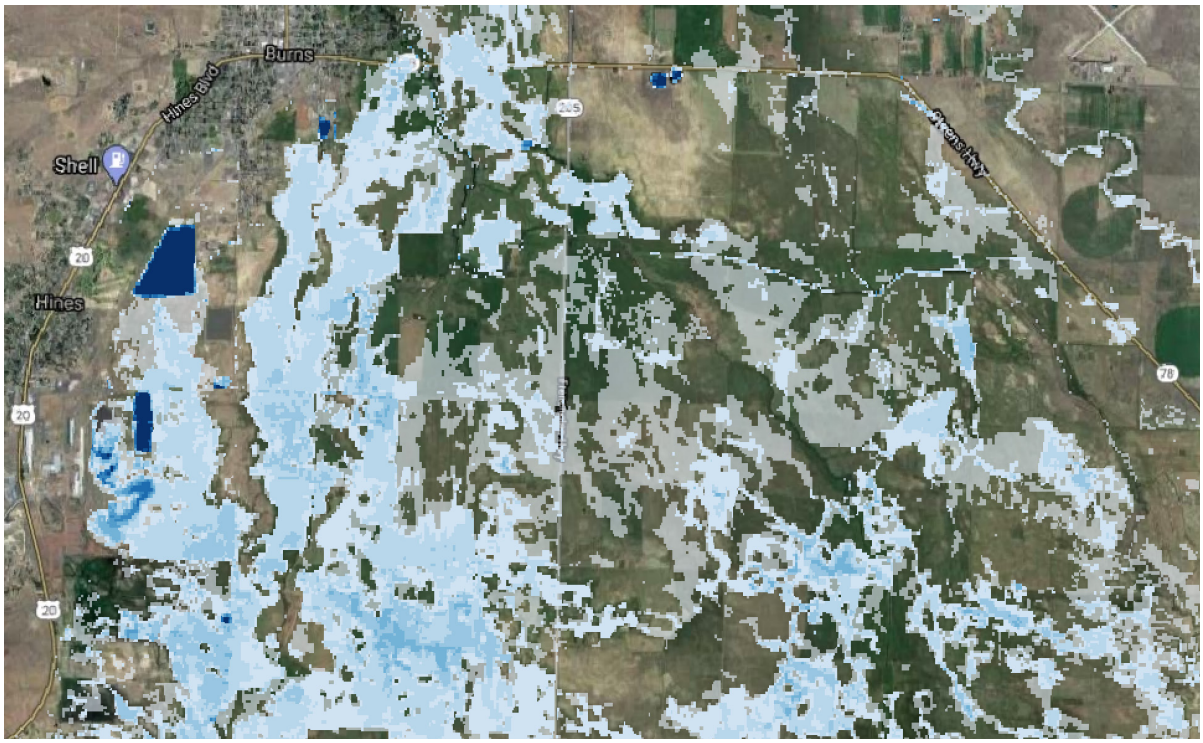

Figure 17

Donnelly and others (2019) concluded that to maintain migratory pathways land managers must maintain dynamic wetland systems. “Our findings emphasize the joint role of public–private wetland resources in supporting migratory waterbirds. While the focus of this work is placed on waterfowl, outcomes are applicable to conservation of all migratory waterbird species. In arid landscapes, predictions of increased climate variability are likely to intensify resource bottlenecks (e.g., fall migration) triggering temporal mismatches in wetland flooding and energetically demanding migration events (e.g., Maron et al., 2015). To bolster landscape resiliency, we encourage development of conservation strategies that maintain wetland function aligned with migratory waterbird needs and timing.” A recent evaluations of climate change on wetland systems in the SONEC identify the changes in wetland types from semi-permanent to seasonal to temporary based on the duration of inundation (Donnelly et al., 2022) and conclude: “Our findings suggest that drought effects are ubiquitous and can impact wetland function regardless of underlying hydrologic mechanisms (e.g., managed or natural)”. The authors (Donnelly et al., 2022) also conclude: “Projected changes are likely to force tradeoffs in water use priorities that could intensify ecological risks already identified in our analysis. Under these scenarios, it will become increasingly important to consider adaptations that preserve ecological and anthropogenic (e.g., flooded agriculture) mechanisms supporting wetland resilience. Emerging solutions include increased recognition of ecosystem services provided through beneficial agricultural practices by giving producers economic incentives to maintain flood irrigation”.

The emphasis on managing water use for a variety of outcomes such as plant community composition, surface water persistence and timing, and maximum productivity has become a significant driver of strategies for further conservation of wet meadow systems. The work of the last few years has focused on building understanding of vegetation-hydrology relationships through the construction of state and transition models where the driving factor is hydrology. Restoration work has primarily focused on improving water management infrastructure to provide a win-win scenario where private landowners gain greater management flexibility of water distribution, reducing the threats of conversion to alternative land uses. The work has led to a more holistic view of the human development activities that has changed water distribution across the Silvies River floodplain

The relatively rapid expansion of reed canary grass in the flood irrigated wet meadows causes concern both for ranch forage production and for bird habitat quality. The Wet Meadow Partners are working with private landowners and public land managers to explore water management and other management activities to reduce or reverse reed canary grass expansion and control its growth. At the same time they are working with Portland Audubon to monitor bird use to develop a better understanding of the habitat factors that affect bird use in flood irrigated wet meadow systems.

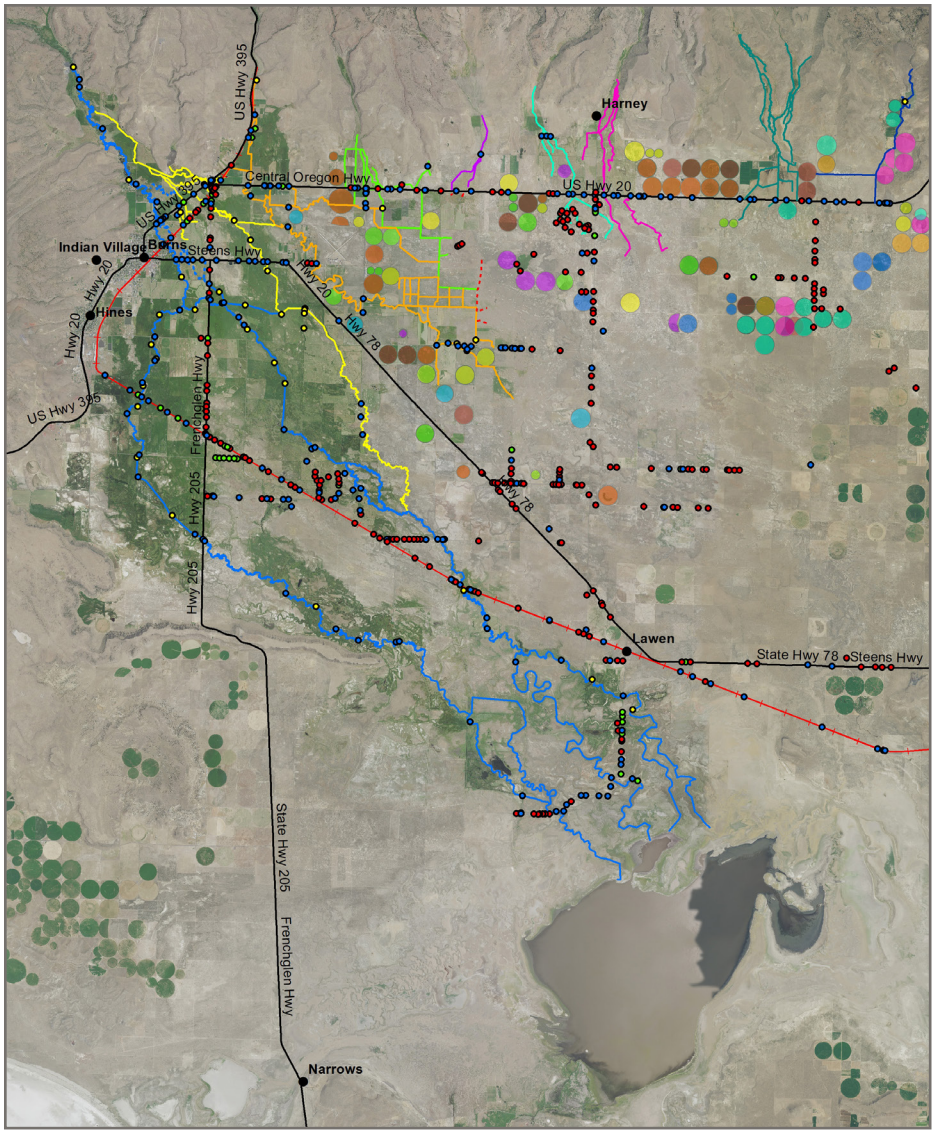

Figure 18. Silvies River Floodplain Alterations (2016 NAIP imagery)

Blue dots: surface conveyance infrastructure.

Red dots: surface conveyance obstructions; could be roads, levees, etc.

Green dots: unknown whether there is infrastructure (culvert) or not.

Yellow dots: dam or diversion infrastructure.

Blue dotted lines: historical channels that are no longer active.

Red lines: suspected drain ditches.

Solid lines: respective stream systems, based on interpretation, separated by color.

Pivots: as they emerge on Google Earth imagery across a timescale from pre 1994 through post 2016, starting in yellow and transitioning through aqua, green, yellow, orange, red, grey, and white as time goes by, with white being only a few years old.

