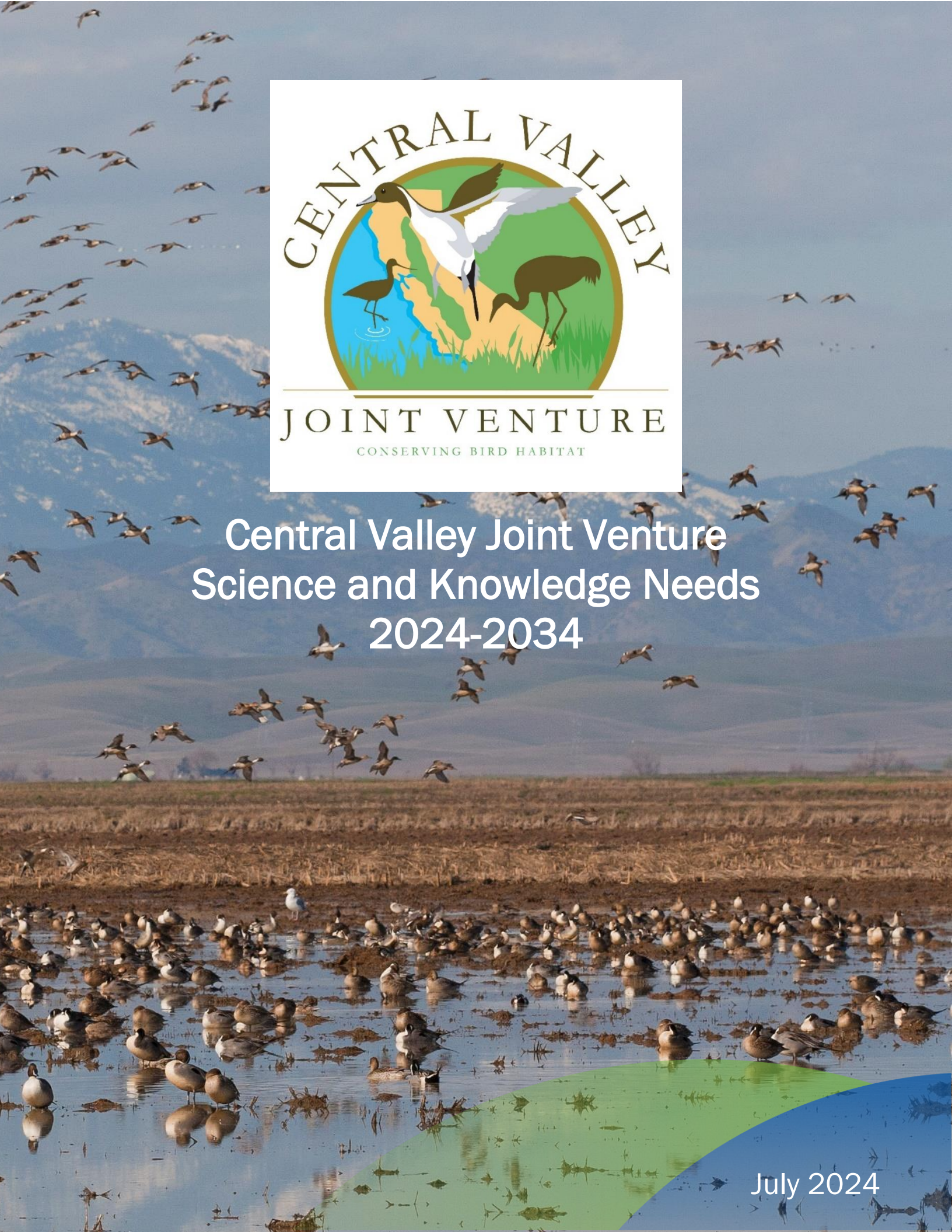

Central Valley Joint Venture Science and Knowledge Needs 2024-2034

July 2024

Black-necked Stilt (credit: Mike Peters)
Cover photo: Ducks in a rice field (credit: Mike Peters)

Central Valley Joint Venture

Science and Knowledge Needs 2024-2034

Contributors

Many individuals have contributed to the development of science and knowledge needs for the Central Valley Joint Venture. We thank the many individuals and partners that worked together on this collaborative effort to determine important science needs for conservation over the next ten years. We especially thank the coordination team, CVJV staff, and the following working groups and committees:

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List of Abbreviations

2020 Plan = 2020 CVJV Implementation Plan
CDFW = California Department of Fish and Wildlife
CVJV = Central Valley Joint Venture
IWJV = Intermountain West Joint Venture
M&E = Monitoring and Evaluation
SHC = Strategic Habitat Conservation
SGMA = Sustainable Groundwater Management Act
SONEC = Southern Oregon, Northeastern California ecological region
USFWS = United States Fish and Wildlife Service.

Yellow-billed Cuckoo. Photo credit: Steve Emmons.

INTRODUCTION

A Foundation in Science

The Central Valley Joint Venture (CVJV) has adopted a strategic, science-based philosophy toward bird habitat conservation and uses a framework called Strategic Habitat Conservation (SHC) to maximize benefits to bird populations while minimizing costs of conservation investments. Strategic Habitat Conservation (Figure 1) is a specific form of adaptive resource management that uses an iterative process to evaluate the effectiveness of habitat management actions. It encompasses four broad elements: biological planning, conservation design, delivery of conservation actions, and monitoring and evaluation. SHC moves wildlife conservation beyond the opportunistic and into the strategic realm, using an adaptive framework to ensure that learning enhances future conservation efforts.

The development and completion of this Science and Knowledge Needs document follows the release of the CVJV 2020 Implementation Plan (2020 Plan). The 2020 Plan included several elements of SHC, notably biological planning and conservation design, and provided some guidance for conservation delivery. The 2020 Plan was developed using the best available science, as directed by the predecessor of this document, the 2010 CVJV Monitoring and Evaluation (M&E) Plan. In the spirit of innovation and adaptive management, this Science and Knowledge Needs Plan represents a more comprehensive assessment. It is intended to evaluate progress toward the biological objectives and to test whether the conservation strategies and actions yield the intended ecological and social outcomes. The iterative process of testing biological assumptions to improve conservation planning and delivery is germane to the SHC process, and it bridges the gap between managers and researchers.

Sandhill Cranes. Credit: Mike Peters

Document Purpose

This document follows the 2020 Plan, which used the best available science to establish habitat and population objectives for the major groups of birds in the Central Valley of California. Following the 2020 Plan, the CVJV sought to understand the important science and knowledge needs for the next 10 years.

This guiding document was created after extensive review of relevant research conducted in the CVJV geography within the last 10 years (available at the Science Needs Library) as well as ongoing research not yet published. While this was not a systematic literature review or gap analysis, previous and ongoing research was presented to and discussed with members of the CVJV community and used as a baseline from which to form the science needs in this document.

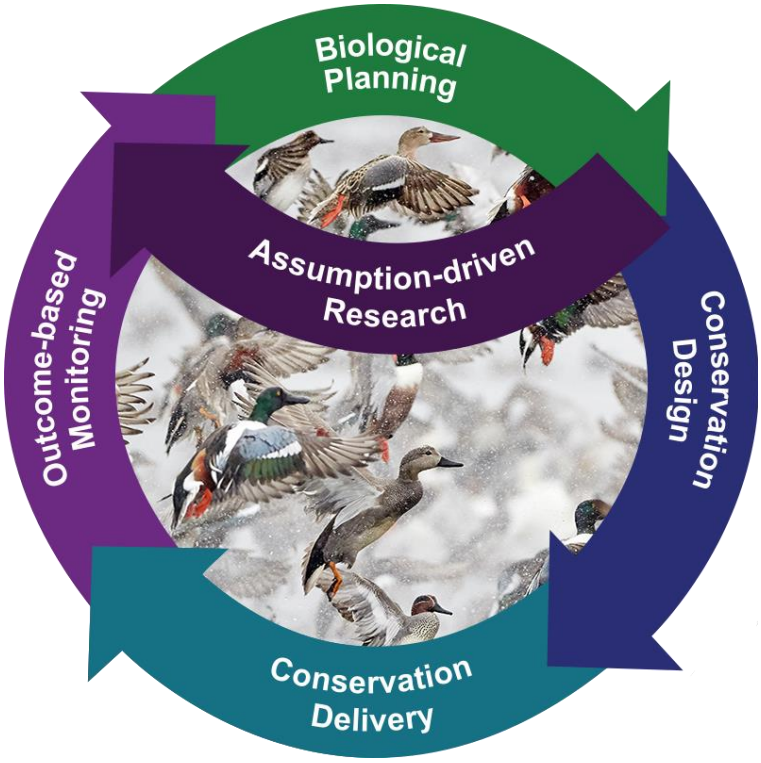

Figure 1. The elements of Strategic Habitat Conservation.

Geography and Bird Groups

The 2020 Plan combines five planning regions, which together comprise the Plan's Primary Focus Area (Figure 2). The American, Butte, Colusa and Sutter Basins now comprise the Sacramento planning region, while the Yolo and Delta Basins comprise the Yolo-Delta planning region. The Suisun Marsh, San Joaquin and Tulare Basins are maintained as separate planning regions. The 2020 Plan also includes a Secondary Focus Area that encompasses the foothills surrounding the Valley floor and generally extends to the crests of surrounding watersheds.

Bird groups covered in the 2020 Plan include breeding and non-breeding waterfowl, breeding and non-breeding shorebirds, breeding and non-breeding waterbirds, breeding riparian landbirds, breeding grassland and oak savannah landbirds, and At-risk bird species. For the purposes of this document, waterbirds include loons, grebes, pelicans, cormorants, herons, egrets, rails, coots, cranes, gulls, and terns. In some cases, science needs went beyond the life stages identified in the 2020 Plan. In 2022, a chapter on Sierra meadows landbirds that included population and habitat objectives was created for the CVJV. All of

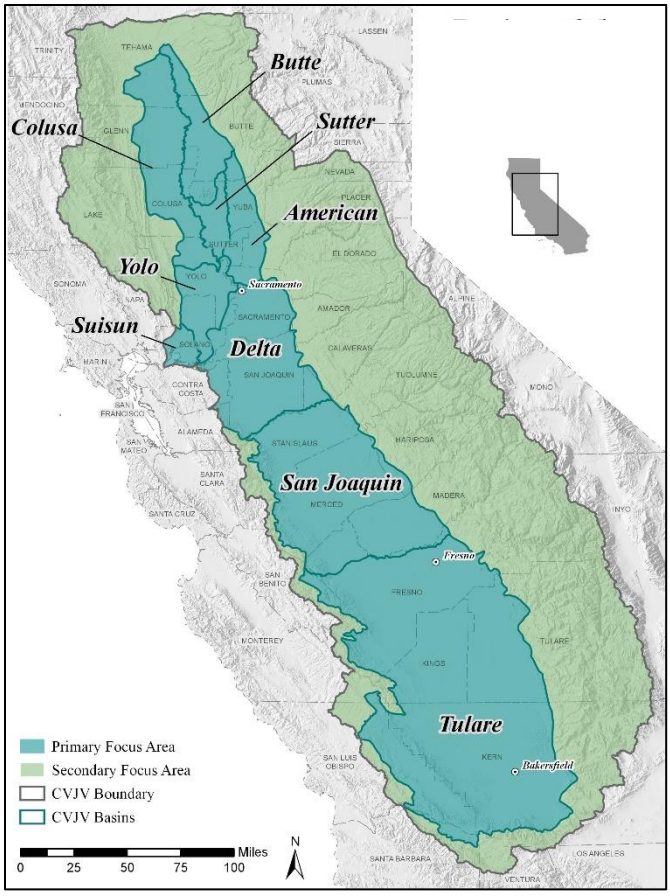

Figure 2. CVJV planning regions, basins, Primary and Secondary Focus Areas, and counties.

these bird groups are addressed in this science and knowledge needs assessment.

