Pacific Flyway Integrated Landscape Conservation: Meeting the Needs of Waterfowl and Shorebirds in a New Era of Water Scarcity

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Supporting Partners:

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INTRODUCTION

The Klamath Basin, Central Valley, and Southern Oregon and Northeastern California (SONEC) collectively support over 60% of all dabbling duck use in the Pacific Flyway between September and May and are critical landscapes for migratory shorebirds. During fall, these birds move through the Klamath Basin on their way to wintering grounds in the Central Valley. By March and April, most birds have departed the Central Valley and are found on spring staging habitats throughout SONEC and the Klamath Basin. In addition, these areas provide regionally important breeding and molting habitats for waterfowl, migration, molting and wintering habitat for shorebirds, and breeding habitat for waterbirds, further connecting cross-seasonal habitat reliance among landscapes.

The contiguous nature of these landscapes (see Figure 1), combined with the ability of birds to move quickly between them, requires an integrated conservation approach across their boundaries. To date, conservation planning for waterfowl and other wetland dependent birds has been conducted by the Central Valley Joint Venture (CVJV) in the Central Valley, the Intermountain West Joint Venture (IWJV) in SONEC, and the Klamath Basin National Wildlife Refuge (NWR) Complex for refuge lands in the Klamath Basin (which was later adopted by the IWJV). As is the norm for JVs across North America, the CVJV and IWJV have developed their conservation plans independent of one another.

These landscapes share three important characteristics: (1) threats to water supplies that have traditionally provided key habitat (vulnerability), (2) an overwhelming reliance on managed water delivery systems (vulnerability), and (3) an essential partnership between managed wetlands and irrigated agriculture (part of any solution).