HBWC is working to gain a more comprehensive understanding of the complexity of water flow across the altered floodplain through several avenues. This work will identify restoration opportunities and limitations. For example, there is no map of all the current infrastructure in the basin. Many roads have undersized culverts flowing under them that are changing the way water flows across the landscape. Nearly all the floodplain area of interest is on private lands; it will require considerable effort and partnerships to improve and restore natural hydrology where feasible (Figure 18). A flood flow model is being developed for the Silvies floodplain that will help to prioritize restoration actions to manage spring flood irrigation waters.

CLIMATE IMPACTS

It is highly possible that the impacts of climate change will affect the efficacy of restoration strategies and/or require future adaptations as conditions evolve. Fortunately, there has been significant evaluation of the potential effects of climate change on wet meadow systems (Donnelly et al., 2020; Donnelly et al., 2022; Haig et al., 2019) and Malheur Lake carp management (Pearson et al., 2020). In a review of the effects of climate change on waterbirds Haig and others (2019) state: "Regional water management strategies will need to consider the mosaic of water needs throughout the annual cycle in order to forestall loss of critical breeding grounds and a hemispheric migratory pathway". The refined understanding of the Harney Basin ecology and hydrology of these critical ecosystems built over the last few years will enable the development of restoration strategies that can be readily adopted by water users to build resilience into the changing wetland systems.

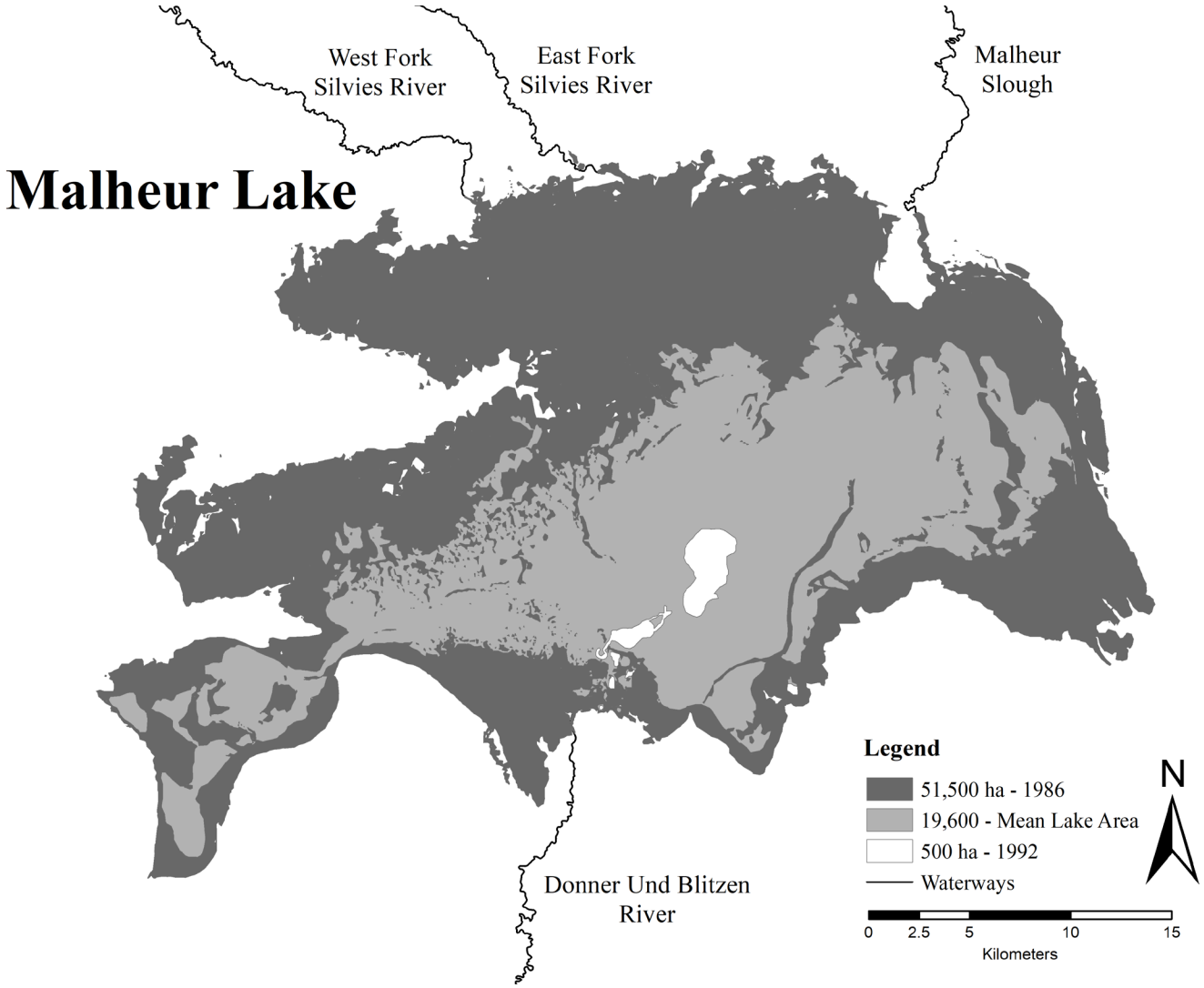

Figure 19. Map of Malheur Lake, located within the Malheur National Wildlife Refuge in Southeastern Oregon. The dark gray region depicts the maximum lake area extent in 1986 (≈ 51,500 ha), the gray region depicts the average fall lake area (≈ 19,600 ha), and the light gray region depicts the lowest lake area extent in 1992 (≈ 550 ha).

MALHEUR LAKE AND BLITZEN VALLEY WETLANDS AND CLIMATE CHANGE

Malheur Lake 2021 and Malheur Lake 2023

Malheur Lake is a large terminal wetland, which exhibits large annual lake fluctuations. For instance, in the past Malheur Lake fluctuated from ≈ 51,500 ha in 1986 to ≈ 550 ha in 1992 (Figure 19). The fluctuations in wetland area are primarily driven by precipitation runoff and evapotranspiration (Hubbard, 1975; Hamilton et al., 1986). Precipitation falls primarily as snow and accumulates in the Steens and Blue Mountains and melts in the spring and early summer. Runoff enters the lake via the Silvies and Blitzen Rivers, which drain a total area of ≈ 7,770 km2 (Hamilton et al. 1986). Malheur Lake is located within the Great Basin region of the United States where climate change projections predict a decrease in the annual snow water equivalent (≈30% decrease in SWE by mid-century in Pacific Northwest; Naz et al., 2016), and more frequent drought conditions (low spring snowpack; Lute et al. 2015), which in turn, will likely reduce the size of Malheur Lake (Dalton et al., 2018; Mote et al., 2018; Snyder et al., 2019).

A recent study on the effects of climate change on SONEC wetlands over the past 35 years (Donnelly et al., 2020) finds a significant loss of wetlands peripheral to Malheur Lake (-81%) and loss of lake area (-59%). Although these figures are especially high as a result of a record flooding and precipitation during the first year of this study (1984), the decline of wetlands over the last 35 years in the Harney Basin, mirrors wetland trends in other snowpack driven closed basins in the Northern Great Basin. These changes are correlated with significantly increased evapotranspiration, a modest decrease in snowmelt equivalent and precipitation over the 1983-2018 period. All this recent information highlights the need for better local information on specific impediments to wetland conservation, such as the correlation between snowpack and surface water availability and timing and helps to direct HBWC work to build wetland ecosystem resilience through restoration and improved water management tools to influence hydrology and associated habitat characteristics.

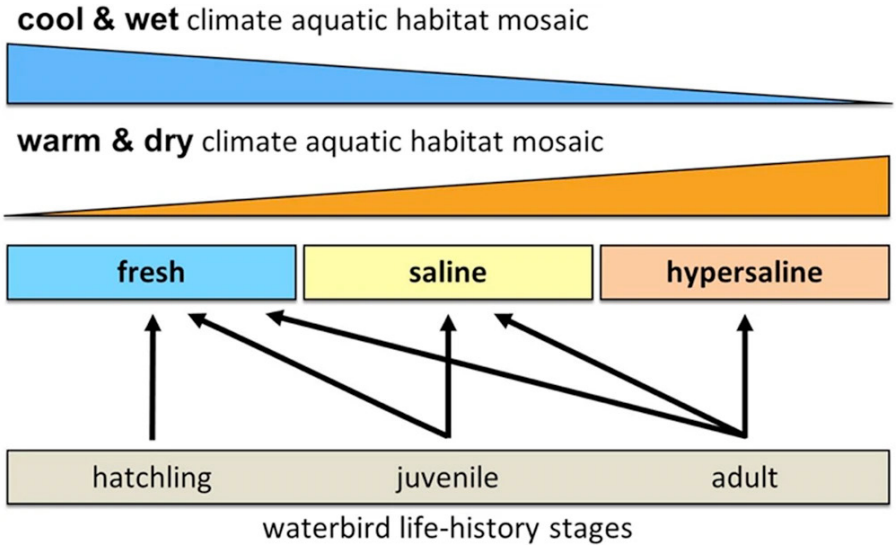

Figure 20: Hydro-climatic relationships in dry systems. Associations of climate variability with wetland water type (fresh, saline and hypersaline) and the connection to specific migratory waterbird life-history stages. The relationship between wetland type and climate illustrates the contraction of variability in wetland type during wet (blue wedge) and dry (orange wedge) years. As shifts continue toward a warmer, drier climate, the diversity of wetland types will transform. (Taken from Haig et al, 2019.)