The Process

The process to determine the science and knowledge needs for the next 10 years began in early 2023 with a review of the 2020 Plan and previous CVJV M&E Plans (written in 2009 and 2010) that were bird-group specific. Bird working groups were assembled and they reviewed relevant work that had been completed over the past ~10 years to address the science needs covered in the M&E plans. From this review, the working groups determined which previous science needs had been met or were no longer relevant, and which still needed research. The groups also discussed new and different science needs that were now needed since the last M&E plans through multiple rounds of meetings and refinement.

The CVJV decided on a different vision for the M&E plans in 2023. Instead of separate plans by bird group, they decided on a single cohesive science needs assessment. Therefore, it was important to bring the working groups together to determine not only where overlap existed, but where new integrated science needs should be addressed (e.g., where there might be a need that transcended a single bird group and/or could benefit multiple bird groups). In a Technical Committee meeting, representatives from each working group came together and developed and discussed these integrated science needs. In addition to science and knowledge needs pertaining to bird groups, the CVJV recognized a need to increase their focus on Human Dimensions, and a Human Dimensions Task Force was present at the Technical Committee meeting as well.

The science and knowledge needs were combined into this overall report, without a focus on prioritization, but with categories that apply across groups and bring into focus the bigger-picture science needs across the entire Central Valley. The following science needs are not listed in any priority order, with some Questions and Expected Outcomes ordered alphabetically (when they are labeled). The exception is Section 2, where these are ordered by bird groups, with waterfowl, shorebirds and waterbirds followed by landbirds. It should be noted that the inclusion of an objective or a question as a science need does not imply that nothing is known on the topic, only that there are important gaps in knowledge with respect

to certain habitat types or bird groups. Considerable progress has been made on the priorities identified in the previous M&E Plans, but in many cases the science is still incomplete or environmental conditions have changed and continued investigation is recommended.

In the 2020 Plan, the CVJV used different approaches to select individual bird species as focal species. For non-breeding waterfowl, guidance was provided to all joint ventures in the updated North American Waterfowl Management Plan. For most other bird groups, representative focal species were selected based on criteria developed by the individual bird working groups. Criteria typically included selecting representative species that had a range of life histories and vegetation/habitat associations, and/or had population or densities sufficiently large enough to be detected during monitoring to document changes in response to management actions. For At-risk bird species, the CVJV developed a list of At-risk birds in the Central Valley based on information from other lists of declining and vulnerable taxa at the continental, national, state, and regional scales. Focal species selected can be found in the bird chapters of the 2020 Plan, and in the special CVJV edition of the San Francisco Estuary and Watershed Science journal.

Section 1: CURRENT AND FUTURE LAND COVER TYPES AND WATER AVAILABILITY

Defining and tracking land cover types

Rationale:
Earth observation satellites have become an integral means of land cover monitoring and crop classification across the planet. In combination with ground surveys, land cover maps can be continuously updated and improved using machine learning techniques and open-source, moderate resolution satellite imagery. However, the quantity and delineation of land cover types in the Central Valley is dynamic, which inherently increases the complexity of mapping and classifying heterogeneous vegetation components. Measuring both the effects of land use change on ecological benefits and the effectiveness of landscape treatments driven by incentive programs and targeted management action is critical for evaluating and applying adaptive management frameworks. Hence, greater effort is needed to define the diversity of land cover types within the Central Valley and assess how conditions in the past can be applied to conservation scenarios of the future. Assessing change in habitat availability over time is difficult without consistency in the definitions of land cover types. Clear definitions of land cover types will help the CVJV better classify and quantify available habitat for focal species, monitor changes over time, and improve landscape-level habitat objectives.

1.1 Define and classify habitats and subtypes: Determine clear definitions for land cover types

Question(s):

1. Agriculture: What crops should be classified as wildlife friendly, including beneficial to nesting birds? What farming activities negatively or positively impact the value of these crops to breeding wildlife?
2. Grassland and oak savannah: How can the CVJV better define and identify “oak savannah” habitat, especially since this is not currently captured in the California Wildlife Habitat Relationships classification system? What are the vegetation subclasses within “grassland and oak savannah” that are most important to bird populations and how are they distributed regionally within the CVJV? Can remotely sensed data discern different grassland characteristics (e.g., height)? Is cover data derived from remote sensing accurately delineating pasture vs. grassland habitat?
3. Riparian: What are the riparian vegetation subtypes (e.g., cottonwood forest, oak forest, willow scrub) that are most important to bird populations, and how are they distributed regionally within the CVJV? How can the CVJV better discern important features from remotely sensed data (e.g., understory cover, frequency of flooding)? How can riparian habitat objectives be further refined to reflect the relative need for each subclass in each region?

4. Sierra meadows: What does the CVJV consider a meadow? What biological characteristics and/or geographical parameters constitute a "Sierra wet meadow"? How can meadows be more accurately characterized using remote sensing information (e.g., can LIDAR be used to understand the complexity and height of willow and other riparian shrubs?)? How can different kinds of meadows be distinguished? How does the CVJV consider degraded meadows and meadows in production agriculture?
5. Upland: What types of upland habitats (e.g., agriculture, pasture, annual grassland) are available spatially and temporally in relation to water, and used by nesting waterfowl and other upland nesting birds (e.g., American Bittern *Botaurus lentiginosus* and the Northern Harrier *Circus hudsonius*)?
6. Wetlands: How can existing water and wetland tracking tools (Water Tracker, Wetland Evaluation Tool) be used to better define, distinguish, and quantify what wetland types are available? What advantages/disadvantages are there to aligning CVJV wetland classifications with other classification systems? Are wetlands in the Central Valley not well represented by other classification systems? (e.g., U.S. Army Corps of Engineers (USACE) hydrogeomorphic classifications, or USFWS National Wetlands Inventory classifications)?

Expected Outcomes (across all questions):

- More accurate definitions for how land cover classes translate to habitat types. Also, a consistent classification of wetland types that can be crosswalked to the classifications used by state and federal agencies. This will help classify and quantify available habitat, improve landscape-level habitat objectives, revise acreage targets, and improve communication across land ownership. Consistency is important in definitions, otherwise change over time is difficult to measure.
- An understanding of land cover subclasses within grassland, oak savannah, riparian, Sierra meadows (i.e., meadow attributes), uplands (e.g., agriculture, pasture, annual grassland), and wetlands to inform prioritization for restoration or protection, ensure a variety of vegetation species are represented, and ensure there is enough suitable subtype habitats for focal species to reach population objectives.
- An upland vegetation tool to identify and delineate the juxtaposition of upland cover (e.g., for duck nesting habitat and other upland nesting birds) to irrigated seasonal, semi-permanent and permanent wetlands. This will help to assess priority areas for breeding waterfowl and areas where water should be provided for brood habitat.

1.2 Track land cover: Understand changes in land cover over time

Question(s):

1. Agriculture: What types of agricultural habitats (e.g., row crop, grains, pasture) are available spatially and temporally in relation to water? What is the availability and long-term trend of flooded agricultural crops (e.g., alfalfa, pasture, corn, rice), and

what are the main drivers of change? Where are the highest conversion rates of annual crops (especially pasture, row crops, rice, and corn) to permanent crops? How do these areas intersect with restoration priorities? How do these areas intersect with local planning priorities including SGMA (Sustainable Groundwater Management Act) implementation?

2. Grassland and oak savannah: How is the extent of grassland and oak savannah habitat (overall and by subtype) changing over time, and how do these trends vary regionally? How are patch sizes and connectivity or spatial patterns among patches changing?
3. Riparian: How is the extent of riparian vegetation (overall and by subtype/successional stage) changing over time? How much riparian restoration is occurring across the landscape? How is the width of riparian corridors changing?
4. Sierra meadows: What is the extent of meadows, both existing and degraded? How will the CVJV incorporate new meadow information/locations as it is generated?
5. Uplands: What is the spatial and temporal pattern of available upland nesting habitat in relation to water for breeding waterfowl, upland birds, and other breeding waterbirds?
6. Wetlands: What wetland types are available spatially and temporally? What are the long-term trends and drivers of change? What are the available flooded wetland habitats during spring and summer for duck broods breeding, molting ducks, and nesting and post-breeding shorebirds and waterbirds, such as Black-necked Stilt *Himantopus mexicanus*, American Avocet *Recurvirostra americana,* White-faced Ibis *Plegadis chihi*, and the Black Tern *Chlidonias niger*?

Expected Outcomes (across all questions):

- A report (ideally annually) detailing acres of land cover types, subtypes, and other important statistics (e.g., the proximity of upland nesting habitat to water, riparian corridor width) by planning region, with maps and spatial data that can be shared. The report would include baseline, protected, and newly restored areas in relation to habitat objectives, and reflect any loss of habitat or conversion of wildlife-friendly agriculture to non-wildlife friendly agriculture. It would include, for example, the total extent of Sierra meadows (both current and degraded) and maps of grassland and oak savannah cover and land use, including whether these lands are being grazed or taken out of production.
- An upland tool that annually tracks the availability of upland habitat for nesting waterfowl, including agricultural habitats. A map of flooded wetland habitats during spring and summer for duck broods and molting habitats, which can be added to the (ideally annual) report.
- A report every 5 years identifying updated restoration and protection priorities and opportunities, and local planning priorities. This would also include where to focus rice and agriculture easements.
- Comprehensive, regularly-updated (~5 year) riparian restoration database/project tracker and land cover maps.

Water and Watersheds

Rationale:
Wetland, cropland, and riparian forest habitats in the Central Valley and meadow and riparian forest in adjoining watersheds depend on water supply availability that varies greatly with climatic conditions, coniferous forest management, and extensive water supply management. Changing climate, impacts of drought, and water demand related to increases in urbanized areas and permanent crops (orchards and vineyards), are challenging the ability to reliably supply water to habitats of water-associated birds. Additionally, even when abundant water supply is available, management and depth of surface water flooding influences the suitability of habitat for waterfowl, shorebirds, and waterbirds. Quantification of acreage and trends of suitable flooded habitat, and quantification of their water requirements and deficits requires tracking water seasonally within and among years. Furthermore, understanding effects of adverse or restorative (through meadow/floodplain restoration) changes in hydraulic connectivity and timing of flooding among watershed meadows, riparian forests and floodplains, and Central Valley wetland and cropland habitats, requires tracking of hydrologic changes across whole river systems and connected habitats. Using this information, managers can better prioritize use of water supplies depending on hydrologic conditions.

1.3 Track Water: Quantify water requirements and flooded habitat

Question(s):

1. Extent of flooded habitat: How many acres of each wetland and agricultural type are flooded annually in each planning region? What are their water sources and forecasted and actual water allocations? To what extent are managed/restored wetlands and crop habitats allocated and delivered sufficient water to serve as habitat, and how does this vary seasonally, annually, and spatially? What are the conditions under which each habitat type is flooded or not?

    Expected Outcome(s):
    - An annual summary of flooded acreage by wetland and agricultural type, management regime, water source, and forecasted and actual water allocation by JV region. This would be managed in a digital data entry system accessible to all partners. The summary should incorporate wetland acre data (forecast, timing, and extent of flooding on public lands) gathered during interagency meetings coordinated by the CDFW (California Department of Fish and Wildlife) Wetland Conservation Program.
    - An improved understanding of water requirements and deficits, informing activities around future water policy, advocacy, and water acquisition for habitat conservation.
    - An improved understanding of patterns of regional, seasonal, and annual variation in functional flooded habitat acres, drivers of this variation, and overall reliability of habitat.
    - An improved understanding of wetland extent, the frequency at which the CVJV needs to update a base map of wetland boundaries, and the value of real-time tracking of the distribution of flooded habitat.

2. Total water requirements: How much water is needed to meet CVJV objectives over time and space, for all habitat types? What proportion is currently provided by surface water vs. groundwater, and how is that expected to change in the future?

   Expected Outcome(s):
   - A report quantifying updated estimates of water requirements to manage and maintain flooded habitats, including seasonal, permanent, and semi-permanent wetlands, vernal pools, planted rice, and post-harvest flooded grains, including which were restored lands.

3. Water depths: When and where does water occur at depths suitable for shorebirds vs. waterfowl vs. wading birds (quantified for each wetland and summed across wetlands at appropriate spatial and temporal scales)? When and where are wetlands providing habitat at depths suitable for multiple water-associated groups (i.e., waterfowl, shorebirds, and waterbirds)?