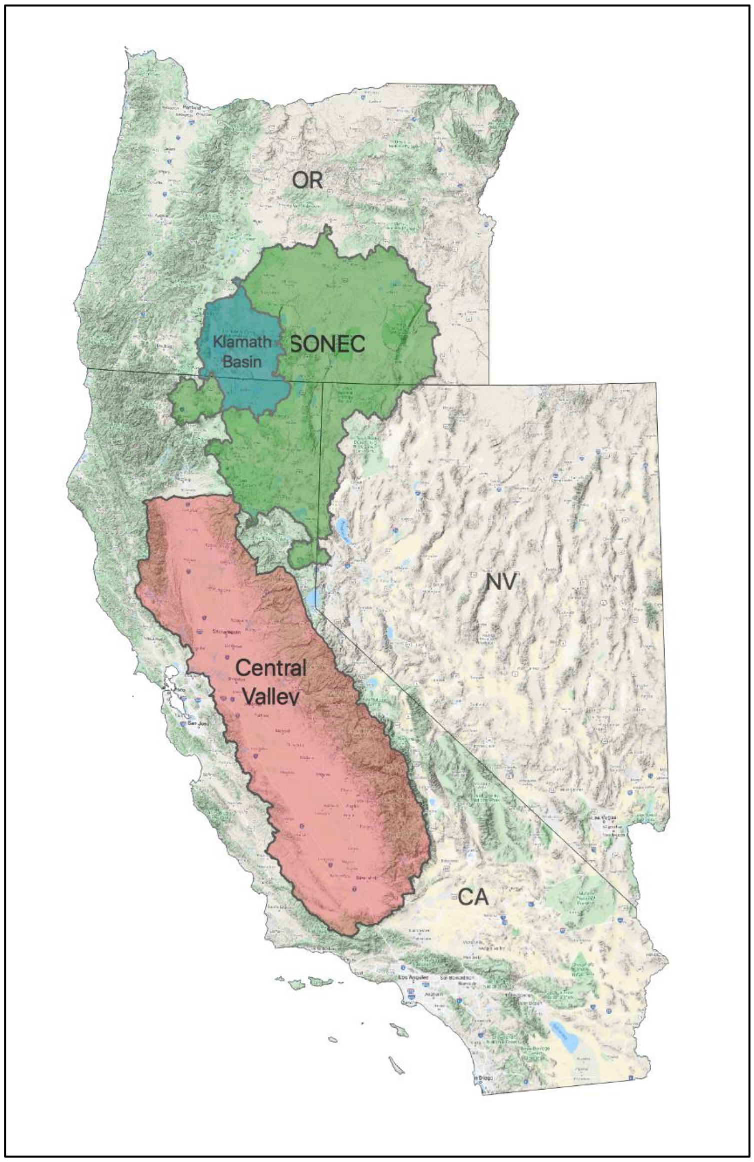

Figure 1. *Project study area*

- **Water = Habitat:** Water sustainability is fundamentally important to the continental network of wetlands that supports migratory waterbird populations. Bird movements within these wetland networks are timed to intercept windows of habitat availability important to breeding, over-wintering and migratory success. Conservation of these networks has often overlooked water security as a limiting factor, instead focusing on land-based protection strategies (e.g., U.S. Fish and Wildlife Service (USFWS) NWR System) that have assumed water resources are static or will not become limiting. However, water scarcity due to changing climate and increasing demands now raises concerns of functional wetland loss (i.e., drying; Reiter et al. 2018) and the emergence of new bottlenecks to continental waterbird migration (Donnelly et al. 2020). Offsetting potential impacts to waterbird populations will require novel conservation strategies considerate of wetland network sustainability in a new era of limited water resources. Wetland managers and other conservation professionals need to understand the availability of surface water in space and time over multiple decades to deliver conservation that will be resilient in a changing water world.

- **Managed Water Delivery Systems:** In the Pacific Flyway, ecologically important wetland and agricultural habitats depend largely upon water from managed water delivery systems. While most wetlands in the Pacific Flyway have been significantly altered, they remain essential to biological processes supporting fish and wildlife populations. Virtually all the wetlands important to waterfowl and other wetland dependent birds in the Central Valley and Klamath Basin are managed seasonal wetlands that require annual applications of water. Similarly, winter-flooded rice fields in the Central Valley and flood-irrigated ranchlands in SONEC depend on deliberate flooding by agricultural producers every year. This is in contrast to many migration and wintering areas where annual precipitation and unmanaged wetlands provide much of what is needed. Many of these water delivery systems are antiquated and require investments in irrigation infrastructure modernization.

- **Wetlands and Irrigated Agriculture:** There is a clear nexus between wetlands and irrigated agriculture in all three landscapes (see below). Rising temperatures, more frequent and severe droughts, and a rapidly growing urban demand have placed growing burdens on both. This shared problem elevates the need for the wildlife and agricultural community to work together in developing solutions to these water supply challenges.

    - *Klamath Basin:* The rich history of collaboration between the Refuge Complex and lease farmers, including Walking Wetlands, serves as a model for the future. Opportunities likely exist to strengthen the wetlands/agriculture partnership in the coming years.

    - *Central Valley:* Rice provides approximately 50% of the food energy to support wintering waterfowl and shorebirds and provides critical habitat during key life cycle events; thus, the rice industry is critical to the future of the Pacific Flyway.

    - *SONEC Flood-Irrigated Working Wet Meadows:* This crucial habitat for waterfowl during spring migration is provided by ranchers that irrigate their meadows for the purpose of forage production. As such, the habitat is inextricably linked to the future of ranching and agricultural flood-irrigation across the key landscapes of the Modoc Plateau (Modoc and Lassen Counties) of California and Closed Basins (Lake and Harney Counties) of Oregon.

Today, waterfowl and other wetland dependent birds in these three landscapes are increasingly at the mercy of unreliable water supplies, the ability of public agencies and private landowners to shoulder the annual costs of flooding, and the long-term financial commitment needed to maintain the infrastructure used to flood wetlands and agricultural lands. Sustainability of Pacific Flyway waterbird networks will require fresh, innovative ways of thinking about water management and habitat conservation that recognize both the economic and ecological demands being placed on limited water supplies.

PROJECT AREA, OBJECTIVES, and METHODS

Project Area

The project footprint will encompass the current boundary of the CVJV, the Klamath Basin with special emphasis on the Lower Klamath and Tule Lake NWRs, and SONEC (see Figure 1). Although the three landscapes have been treated as geographically distinct planning units, they have adopted the same planning process for waterfowl. Population objectives that were derived from the North American Waterfowl Management Plan (NAWMP) were established for each, and each has used the same assumptions and a bioenergetic model to translate these population objectives into habitat objectives within a Strategic Habitat Conservation framework. This shared approach provides a solid platform for developing an integrated science foundation. Bioenergetics modeling has also been used to identify food-energy deficits for shorebird population objectives as part of CVJV planning.