As decreased snowpack occurs from a changing climate, Malheur Lake will respond to changing level and timing of lake levels. These changes will have an effect on the establishment of emergent vegetation. Concerns of the impacts of climate change throughout the Great Basin on terminal lakes include the potential of traditional freshwater lakes shifting towards saline lakes, and existing saline lakes becoming hypersaline lakes (Haig et al., 2019).

The generally drier conditions expected in the future may decrease carp biomass which will make carp populations easier to control; however, this may not compensate for other negative impacts of climate change on the aquatic ecosystem (Pearson et al., 2020). Drier conditions may result in desiccation of what little emergent vegetation presently exists in Malheur Lake. This could further exacerbate the already significant wind fetch problem that significantly contributes to poor water quality (Pearson et al., 2020). Following two years of low water in Malheur Lake, emergent vegetation has become established throughout the lake bed.

Greater Sandhill Cranes and livestock in the wild flood irrigated wet meadows of the Harney Basin. Photos by Brandon McMullen.

FLOOD-IRRIGATED WET MEADOWS AND CLIMATE CHANGE

Snowpack driven wetland systems appear to be more vulnerable to climate change than monsoonal wetlands in the southern end of the Central and Pacific Flyway (Donnelly et al., 2020). Snowpack driven wetlands are facing functional reductions and losses as a result of climate change. As previously noted, privately owned flood-irrigated wet meadows comprise the majority of wetland acres in closed basins. Investments on private lands will be critical for the future of wetland ecosystems. To address changing climate conditions, the partnership will expand communications with private landowners to use information developed from the state and transition models of wet meadow systems in managing irrigation water. The ongoing Harney County community-based water planning effort will be an opportunity to adjust allocation of surface water using the information on the appropriate timing, depth, and duration of flooding that optimizes bird use and pasture production. Additionally, tools for private landowners to understand the effects of water use on plant

communities and improved water management infrastructure can assist in the management of surface flood waters. To counter the effects of significantly increased evapotranspiration, modest decreases in snowmelt equivalent, and precipitation in the catchments tributary to Malheur and Harney Lakes will require careful consideration of water distribution during the spring freshets. Flood irrigation in the Harney basin is conducted on an ownership basis. Each landowner maintains and manages their own irrigation system, thus adjustments to the built infrastructure are individual decisions. However, multiple projects will be required to allow for effective water management. New tools and models will inform strategies that can identify where projects can be developed and implemented to assure flooding of core areas critical for both hay production and bird nesting and feeding. The selection of irrigation infrastructure upgrades and other projects to improve flooded habitats will focus on retaining resiliency of these critical seasonal wetland habitats.

The recent expansion of reed canary grass and smooth brome in flood irrigated wet meadow systems has raised concern about both forage quality and bird habitat quality. A significant focus of the restoration effort is to understand, communicate and adopt management practices that reduce the rate of spread, manage the structure, and/or reduce the spread of reed canary grass and other exotic species in flood irrigated wet meadow systems.

Since the flood-irrigated wet meadows are managed by private ranchers, the focus of our efforts is to provide information in a way that can influence their decision making (Sketch et al., 2020). HBWC expects that through improved economic viability of wet meadow-dependent ranches, and improved decision-making for wetland habitat managers who do not have forage production as a primary objective change in irrigation management will provide improved benefits to both ranchers and migratory birds. The overall goal is to maintain productivity and improve biodiversity of plants and animals in the face of changing climate.

From a bigger picture standpoint, this effort will also test an approach that, to the knowledge of HBWC partners, has not been attempted within the climate adaptation community. The nature of water availability is clearly going to change in the future, and managers need a way to approach that change. The information generated by this effort will be shared with water planning efforts in the area, since those efforts may impact irrigation of flood-irrigated wet meadows.

8. Theory of Change

The following results chain (Figure 21) is a graphical representation of HBWC partner's theory of change. Please note the assumed or predicted relationships between strategies, implementation results (outputs), and near- and long-term ecological results (outcomes), as well as the connections to economic and social priorities that represent HBWC/HDP broader goals.

Numbered results are those HBWC desires to integrate into a progress monitoring framework that facilitates its ability to measure progress toward both near- and long-term objectives. Each numbered result in the results chain corresponds to the same results in Tables 1 and 2 where objectives are defined and metrics or indicators are shown.

STRATEGIES

HBWC strategies fall into four general categories:

1. Improved Management of Malheur Lake and Blitzen Valley Wetland Restoration
2. Improved Management of Flood-Irrigated Wet Meadows
3. Building Knowledge for Management
4. Community Engagement

Together, these strategies are designed to advance two overarching goals:

1. Improved Management of Malheur Lake and Blitzen Valley Wetlands: restore ecosystem structure and processes necessary to return Malheur Lake to a clear water stable state supporting abundant emergent and submergent vegetation and the migratory and breeding bird species dependent on marsh habitats.
2. Improved Management of Flood-Irrigated Wet Meadows: Provide land managers with tools to manage floodplain wet meadows in the Harney Basin to support healthy bird populations, floodplain function and reduce the threat of expanding reed canary grass and other exotic plant species.

STRATEGY 1: IMPROVED MANAGEMENT OF MALHEUR LAKE AND BLITZEN VALLEY WETLAND RESTORATION STRATEGIES

CONSERVATION ACTION 1: *Enhance Emergent Vegetation Establishment Opportunity*

Theory of Change

Restoration of lake bottom microtopography creating wind barriers 1-2 and planting of emergent vegetation are intended to reduce the area of open water and therefore the reduction of wind fetch. These outcomes will contribute to a reduction of suspended sediment and an increase in water clarity E-3 directly or through a reduction in nutrients E-4 that are available for phytoplankton production. Improved water clarity E-3 will increase photosynthetic radiation necessary for emergent and submerged aquatic vegetation germination, maturation, and proliferation E-12. As emergent and submergent vegetation increases, food abundance and availability for birds and fish increases respectively. These outcomes are predicted to produce an overall increase and shift toward breeding bird populations and use E-11 for species that depend on these types of aquatic habitats in Malheur Lake wetlands.

CONSERVATION ACTION 2: *Reduce Lake Turbidity*

Theory of Change

Sediment stabilization by addition of aluminum sulfate or other measures 2-1 (alum) into the lake water column is expected to reduce nutrient concentrations E-4 and suspended sediment by promoting the formation of a floc (when alum binds to phosphates) that then settles to the lake bottom where it is unavailable for phytoplankton production. The resulting reduction in phytoplankton will improve water clarity E-3. Reduced suspended sediment contributes to an increase in submerged aquatic vegetation E-12, habitat for birds E-1, and aquatic invertebrates that are an important food resource for birds and fish. Explore ways to reduce sediment input from the Blitzen River.

CONSERVATION ACTION 3: *Reduce Carp Population*

Theory of Change

Implementation of carp control measures including actions to limit carp reproduction 3-1, constructing barriers to prevent carp access to the lower Blitzen River to spawn will reduce the population growth. During low water years carp move from the wetlands of Malheur Lake into the lower Blitzen River. Providing an electronic barrier will both prevent access to the lower river and increase the opportunity to remove carp as they accumulate at the barrier 3-2, and the active removal or harvesting of carp 3-3 will result in a reduction in the spatial distribution and overall biomass of carp E-3. Fewer carp across a smaller spatial extent will contribute to an overall increase in water clarity E-5 by reducing suspended sediment.

Improved water clarity E-3 will increase photosynthetic radiation and increase the abundance and spatial extent of aquatic vegetation E-12. As emergent and submergent vegetation increases, food abundance and availability for birds and fish (in the form of aquatic invertebrates) increases. These outcomes will produce an overall increase and positive shift in the relative abundance of bird populations and use E-11 for species that depend on these types of aquatic habitats in Malheur Lake and an increase in growth and productivity of native fish species. In addition, an increase in invertebrates that consume phytoplankton will also contribute to an increase in water clarity E-3.

CLICK TO LEARN MORE

A new and novel approach to controlling invasive fish species has been developed. The approach is to alter the genetics of the species so that a single sex is produced from breeding animals. While the trial in trout species has been successful in a local area, the genetics work has not been completed for carp. As the genetic work and hatchery development of a single species breeding population is developed in the near future, Malheur Lake and tributaries will be an ideal place to implement such an approach. Early communications have determined that the funding for the genetics work and hatchery production has been developed, a trial effort in Malheur Lake could be the first field trial.

CONSERVATION ACTION 4: *Formulate New Strategies*

MALHEUR LAKE AND BLITZEN VALLEY WETLAND MANAGEMENT

HBWC and the MNWR will continue to learn from all restoration efforts, current research on emergent vegetation establishment, carp research, and water quality data. Planned and ongoing mesocosm study will show which strategies are working and which need improvement. The wetlands are a very dynamic system that presents difficulties in predicting outcomes of management efforts.

Future water management strategies to be explored:

- Explore Lake management alternatives that include physical changes to the lake,
- Create "living" bulrush wind barriers,
- Reestablish emergent vegetation,
- Abate sediment.