   Expected Outcome(s):
   - An improved understanding of the seasonal and spatial variation in suitable depths, contributing to refining the assumptions in food-based models and refining habitat objectives.
   - A document linking water depths to flooding curves and WaterTracker to inform shorebird, waterfowl, and wading bird habitat objectives/availability.

1.4 Track hydrologic connectivity and changes in access to floodwater or groundwater

Question(s):

1. Floodplain connectivity: How does floodplain connectivity, stream flow, frequency of flooding, and depth to water table vary regionally, seasonally, and annually and how does this impact riparian and meadow habitat?

   Expected Outcome(s):
   - An improved understanding of the extent to which riparian and meadow habitat has access to floodwater or groundwater, and how this may be changing over time. This will inform locations for riparian restoration and potentially influence population, density, and habitat objectives.

2. Wetland and river connectivity: What is the status of the connectivity between wetlands and river systems (i.e., which ones are connected and how), and what is the role of river connectivity in influencing wetland vegetation health, invertebrate abundance (benthic and water column), and benefits to fish populations?

   Expected Outcome(s):

- An improved understanding of the extent to which wetlands are connected to river systems, and any role this may have in influencing habitat quality. This may inform optimal locations for different wetland management goals.

Future Land and Water

Rationale:
Many natural, managed, and farmed habitats and their associated water resources (managed and natural) are facing various threats due to climate change, urban sprawl, increased frequency of large wildfires, and changes in farmland management and cropping trends. Habitat conservation strategies and bird population goals need to account for rapid, ongoing, or even accelerating threats to land and water resources to effectively prioritize future conservation activities. The ability to develop adaptive habitat conservation strategies and bird population goals will be severely limited without identifying potential conservation opportunities, or evaluating and forecasting the scope and range of environmental impacts these threats will have on habitats. Monitoring bird response to changing conditions (e.g., urbanization, crop trends, water supply/use patterns, SGMA) and extreme events (wildfire, severe drought), remains vital in understanding current and future ecological and population impacts to birds, as well as our ability to adapt conservation strategies and goals based on this understanding. Combined, information on environmental trends and bird response can support relatively long-term conservation and management decisions by CVJV partners.

1.5 Develop spatial prioritizations for habitat conservation under current and future scenarios

Question(s):

1. Expansion of perennial crops: Where is the expansion of perennial crops continuing at high rates, and what habitats (e.g., grasslands) and wildlife-friendly crops are at highest risk? What spatial attributes affect vulnerability? How can conservation interests collaborate and obtain more information from non-rice crops (e.g., almond) about projected industry changes?

   Expected Outcome(s):
   - A spatial prioritization of lands that need protection, and an improved understanding of the risk of urban development and continued perennial crop expansion over the next 30 years.

2. Other crops: What are future projections of cropland habitat areas? Which crop types are expanding, declining, or shifting distributions within the Central Valley? What conservation opportunities and challenges will be associated with these changes?

   Expected Outcome(s):

- Projections for crop types across the Central Valley, which will be used to predict habitat change relative to conservation goals and identify areas with conservation opportunity.

3. Rice footprint: Where is rice conversion highest, and what spatial attributes affect vulnerability? Will rice expansion in the Delta continue and is the expansion of rice crops into the Delta positively or negatively affecting waterfowl, shorebird and/or waterbird populations? What land covers are being converted to rice, and what are the benefits and trade-offs? How does the Lands Committee ranking criteria for agricultural easements in the Sacramento Valley overlap spatially with these concerns? How will losses in winter-flooded rice affect habitat objectives for wetlands?

   Expected Outcome(s):
   - A spatial representation of rice (including translating the Lands Committee's ranking criteria for protecting rice into a spatial representation within the Sacramento Valley), which will inform strategic protection of these lands important for bird conservation. Improved habitat objectives for rice.

4. Riparian/Sierra meadow prioritization framework: Given the projected changes in climate, hydrology, and land use, and considering the importance of landscape connectivity, riparian habitat diversity, and river processes (e.g., flooding), where are the most important places to protect, manage, and restore riparian and meadow habitat? Where should restoration projects be prioritized? Besides their contribution to meeting riparian and meadow conservation objectives, what other factors or co-benefits should be considered?

   Expected Outcome(s):
   - Maps with updated projections for changes in Central Valley riparian and Sierra meadow habitat and focal species distributions within each CVJV planning region. The CVJV can prioritize conservation, management, and restoration based on projected changes. An explicit framework for prioritizing the selection of riparian conservation and restoration projects.

5. Urbanization: Where are urban areas expected to expand over the next 30 years, which habitats are most vulnerable (e.g., agricultural lands, forests, grasslands, uplands), and what spatial attributes affect vulnerability?

   Expected Outcome(s):
   - A spatially explicit understanding of what habitats are most vulnerable to urban expansion over the next 30 years and what attributes affect vulnerability.

6. Wetlands: Where are the best places to do wetland habitat restoration to benefit birds (and potentially other wetland-dependent species, e.g. Giant Gartersnake *Thamnophis gigas*)? How does including different species or groups influence the results?

Expected Outcome(s):

- Maps showing priority areas for wetland restoration depending on the target species.

1.6 Understand climate change effects on habitat and water

Question(s):

1. Flood/Drought: In years where the impact of climate change (e.g., widespread flooding, prolonged drought events) varies among CVJV regions, how are habitat and population objectives impacted regionally?

   Expected Outcome(s):
   - Updated regional habitat objectives in the next (2030) Implementation Plan to consider regional variation in drought and flooding projections and impacts,

2. Riparian: How will riparian habitat shift in each CVJV planning region, given current projections for climate, hydrology, and land use? How will climate change affect our assessment of the extent of riparian habitat that is feasible to restore? How are wildfires impacting riparian habitat? What characteristics make riparian habitat wildfire-resilient or more vulnerable?

   Expected Outcome(s):
   - A document with refined projections of changes in existing riparian habitat for each CVJV planning region due to climate change that will inform adaptation strategies and conservation priorities. This information could also inform monitoring recommendations to capture shifts in species distributions in response to these changes.
   - An understanding of wildfire impacts and risk, including mapping wildfires and their impact. This could potentially alter habitat objectives, locations for riparian restoration, restoration designs, and approaches for improving resilience.

3. Sierra meadows: Upstream of reservoirs, how will climate change impact water resources crucial for meadows to act as functional habitat for birds?

   Expected Outcome(s):
   - Water budgets for Sierra meadows to estimate potential change in runoff to meadows and inform forest management strategies to prioritize sustainable restoration of meadows (e.g., harvest of trees to reduce water demand in meadow watersheds).

4. Wetlands: What are current and future impacts of climate change on availability, quality, and cost of management for wetland habitats? How can the CVJV and

partners prepare for climate change impacts? How does changing water availability impact wetland productivity?

Expected Outcome(s):

- An understanding of current and future impacts of climate change on wetland habitats and wetland management. Consideration of climate change in research and analyses to address management concerns (e.g. water availability).

Section 2: BIRD POPULATIONS AND HABITAT USE

Population sizes, trends, and vital rates

Rationale:
CVJV habitat objectives and bird population goals have expanded regionally (primary and secondary focus areas) to include birds using meadow, riparian, grassland, and oak savannah habitats. Bird groups included are waterfowl, shorebirds, waterbirds, riparian landbirds, grassland-oak savannah landbirds and 38 "At-risk" species (identified to be at high risk of future or ongoing population decline). New and current information is needed on bird populations, their associated habitat requirements, and future threats/impacts for all major bird groups identified in the 2020 CVJV Implementation Plan. These data will be used to adjust current and develop new population goals and related habitat conservation objectives and for adaptive management of habitats across the Valley. Consequently, research is required to design protocols and conduct population monitoring that will provide estimates of population baselines, trends, distributions, vital rates, and annual habitat relationships across bird groups and life history stages. Furthermore, research and monitoring information must be reported in appropriate spatial and temporal scales and formats useful for CVJV managers and conservation stakeholders (e.g., adaptive management of habitats or revision of conservation objectives/goals).

2.1 Develop monitoring protocols where lacking

Question(s):

1. Breeding waterfowl: What are appropriate metrics for assessing the distribution and success of breeding waterfowl?

   Expected Outcome(s):
   - A monitoring protocol that will produce an estimation of annual productivity, recruitment rates, vital rates, and chronology of nesting waterfowl. This will likely include nest searching and monitoring as well as nest density and nest survival estimation. Additional brood surveys could enhance estimates of productivity.

2. Breeding and non-breeding waterbirds: What are repeatable and cost-effective approaches to monitoring breeding and non-breeding waterbirds (terns, grebes, ardeids, cranes, etc.) across the Central Valley that can be regularly repeated over time?

   Expected Outcome(s):
   - Straight-forward and cost-effective monitoring programs that can be regularly repeated and allows tracking of region- and species-specific breeding waterbird population densities, non-breeding waterbird population sizes, and trends over time throughout the CVJV primary focus area. This monitoring

program should allow for comparisons between regions and over time. Approaches to monitoring will likely be different for different waterbird species such as herons/egrets, terns, grebes, secretive marsh birds, cranes etc.
    - A multi-species monitoring program designed to efficiently generate data allowing CVJV partners to understand how populations and distributions are changing for waterbirds in the Central Valley.

3. Breeding riparian landbirds: What is an easily repeatable and cost-effective approach to regional-scale riparian bird monitoring that can be used across the Central Valley and regularly repeated over time?

    Expected Outcome(s):
    - A simple and cost-effective riparian monitoring program that can be regularly repeated and allows tracking of region-specific changes in riparian bird population densities and trends throughout the CVJV primary focus area. This monitoring program should allow for comparisons between regions and over time.

4. Landbirds where point counts are not appropriate: What is the best consistent survey method for landbird species that cannot be reliably counted in point counts (e.g., raptors, owls)?

    Expected Outcome(s):
    - A review of population assessment approaches and associated survey protocols for landbird species where point counts are not appropriate including the Burrowing Owl *Athene cunicularia*, the Short-eared Owl *Asio flammeus*, Sierra Great Gray Owl *Strix nebulosa yosemitensis*, the Northern Harrier, American Kestrel *Falco sparverius*, the Yellow-billed Magpie *Pica nuttalli*, the Bank Swallow *Riparia riparia*, and the Yellow-billed Cuckoo *Coccyzus americanus*.

5. Leveraging existing protocols: How can protocols or data from other monitoring programs be used to address CVJV monitoring needs (e.g., CDFW Songbird Diversity program)? How can new technologies (e.g., Autonomous Recording Units [ARUs], Motus Wildlife Tracking System, and/or Sentinel sites) or community science data sets (e.g. eBird) be leveraged?

    Expected Outcome(s):
    - An understanding of how protocols and data from other monitoring programs, as well as new technologies and community science, can be used to address CVJV monitoring needs.

2.2 Population monitoring

Question(s):

1. Breeding and non-breeding waterfowl:
   - How can the CVJV support (and better integrate data from) efforts to monitor waterfowl populations through county-level harvest surveys, breeding population surveys, and aerial surveys? What alternative datasets can be used to supplement or in place of existing surveys? Can eBird data be incorporated/useful?
   - What is the population status of breeding waterfowl, especially in unsurveyed areas?
   - Where are core nesting regions for waterfowl and how do they change over time? What proportion of nesting ducks use agriculture vs. natural uplands? What is the relative importance of the different brood habitats in the Central Valley, including wetlands, ricefields, and other habitats?
   - What level of domestic hybridization is there with mallards in the CVJV? What threats does domestic hybridization pose to waterfowl populations in the CVJV? How can/should the CVJV support efforts to monitor the genetic health of waterfowl in California (e.g., through the DuckDNA program)?
   - What is the current and historical contribution of the locally breeding populations of ducks to hunter harvest during the winter, assessed using isotopes, surveys, and banding data?