Most of the Project Area has been the subject of detailed conservation planning, much of it recent. The CVJV just completed it 2020 Implementation Plan, which leveraged new hydrological data on timing and variation in wetland habitats (Dybala et al. 2017; Reiter et al. 2018). In 2008, the waterfowl carrying capacity of Lower Klamath NWR and Tule Lake NWR was evaluated relative to the refuges' waterfowl population objectives. That 2008 analysis is now being updated to reflect changes in refuge water supplies and will be completed in June 2020. The portion of SONEC that is characterized by flood-irrigated ranchlands was treated extensively in the IWJV's 2013 Implementation Plan. Recent work by Patrick Donnelly of the IWJV (Donnelly et al. 2019) to describe annual variation in wetland dynamics within this landscape will allow us to greatly improve on these earlier IWJV efforts.

Project Objectives

The water supply and water management vulnerabilities associated with the Central Valley, Klamath Basin, and SONEC spill across Joint Venture boundaries. For example, water supplies for some refuges in the Klamath Basin have been drastically reduced over the last decade because of drought and Endangered Species Act requirements for addressing the needs of listed fish species. These water supply reductions have resulted in a predictably sharp decline in fall waterfowl use of the refuges and in change in shorebird use of the landscape. How might this increase the number of birds using the Central Valley in fall, and what is the conservation price tag for supporting these additional birds? Until we integrate our planning efforts across these landscapes, it will be difficult to answer such questions.

Given the growing challenge of providing adequate habitat for waterfowl and other wetland dependent birds in these water-limited and intensively managed landscapes, public agencies, NGOs, private landowners, and water managers require a better picture of the risks and potential impacts of declining water supplies in each of these landscapes—and how such impacts may compound one another to the detriment of both birds and people. The objectives of this proposed study are to:

1. Document monthly changes in the amount of flooded waterfowl and shorebird habitat, both wetland and agricultural, for each landscape over the past 37 years using a consistent methodology. This retrospective analysis is foundational to addressing the objectives that follow.
2. Clearly identify the risks to surface water supplies that are important to waterfowl and other wetland dependent birds in each landscape.
3. Estimate how these risks to surface water supplies would impact waterfowl and shorebird carrying capacity within each landscape.
4. Evaluate how a decline in surface water supplies within one landscape may compound the conservation challenges for waterfowl and shorebirds in the other landscapes.
5. Integrate management scenarios across the three landscapes and determine the conservation actions needed to maintain the overall resiliency of this "one big landscape". Although the proposed study focuses on waterfowl and shorebirds, the integrated science foundation across this entire region has broad application for waterbirds and potentially other wetland-dependent species.

The IWJV, CVJV, Klamath NWR Complex, Ducks Unlimited, Point Blue Conservation Science, and the University of Montana have teamed up to address this pressing wetlands and agricultural conservation challenge through cutting-edge science involving three approaches (outlined below), led by the following three experienced landscape conservation experts:

- Wetland dynamics modeling (Patrick Donnelly, IWJV Spatial Ecologist)
- Waterfowl bioenergetics modeling (Dr. Mark Petrie, Ducks Unlimited);
- Shorebird habitat assessment and bioenergetics (Matt Reiter, Point Blue Conservation Science)

This project will be coordinated by a technical team of representatives from the Klamath Basin, Central Valley, and SONEC regions. Oversight and direction will be provided by Dave Smith, IWJV Coordinator; Greg Austin, USFWS Klamath NWR Complex Project Leader; CVJV Leadership; Claudia Mengelt and John Tull, USFWS Science Applications.

Project Methods

Objective 1: Document monthly changes in the amount of flooded waterbird habitat, both wetland and agricultural, for each landscape over the past 37 years. This retrospective analysis is foundational to addressing the objectives that follow.

Following methods outlined by Donnelly et al. 2019, spatiotemporal dynamics of seasonal wetland inundation will be quantified from 1984-2020 using Landsat satellite imagery for all three landscapes. Surface water extent will be measured using constrained spectral mixture models to provide proportional estimations of water contained within 30 m^2 Landsat pixels (Halabisky et al. 2016; Jin et al. 2017). This approach provides an accurate account of inundation when only a portion of surface water is visible due to interspersion of water and emergent vegetation, a common characteristic among shallow seasonal wetlands.