STRATEGY 2: FLOOD-IRRIGATED WET MEADOW MANAGEMENT

The flood-irrigated wet meadows in the Silver Creek, Silvies River, and other tributary streams to Harney and Malheur Lakes are critical for migratory and breeding birds and other wildlife and for the ranching community forage and hay production. HBWC partners will continue efforts to maintain flood-irrigated land use and respective wet meadow habitat and processes on private lands and on lands managed by the MNWR. Flood-irrigated wet meadows on private lands support spring migration habitat water birds, breeding habitat for some birds. Managed wet meadows on MNWR lands are intended to provide breeding and migrating habitat for both water and land birds. Actions on both private and MNWR lands may also include improvements for fish passage in conjunction with irrigation infrastructure upgrades where needed and possible. Management of invasive grass species such as reed canary grass, smooth brome and others to maintain quality bird habitat and forage is a critical approach to the flood irrigated wet meadow strategy.

CONSERVATION ACTION 5: *Improve Water Management Infrastructure*

This strategy focuses on improving flood irrigation infrastructure so that it is safe to operate, efficient, and allows for optimal water management and improved fish passage 5-1.

A new concrete diversion structure to more effectively move water to the head gate in the distance. The head gate can be opened as needed to flood the meadow with water that lies beyond the gate. Photo by Jeremy Hill, jhillimages.com.

Theory of Change

Upgrading flood irrigation infrastructure will improve operator safety and efficiency with which water can be effectively managed for multiple uses 5-2 including the maintenance (or expansion) of shallow water flood-irrigated wet meadows E-6. Using the flood model being developed, priority impediments to efficient flow and management of flood waters across the Silvies floodplain will be identified. This will provide a tool to work with the many historic alterations to the floodplain that affect flood irrigation and bird habitat.Effective water management and maintenance of flood-irrigated wet meadows will reduce the drivers of wet meadow habitat loss on private lands in part because these will improve or maintain the profitability of forage production, reducing the incentive to convert flood-irrigated meadows to other land uses. Maintenance or expansion of shallow water flood-irrigated wet meadows through improved water management will result in the habitat of sufficient quantity and quality to support current or increasing use and abundance of target migratory waterbirds on both MNWR and private lands across the Harney Basin E-10. Increased operational flexibility of irrigation systems will also allow water to be managed in a way that inhibits invasive plant species and promotes desirable vegetation. A reduction of the extent of invasive plants E-7 promotes the abundance and diversity of native and desirable non-native plant associations E-8 and the maintenance or expansion of areas of wet meadow with short stature vegetation in the spring E-9 needed to provide habitat for target migratory waterbirds.

Fish passage improvements 5-1 will also be integrated into irrigation infrastructure upgrades to contribute to an increase in the resilience of native fish populations. For example, the state sensitive Great Basin redband trout use ephemeral and perennial streams to migrate and spawn as well as seek thermal refuge during times of drought.

CONSERVATION ACTION 6: *Formulate and Implement Targeted Management Strategies*

This strategy constitutes actions defined by a management tool or guide 6-2, the state and transition model. Actions include weed treatment 6-1 or water management approaches that inhibit invasives and promote desirable vegetation and agricultural management practices in flood-irrigated wet meadows associated with hay production or grazing that contribute to improved meadow conditions as it relates to bird habitat and forage quality. One of the primary threats to bird habitat and forage quality is the expansion of reed canary grass and other exotic grass species. Management to minimize and/or reduce the effect of these species will be a focus of this strategy. The management actions will vary from water management, grazing management, to mowing or other physical management activities

Other actions (to be defined) 6-3, 6-4 will be implemented to reduce drivers of wet meadow habitat loss on private and MNWR lands.

Theory of Change

The development of a management tool or guide based on a state and transition model will inform weed treatments and water management actions to reduce the extent or expansion of invasive species E-7 and therefore maintain or increase the abundance and diversity of native and desirable non-native species E-8. A reduction in invasive species E-7 also promotes the acreage of flood-irrigated wet meadows with short stature in the spring E-9. These are outcomes needed to increase wet meadow habitat of sufficient quality and quantity to support an increase in the abundance and use of target bird species on private and MNWR lands E-10.

TRIBUTARY RESTORATION STRATEGIES

CONSERVATION ACTION 7: *Riparian and Channel Evaluation and Enhancement*

Theory of Change

There is no uniform assessment of riparian conditions across the Harney Basin. Enabling a uniform approach to assessing conditions using a common methodology would provide the opportunity to identify priorities for management changes and restoration actions. The recently developed Threat-Based Land Management in the Northern Great Basin for Creeks, Streams, and Rivers could be used for a consistent methodology.

Actions to consistently evaluate and enhance riparian areas tributary to Malheur and Harney Lakes 5-1 will be used to increase the extent of riparian vegetation E-1 which stabilizes streambanks and reduces erosion and subsequent sediment inputs into the stream and ultimately improving Malheur Lake water clarity E-3. Riparian enhancement also contributes to a reduction in nutrient inputs and concentrations in Malheur Lake E-4 and associated phytoplankton and cyanobacteria production in the lake. A reduction of sediment inputs and nutrients therefore contributes to an increase in the lake's water clarity E-3.

Stream channel enhancements designed to raise the bed elevation will consequently raise the water table E-2. An elevated water table contributes to the maintenance and increase in the area of flood-irrigated wet meadows. This outcome contributes to improving the profitability of forage production on private lands and the development of habitat quality necessary for migrating waterbirds on private and MNWR lands and therefore contributing to the increased use and abundance of target birds of flood-irrigated wet meadows across the Harney Basin E-10.

An elevated water table E-2 also increases the duration and discharge of water in stream systems that support habitat necessary for sustaining native fish populations and increased resiliency in the face of climate change (Silverman et al., 2019).

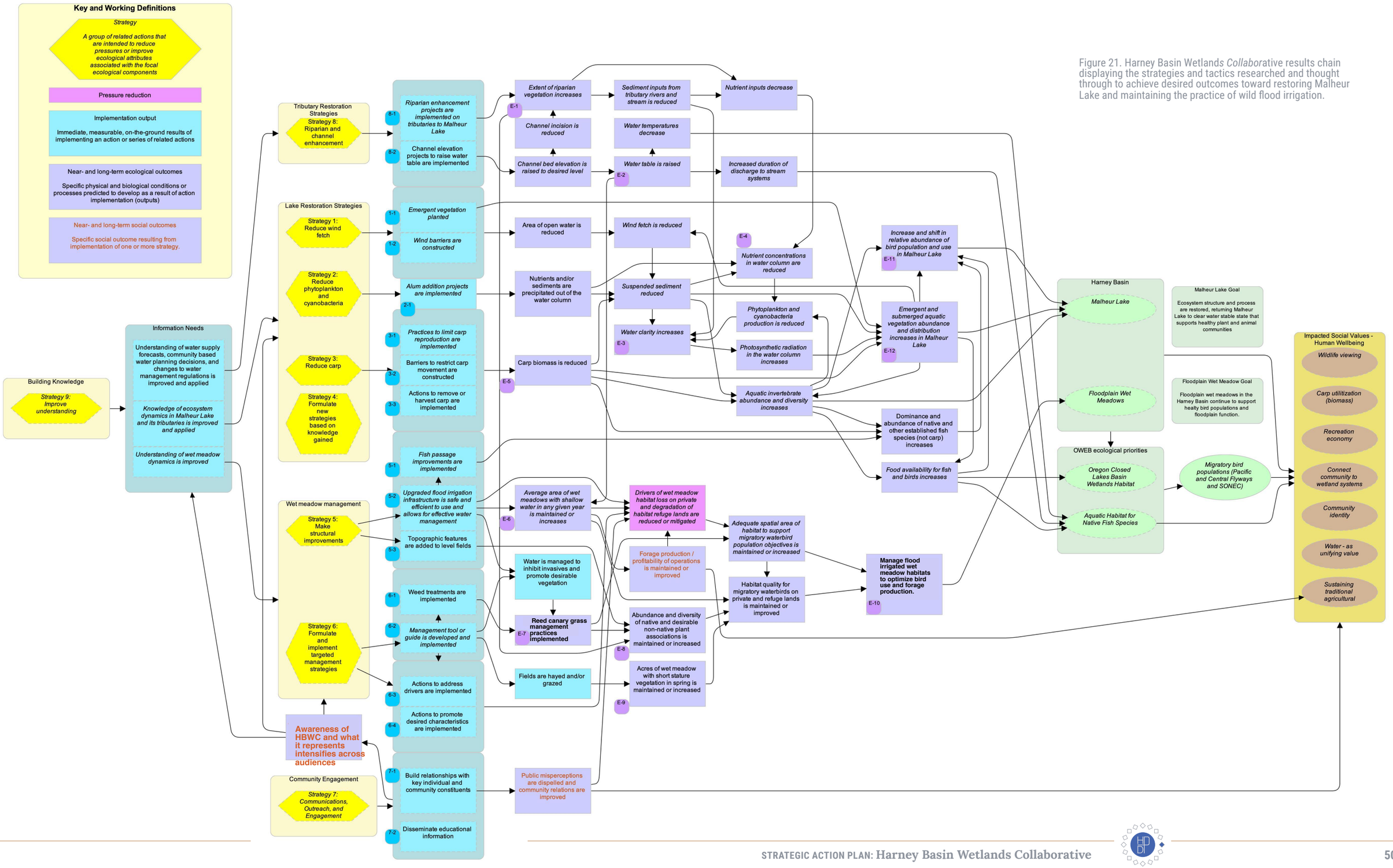

Figure 21. Harney Basin Wetlands *Collabor*ative results chain displaying the strategies and tactics researched and thought through to achieve desired outcomes toward restoring Malheur Lake and maintaining the practice of wild flood irrigation.