     Expected Outcome(s):
     - A strategic plan for collecting data using traditional and alternative methods collection in the face of uncertain budgeting and declining support for aerial surveys.
     - Species accounts (for species other than mallards) that summarize current biological information and critical information needs, which will help to initiate or inform conservation planning.
     - Annual nesting population and/or productivity surveys.
     - An evaluation of whether breeding waterfowl trends (using the Waterfowl Breeding Population and Habitat Survey [BPOP]) are related to land use change and water availability. This should consider the timing of surveys in relation to the timing of rice agricultural activities and crop progress (especially rice), and could inform future habitat management with a goal to help reverse declining duck population trends.
     - A multi-regional evaluation of California's duck harvest to evaluate the contribution (both current and historical) from locally nesting ducks (i.e., derivation of harvest).
     - Multi-region genetic analysis of breeding mallards to determine baseline genetics and levels of hybridization with domestic mallards.

2. Non-breeding shorebirds:
   - How has the population and distribution of migrating and wintering non-breeding shorebirds changed since the late 1990s?
   - What shorebird species have a large proportion of the global population using the Central Valley, and what specific habitat types are they utilizing?

- How can the CVJV support (and better integrate data from) efforts to monitor shorebird populations through the Pacific Flyway Shorebird Survey (PFSS) and the Central Valley Shorebird Survey (CVSS), etc?

  Expected Outcome(s):
  - Updated migrating and wintering non-breeding shorebird population estimates for the Central Valley and important planning regions.
  - An understanding of what portion of the global populations depend on the Central Valley as key for overall population sustainability, which will inform conservation priorities and action for species and associated habitat type.

3. Breeding and non-breeding waterbirds:
   - How has the population and distribution (time and space) of various waterbird guilds (ibis, terns, grebes, ardeids, rails, etc.) changed over time?

     Expected Outcome(s):
     - Population estimates and an updated understanding of how different guilds of waterbirds use and rely on Central Valley habitats.

4. At-risk species:
   - How can/should the CVJV support (and better integrate data from) current efforts to monitor Sandhill Crane *Antigone canadensis* populations (e.g., Ivey, The Nature Conservancy [TNC], USFWS, United States Geological Survey [USGS] recent/ongoing efforts on marking/tracking cranes), including for the Greater Sandhill Crane *Antigone canadensis tabida*?
   - What are the current population sizes and trends of At-risk species for which estimates are lacking in the 2020 Implementation Plan, including Purple Martin *Progne subis*, LeConte's Thrasher *Toxostoma lecontei*, Suisun Song Sparrow *Melospiza melodia maxillaris*, Yellow-headed Blackbird *Xanthocephalus xanthocephalus,* Mountain Plover *Charadrius montanus*, and California Black Rail *Laterallus jamaicensis coturniculus*)?
   - What are the current population densities of the species above within their key habitats in the CVJV? What are the primary factors limiting their population sizes?
   - How can/should the CVJV address the California Black Rail in the 2020 Implementation Plan and support efforts to monitor their populations?

     Expected Outcome(s):
     - Improved coordination of data collection for Sandhill Cranes. This is needed for population trend assessment and development of CVJV habitat objectives and population goals especially for the state-threatened Greater Sandhill Crane subspecies which is principally found in the Delta and Sacramento Valley. A better understanding of if/how the CVJV can better incorporate monitoring information into the Implementation Plan's conservation objectives and strategy.
     - Quantification of current population sizes and densities within key habitats for At-risk species including Purple Martin, LeConte's Thrasher, Suisun Song Sparrow, and Yellow-headed Blackbird, Mountain Plover, and California Black

Rail, including an understanding of what limits their populations. This will be crucial for setting population objectives and understanding the conservation needs, such as habitat enhancement objectives, to meet population objectives.
    - A better understanding of if/how the CVJV and partners can help support populations of the California Black Rail in the Central Valley and incorporate monitoring information into the Implementation Plan's conservation objectives and strategy.

5. Riparian landbirds: What are the current population sizes, densities, and trends of riparian landbird focal species in each planning region, especially the Tulare planning region? How does the community composition shift seasonally and regionally? What role does riparian habitat play in supporting landbird populations during migration and over winter?

    Expected Outcome(s):
    - Updated estimates of population sizes, densities, and trends, especially for the Tulare planning region for which data are lacking in the 2020 Implementation Plan. An improved understanding of the role of Central Valley riparian habitat during migration and over winter, potentially informing updated conservation objectives and restoration priorities.

6. Grassland and oak savannah landbirds: How does community composition in grassland and oak savannah habitats shift seasonally and regionally? What role does grassland and oak savannah habitat play in supporting landbird populations during migration and over winter?

    Expected Outcome(s):
    - An understanding of regional and temporal variation in species compositions. This will improve habitat enhancement objectives for a shifting suite of species in the same location, or for planning region-specific needs.

7. Sierra meadows:
    - What is the ability of Sierra meadows to support population objectives for Willow Flycatchers *Empidonax traillii*, the Yellow Warblers *Setophaga petechia*, and other songbirds, shorebirds, and waterfowl over time? How does each meadow type contribute to bird population objectives?
    - Some species prefer high elevation and/or small meadows: how do these meadows contribute to overall population density and abundance estimates? How can these meadows best be used in density estimates / analyses considering edge effects of sampling and the undersampling of these meadow types?

    Expected Outcome(s):
    - The continuation of existing broad scale monitoring of meadows and the contribution of different meadow types to bird population objectives. This is

crucial to understanding meadows' ability to support population objectives over time and to inform progress toward habitat objectives.
- Better population estimates for high elevation meadows and small meadows, which will improve population objectives.

2.3 Determine landscape scale vital rates and habitat parameters

Question(s):

1. Breeding and molting waterfowl:
   - What are the regional and habitat-specific vital rate estimates for nesting ducks? How are nesting duck vital rates (nest survival, nest density) influenced by various habitat types (e.g., vegetation type and structure, field size) and management strategies (e.g., number of years managed as upland/agriculture vs. other types)?
   - What upland vegetation habitat types promote increased nest survival and density? What is the optimal size upland field for planting to improve nesting density and survival?
   - What habitats are required for breeding waterfowl, including the ideal juxtaposition of upland nesting habitats and wetlands suitable for duckling habitat?
   - How does nest density and predator abundance relate to field type, location, and management history? What ecological traps/sinks exist (e.g., nesting in grain or hayfields).
   - What is the carrying capacity of uplands and associated spring water for nesting pairs? What is the size, frequency and duration of flooding, dominant cover types, quality of habitat, and management history of wetlands relative to their use?
   - What are the regional and habitat-specific survival rate estimates for brood rearing hens and ducklings? How is survival influenced by habitat type and their management? What habitat qualities create ideal brood rearing habitat?
   - What critical molting areas are reliably available throughout the CVJV focus areas, California, and Oregon for Mallard *Anas platyrhynchos*, Gadwall *Mareca strepera*, Cinnamon Teal *Spatula cyanoptera*, Wood Duck *Aix sponsa*, and the Redhead *Aythya americana*? How do they differ in habitat and duck survival rates? What factors influence molt site selection? How does survival during the molting period influence population growth rates of breeding waterfowl? What role does disease play in survival during molt, especially for smaller breeding populations?

   Expected Outcome(s):
   - A concurrent multi-regional research program to understand habitat influence on nesting duck vital rates (e.g., assess correlations of habitat types and breeding bird vital rates). This would include models and perturbation analyses to estimate the relative importance of changes in vital rates to population growth. This information will help to track progress toward objectives and habitat conservation, and direct habitat management decisions.

- Research on breeding pair habitat, including semi-permanent or permanent water, and associated upland habitats. An analysis to understand habitat requirements for breeding waterfowl, including the juxtaposition of upland nesting habitats to wetlands suitable for duckling habitat.
- Concurrent data on distribution and vital rates for nesting, brood-rearing, and molting ducks across CVJV focal areas. From these data, an identification of where in the annual life cycle population growth is limited and the associated landscape/habitat variables. These results would help to tailor habitat management prescriptions and management tools to regions and to improve key habitats. It would also inform where to prioritize and secure traditional molt areas throughout the CVJV and SONEC planning areas.

2. Breeding shorebirds:
   - What is the reproductive success of breeding shorebirds in rice and wetlands, including recharge basins, FloodMAR (flood-managed aquifer recharge), and Tulare Lake when inundated?
   - Where applicable, how do specific management practices (e.g. alternate wetting and drying in rice, drawdowns in wetlands in late-April) influence reproductive success?

     Expected Outcome(s):
     - An improved understanding of the reproductive success of breeding shorebirds in key habitats.
     - Practice-specific understandings that will help inform management practices that should be avoided (e.g., draining mid-incubation) or encouraged (potentially through incentive programs if there is opportunity to expand a practice).

3. Breeding riparian landbirds, grassland and oak savannah landbirds, Sierra meadow landbirds: How do vital rates vary spatially (e.g., between CVJV planning regions) and between remnant and restored sites? How do habitat attributes affect vital rates and population trends?

   Expected Outcome(s):
   - An improved understanding of reproductive success and survival of landbirds in key habitats in each of the CVJV planning regions and the role of reproductive and survival rates in contributing to variation in population densities and trends identified in broader population monitoring efforts. This would further inform restoration designs, regional priorities, and habitat objectives.
   - An established monitoring program to estimate and track landbird vital rates in each of the CVJV planning regions, such as by adopting MAPS (Monitoring Avian Productivity and Survivorship) program protocols. Where possible, multiple monitoring sites in each region should be representative of the range of habitat conditions in each region, including remnant and restored sites, with a sufficient sample size so that inferences may be drawn regarding differences among sites.

2.4 Update population and habitat objectives where needed

Question(s):

1. Breeding waterfowl:
   - What is the existing carrying capacity of the Central Valley for nesting waterfowl and how does this affect the current CVJV breeding duck population objectives?
   - How much upland nesting habitat is required in the Central Valley to meet the breeding duck population objectives established by the CVJV?
   - What is the relative abundance and reproduction potential of breeding waterfowl using habitats in the secondary focus area?

     Expected Outcome(s):
     - A report which estimates the carrying capacity of the Central Valley for nesting waterfowl, determines the amount of upland nesting habitat needed to achieve CVJV breeding population objectives, and examines the current CVJV breeding waterfowl population objectives based on future habitat projections.

2. Non-breeding shorebirds: Should the CVJV develop population objectives for individual species? For which species is the Central Valley supporting a large percentage of the population? How would this affect habitat objectives?

   Expected Outcome(s):
   - Updated population and habitat objectives (if determined to be necessary) considering which species are a high priority in the Central Valley.

3. At-risk species:
   - For Greater Sandhill Cranes breeding in Sierra meadows, what are habitat requirements for reproduction based on home range characteristics, habitat selection (within and among meadows) of breeding adults and broods, and survival estimates of nests and young?
   - For Sandhill Cranes wintering in the Central Valley, what are their population trends and are their wintering habitat needs being met? Based on updated science, is there evidence the CVJV needs to update wintering population and habitat objectives?
   - What are the current extents of key habitats for species that are expected in habitats not included in the 2020 Implementation Plan: Purple Martin and LeConte's Thrasher? What would their habitat objectives be? What are the trade-offs with conserving these habitats and other habitat objectives of the CVJV?
   - What would population objectives be for the Purple Martin, the Suisun Song Sparrow, and the Yellow-headed Blackbird? What would population objectives be for the LeConte's Thrasher, a species using desert scrub and fallowed land in the southern San Joaquin planning region?

Expected Outcome(s):

- Breeding season population objectives for the Greater Sandhill Crane in Sierra meadows. Individually based (animal movement and nest monitoring) methods could be used to estimate demographic-ecological relationships and to derive breeding population objectives.
- For Sandhill Cranes wintering in the Central Valley, updated population and habitat objectives using an evaluation of existing data, including coordinated roost surveys, foraging counts, and aerial surveys, to better understand population trends. This should consider the changing agricultural landscape (e.g., rice replacing corn) and management practices when evaluating a potential reduction in foraging habitat.
- Population and habitat objectives for At-risk species, including Purple Martin, LeConte's Thrasher, Suisun Song Sparrow, Yellow-headed Blackbird.
- Population and habitat objectives within the desert scrub region (e.g., Carrizo) and in fallowed land in the southern San Joaquin planning region.

4. Landbirds: What are continental landbird population objectives and how would CVJV population objectives be adjusted based on these?