To depict timing and extent of surface water inundation, wetland dynamics will be summarized monthly as a five-year rolling mean and annually within breeding, migration and overwintering periods. Because hydrologic regimes are an important predictor of waterfowl and shorebird habitat values, modeling will be used to quantify annual abundance by different wetland types defined as 'temporary' (flooded < 2 months), 'seasonal' (flooded > 2 and < 8 months), and 'semi-permanent' (flooded > 8 months) (Cowardin et al. 1979). The utilization of consistent methodology in the Klamath Basin, Central Valley, and SONEC is particularly important from a waterfowl conservation planning standpoint due to the abundance of emergent vegetation in managed wetlands and flood-irrigated habitats at certain times of the year. See Appendix A for further details on Objective 1 methods.

Objective 2: Identify the risks and drivers associated with surface water supplies that are important for providing waterbird habitat in each landscape.

We will attribute the importance of climate and human water use to the prediction of wetland surface water trends using randomForestSRC regression tree analysis (Ishwaran and Kogalur 2019) as a nonparametric measure of variable importance. This approach is applicable to dynamic ecological systems with typically non-normal statistical distributions. Variables identified as important predictors of wetland change will be combined with climate projection models to forecast future wetland availability, building upon the work of Point Blue and the U.S. Geological Survey in the Central Valley. Outcomes will identify important landscape limiting factors that may be used to inform meaningful wetland conservation. Drought and wetlands have already been analyzed in the Central Valley, as well as changes in water delivery (Reiter et al. 2018; Reiter and Jongsomjit 2019; Matchett et al. 2018; Byrd et al. 2020). This study will provide the foundation for digging deeper into water supplies relative to water sources and water management infrastructure across the entire landscape. In addition to these formal analyses, we will consult with natural resource professionals who have a practical understanding of surface water issues in each landscape to further our understanding of the risks and drivers associated with these water supplies.

Objective 3: Estimate how current trends and future risks to surface water supplies would impact waterfowl, shorebird, and waterbird habitat availability within each landscape.

To understand potential impacts of wetland habitat change, relative estimations of seasonal waterfowl, shorebirds, and waterbird abundance will be developed from observational data (e.g., eBird and ocular surveys) in each landscape during breeding, migration, and wintering periods. These estimates will be aligned spatially and temporally with long-term wetland patterns and known habitat needs of individual species to identify emerging gaps associated with wetland availability. Currently, long-billed dowitchers, white-faced ibis, sandhill cranes and dabbling duck species (e.g., breeding mallards) will be included in this analysis. Additions of other wetland-dependent species will be determined by quality and abundance of observational data currently being explored.

More detailed estimations of landscape carrying capacity for migrating and wintering waterfowl and shorebirds species will be developed to determine if current and projected wetland conditions can support existing population goals. As described earlier, this update is complete for the Central Valley and nearly complete for key refuges in the Klamath Basin (Lower Klamath and Tule Lake NWRs). In SONEC, we will update estimates of carrying capacity for flood-irrigated ranchlands and public habitats (e.g., Summer Lake, Ash Creek, and Butte Valley Wildlife Areas) for waterfowl only.

All estimates of waterfowl carrying capacity in this study, completed or otherwise, rely on the model TRUEMET (Petrie et al. 2016). Shorebird carrying capacity will be assessed using a bioenergetics model developed for CVJV planning (Dybala et al. 2017). Most Joint Ventures have used a food energy approach to evaluate carrying capacity and to establish conservation objectives for migrating and wintering waterfowl (Williams et al. 2014). Only the CVJV has used this approach for shorebirds. The TRUEMET and shorebird model was developed to estimate waterfowl habitat requirements by comparing food energy needs to food energy supplies. Both models calculate population energy needs from the daily energy requirements of a single bird and from time-specific population objectives. Food energy supplies are dependent on the availability and amount of waterfowl and shorebird habitat, as well as the quantity and quality of foods contained in these habitats. Both models account for the combined effects of waterfowl or shorebird consumption, decomposition of foods over time, and changes in habitat availability that result from wetland flooding schedules or other events such as the timing of agricultural harvest (Petrie et al. 2016; Dybala et al. 2017).