STRATEGY 3: BUILDING KNOWLEDGE TO SHARE STRATEGIE

CONSERVATION ACTION 8: *Improve Understanding*

This strategy is designed to maximize the likelihood of successful implementation of all restoration strategies by ensuring that critical information gaps are filled, and actions are designed based on the most current understanding. Specific areas of knowledge needed to inform action include:

Understanding of water supply forecasts, community-based water planning decisions, and changes to water management regulations.

Knowledge of ecosystem dynamics in Malheur Lake and its tributaries:

- Carp dynamics, wind, emergent vegetation loss, sediment and nutrient inputs.
- Improved understanding of seasonal snowpack and snowmelt relationships:
- Water timing and duration.
- Learning appropriate agriculture and ranching practices that reduce water consumption, reduce or control exotic grass invasion and increase production.
- Understanding of how ecological improvements are linked to economic and social outcomes.
- Knowledge of climate change impacts and mitigation strategies.

STRATEGY 4: COMMUNICATIONS, OUTREACH, AND ENGAGEMENT

A new event for the Harney County Migratory Bird Festival, a Wetlands Happy Hour took place Thursday April 13, 2023 as the annual Harney County Migratory Bird Festival got underway. Thanks to several Harney Basin Wetlands Collaborative partners it proved to be a fun and educational event about why birds use some areas more than others; what entices birds to rest and nest at different locations in the Harney Basin and a bit about wet meadow restoration that is enhancing this habitat and agriculture land.
Photos by Brandon McMullen.

Theory of Change

Community support and engagement is necessary to advance all these strategies. Community stakeholders will be engaged through a series of ongoing educational and awareness activities, direct communications, landowner outreach, and community events. 7-2 Through this engagement the aim is to broaden public awareness of HBWC's purpose, goals, and activities to build greater trust and expand community support for the long-term stewardship of Harney County's ecosystems and local economy. Relationships built through outreach activities 7-1 will help keep people informed, dispel misperceptions, deepen understanding of conservation challenges, and bolster community engagement needed to mitigate the drivers of wet meadow habitat loss on private and MNWR lands. Examples of a communication effort aimed at building community buy-in can be found in this story about infrastructure improvements at LY Ranch and this story about Sweek and Tyler dam replacements. Published in the local newspaper, shared through social media and HDP's website, these stories showcase the win-win scenarios that infrastructure improvement projects can provide for flood irrigators and wetland conservation.

Greater community awareness, attention, and trust will lead to improved wetland conditions for migratory and resident birds because the buy-in, support, and social license will exist to move forward with the conservation strategies identified in this document, as well as bolster Harney County's ranching community directly by maintaining the practice of flood meadow irrigation through investment in flood irrigation infrastructure. Furthermore, participation of private landowners will increase from existing partnerships. The groundswell of public interest and support for reviving Malheur Lake to a healthier state will positively influence management decisions as they are explored, tested, and implemented.

Influencing communications efforts will also be participation with local workgroups, like the Harney County Watershed Council and the Burns Paiute Tribe's Ad Hoc Water Committee. Partnerships with these groups will add to the core knowledge of HBWC and impact communication strategies and tactics. For example, the Harney County Watershed Council's community-based water planning collaborative has an ecological working group that is helping bring awareness to groundwater-dependent springs in the basin.

As relationships with key individuals and community constituents are strengthened, increased support from stakeholders, partners, and the general public will increase as more people see themselves playing a role in advancing HBWC, and how this work fits into the larger HDP framework of working together. This result supports successful implementation of all restoration strategies and improves the likelihood of achieving desired long-term and sustainable outcomes.

9. Progress Monitoring Framework

BACKGROUND

Closed lake basin wetland conditions change with annual precipitation and are affected by water management and changing climate. The high level of variability creates a challenge to monitoring changes from conservation actions by measuring wetland area alone. The challenge is exacerbated by limited knowledge of the ecological processes affecting closed basin wetlands.

Given the challenges, HBWC has closely linked conservation actions to research on basic ecological interactions to adapt management as ecological information grows. Recognizing the complex drivers of wetland conditions, the HBWC is adopting a large- scale wetlands monitoring tool developed by the IWJV. The Wetland Evaluation Tool will be modified for use at the Harney Basin scale to track changes both annually and seasonally (spring migration season, summer molt season, fall migration season).

Wetland conditions will be documented in relation to climatic inputs and restoration activities. The application of seasonal evaluation of wetland type (temporary, seasonal, semi-permanent) will track changes related to seasonal water availability, water management decisions, and restoration actions. The relationship between wetland types and their timing, and the habitat needs for waterbird guilds will document wetland system change from both natural condition changes and restoration actions.

STRATEGY 1: IMPROVED MANAGEMENT OF THE MALHEUR LAKE AND BLITZEN VALLEY WETLANDS MONITORING

Management of water in the lower Malheur Lake and Blitzen Valley Wetlands is dominated by the MNWR. Management of the wetlands of this area is guided by the refuge's Comprehensive Conservation Plan and refined evaluations of wetland conditions. As management directions are revised, the progress will be documented. The conservation actions to manage carp, and reconnect the river to its floodplain and maintain wetlands and ponds for waterbirds will be evaluated. An integrated monitoring program that evaluates water quality, submerged aquatic vegetation, emergent vegetation, fish abundance, and bird use will be deployed at two locations in Malheur Lake that are inundated year round. Similar protocols will be employed in locations where the lake shore is intermittently exposed with additional shorebird surveys. Sediment delivery from the Blitzen River will be evaluated as to the location of sources to identify restoration priorities. Ice disruption to emergent vegetation will be evaluated to identify appropriate locations for emergent vegetation restoration Carp abundance will be tracked by harvest results.

STRATEGY 2: IMPROVED MANAGEMENT FLOOD-IRRIGATED WET MEADOW MONITORING

Management of the wet meadows of private land ranches depends on annual precipitation, infrastructure conditions, and water management. These factors determine both the extent of wetlands and habitat conditions of the wetlands.

Table 2. Implementation Results, Ecological Objectives, and Measurement Metrics for Blitzen Valley and Malheur Lake Wetlands.

Implementation Results (Key Outcomes)	Ecological Objective	Measurement Metric
1-1: Emergent vegetation planted	3000 hectares of emergent vegetation is planted by 2035	Hectares of emergent vegetation established
2-1: Alum addition projects are implemented	Reduce phosphorus levels in Malheur Lake by 25% by 2028	Volume Alum added
3-1: Implement carp control through genetic modification for same sex carp.	Practices to limit carp reproduction & recruitment are implemented by 2029	Practices implemented
3-2: Barriers to restrict carp movement into Blitzen River are constructed	Barriers to restrict carp movement are implemented by 2026	Barriers constructed. Annual assessment of the carp population
3-3: Actions to remove or harvest carp are implemented	Actions to remove or harvest carp are implemented by 2024	Actions implemented
5-1: Riparian enhancement projects are implemented on tributaries to Lake Malheur	Nutrient input to Malheur Lake is reduced	Nutrient discharge to Malheur Lake (kg/day)
5-2: Channel elevation projects to raise water table are implemented	Flood irrigated wet meadow habitat is improved or enhanced (i.e. management capabilities and efficiencies, improved seasonal duration, species composition, etc.)	Channel miles restored
I-2: Lake bottom topography modified	10 wind fetch reduction projects are completed by 2026 and emergent establishment environment created	Wind barriers are constructed
7-1: Build Relationship with key individuals and community constituents	Ten new community constituents and individuals engaged by 2028	Number of new partners
7-2 Disseminate educational information	Educational information regarding the benefits of flood irrigation are developed and disseminated by 2028	Number of educational pieces developed

Table 2

Table 3. Ecological results and metrics for effectiveness monitoring. The result numbers correspond to results shown in the results chain (Figure 21) and theories of change. Given the ecosystem complexity, continued assessment and planning will be required to support development of specific, measurable objectives for the desired ecological outcomes. Objectives in this table are italicized to reflect that they may be refined in the future.

Limiting Factor Reduction or Intermediate Ecological Outcome	Working Objective	Potential Metric
E-1: Emergent and submerged aquatic vegetation abundance and distribution increases in Malheur Lake	Objective E1.1: Spatial distribution of emergent vegetation increases to 3000 hectares by 2028 Objective E1.2: Spatial distribution of submerged aquatic vegetation increases to 500 hectares by 2028	Area (acres/hectares) of vegetation expansion
E-3: Water clarity increases	Objective E5.1: Turbidity (NFU) of Malheur Lake decreased by 50% by 2028	Continuous monitoring of SSC – mg/L
E-4: Nutrient concentrations in water column are reduced	Objective E8.1: Phosphorus concentrations in Lake Malheur are reduced 25% by 2028 Objective E8.2: Nitrogen concentrations in Lake Malheur are reduced 25% by 2028	mg/L of Phosphorus (Total P)
E-5: Carp biomass is reduced	Objective E12.1: Biomass of carp is reduced to 50kg per hectare by 2030	Density (Kg / Hectare)
E-6: Annual wetland type (semi-permanent, seasonal,and temporary) change	Objective E7.1 Change in spatial extent of seasonally ponded water and wetland types related to annual precipitation	Area of wetland type vs. annual precipitation
E-7: Reed canary grass management practices implemented	Objective E6.1: Spatial extent of invasive species rate will be lowered by 2026.	Amount of change in reed canary grass cover

Limiting Factor Reduction or Intermediate Ecological Outcome	Working Objective	Potential Metric
E-8: Abundance and diversity of native and desirable non-native plant associations is maintained or increased	Management actions to promote desirable plant associations are implemented.	Number of increased desirable plants
E-9: Acres of wet meadow with short stature vegetation in spring is maintained or increased	Adequate acres of hayed or grazed working wet meadows are maintained in the basin to support migratory water birds	Average hectares of wet meadows with shallow water (1-18 inches) in a year
E-10: Manage flood irrigated wet meadow habitats to optimize bird use and forage production.	Objective E4.1: Bird use and abundance in wet meadow habitat is monitored in correlation with habitat characteristics to improve understanding of bird habitat requirements and preference	Bird use by species Bird abundance
E-11: Increase breeding bird use of Malheur Lake wetlands	Objective 10.1: Increased wetland vegetation (submergent and emergent) increases breeding bird habitat.	Breeding bird species and abundance

Table 3 (cont.)