   Expected Outcome(s):

   - A report that places CVJV landbird population objectives within the context of continental landbird objectives. Population objectives can be adjusted with consideration of a larger geographic context.

Fine-scale habitat use

Rationale:

As wildlife populations, landscape patterns, and climate conditions change, so do the management actions and management needs. In recent years, the trend has been towards developing more multi-species conservation goals in a landscape mosaic of shifting habitat conditions. This shift is significant in highly impacted systems like the Central Valley, where habitat doesn't occur passively. Instead, resources are often provided intentionally through active management or unintentionally as byproducts of water delivery and agricultural patterns. Assessing wildlife value and conservation delivery requires an accurate assessment of habitat use, which is often specific to individual life history needs. Therefore, any effective land and habitat management must consider the particular needs of different species and provide the necessary resources to support their survival and well-being. Fine-scale habitat use information can help inform habitat management, the interpretation of population surveys, provide empirical estimates for parameters in bioenergetic models and validate their predictions, and quantify the ecological effects of changing wildlife distributions, climatic shifts, and any agricultural changes or conservation challenges that result.

2.5 Understand and document important fine-scale habitat and landscape features

Question(s):

1. Breeding and molting waterfowl:
   - What upland and agricultural habitat qualities create ideal nesting conditions for ducks? How do ducklings move from upland nesting fields to brood wetlands? How do philopatric hens respond to the dynamic nature of agriculture (crop rotations)? How do predators use the landscape in relation to nesting ducks, and what other species use these upland nesting areas? How do upland types vary in quality and use by nesting waterfowl?
   - What habitat qualities create ideal molting habitat for ducks and duckling/brood rearing habitat (e.g., habitat type, location, size, duration and frequency/reliability of flooding, history of land use) and what other species use these areas? What is the ideal vegetative cover to open water ratio? What other potential molting and/or brood rearing habitats may be available (i.e., riparian, seasonal wetlands, growing rice), and where?

     Expected Outcome(s):
     - An understanding of ideal upland and agricultural habitat characteristics for nesting and brood rearing. The data would come from monitoring vital rates, vegetation, and movements among upland and wetland habitats. Individually based (animal tracking) methods could be used to analyze the selection of agricultural habitats for nesting by ducks. Survey methods to assess use by other bird groups could also be used. This information will help determine objectives and habitat conservation, and direct incentive programs to areas with lacking habitat.
     - An understanding of the ideal habitat characteristics for molting. Individually based (animal tracking) methods to analyze selection of habitats for molting by ducks. Surveys to assess use by other bird groups could also be conducted. This information will help determine objectives and habitat conservation, direct us to areas lacking habitat, and increase the ability to anticipate disease outbreaks (e.g., avian botulism).

2. Breeding waterbirds: What habitats or specific landscape features in the agroecosystem of the Central Valley landscape are important to nesting habitat selection by waterbirds? (Specifically, herons and egrets, White-faced Ibis, the Black Tern, and other species of special concern such as the California Black Rail).

   Expected Outcome(s):
   - An understanding of nesting habitat selection (local and landscape scale) for waterbirds. These may include mixes of habitats, or habitat features different from other bird groups and will depend on the suite of waterbirds considered, e.g., herons and egrets nest in riparian trees near wetlands and flooded agriculture. Individual-based (animal tracking) and survey methods to analyze waterbird habitat selection could be used.

3. Sandhill cranes: How is reducing corn in the Delta and increasing rice likely to influence winter food availability for Sandhill Cranes?

   Expected Outcome(s):
   - An understanding of the population-level effects on Sandhill Cranes due to the amount of available rice and corn on the landscape.

4. Breeding riparian and Sierra meadow landbirds: How does riparian vegetation subtype (e.g., cottonwood forest or willow scrub), habitat structure (e.g., understory cover, riparian corridor width), and other important features (e.g., frequency of flooding, groundwater connectivity) affect habitat quality, bird community composition, and population densities?

   Expected Outcome(s):
   - An improved understanding of the role of different habitat features in contributing to breeding densities, population sizes, and trends, which will inform restoration designs, regional priorities, and habitat objectives.

5. Breeding grassland and oak savannah landbirds: How do focal species respond to threats to grassland and oak savannah habitat, including urban development/fragmentation near urban centers, degradation resulting from management practices (e.g., grazing or lack thereof, woody encroachment), prescribed fire/wildfire, noxious weeds (e.g., yellow star-thistle), and expansion of agriculture (especially nut crops). What are the trends of these threats?

   Expected Outcome(s):
   - An improved understanding of species responses to habitat, including the impact to birds of city development in Solano County. Improved habitat and population objectives with an understanding of effects on focal species populations of these threats.

2.6 Integrating habitat and species benefits across expected species-habitat associations

(see also Section 5)

Question(s):

1. Breeding and non-breeding waterfowl, shorebirds, and waterbirds: To what extent do waterfowl, shorebird, and waterbird species rely on wetland, agriculture, uplands, and other habitat types/land covers in the CVJV region? How much does their reliance on each of these habitat types vary diurnally, seasonally, or annually, and by focus area, planning region, or CVJV planning scenario?

   Expected Outcome(s):
   - An understanding of waterfowl, shorebird, and waterbird use of upland, agricultural, and wetland habitats at various scales. This can be used to

assess trends, compare the use of different habitats or management activities, and inform conservation objectives.

2. Wetlands, agriculture, and uplands: Do the waterfowl, shorebird and waterbird focal species adequately represent the full range of avian biodiversity that relies on these habitat types (wetland, agriculture, uplands) year-round? How important are these habitat types in supporting other bird groups (e.g., landbirds) and how does this use vary seasonally, annually, regionally, or by CVJV planning scenario?

   Expected Outcome(s):
   - Complete, year-round list of bird species that depend on each habitat type (including beyond waterfowl, shorebirds and waterbirds). The list could be incorporated into community-level indices for restoration projects.

3. Riparian landbirds: To what extent do the landbird focal species selected to represent these specific habitat types also use other surrounding habitat types/land covers? (In particular, how much do riparian landbirds benefit from managed wetlands?) How much does their use of other habitat types vary seasonally, annually, by planning region, or by CVJV planning scenario? How should these other land covers be incorporated into population size estimates and conservation objectives?

   Expected Outcome(s):
   - An understanding and quantification of the extent to which riparian landbird species use other habitat types/land covers and how each habitat type contributes to population objectives.

4. Riparian, grassland and oak savannah, and Sierra meadows: Do the landbird focal species adequately represent the full range of avian biodiversity that relies on these habitat types (riparian, grassland and oak savannah, and Sierra meadows) year-round? How important are these habitat types in supporting other bird groups (e.g., waterbirds) and how does this use vary seasonally, annually, regionally, or by CVJV planning scenario? How are temporarily flooded uplands (e.g., grassland and oak savannah) used by waterfowl and waterbirds?

   Expected Outcome(s):
   - Complete, year-round list of bird species that depend on each habitat type (including beyond landbirds). The list could be incorporated into community-level indices for restoration projects.

5. Sierra meadows: Which species of shorebirds, waterfowl, and waterbirds (e.g., breeding Sandhill Cranes) use Sierra foothills and meadows, and how do they use it? How well do Sierra foothills and meadows provide for shorebirds and waterbirds and contribute to population objectives.

   Expected Outcome(s):

- Complete, year-round list of bird species that depend on each habitat type (including beyond landbirds). The list could be incorporated into community-level indices for restoration projects.

Bioenergetics and habitat foraging value

Rationale:
Bioenergetic models have been widely adopted by conservation planners to aid in the management of migratory bird populations by contributing to the development of habitat objectives. The application of bioenergetic models relies on the hypothesis that populations are limited by food resources, allowing for models to connect populations to habitats through the currency of energy (often calories). The Central Valley Joint Venture utilized a bioenergetic approach to define regional wetland conservation objectives for non-breeding waterfowl starting in the 1990 Implementation Plan, which grew to include shorebirds in the 2006 Implementation Plan. The 2020 Implementation Plan included improvements to bioenergetic models for non-breeding waterfowl and introduced a model specific to non-breeding shorebirds. Ultimately the validity of bioenergetic models depends, in large part, on accurate estimates of available food resources. A better understanding of how energy availability is influenced by changing climatic conditions, and the contribution of additional energy sources (invertebrates, green browse, non-rice agricultural) would greatly improve current bioenergetic modeling efforts. Bioenergetic models can also be improved such that additional water-associated species (e.g., shorebirds and waterbirds), sublethal effects, and other critical life history stages (such as molt) can be evaluated. In addition, information about food production and the role of restoration and management in affecting productivity can inform conservation priorities for species without bioenergetics models.

2.7 Refine understanding of foraging habitat values

Question(s):

1. Wetlands: How does productivity/quality (seed or invertebrate production) of each wetland type vary spatially and temporally? How consistent and reliable is productivity across years, and how do management practices and flooding regimes/depths influence availability and productivity?

   Expected Outcome(s):
   - A better understanding of the effect of management practices in wetlands on the various kinds of food resources available to waterfowl, shorebirds, and waterbirds. This will enable managers to create specific management plans to meet objectives where and when needed. Data on temporal and spatial food availability in different habitat types can better inform energetic models.

2. Seeds and green forage: What is the abundance, timing, and spatial distribution of waterfowl foods (wetland seeds, crop seeds, green forage/browse) in tidal marshes, managed wetlands, and agriculture lands (rice and non-rice)? Are there adequate food resources when/where needed in each CVJV planning region?

Expected Outcome(s):

- An understanding of the abundance of non-invertebrate waterfowl food in managed wetlands and flooded agriculture (rice and grain corn has already been estimated). An assessment of the ability of available habitat to meet winter waterfowl population goals under various habitat conditions/scenarios. This information could improve bioenergetics models, refine population goals based on food availability, and inform regional habitat management and restoration to improve waterfowl food supplies.

3. Aquatic invertebrates: What is the abundance, timing, density, and spatial distribution of invertebrate availability in managed wetlands and flooded agriculture (in both the benthos and water column)? Are there appropriate food resources when/where needed for shorebirds and waterfowl in each CVJV planning region? How does land and water management influence invertebrate abundance? How long is the delay between flood-up and aquatic invertebrate availability, and how long after drawdown are benthic invertebrates still accessible in mudflats?

   Expected Outcome(s):

   - An assessment of benthic (0-20 cm) and water column invertebrate food availability in Central Valley managed wetland and flooded agriculture (e.g., rice, irrigated pasture, corn) and factors that influence invertebrate abundance, energy content, and growth (e.g., timing and duration of flooding, water source, depths, percent vegetation, mosquito abatement). This will enable important refinement of shorebird and waterfowl bioenergetic models, and refinement of practice standards for incentive programs.

4. Shorebirds: What are the most important aquatic invertebrate prey species (in both the benthos and water column) for shorebirds in wetlands and flooded agriculture (rice and non-rice), and how much does this vary seasonally, annually, or regionally? What are the daily energy needs of shorebirds during (and in preparation for) fall and spring migration? What is the "giving up" invertebrate density at which shorebirds will abandon available foraging habitat, and how close must available foraging habitat be to roost sites to be worth the energy cost of travel? To what extent do shorebirds forage in uplands (e.g., the Long-billed Curlew *Numenius americanus*), and what are the most important non-aquatic prey?

   Expected Outcome(s):

   - A better understanding of the preferred aquatic and non-aquatic food resources for shorebirds in wetlands, flooded agriculture, and uplands (year round) and daily energy needs during migration. This, combined with the availability component above, will improve bioenergetics models and habitat objectives, and influence how habitats are managed and incentivized in the Central Valley.

5. Riparian, grassland and oak savannah, and Sierra meadows: What is the abundance, timing, density, and spatial distribution of aquatic and terrestrial invertebrate availability in riparian, grassland and oak savannah, and Sierra meadows of varying ecological condition? Are restoration efforts, grazing management practices, and other management efforts creating opportunities for abundant and diverse invertebrate populations across the temporal scale? What is the impact of pesticide application? What are the most important invertebrate prey during peak songbird fledging period, or during peak fall migration?