The bioenergetics models can also be used to predict how changes in landscape conditions may alter carrying capacity. For example, how might declines in surface water supplies for winter-flooding of rice in the Central Valley impact the region’s ability to meet its waterfowl and shorebird population objectives? The risks to surface water supplies identified from Objectives 1 and 2 will be modeled for each landscape to evaluate how these risks will alter the current carrying capacity of these landscapes should they be realized. Together, Objectives 1, 2, and 3 identify the threats to surface water supplies within each landscape and translate these threats into future losses, if any, in waterfowl and shorebird carrying capacity.

Objective 4: Evaluate how a decline in surface water supplies within one landscape may compound the conservation challenges for waterfowl and other wetland dependent birds in the other landscapes.

Objectives 1, 2, and 3 are conducted independently for each landscape. In contrast, Objective 4 recognizes the dependent nature of these landscapes from both a bird and conservation standpoint. Although waterfowl population objectives for each of these landscapes was derived from the same source (NAWMP), these population objectives need to be integrated across the entire region if we are to model the compounding effects of water shortages from one landscape to another. Shorebird population objectives will be developed for the Klamath and aligned with those for the CVJV. The seasonal movement of waterfowl and shorebirds among these landscapes are reflected in traditional patterns of migration chronology. For example, spring migrating waterfowl begin departing the Central Valley in mid- to late February. This movement produces traditional and predictable changes in bird numbers in SONEC and the Klamath Basin from February through May.

Habitat loss that results from declining surface water supplies would likely alter these traditional patterns of migration chronology. Conservation planning in each of these landscapes, and the habitat objectives that result from this planning, is strongly influenced by our assumptions about migration chronology, as this chronology dictates the number of birds that must be supported over time. To examine how the loss of surface water supplies in one landscape may compound challenges elsewhere, we’ll examine how changes in traditional migration chronologies would alter habitat objectives using bioenergetics models. For example, the loss of refuge water supplies in the Klamath Basin may accelerate fall migration into the Central Valley, which would likely increase our habitat objectives for waterfowl in the Valley. Although the cumulative population objective of these landscapes does not change, how we distribute this overall population objective in time and space would be altered in the bioenergetics models depending on our understanding of future water supplies.

Objective 5: Integrate management scenarios across the three landscapes and determine the conservation actions needed to maintain the overall resiliency of this “one big landscape”.

Identify opportunities and approaches for addressing water-related challenges through proactive, innovative, and collaborative conservation is critical. The analyses described above will provide a much-needed integrated science foundation for addressing water issues across this “one big landscape” by explaining what is at stake and what the most promising avenues for achieving adequate water and habitat resiliency are. The final report will identify potential approaches for addressing key vulnerabilities, including the funding, program adjustments, and new ways of thinking needed to usher in a new era of collaboration in addressing water-related challenges across boundaries.

Developing a cohesive conservation strategy for these three landscapes compels us to understand the strengths and weaknesses of each in terms of future water supplies. Seeing things as they are, not as we wish them to be…so to speak. What should be the role of Lower Klamath NWR given fundamental changes in the amount and timing of refuge water deliveries? Should the refuge continue to focus on fall migrating waterfowl, or should it focus on other life history events (molting, breeding) that might better align with its new water realities? Could we seek innovative partnerships with landowners in the Klamath Basin who have robust water rights and who might help offset the loss of fall habitat using normal agricultural practices? Are there state wildlife areas in SONEC (e.g., Ash Creek, Butte Valley, Summer Lake, Shasta Valley) that could shoulder a larger load if we invested more in these public lands, thus helping offset the loss of carrying capacity on more well-known refuges? Can the Central Valley realistically support more ducks given its own water challenges? How do we support both waterfowl and shorebirds that may have differences in the timing of habitat need across this shared migratory landscape? In addition to providing spring migration habitat, could some flood-irrigated habitats in SONEC provide habitat for breeding waterbirds or southbound migratory shorebirds if we supported their efforts to modernize their irrigation infrastructure and extend flooding into summer (especially where they have strong water rights). Such efforts could help offset the loss of breeding wetland habitats in the Central Valley where the availability of summer surface water supplies has declined. All good questions, but all require an integrated science foundation before we can address them.