10. Adaptive Management

Conducting water quality testing and aquatic vegetation surveys at Malheur Lake summer 2023.

Strategies change all the time—that is adaptive management. Practicing adaptive management is the process of using monitoring to improve management decisions over time to examine different management alternatives (Reever-Morghan et al. 2006). The process incorporates management objectives, monitoring, analysis of data, and decision-making to determine the best course of action as management progresses. HBWC partners have been on the frontline of learning-by-doing to adaptively manage Harney Basin wetlands as a collaborative group. Quarterly meetings are held with data reviews and latest research findings shared. HBWC meeting participation is consistently strong leading to valuable discussions that guide the adaptive management process with shared science that has been developed with and by HBWC partners.

Adaptive management promotes flexible, informed decision-making, allowing for necessary adjustments to be made as outcomes from management actions and other events are better understood. In addition, adaptively managing across ecological, economic, and social factors has added a layer of complexity for how decisions are ultimately made and adjusted as new information comes to the collaborative.

The unique wetlands of the Harney basin have required significant application of adaptive management. By engaging with fisheries studies, limnology studies and applied macrocosm studies, significant new information on the ecology of the wetlands has been gained. These studies have caused a significant redirection and refinement of restoration approaches. Beside the redirection, the evaluations have led to multiple peer reviewed scientific publications that can help other closed lake basin wetlands in their management difficulties.

MALHEUR LAKE AND BLITZEN VALLEY WETLAND MANAGEMENT

Emerging Knowledge

In HBWC's original strategic action plan and the Malheur National Wildlife Refuge Comprehensive Conservation Plan, carp control was the primary strategy to improve water quality and aquatic health in Malheur Lake. With new information, partners now realize that additional factors (e.g., wind stress, turbidity, phytoplankton) contribute to the lake's highly turbid and degraded conditions. Partners have since proposed, come to consensus on, and implemented projects that will help inform a more comprehensive systems model, enabling partners to test alternative restoration strategies for Malheur Lake (e.g., lake bottom topographic alteration, water management, Blitzen River sediment input management, etc.) with the OWEB's FIP 1 investment. HBWC partners have also modified some of its original timelines due to project implementation issues or new scientific findings. Recent findings of sediment input from the Blitzen River (Smith and Wood, 2023) as a significant contributor to Malheur Lake wetland turbidity points to new restoration approaches.

ECOLOGICAL LESSONS LEARNED

In OWEB's FIP 1, HBWC used a mechanistic system modeling approach to provide a greater understanding of the drivers of turbidity in Malheur Lake and demonstrated the efficacy of multiple restoration alternatives targeted at shifting the aquatic ecosystem from a turbid to a clear state. Treating Malheur Lake as a lake system, the initial focus was on controlling the harmful effects of carp via removal efforts aimed at suppressing the carp biomass below the 50 kg/ha threshold (Peterson et al., 2023). Research sponsored by the FIP created simulations that demonstrated that the carp population in Malheur Lake is more affected by environmental fluctuations than imposed mortality rates via removal efforts (Pearson et al., 2022). Ultimately these results demonstrated that focusing resources on carp control as a sole mechanism for lake restoration is likely to be ineffective, and investigations of other mechanisms adding to the turbid state were necessary. The second focus was on sediment resuspension via wind. We determined that there is a strong relationship between the wind speed and the amount of re-suspended sediment, and it may be possible to manage the resuspension of sediment effects of the wind energy via wind reduction barriers targeted at decreasing the wind's energy and ultimately increasing the water clarity (Smith and Wood, 2023).

The primary adaptive realization was that the wetlands of the lower Blitzen River and Malheur Lake are an integrated wetland system. This realization brought better understanding that management of factors affecting sediment delivery and floodplain functions of the Blitzen River has a direct effect on the wetlands of Malheur Lake. While carp management remains an important goal, broader management approaches are necessary to better integrate the wetland systems of the Blitzen valley and Malheur Lake. Together the completed and ongoing projects funded by OWEB in FIP 1 have led us to determine that the path forward to restoring the wetlands of Malheur Lake will be achieved by managing the system as a whole and considering the reinforcing feedback cycles that are continuously working towards one of the two states: clear or turbid. Based on these results, HBWC has demonstrated that restoration efforts in Malheur Lake should no longer take a singular approach focused only on removing carp and instead take a broader view of restoration, focusing on the multiple drivers of the turbid state, using a combination of actions targeted

at carp suppression, emergent vegetation reestablishment, and improving water clarity via decreased wind resuspension of lake sediments.

The goal is to shift the aquatic ecosystem of Malheur Lake from the currently turbid state to a clear state, which will allow emergent and submergent vegetation to thrive and support an abundance of birds and other wildlife.

Today, understanding of aquatic resources in the Harney Basin has continued to evolve and expand. Additional work on water availability, ranging from groundwater and spring systems to evaluation of streamflow regimes and habitat availability in the basin's terminal lakes (Harney, Mud, and Malheur Lakes), has placed a central focus on water (Gingerich, et al. 2022). Ongoing work in the headwaters of the Blitzen River is seeking to better understand sources of water during increasingly frequent drought conditions (J. Dunham, U.S. Geological Survey, unpublished data). New work downstream in both the Silvies and Blitzen Rivers, as well as the lakes themselves, seeks to understand multiple components of water quality, including temperature, turbidity, and nutrient dynamics (C. Smith, U.S. Geological Survey, unpublished data). Collectively these data provide a foundation for understanding a much broader range of ecosystem processes and system dynamics for addressing not only the lake, but the streams, groundwater, and wetland ecosystems that collectively comprise the diverse hydro system that sustains agriculture and ecosystem services in the Harney Basin.

With the surprising change in Malheur Lake wetlands in 2023 and the extensive abundance of emergent vegetation, submergent vegetation, and clear water the way forward appears clearer. The unexpected effects of climatic variance helps to build understanding of the factors that affect emergent vegetation to become established (Boos, 2023). The modeling of the effects of emergent vegetation establishment (wind barrier, less disruption, sediment stability, submergent vegetation germination and flourishing, etc.) on the wetland ecology of Malheur Lake has helped to identify when and what opportunities are available to restore wetland conditions.

ECONOMIC LESSONS LEARNED

Through both experience with commercial fishing and modeling of the carp population it has become clear that commercial fishing is insufficient to affect the carp population. Alternative strategies built around lake levels (area) to harvest carp have been identified. David Kling, an Applied Economics Assistant Professor at Oregon State University has developed a report about the bioeconomics of Malheur Lake and harvesting carp. The insights provided within this report are anticipated to provide some valuable information to help determine strategies for harvesting carp. While carp harvest appears not to be a commercial venture, continuing harvest focused during low water years and keeping carp out of the Blitzen River as lake water levels decline allow managers to reduce carp numbers.

A new strategy has been identified that could have a long term effect on carp populations. Recent work to alter the genetics of invasive fish species to produce single sex progeny, thus eliminating the breeding population appears to be effective in a trial effort. Applying the technique to common carp is planned for Malheur Lake. It will take time to produce the genetic variant and produce enough fish to liberate into the lake. This approach could have long-term effects on carp population management.

FLOOD-IRRIGATED WET MEADOWS

Emerging Knowledge

The spread of reed canarygrass in wet meadow systems,management of water, grazing, and other techniques to reduce the spread is being realized as a serious issue throughout the basin. Reed canary grass is a non-native species that can be very aggressive at creating a monotypic stand that is not very valuable as forage for livestock. Ongoing studies are being conducted to determine the use of these communities by birds but HBWC partners know tools and management strategies to control reed canarygrass will be an important outcome in the next several years (Lev & Svejcar 2020).

The work that has been conducted in the Harney Basin over the last 10 years has made it clear that maintenance or expansion of shallow water flood-irrigated wet meadows through improved water management will result in the habitat of sufficient quantity and quality to support current or increasing use and abundance of target migratory waterbirds on private lands across the Harney Basin. Increased operational flexibility of irrigation systems will also allow water to be managed in a way that inhibits invasive plant species and promotes desirable vegetation. A reduction of the extent of invasive plants promotes the abundance and diversity of native and desirable non-native plant associations and the maintenance or expansion of areas of wet meadow with short stature vegetation in the spring needed to provide habitat for target migratory waterbirds.