   Expected Outcome(s):
   - An understanding of shallow wetland, aquatic, and terrestrial invertebrate food availability in riparian, grassland and oak savannah, and Sierra meadows and factors that influence invertebrate abundance, species richness, and timing of emergence (e.g., timing and duration of spring overbank flows, water source, depths, presence of oxbow ponds, percent woody and herbaceous vegetation). This will enable important refinement of restoration, livestock grazing techniques, and other management actions for songbird management, and refinement of practice standards for incentive programs.

6. Climate change: How does climate change impact food production and availability for landbirds, waterfowl, shorebirds, and waterbirds, directly or indirectly? How will climate change influence land and water management practices that will affect productivity?

   Expected Outcome(s):
   - An understanding of the effects of climate change on food production and availability. This information can help refine bioenergetic models and conservation objectives.

2.8 Create and/or improve bioenergetics models

Question(s):

1. Breeding and non-breeding waterfowl:
   - What is the energetic requirement for breeding waterfowl, and is the energetic requirement for nesting females being met with invertebrate forage?
   - What is the carrying capacity of wintering waterfowl based on updated seed and invertebrate densities in each CVJV planning region? Does non-breeding waterfowl body condition and survival fluctuate with changes in food resources?

   Expected Outcome(s):
   - An understanding of the relationship between food abundance and waterfowl body condition and survival. This would validate the bioenergetics approach if the body condition of ducks declines with drought, less flooded habitat, and

reduced food abundance, and body condition increases when the opposite is true.
    - Evidence that more flooded habitat improves survival of waterfowl, shorebirds, and/or waterbirds, would support advocacy efforts and increased water allocations for habitat and potentially inform distribution of water to habitats by management.

2. Molting waterfowl: How much do molting waterfowl rely on food resources provided by the wetland selected to undergo molt (exogenous) vs lipid reserves developed prior to molt (endogenous)? What type of foods are waterfowl selecting for during molt (invertebrates, submerged aquatic vegetation, moist-soil seeds)? Does food availability and types of foods within the wetland affect molt duration and success? Are there carryover effects from breeding into molt and fall/winter?

    Expected Outcome(s):
    - An understanding of what food resources are preferred and available to molting waterfowl and how they influence molt duration and body condition. This information could direct regional habitat management and restoration efforts, improve our understanding of the bioenergetic needs, and ultimately improve survival rates of molting waterfowl.

3. Non-breeding shorebirds:
    - Should the shorebird bioenergetics model become more spatially explicit, incorporating information about the spatial distribution of available habitat across the Central Valley? Should it become more species-specific, incorporating species- and region-specific population estimates and objectives, habitat preferences, and behavior? Should an agent-based model be considered instead?
    - How can an improved understanding of spatial, seasonal, and/or annual variation in benthic invertebrate abundance and growth rates be incorporated into the shorebird bioenergetics model?
    - How can an improved and more complex understanding of seasonal and regional variation in suitable depths and vegetation density for shorebirds be incorporated into the shorebird bioenergetics model?
    - How can the shorebird bioenergetics model best be used to project the potential benefits (or impacts) of alternative scenarios or management actions on spatial scales smaller than the entire Central Valley?

    Expected Outcome(s):
    - A significantly refined bioenergetic model for non-breeding shorebirds. This should enable more refined habitat objectives and improved applications to projecting the bioenergetic impacts of alternative scenarios.

4. Waterbirds: Which (if any) other species or guilds of waterbirds have sufficient understanding of population size, preferred food resources, habitat selection, and available food energetics to attempt a bioenergetic analysis of habitat needs?

Expected Outcome(s):

- An assessment of which species or guilds of waterbirds should be the next priority for developing a bioenergetic model and an outline of what data are still needed to accomplish this.

Bird movement and connectivity

Rationale:

With vast decadal habitat losses across California, it is critical to ensure remaining habitats are managed effectively for bird populations that rely on them. Riparian and wetland habitats often lack connectivity in the Central Valley of California and bird populations need a mosaic of different habitat types to meet their needs. In addition, the Central Valley is intimately connected with other regions of the Pacific Flyway providing wintering, migrating and breeding areas for millions of migratory birds from the north and south. Conservation and management actions focused on wintering habitat for waterfowl have met with some success, but other habitats such as breeding and molting areas, remain insufficient and, for some populations/breeding areas, distant and disconnected. Specifically, the Klamath Basin is a critical location for breeding, molting, staging and overwintering migratory birds in California. When wetland habitat becomes unavailable in the Klamath Basin (such as drought years), the shortfall must be offset with productive habitat in the Central Valley. More recently, the Central Valley has also been recognized as an important region for wintering songbirds (e.g., boreal-breeding) and raptors that depend on a variety of habitats. By gaining insight into birds' movements and habitat use across the landscape the CVJV can determine the importance of connectivity and prioritize habitat conservation for multiple species. Collectively, this information also contributes to improving adaptive management in the face of increasingly variable conditions expected under climate change.

2.9 Improved understanding of bird distributions and movements

Question(s):

1. Impacts of hunting and land use on waterfowl movements:
   - What are the impacts of hunting and/or changing land use on waterfowl distribution and movements?
   - How do managed habitats that act as sanctuaries impact the distribution and movement patterns of waterfowl?
   - What are the impacts of hunting sanctuaries and/or changing land use on waterfowl distribution and abundance on public and private managed wetlands?

     Expected Outcome(s):

     - An evaluation of the impacts of hunting and land use changes on waterfowl distribution and movements. The answers to these questions provide understanding on the waterfowl carrying capacity of public and private managed wetlands and impact the sustainability of current public and private

waterfowl hunting areas (related to hunter satisfaction). Waterfowl Managers may need to better strategize on how to best utilize closed hunting areas to provide the necessary waterfowl resources (e.g., food, minimized disturbance) but also maintain harvest opportunity.

2. Flood bypasses and waterfowl distribution: How does the current operation of flood bypasses affect waterfowl distribution? How will the Fremont Weir Notch and similar projects affect waterfowl distribution in the future?

   Expected Outcome(s):
   - An understanding of waterfowl distribution under current floodplain operations and their response to the Fremont Weir Notch and similar projects, i.e., response to an increase in the duration and depth of inundated floodplain conditions.

3. Waterfowl movement within the CVJV and across other JVs: How do waterfowl move within the CVJV regions and across other JVs (e.g., the Intermountain West Joint Venture [IWJV] and San Francisco Bay Joint Venture [SFBJV]) throughout the pre-nesting, nesting, brood-rearing, and molting stages?

   Expected Outcome(s):
   - An understanding of waterfowl movements within the CVJV and to other JVs. This would inform CVJV work and cooperation with other JV partners (e.g., the IWJV).

4. Non-breeding shorebirds and waterfowl habitat deficits: How are non-breeding shorebird and waterfowl movements changing as a result of habitat deficits in the Klamath Basin, San Francisco Bay, and Central Valley as a result of drought?

   Expected Outcome(s):
   - An improved understanding of how shorebird and waterfowl movements change during drought within the Central Valley, San Francisco Bay, and Klamath Basin. This can aid in prioritizing wetland water allocations, habitat restoration/creation projects, and incentive program locations when water is limited on the landscape.

5. Effects of incompatible crops: How has conversion to incompatible crops such as orchards and vineyards influenced duck and shorebird movements during the breeding and non-breeding seasons? How do ag-breeding waterfowl settle on an ever-changing landscape across multiple breeding seasons?

   Expected Outcome(s):
   - An evaluation of the impacts of land use change on duck and shorebird distribution and movements. This could help inform future locations for agricultural easements and incentive programs.

6. Temporarily flooded habitats: Which bird groups and species are using temporarily-flooded habitats (e.g., agriculture, grasslands, or riparian floodplains)? Under what conditions are these habitats more likely to be available and used?

    Expected Outcome(s):
    - An understanding of movements through temporary habitats and the overlap in their importance to different bird groups. This information could help inform management of floodwaters (depth and duration) and floodplain habitats and whether the CVJV should set annual temporary habitat objectives.

2.10 Improved understanding of bird connectivity

Question(s):

1. Molting waterfowl: How are breeding bird populations connected to molting areas (e.g., admixed)?

    Expected Outcome(s):
    - An understanding of the connectivity to molting areas for breeding waterfowl. This would inform CVJV work and cooperation with partners in northern areas (e.g., IWJV). The level of importance of these areas can be used in sensitivity analyses, for gathering support for those areas, and in collaborative conservation of critical molting areas.

2. Waterfowl and shorebirds connected to the Klamath Basin:
    - How does habitat loss in Klamath Basin affect the amount of habitat needed in the Central Valley and how does this impact habitat objectives? Does the Central Valley get proportionally more early migrants due to habitat loss in Klamath Basin? How much energy is lost in the system and how can the CVJV make up for that? Does the CVJV need to support a greater number of birds at the beginning of the season? Are more birds staying longer in the Central Valley prior to spring migration due to lack of habitat in the Klamath Basin?
    - How does habitat loss in Klamath Basin impact the frequency of major disease outbreaks? How do those outbreaks affect small populations of breeding birds (e.g., CA mallards)?
    - How do changes in the Klamath Basin (disease outbreaks, lack of resources, etc.) affect populations of rapidly declining species such as Long-billed Dowitchers *Limnodromus scolopaceus*? Which breeding and wintering populations (or proportion of world population) of Long-billed Dowitchers rely on a functioning Klamath Basin?

    Expected Outcome(s):
    - An increased understanding of the effects of habitat loss in Klamath Basin on CVJV waterfowl and shorebird populations. This will inform adaptive habitat

objectives to meet bird needs and an overall water management strategy in regard to timing and extent of habitat provided.

3. Landbirds: How strong is the migratory connectivity between the Central Valley and landbird populations breeding in Alaska and Canada? How strong is the migratory connectivity between breeding landbirds in the Central Valley and overwintering areas in Central America? How important are different Central Valley habitats (including riparian, grasslands, and wetlands) to migrating and overwintering boreal breeding landbirds, and for which individual species?

   Expected Outcome(s):
   - An improved understanding of the importance of the Central Valley to landbirds migrating on the Pacific Flyway, and especially as habitat during the non-breeding season. For example, if the Central Valley provides key non-breeding habitat for declining populations of boreal-breeding landbirds (e.g. White-crowned Sparrow *Zonotrichia leucophrys*, Fox Sparrow *Passerella iliaca*, and Yellow-rumped Warbler *Setophaga coronata*), this information would inform CVJV conservation priorities and motivate landbird monitoring efforts during the winter. Similarly, understanding habitat use of non-breeding landbirds in the Central Valley can help inform management of specific habitats to meet landbird needs.

2.11 Use real-time bird movement data to inform management decisions

Question(s):

1. How can the CVJV use real-time bird movement data to inform management?

   Expected Outcome(s):
   - Near real-time data on bird movement. This could be used to inform refuge management in multiple ways. Land managers can evaluate bird use due to specific management outcomes and measure the effectiveness of their management actions. For instance, a manager can utilize the bird movement data to assess whether ducks are using a specific unit at night which would indicate a preferred feeding area. Additionally, managers can assess the use of sanctuary/non sanctuary habitats by waterfowl during the hunting season during both day and nighttime periods.
   - An evaluation of the efficacy of habitat restoration using real time bird movement, such as the addition of swales and improved water control structures to assess bird use of the improvements.
   - Identified critical habitat in a given water year based on real-time bird movement data and remotely sensed data. This can help guide water management during times of limited resources.
   - An understanding of the importance of various habitat features on the landscape including feeding, roosting, nesting, molting and migratory stopover areas.

- An understanding of where and when habitats should be flooded using real-time movement data. This can help inform the effectiveness of the timing of habitat delivery to effectively provide habitat across multiple life history stages.

2.12 Determine opportunities for collaboration with other Joint Ventures

Question(s):

1. What are most effective collaboration opportunities with other Joint Ventures for full life cycle bird conservation?

Expected Outcome(s):

- Work collaboratively with the Intermountain West Joint Venture, focusing on the southern Oregon - northeastern California (SONEC, specifically the Klamath Basin) region to improve habitat conditions and water availability to benefit birds through many stages of their life cycle. Work collaboratively with the San Francisco Bay Joint Venture and Sonoran Joint Venture to support conservation policy and projects that contribute to shared conservation objectives across regions.