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PROJECT BUDGET

Partner	Item	Total Cost	Partner Contributions						FWS SA Request
			DU	IWJV	CVJV	Point Blue	Klamath Basin NWR Complex	Total	
Ducks Unlimited	Science staff - salary/benefits	112,000	12,000		20,000			32,000	80,000
	Indirect (14.9%)	16,688	16,688					16,688	-
Point Blue Conservation Science	Science staff - salary/benefits	25,337				5,000	10,337	15,337	10,000
	Travel	1,885					1,885	1,885	-
	Indirect (35%)	7,778					7,778	7,778	-
University of Montana	Science staff - salary/benefits	10,000						-	10,000
	CESU Indirect (17.5%)	1,750						-	1,750
Intermountain West JV	Science staff - salary/benefits	20,000						-	20,000
	IWJV Operations, Administration & Management (10%)	19,544		19,544				19,544	-
Totals		**214,982**	**28,688**	**19,544**	**20,000**	**5,000**	**20,000**	**93,232**	**121,750**

Appendix A: Identifying cross landscape bottlenecks to waterbird habitat needs through long-term monitoring of wetland and agricultural flooding

METHODS AND OUTCOMES

Project Area

The project footprint will encompass important waterbird habitats in the Central Valley and the SONEC region of the Intermountain West, including the Klamath Basin (see Figure 1). Analyses will be inclusive of all public and private lands.

Monitoring long-term wetland trends

Following methods outlined by Donnelly et al. 2019, spatiotemporal dynamics of seasonal wetland inundation will be monitored from 1984-2020 using Landsat satellite imagery. These data already exist for the Central Valley (Reiter et al. 2015, 2018; Schaffer-Smith et al. 2017) with some limitations regarding tracking heavily vegetated seasonal wetlands in early fall. Surface water extent will be measured using constrained spectral mixture models to provide proportional estimations of water contained within 30 m^2 Landsat pixels (Halabisky et al. 2016; Jin et al. 2017). This approach provides an accurate account of inundation when only a portion of surface water is visible due to interspersion of water and emergent vegetation, a common characteristic among shallow seasonal wetlands. To depict timing and extent of surface water inundation, wetland dynamics will be summarized monthly as a five-year rolling mean and annually within waterbird breeding, migration and overwintering periods (see Figure 2 next page).