LESSONS LEARNED

Water management of flood irrigated fields determines the extent, duration and depth of water throughout meadows in the Harney Basin. When water is released and the duration it spends on the meadows impacts forage quality and production as well as the quality of habitat for birds and wildlife. Working with landowners within HBWC the group is determining how to optimize water management for both forage and wildlife.

HBWC has learned that infrastructure upgrades must also include fish passage improvements to contribute to an increase in the resilience of native fish populations. For example, the state sensitive Great Basin redband trout use ephemeral and perennial streams to migrate and spawn.

11. Sustainability

The HDP is dedicated to creating and maintaining collaborative efforts in the Harney Basin. This unique organization provides a sustainable framework for the HBWC. They formed the collaborative and have shepherded it through difficult times of COVID pandemic, hostile takeover, and drought. The capacity to support the collaborative is provided by HDP through outside fundraising, program, and fiscal management. HDP and HBWC partners are committed to finding other funds, maintaining and updating the ecological focus of the collaborative, and providing the capacity to implement the necessary conservation actions.

Part of the long-term stability for wetland management in the basin is the presence and capacity of the MNWR. Management of the wetlands of the Blitzen Valley and Malheur Lake is a primary responsibility of the MNWR. Historic changes to the Malheur Lake and Blitzen Valley Wetlandpresent a significant challenge to management of the refuge. By building a stronger shared-science understanding of wetland ecosystem dynamics, management options are being adapted to the current understanding of the wetlands of Malheur Lake as a part of the Blitzen River watershed. Long-term management of the Malheur Lake and Blitzen Valley Wetlands will continue to be implemented by MNWR in close cooperation with the local community, so management activities are communicated, understood, and supported.

From the beginning of HBWC, partners agreed that the conservation of flood-irrigated wet meadow systems had to be based on the joint ability to sustain viable ranching operations and provide flooded fields for migratory and resident birds. Building greater understanding of the interconnection between water management and its impact on bird use and wet meadow plant ecology in a relatable and usable manner by private landowners has been essential for long-term sustainability of the flood-irrigated wet meadow systems. If ranchers better understand the relationships between water management, bird use, and hay production they can manage to optimize opportunities into the future.

PLAN TO SECURE SUFFICIENT FUNDING

The HBWC has been successful in obtaining a variety of funding to support their efforts. Direct funding from the Oregon Legislature in 2023 and funding from Congress facilitated by Senators Merkley and Wyden have provided support to match state and federal funds. Additionally, the USFWS through the Malheur Refuge has been a funding partner for activities that can help build understanding of the Malheur Lake and Blitzen River wetlands. Annual grant funding from the North American Wetlands Conservation Act (NAWCA) can be applied for to match state funds as well. Partnering with the Intermountain West Joint Venture has made NAWCA funds available to the Harney Basin. The Audubon Society of Portland has made staff available and provided funding for projects to improve wetlands and understanding of the importance of wetland conditions to different groups of birds. Audubon is an important partner in the HBWC. Additionally, High Desert Partnership has been successful in obtaining philanthropic support that supports HDP staff who support the collaborative efforts.

APPROACH TO MAINTAINING PARTNERSHIP

Partnerships are maintained by meeting common objectives. The HBWC has been diligent in trying to maintain focus on the importance and necessary efforts to maintain a growing understanding of the commonalities among the partners. Regular meetings and direct conversations about what keeps the partners together occur in the HBWC. Using a consistent facilitator for the HBWC meetings has also helped to maintain continuity and collegiality among partners. With the diversity of funding currently available and the potential for long-term commitment of state funding, the partners see the opportunity to achieve more together than separately.

SUSTAINING CAPACITY TO TRACK PROGRESS

Monitoring and tracking progress is often the weakest part of any restoration program. The HBWC is fortunate to partner with the IWJV which has a basin scaled evaluative tool that can provide a year to year comparison of wetland and surface water conditions. While the tool will not evaluate the individual project effectiveness it will be able to help identify system changes and the changes that can be attributed to management changes and restoration interventions. Project tracking and monitoring will be conducted by project partners and accumulated annually for the HBWC. There will be an annual conversation on what occurred over the year, what conservation actions were accomplished, and to the extent that information is available, what ecological or other outcomes were evident.

12. Literature Citations

Albanese, G., C. A. Davis, and B. W. Compton. 2012. Spatiotemporal scaling of North American continental interior wetlands: implications for shorebird conservation. Landscape Ecology 27:1465–1479.

Beatty, W. S., E. B. Webb, D. C. Kesler, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2014. Landscape effects on mallard habitat selection at multiple spatial scales during the non-breeding period. Landscape Ecology 29:989–1000.

Boos, Beth Lauren. 2023. Evaluating abiotic and biotic factors affecting plant succession processes at Malheur Lake. M.S. Thesis. Louisiana State University. August 2023. 124 pp.

Carpenter, S. R., Elser, J. J., & Olson, K. M. 1983. Effects of roots of Myriophyllum verticillatum L. on sediment redox conditions. Aquatic Botany, 17(3-4), 243-249.

Christy, J. A. 2016. Wet meadow plant associations, Double o unit, Malheur national wildlife refuge, Harney county, Oregon. Oregon Biodiversity Information Center, Institute for Natural Resources, Portland State University. 47 p.

Crivelli, A. J. 1983. The destruction of aquatic vegetation by carp. Hydrobiologia, 106(1), 37-41.

Dalton, M. M. Rupp, D. & Hawkins, L. 2018. Future climate projections: Harney County, Future climate projections: Harney County. Corvallis, OR.

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

Donnelly JP, King SL, Silverman NL, Daniel P. Collins, Eduardo M. Carrera-Gonzalez, Alberto Lafón-Terrazas,and Johnnie N. Moore. 2020. Climate and human water use diminish wetland networks supporting continental waterbird migration. Global Change Biology: 26:2042–2059. https ://doi.org/10.1111/gcb.15010

Donnelly JP, Moore JN, Casazza ML and Coons SP. 2022.Functional Wetland Loss Drives Emerging Risks to Waterbird Migration Networks. Front. Ecol. Evol. 10:844278.doi: 10.3389/fevo.2022.844278

Duebbert, H.F. 1969. The ecology of Malheur Lake and Management Implications. U.S. Fish and Wildlife Service Refuge Leaflet 412. 24 pp.

Esquivel, Robert A. 2018. Aquatic Health Basin-Wide Baseline Monitoring Report, 2016 – 2018. A Report to the Oregon Watershed Enhancement Board for Project Number 216-8202-12979. 33 p.

Fleskes, Joseph P. and Gregory, Christopher J. 2010.Distribution and dynamics of waterbird habitat during spring in southern Oregon–northeastern California, Western North American Naturalist: Vol. 70 (1) 26–38.

Gingerich, S. B., Johnson, H. M., Boschmann, D. E., Grondin, G. H., & Garcia, C. A. (2022). Groundwater resources of the Harney Basin, southeastern Oregon (No. 2021-5103). US Geological Survey.

Haig, S.M., S.P. Murphy, J.H. Matthews, I. Arismendi, and M. Safeeq. 2019. Climate-altered Great Basin wetlands and deterioration of a migratory flyway. Nature Scientific Reports 9: paper 4666.

Hall, D. K., Kimball, J. S., Larson, R., DiGirolamo, N. E., Casey, K. A., & Hulley, G. 2023. Intensified warming and aridity accelerate terminal lake desiccation in the Great Basin of the western United States. Earth and Space Science, 10, e2022EA002630. https://doi.org/10.1029/2022EA002630

Hamilton, D.B., G.T. Auble, R.A. Ellison, and J.E. Roelle.1986. Effects of flood control alternatives on hydrology, vegetation, and wildlife resources of the Malheur-Harney Lakes Basin. Report NEC-86/20. Washington, D.C.: National Ecology Center, Division of Wildlife and Contaminant Research, Fish and Wildlife Service, U.S. Department. of Interior.95 p.

Hargeby, A., Blindow, I., & Hansson, L. A. 2004. Shifts between clear and turbid states in a shallow lake: multi-causal stress from climate, nutrients and biotic interactions. Arch. Hydrobiol, 161(4), 433-454.

High Desert Partnership. 2015. Harney Basin Wetlands Initiative Strategic Action Plan 2015-2021. 80 p.

Horppila, J., Kaitaranta, J., Joensuu, L., & Nurminen, L. 2013. Influence of emergent macrophyte (Phragmites australis) density on water turbulence and erosion of organic-rich sediment. Journal of Hydrodynamics, 25(2), 288-293.

Horppila, J., & Nurminen, L. 2005. Effects of different macrophyte growth forms on sediment and P resuspension in a shallow lake. Hydrobiologia, 545(1), 167-175.

Hostetler, S. W., & Bartlein, P. J. 1990. Simulation of lake evaporation with application to modeling lake level variations of Harney-Malheur Lake, Oregon. Water Resources Research, 26(10), 2603-2612.

Hubbard, L.L. 1975. Hydrology of Malheur Lake, Harney County, southeastern Oregon. USGS Water Resources Division, Portland, Oregon. Water Resources Investigation Reports WRIR 21-75, 46 pp.

Janssen, A. B., Teurlincx, S., An, S., Janse, J. H., Paerl, H. W., & Mooij, W. M. 2014. Alternative stable states in large shallow lakes?. Journal of Great Lakes Research, 40(4), 813-826.

Kates, R. W., Travis, W. R., & Wilbanks, T. J. 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. Proceedings of the National Academy of Sciences, 109(19), 7156-7161.