Inter-species interactions for birds

Rationale:
Over the last century, anthropogenic and agricultural expansion and development has transformed the landscape of the Central Valley. The shifting dynamic of the Valley's land cover has created challenges for some bird species while generating niche opportunities for others. Species such as Common Raven *Corvus corax* and white geese (Snow geese *Anser caerulescens* and Ross's geese *Anser rossii*) have seen vast population increases over the last couple of decades by taking advantage of these landscape changes, consequently putting competitive pressure on other bird species that share the same habitats and resources. Conversely, Northern Harriers and breeding ducks, which often nest in close proximity to each other, have declined in the Central Valley with a reduction in available upland habitat. Changes in the abundance, distribution and composition of birds can lead to novel inter-specific interactions that may have implications for declining and At-risk species as well as for our conservation strategies.

2.13 Understand the impacts of expanding or declining bird populations

Question(s):

1. Northern Harriers and nesting ducks: How does the declining Northern Harrier population impact nesting ducks, such as indirectly through protection against terrestrial predators and/or directly through duck nest predation?

   Expected Outcome(s):
   - An understanding of the interaction between nesting ducks and Northern Harriers. This approach could use distance between nests versus random placement and analyze if distance from harrier nests effects/improves duck nest survival.

2. Geese: How do increasing goose populations compete for available habitat and food with other species, such as rails and shorebirds? How are they interacting, and how does this vary spatially and temporally?

   Expected Outcome(s):
   - An understanding of the effects of geese on other bird populations in the Central Valley and montane meadows.

3. Common Raven, Brown-headed Cowbird, European Starling, and Wild Turkey: What is the impact of expanded Common Raven, Brown-headed Cowbird *Molothrus ater*, European Starling *Sturnus vulgaris*, and Wild Turkey *Meleagris gallopavo* populations on other breeding bird populations in the Central Valley, foothill and montane towns and cities?

   Expected Outcome(s):
   - An understanding of current Common Raven distribution and relative densities in the CVJV primary and secondary focus areas and inclusion of Common Raven depredation in duck nest monitoring.
   - An understanding of the current distribution and relative densities in the CVJV primary and secondary focus areas for Brown-headed Cowbirds and European Starlings, especially as urban areas expand into mountains, foothill, and desert areas.
   - An understanding of the current distribution and relative densities of Wild Turkey in the CVJV primary and secondary focus areas, especially coastal and montane foothills and mountains. An understanding of competition for food resources with other acorn mast foraging birds and the role Wild Turkeys may have on ground nesting species such as California Quail *Callipela californica*.

Population dynamics and addressing steep declines

Rationale:
Understanding the population dynamics of a species can assist in determining its conservation needs. Population and metapopulation dynamics are outdated or unknown for many focal species, particularly for birds that use Sierra meadows. This understanding will allow the CVJV to refine population and habitat objectives to better guide conservation

delivery. Identifying species in steep decline allows CVJV partners to initiate conservation work to halt or slow decline before vulnerable species become further imperiled.

2.14 Determine population and metapopulation dynamics for focal species

Question(s):

1. Riparian and grassland and oak savannah landbirds:
   - Is there more than one biologically-distinct breeding population per focal species within CVJV riparian or grassland and oak savannah habitats (especially for At-risk breeding riparian landbirds: Yellow-billed Cuckoo, Least Bell's Vireo *Vireo bellii pusillus*, Bank Swallow, the At-risk "Modesto" Song Sparrow *Melospiza melodia*, Yellow-breasted Chat *Icteria virens*, and Yellow Warbler; and for At-risk grassland and oak savannah landbirds: Northern Harrier, Burrowing Owl, Grasshopper Sparrow *Ammodramus savannarum*, Loggerhead Shrike *Lanius ludovicianus*, and Yellow-billed Magpie)? To what extent is there mixing or dispersal between focus areas or planning regions, especially for non-migratory species?
   - How do riparian focal species that are more generalist outside the Central Valley or in urban areas contribute to the population dynamics?
   - How can a stable breeding population of the At-risk Least Bell's Vireo be re-established in the Central Valley? What changes in habitat conditions would be required to support successful dispersal from existing populations, and where are the priority areas for these changes? Would active reintroduction efforts be required?
2. Sierra meadows:
   - Is there more than one biologically distinct breeding population per focal species within Sierra meadows broadly, and/or within each planning region? For focal species that breed outside meadows, how can these other habitat types be best incorporated - are they sources or sinks?
   - How do individuals on the edges of Sierra meadows or breeding in uplands contribute to the population?

Expected Outcomes (both questions):

- An understanding of population and metapopulation dynamics for focal species in riparian, grassland and oak savannah, and Sierra meadows. This will assist in setting population objectives, as these objectives assume independent populations by planning region. This information will therefore improve population and corresponding habitat objectives.
- An improved understanding of the effort required to establish a stable breeding population of At-risk Least Bell's Vireo in the Central Valley.
- An understanding of the population contribution of individuals on the edges of meadows or breeding in uplands. This can reduce sampling bias in analyses.

2.15 Addressing steep declines and/or low population sizes

Question(s):

1. Breeding waterfowl: What is causing the decline in nesting mallards and other focal waterfowl species (Cinnamon Teal, Gadwall)?

    Expected Outcome(s):
    - A halt and then reverse in the declines in nesting waterfowl. A return to the population objective sizes set by the CVJV for the breeding duck populations.

2. Non-breeding shorebirds: What is causing the steep decline in some migratory shorebirds, including Dunlin *Calidris alpina* and Long-billed Dowitchers which commonly use the Central Valley? When considering those shorebird species for which the Central Valley is especially important for migration, overwintering, and breeding, which are suffering the greatest declines?

    Expected Outcome(s):
    - An understanding of the causes of decline for individual species of migratory shorebirds, and the extent to which conditions in the Central Valley are influencing this. This can help focus conservation efforts and halt and reverse declining populations.

3. At-risk species: For other At-risk species, what is causing steep declines or constraining population growth (e.g., Swainson's Hawk *Buteo swainsoni*, Tricolored Blackbirds *Agelaius tricolor*, Greater Sandhill Cranes, California Black Rails, Mountain Plover, Black Terns, Yellow-billed Magpie, Purple Martin, and Leconte's Thrasher)?

    Expected Outcome(s):
    - An understanding of the causes of decline for At-risk species. Progress on goals outlined in species recovery and/or management plans.

4. Breeding riparian landbirds: What is contributing to the large breeding population fluctuations of the At-risk Bank Swallow (especially on the Sacramento River where ~70% of the state's birds breed) and historic declines of the At-risk Yellow-billed Cuckoo in the Sacramento Valley planning region? Are these declines continuing? What other CVJV focal species of riparian habitats are declining rapidly? What are the most important management actions to slow or reverse these declines? What additional research is needed to identify causes of declines or show effectiveness of management actions?

    Expected Outcome(s):
    - For the At-risk Bank Swallow: A breeding population that is stable or increasing, with no net loss of breeding habitat on the Sacramento and Feather rivers.
    - For the At-risk Yellow-billed Cuckoo: A breeding population that is stable or increasing.

5. Sierra meadows: What is causing the steep decline of Willow Flycatcher populations in the Sierra? What subspecies are breeding in meadows (*brewsteri*, *adastus*, and/or *extimus*)?

    Expected Outcome(s):
    - For Willow Flycatcher, a breeding population that is stable or increasing and the establishment of a Willow Flycatcher Working Group.

Future populations under climate change

Rationale:
A changing climate will provide numerous challenges to management and recovery goals within the CVJV Planning Region. Expected changes in overall annual temperatures and annual precipitation patterns may result in the changing distributions of birds and avifaunal community structure. In addition, changing climate conditions are predicted to impact water availability, from year to year, resulting in less predictable allocations for wildlife, and intensifying competition for an already over-allocated resource. Climate-driven loss of water availability is predicted to impact flooded habitat availability, thus threatening future habitat and management. Understanding how avian communities and focal species might respond to changing climate remains a priority for future goals within the CVJV Planning Region. Primary research needs include understanding the impacts of a changing climate on avian reproduction, fitness, and populations, as well as spatial and temporal species distribution, and habitat occupancy. These studies will help guide decisions to ameliorate impacts, and remain a primary research need for an adaptive approach to habitat and species management. CVJV Partners will also need to track policy to ensure that water and land resources needed for habitat and birds remain a priority.

2.16 Understand changes to populations (e.g., distribution, composition, and reproductive) under climate change

Question(s):

1. Non-breeding and breeding waterfowl:
    - How will climate change impact waterfowl distribution among CVJV planning regions, given current projections for climate, hydrology, and land use. Which variables will the CVJV have the ability to influence through habitat conservation?
    - How has climate change influenced the nesting demographics of waterfowl, including effects on the timing of nesting, increased temperature on egg survival, altered vegetation interacting with predators on nest survival, and changes in vegetation on nesting densities?

    Expected Outcome(s):

- Climate change scenarios focusing on water allocation and agricultural trends/forecasts and a better understanding of high-ranking variables and how they may be manipulated for habitat improvements; more policy focused approach for conservation due to limited funding.
- An understanding of the impact of climate change on duck nesting demographics, including effects on nesting chronology, increased ambient temperature on egg survival, and changes in vegetation on nest survival and density.

2. Non-breeding and breeding shorebirds/waterbirds: How do recent droughts and extreme events impact populations and spatial distributions of shorebirds and various waterbirds? How will suitability for shorebirds change under projections of future habitat availability?

   Expected Outcome(s):
   - A greater understanding of how shorebirds and waterbirds respond to drought and other environmental changes. This would provide insight into best management options under a variety of conditions. An understanding of the potential impact of different future scenarios of habitat availability on shorebird distribution and abundance. This would provide insight into possible conservation strategies and areas with high conservation value.

3. Riparian landbirds:
   - Have Central Valley riparian breeding and wintering bird populations shifted their distributions or migration timing over the last several decades?
   - How are riparian focal species distributions and riparian bird communities expected to shift in each CVJV planning region, given current projections for climate, hydrology, and land use changes?

   Expected Outcome(s):
   - A report that evaluates the evidence for shifts in current distribution or migration timing in Central Valley riparian bird populations. This would assist in planning riparian restoration and management efforts based on distributional shifts.
   - A document that updates and refines future projected changes in focal species distributions and riparian bird communities for each CVJV planning region. The document will include adaptation strategies prioritizing riparian conservation and restoration based on projections, monitoring recommendations to capture shifts in species distributions, and recommendations on potentially altering density objectives to account for changes in potential footprint.

4. Sierra meadows: Do high elevation meadows act as climate refugia for birds, for example, during drought years? How do bird species using Sierra meadows respond to drought?

   Expected Outcome(s):

- An understanding of how meadow birds respond to drought. This will inform meadow conservation strategies under plausible drier future conditions.

Section 3: LAND AND WATER MANAGEMENT

Evaluating habitat values in the context of existing management practices

Rationale:
A core goal of CVJV is to meet population objectives of migratory birds. For over a half century, management techniques have been developed to improve suitability and food production of landscapes on which migratory birds rely throughout their annual cycle. Due to drastic declines in natural wetland habitats, migratory birds rely heavily on both agricultural and managed wetland habitats. While previous CVJV monitoring and evaluation plans have explored how existing management practices influence habitat value, many questions remain and efforts to expand knowledge beyond influences on waterfowl are needed. For example, a better understanding on how invertebrate populations respond to water and crop residue management on agricultural lands and managed wetlands, could lead to the development of best management practices for different migratory bird species across the Central Valley and within specific regions. Exploring how various management practices influence demographic rates will maximize the impact of habitat management on population growth rates. To improve management and maintain hunter satisfaction on public lands, a better understanding of sanctuaries and disturbance is also needed. Evaluating how existing management practices influence habitat values will ensure the long-term management of migratory bird populations in the Central Valley.