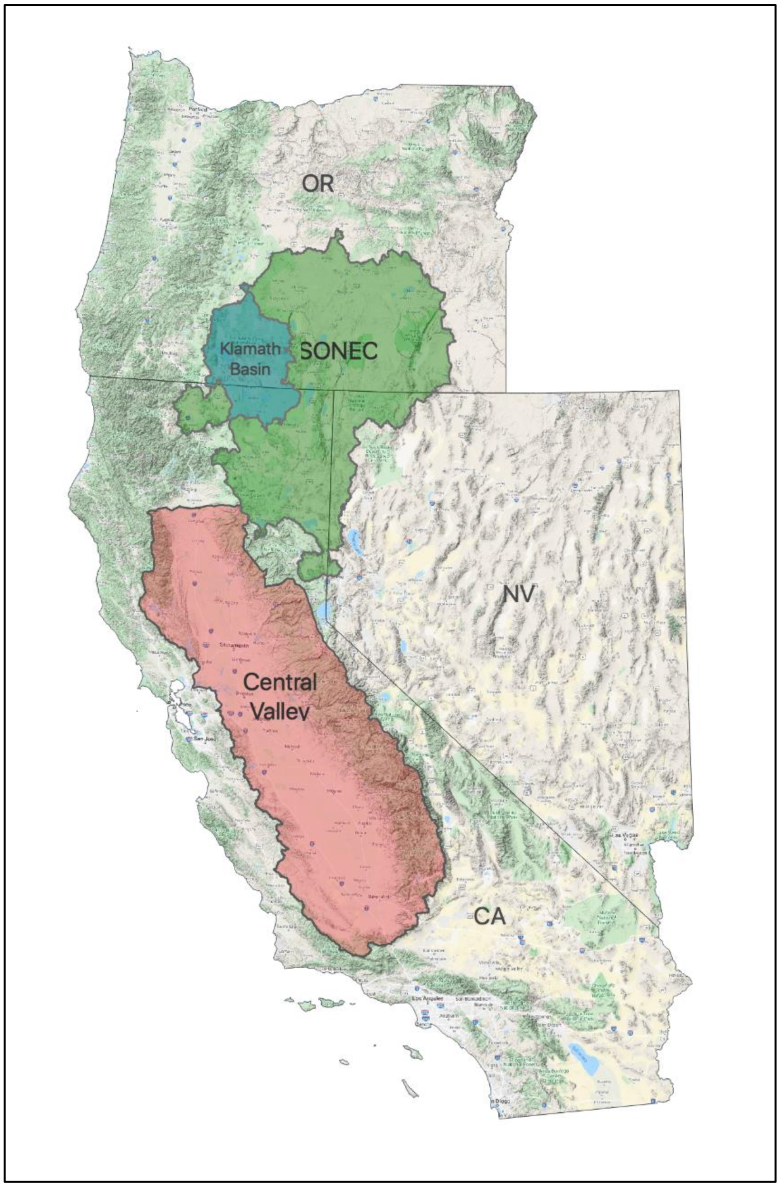
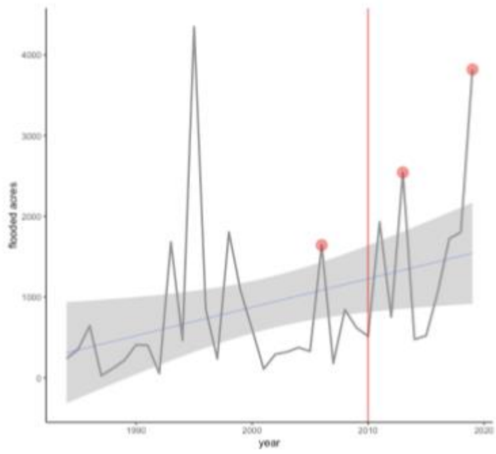


Figure 1. *Project study area defined by Central Valley Joint Venture boundary and SONEC region.*



Monitoring example; wetland restoration and climate influences on spring surface water trends - Ash Creek Wildlife Area 1984-2019. Red line marks pre-post restoration. Red points correlate to model outputs shown - 2006, 2013, and 2019. Blue line is least squares regression with the 0.95% confidence interval of the slope shown in gray fill.

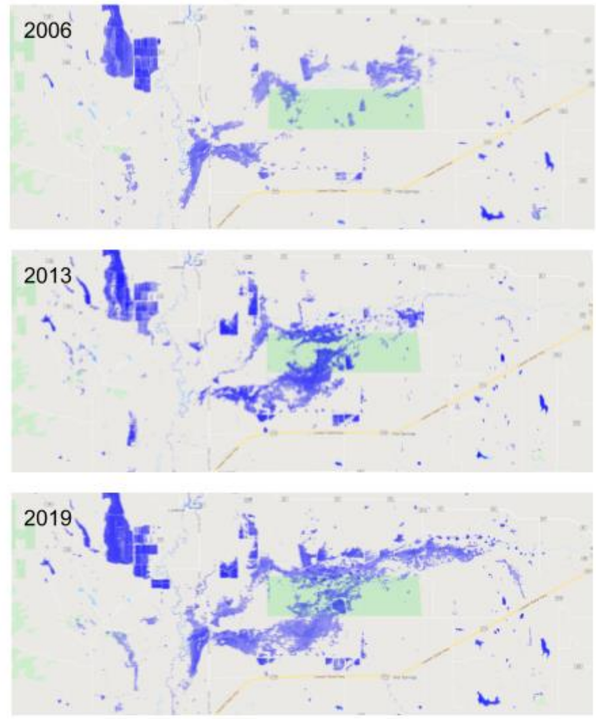


Figure 2.

Because hydrologic regimes are an important predictor of waterbird habitat values, modeling will be used to quantify annual abundance by different wetland types defined as ‘temporary’ (flooded < 2 months), ‘seasonal’ (flooded > 2 and < 8 months), and ‘semi-permanent’ (flooded > 8 months) (Cowardin et al. 1979). This project builds out the IWJV’s SONEC modeling to encompass the whole year (beyond the current spring and fall migration time-periods) and expands the modeling to the Central Valley. We will also compare our results to previous and ongoing water and wetland data being generated for the Central Valley (Reiter et al. 2018; www.pointblue.org/watertracker). However, we are applying our existing model (Donnelly et al. 2019) from the Intermountain West for this analysis so we will have a consistent approach across all of the landscape.