King, Sammy L., Murray K. Laubhan, Paul Tashjian, John Vradenburg, and Leigh Fredrickson. 2021. Wetland Conservation: Challenges Related to Water Law and Farm Policy. Wetlands 41.54. https://doi.org/10.1007/s13157-021-01449-y

Langston, Nancy . 2003. Where Land and Water Meet: A Western Landscape Transformed. University of Washington Press. Seattle. 230p.

Lev, E., Svejcar, T. 2020. Project Completion Report for OWEB Grant 218-8202-16862 Wet Meadow Water and Vegetation Management.

Lougheed, V. L., Crosbie, B., & Chow-Fraser, P. 1998. Predictions on the effect of Common Carp (Cyprinus carpio) exclusion on water quality, zooplankton, and submergent macrophytes in a Great Lakes wetland. Canadian Journal of Fisheries and Aquatic Sciences, 55(5), 1189-1197.

Mackell, D. A., Casazza, M. L., Overton, C. T., Donnelly, J. P., Olson, D., McDuie, F., Ackerman, J. T., & Eadie, J. M. 2021. Migration stopover ecology of Cinnamon Teal in western North America. Ecology and Evolution, 11, 14056–14069. https://doi.org/10.1002/ece3.8115

Maron, M., C. A. McAlpine, and J. Watson. 2015. Climate-induced resource bottlenecks exacerbate species vulnerability: a review. Diversity 21: 731–743.

Matsuzaki, S. I. S., Usio, N., Takamura, N., & Washitani, I. 2007. Effects of Common Carp on nutrient dynamics and littoral community composition: roles of excretion and bioturbation. Fundamental and Applied Limnology/ Archiv für Hydrobiologie, 168(1), 27-38.

McCormick, Joshua L., D.J. Schill, and K.A. Meyer. 20213. Simulated use of YY male stocking and suppression for eradicating common carp populations. North American Journal of Fish Management.41: 306-382.

Miller, S. A., & Crowl, T. A. 2006. Effects of Common Carp (Cyprinus carpio) on macrophytes and invertebrate communities in a shallow lake. Freshwater Biology, 51(1), 85-94.

Morghan, K. J. R., Sheley, R. L., & Svejcar, T. J. 2006. Successful adaptive management—the integration of research and management. Rangeland Ecology & Management, 59(2), 216-219

Mote, Philip W., S. Li, D.P. Lettenmaier, M. Xiao, and R. Engel. 2018. Dramatic declines in snowpack in the western US. Climate and Atmospheric Science 1:2. https://doi.org/10.1038/s41612-018-0012-1

Naz, B. S., Kao, S. C., Ashfaq, M., Rastogi, D., Mei, R., & Bowling, L. C. 2016. Regional hydrologic response to climate change in the conterminous United States using high-resolution hydroclimate simulations. Global and Planetary Change, 143, 100-117.

Ozimek, T., Van Donk, E., & Gulati, R. D. 1993. Growth and nutrient uptake by two species of Elodea in experimental conditions and their role in nutrient accumulation in a macrophyte-dominated lake. In Nutrient dynamics and retention in Land/Water ecotones of lowland, temperate lakes and rivers (pp. 13-18). Springer, Dordrecht.

Pearson, James, Jason Dunham, J. Ryan Bellmore & Don Lyons. 2019. Modeling control of Common Carp (Cyprinus carpio) in a shallow lake–wetland system. Wetlands Ecology and Management volume 27, pages 663–682.

Pearson, James B., J.Ryan Bellmore, and Jason B. Dunham. 2022.Controlling Invasive Fish in Fluctuating Environments: Model Analysis of Common Carp (Cyprinus Carpio) in a Shallow Lake. Ecosphere13(5): e3985. https://doi.org/10.1002/ecs2.3985ECOSPHERE15 of 15

Pearson, J. B. 2020. Carp, Climate, and Water Quality: Applying Systems Modeling to Ecosystem Recovery in Malheur Lake.https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/d791sp43v

Peterson, D., James Pearson, and William Simpson. 2022.Effects of common carp on water quality and submerged vegetation: results from a short-term mesocosm experiment in an artificial wetland. Marine and Freshwater Research, 73(7): 973–994. doi:10.1071/MF22008

Rose, K. A., Cowan, J. H., Winemiller, K. O., Myers, R. A., & Hilborn, R. 2001. Compensatory density dependence in fish populations: importance, controversy, understanding and prognosis. Fish and Fisheries, 2(4), 293-327.

Sauder, R.A. 1989. Patenting an Arid Frontier: Use and Abuse of the Public Land Laws in Owens Valley, California. Annals of the American Association of Geographers 79(4):544 - 569 DOI: 10.1111/j.1467-8306.1989.tb00276.

Sauder, R. A. 1989. Sod land versus sagebrush: early land appraisal and pioneer settlement in an arid intermountain frontier. Journal of Historical Geography 15:402–419.

Scheffer, M., Hosper, S. H., Meijer, M. L., Moss, B., & Jeppesen, E. 1993. Alternative equilibria in shallow lakes. Trends in ecology & evolution, 8(8), 275-279.

Sketch, Mary, A.A. Dayer, and A. L. Metcalf. 2020. Western Ranchers' Perspectives on Enablers and Constraints to Flood Irrigation. Rangeland Ecology and Management 73: 285-296.

Silverman, N. L., Allred, B. W., Donnelly, J. P., Chapman, T. B., Maestas, J. D., Wheaton, J. M., … Naugle, D. E. 2018. Low-tech riparian and wet meadow restoration increases vegetation productivity and resilience across semi-arid rangelands. Restoration Ecology. https://doi.org/10.1111/rec.12869

Smith, C.D., and Wood, T.M., 2023, Implications of water, sediment, and nutrient budgets for the restoration of a shallow, turbid lake in semiarid southeastern Oregon: U.S. Geological Survey Scientific Investigations Report 2023–5098, 31 p.,https://doi.org/10.3133/sir20235098.

Snyder, K. A., Evers, L., Chambers, J. C., Dunham, J., Bradford, J. B., & Loik, M. E. 2019. Effects of changing climate on the hydrological cycle in cold desert ecosystems of the Great Basin and Columbia Plateau. Rangeland Ecology & Management, 72(1), 1-12.

Timms, R. M., & Moss, B. 1984. Prevention of growth of potentially dense phytoplankton populations by zooplankton grazing, in the presence of zooplanktivorous fish, in a shallow wetland ecosystem. Limnology and Oceanography, 29(3), 472-486.

Vilizzi, L., Tarkan, A. S., & Copp, G. H. 2015. Experimental evidence from causal criteria analysis for the effects of Common Carp Cyprinus carpio on freshwater ecosystems: a global perspective. Reviews in Fisheries Science & Aquaculture, 23(3), 253-290

Weber, M. J., and M. L. Brown. 2009. Effects of Common Carp on aquatic ecosystems 80 years after 'carp as a dominant': ecological insights for fisheries management. Reviews in Fisheries Science 17:524– 537.

Williams, A. E. 2005. The Theory of Alternative Stable States in Shallow Lake Ecosystems. Water Encyclopedia, 3, 272-274.

Wium-Andersen, S., Anthoni, U., Christophersen, C., & Houen, G. 1982. Allelopathic effects on phytoplankton by substances isolated from aquatic macrophytes (Charales). Oikos, 187-190.

Wood, T.M., and Smith, C.D., 2022, Light attenuation and erosion characteristics of fine sediments in a highly turbid, shallow, Great Basin Lake—Malheur Lake, Oregon, 2017–18: U.S. Geological Survey Scientific Investigations Report 2022–5056, 51 p., https://doi.org/ 10.3133/ sir20225056.

Zhang, X., Liu, Z., Gulati, R. D., & Jeppesen, E. 2013. The effect of benthic algae on phosphorus exchange between sediment and overlying water in shallow lakes: a microcosm study using 32 P as a tracer. Hydrobiologia, 710(1), 109-116.

13. Partnership Certification

This strategic action plan was developed under the guidance of the HBWC. This collaborative group will oversee the implementation of the strategic action plan and support collaborative, sustainable partnerships for the restoration of Malheur Lake and flood-irrigated wet meadows in the Harney Basin. The following partners were heavily involved in the development and refinement of the strategic action plan.

CERTIFICATION

I certify that this strategic action plan is a true and accurate representation of the proposed work and that I am authorized to sign as the partner representative.

Name	Position	Organization	Signature	Date
Dave Banks	District Fish Biologist	Oregon Department of Fish and Wildlife		
Ed Contreras	SONEC Conservation Delivery Coordinator	Intermountain West Joint Venture		
Greg Green	Director of Conservation Programs	Ducks Unlimited		
Dustin Johnson	Range Scientist	Oregon State University Extension Services		
Esther Lev	Coordinator	Wet Meadow Partners		
Karen Moon	Coordinator	Harney County Watershed Council		
Dan Nichols	Owner/Operator	McCoy Creek Ranch		
Bob Sallinger	Executive Director	Bird Conservation Oregon		
Kristen Shelman	Commissioner	Harney County		
Brenda Smith	Executive Director	High Desert Partnership		
Casie Smith	Ecologist	U. S. Geological Survey		
Tony Svejcar	Coordinator	Wet Meadow Partners		
Teresa Wicks	Eastern Oregon Field Biologist	Portland Audubon		
Lisa Wilson	Malheur Project Leader	Malheur National Wildlife Refuge		