Cross landscape relationships

To assess landscape synchrony, we will compare monthly patterns of inundation by wetland type (i.e., temporary, seasonal, semi-permanent) between SONEC and the Central Valley from 1984 to 2020. Relationships will focus on timing and abundance of wetland flooding linked to important waterbird lifecycle events (e.g., breeding, migration, and overwintering). Known lifecycle chronologies will be used to structure sampling periods. Analyses will identify divergence in cross-landscape patterns associated with wetland drying that may lead to emergence of bottlenecks in species habitat needs. Results will be isolated by land ownership, resource agency, wildlife area/refuge, and land use practice (e.g., rice cultivation) that isolate ecological effects to inform collaborative conservation planning.

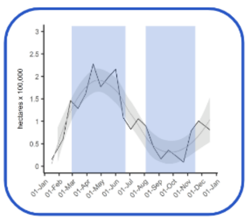
Landscape limiting factors

We will attribute the importance of climate and human water use to the prediction of wetland surface water trends using randomForestSRC regression tree analysis (Ishwaran and Kogalur 2019), as a nonparametric measure of variable importance. This approach is applicable to dynamic ecological systems with typically non-normal statistical distributions. Variables identified as important predictors of wetland change will be combined with climate projection models to forecast future wetland availability. Outcomes will identify important landscape limiting factors that may be used to inform meaningful wetland conservation. For example, if drought is identified as the major driver of wetland declines, investments in climate resilient strategies may be prioritized to best offset ecological impacts.

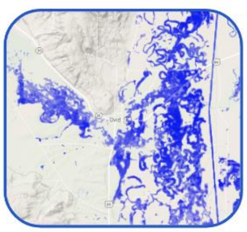
Data integration into web-based viewing platform

Wetland data will be made available through a web-based data viewer being funded and developed independently of efforts outlined in this proposal. We will also assess opportunity to integrate the new data layers into the existing wetland and water tracking system in the Central Valley – Water Tracker (www.pointblue.org/watertracker).

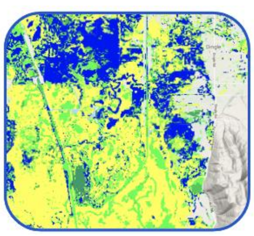
Available wetland data layers will include the following:



1. Annual mean spring and fall wetland flooding – layers depict mean surface water extent over annual three-month maximum (spring) and minimum (fall) periods.

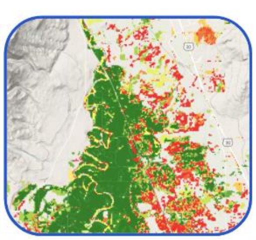


2. Rolling five-year monthly wetland flooding mean – layers depict surface water extent as a monthly rolling five-year mean.



3. The 36-year trend in seasonal surface water resiliency – layer identifies linear trend in surface water occurrence to determine if wetland hydrology is unchanged, drying, or increasing periods of flooding.

4. Wetland hydroperiod classification – classifies period of seasonal flooding by summarizing the length of time an area is wet annually.



5. Probability of monthly wetland flooding – layers depict probability an area will be flooded within specific months of the year.

Technical transfer

To accelerate the integration project outcomes into Flyway and local scale biological planning, the IWJV will host webinars outlining data interpretation for conservation practitioners. Presentations will include separate technical sessions for science support staff that wish to apply model outputs to agency-specific projects.

TIMEFRAMES AND DELIVERABLES

Modeling and data development will commence in June 2020. Completion of this element of the project will occur by May 31, 2021. All associated spatial and tabular data will be made available to funding partners. Summary results will be provided initially as a technical report followed by a peer-reviewed scientific publication. Deliverables include:

1. Access to wetland monitoring data through a web-based viewer.
2. Element of technical report summarizing study outcomes.
3. Two webinar based workshops to support data use and incorporation into existing planning efforts for state, federal, NGO, and agricultural conservation partners.

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