3.1 Evaluating effects of existing land and water management practices on bird populations

Question(s):

1. Cereal grains, pasture, and row crops: How important are cereal grains, pasture, or row crops for breeding bird species (e.g., waterfowl and the At-risk Tricolored Blackbirds)? What is the minimum acreage needed at a field scale for cereal grains or row crops to provide benefits to breeding bird species (is there a minimum threshold in which birds will not utilize a field?)?

    Expected Outcome(s):
    - An understanding of the benefits of cereal grains, pasture, and row crops. Identify important crops for breeding birds and track acreages of these crops across the landscape. Ensure management practices on these crops are beneficial for nesting birds (i.e., harvested after the nesting season [July 15]).

2. Invertebrates and water and soil management: How do water and soil (tilling, stomping, etc.) management practices influence the availability of invertebrates in wetlands and flooded agricultural fields? What depths and flooding durations are necessary to maintain/create abundant invertebrate populations, both in the water column and benthos?

Expected Outcome(s):

- Better and updated information on invertebrate species composition and abundance in different habitat types (i.e., flooded rice, wetlands) and how these change temporally and under certain management scenarios (e.g., water depth, hydroperiod, tillage).

3. Management strategies and breeding ducks: How do habitat variables (e.g., cover density, vegetation height, and the type, size and proximity of summer wetlands) and management strategies (e.g., habitat type [native grass vs. cover crop vs. cereal grain] and mowing practices), impact key vital rates of breeding ducks and nesting densities at local habitat scales (especially agricultural habitats)? Specific vital rates should include nest success, nest densities, egg hatching success, clutch size, breeding propensity, duckling survival, hen survival, winter survival, and post-breeding survival (including molt survival).

   Expected Outcome(s):

   - An experimental assessment of habitat management on breeding duck vital rates. Regional prescriptions for optimum upland and wetland size and management, regional cost estimates to improve vital rates (with emphasis on breeding success and molt survival due to large habitat deficits within CV), knowledge of the effectiveness of prescribed alternative habitat (e.g., wildlife friendly crops), baseline data that will support preparation and selection of project proposals for grant solicitations (e.g., North American Wetlands Conservation Act, Duck Stamp).

4. Moist-soil management regimes: How do different moist-soil management regimes affect the availability of waterfowl food (i.e., seeds, invertebrates)? How does management and productivity vary by region and year and what are impediments to optimal management? Does use by waterfowl increase with moist-soil management vs. without? Is there a rapid assessment tool used to estimate seed type calories in any given wetland unit?

   Expected Outcome(s):

   - Better and updated information for identifying the most effective management strategies within each region to increase moist-soil seed production and/or invertebrate abundance. A prioritization on how to use limited water supplies to maximize food production for non-breeding and breeding birds. This information could also serve as a metric of treatment habitat value and, for example, modify waterfowl food habitat values to include invertebrates and or increased seed production).

5. Pesticides: What are the direct and indirect impacts of pesticides across all habitat types and bird groups, and how do these impacts vary regionally, seasonally, and annually? Which species and habitat types are most affected?

   Expected Outcome(s):

- An understanding of the impact of pesticides, including areas of high pesticide impacts to avoid. This will help with determining ways to mitigate pesticide impacts.

6. Post-harvest rice treatments: To what extent are different post-harvest treatments of rice fields used? How does post-harvest treatment affect the abundance and availability of seeds and invertebrates?

   Expected Outcome(s):
   - A better understanding of post-harvest treatments for winter-flooded rice. An improvement in understanding of the food availability (seeds and invertebrates) under various conditions/scenarios and improvement in food supply parameters of bioenergetics models (waterfowl, shorebirds, other waterbirds). An understanding of how different rice post-harvest residue management practices (tilling, stomping, chopping, baling, etc.), flooding, and reflooding are each related to waterfowl/shorebird/waterbird use of treatments. This information could serve as a metric of treatment habitat value and, for example, modify waterfowl food habitat goals to include invertebrates (not only seeds) if determined to be important.

7. Rice fallowing: How can the impacts of fallowing rice be minimized to waterfowl, shorebirds, waterbirds, At-risk birds and Giant Gartersnakes? How can fallow ricefields be managed to maximize benefits for wildlife, especially nesting birds?

   Expected Outcome(s):
   - Minimized impacts of fallowing rice with maximized benefits to wildlife. Conservation actions identified, including novel opportunities during major fallowing events such as drought years.

Enhancing habitat quality and evaluating new management approaches

Rationale:
Wetland restoration and management within the Central Valley has historically focused on improving seasonal wetlands that provide food resources to overwintering waterfowl, with additional benefits for shorebirds and other bird species. This strategy has been successful as winter body condition of most dabbling ducks has increased significantly since the 1980s. However, while this strategy has been beneficial for many wintering bird groups, California's breeding waterfowl and migratory shorebird populations have been in steep decline since the early-2000s. For breeding waterfowl, this decline has largely been due to decreased breeding success and post-breeding survival, specifically during the wing molt and likely driven by habitat constraints. The steep declines for migratory shorebirds are not well understood, but habitat limitations during the fall (July–September) are expected to be a contributing factor. Expanding habitat availability during critical life-history stages will help reverse these population trends. There may be opportunities to develop novel management strategies that can provide breeding and molting habitat for waterfowl and fall habitat for shorebirds simultaneously.

3.2 Optimize water management

Question(s):

1. Summer water in agriculture: How important is agriculture (e.g., rice) in providing summer water for breeding pairs, brood rearing and molting for waterfowl, shorebirds, and other waterbirds? How important is it for early fall shorebird migrants? Are there other agricultural crops (e.g., flooded pasture) besides rice that play an important role in providing flooded habitat in summer?

    Expected Outcome(s):
    - An understanding of how various agricultural crops, such as rice, are used by breeding waterfowl, post-breeding waterfowl, shorebirds, and waterbirds within each region and how brood survival compares to use in summer wetlands.

2. Summer wetlands: What wetland designs and/or novel management strategies can be implemented to reduce the overall costs (e.g., mosquito abatement, water costs, invasive vegetation management costs) of providing summer wetland habitat? Are there ways to provide summer wetlands while balancing water use and associated management costs that come with increasing water use?

    Expected Outcome(s):
    - Novel, cost effective, and water efficient wetland designs (e.g., mosquito predator reservoirs) and management strategies implemented through working with wetland managers. An adaptive management framework to monitor successes and failures.

3. Water depth management: What are the trade-offs in water depth management in flooded agriculture and wetlands. For example, what is the trade-off between bird habitat needs (whether species diversity, abundance, and life histories are supported and how many use-days support lasts) vs. management needs or constraints (crop yields, labor cost/difficulty of maintaining shallow vs deep water, risk of weed production and mosquito production, cost of managing weeds and mosquitos). How will changes to water depth and duration influence as well as breeding and non-breeding waterfowl, shorebirds, or waterbirds?

    Expected Outcome(s):
    - An understanding of whether there are optimal depths (or distributions of depths) to provide maximum multi-species benefits indicated by metrics estimating species diversity, abundance, life histories activity budgets, and species-specific duration of use of flooded fields and wetlands in combination with management information (e.g., costs, constraints, risks).

4. Wetland management strategies: What are the trade-offs between managing wetlands to provide spring/summer water (for breeding and post-breeding (molting) ducks, breeding and migrating shorebirds, and breeding waterbirds) vs. seasonal wetlands (for wintering waterfowl, shorebirds, waterbirds and raptors)? What alternative or novel management strategies (e.g., annual rotation of summer water units) and/or habitat types (e.g., semi-permanent, reverse-cycle) can be implemented to improve brood and molt success? Can novel management strategies be implemented that provide spring/summer habitat and still provide moist-soil plants for winter waterfowl? What is the ideal timing of flooding wetlands to provide flooded wetlands for ducklings during summer?

   Expected Outcome(s):
   - Novel, cost effective, and water efficient management strategies created in collaboration with wetland managers to support waterfowl, shorebirds, and waterbirds, including an adaptive management framework to monitor successes and failures.
   - A better understanding of required minimum summer wetland habitat (total acres and timing of flooding) regionally to improve breeding success and recruitment of resident waterfowl populations.
   - A better understanding of how an increased rotation of seasonal wetland acres into summer water may impact the body condition of wintering waterfowl, shorebirds, and waterbirds (at a regional and CV scale).
   - A better understanding of optimal management and habitat types that maximize duckling survival and molt survival.

3.3 Optimize wetland vegetation management

Question(s):

1. Breeding waterfowl: What is the emergent vegetation to water ratio (hemi-marsh concept) to optimize duckling survival in each region? What are the vegetation types, composition, density, and height that improves duckling survival?

   Expected Outcome(s):
   - Better and updated information on the relationship between duckling survival and wetland habitat covariates (e.g., emergent vegetation percent, water quality, unit size).

2. Sierra meadows: How do grazing management practices such as rest-rotation, solar hot-wire temporary pasture, use of virtual fencing for more surgical rest of critical areas, affect willow recruitment?

   Expected Outcome(s):
   - Best management practices for livestock grazing in montane meadows for ensuring conservation of willow habitat.

3. Waterfowl and shorebirds: What are the trade-offs between optimizing a summer wetland for waterfowl brood success (e.g., increased emergent vegetation and less open water) and providing habitat to breeding and fall migrant shorebirds?

    Expected Outcome(s):
    - Better and updated information on the relationship between shorebird use of summer wetlands and habitat covariates (e.g., emergent vegetation, unit size, depth).

4. Summer wetlands and invasive aquatic vegetation: Are there novel and cost-effective approaches to controlling invasive aquatic primrose and other wetland vegetation when providing summer wetlands?

    Expected Outcome(s):
    - Novel and cost-effective methods for controlling invasive vegetation associated with managing summer wetlands.

3.4 Optimize management of non-wetland habitats

Question(s):

1. City planning: How will planned and forecasted real estate development impact agricultural and natural areas in the Central Valley? How can city planning incorporate habitat features that benefit water-associated birds (waterfowl, shorebirds, and waterbirds) and landbirds as well as human interests?

    Expected Outcome(s):
    - An assessment of real and forecasted real estate developments in agricultural areas (i.e., American Basin), including better and updated information on the benefits of urban habitats to water-associated birds (waterfowl, shorebirds, and waterbirds) and landbirds.

2. Clean Farming Practices: Has the implementation of clean farming practices (e.g., disking levees) led to meaningful benefits (e.g., increased yields) for farmers? What are the trade-offs to nesting birds?

    Expected Outcome(s):
    - An assessment of the benefits (e.g., financial) that clean farming practices provide to growers, including an assessment of the trade-offs to birds and pollinators.

3. Grassland landbirds and agriculture: Are there any agricultural practices or crops compatible with grassland birds (e.g., fallow land, buffers between rows, cover crops, grass hay, alfalfa, wheat), and how can these lands benefit grassland birds?

    Expected Outcome(s):

- Best Management Practices for grassland (and pollinator) bird-friendly agriculture, including recommendations to growers that will benefit neighboring bird communities.

4. Grassland landbirds and grazing: Can grazing be used within uplands to improve habitat quality for breeding grassland landbirds? What changes could be implemented to grazing upland/grassland habitats that could provide benefits (e.g., increased nest success, increased invertebrate production) for upland nesting birds?

   Expected Outcome(s):
   - An understanding of what grazing management or rotation schedules would provide the best control of invasive weeds, promote perennial grasses, and provide benefits to grassland nesting birds, without degrading the upland/grassland habitats. Best management practices for livestock grazing in upland/grassland habitats. An understanding of what management activities landowners would be willing to implement and if incentive programs are necessary to support them.

5. Long-term upland habitat: How can incentive programs help landowners with long term management of upland restorations?

   Expected Outcome(s):
   - A better understanding of what upland management activities (e.g., herbicide spraying, mowing) provide the greatest habitat benefits to nesting waterfowl and other ground nesting birds, including the costs associated with each activity.

Section 4: PRACTICES AND PARTNERS IN CONSERVATION

Incentive Programs and Temporary Enhancements

Rationale:
Incentive programs play a crucial role in promoting conservation activities on private lands and help the Central Valley Joint Venture meet its habitat objectives. In fact, it is unlikely that objectives could be met without the involvement of private landowners, as they own roughly 70% of the land within the Central Valley. These programs engage private landowners and encourage land management activities that benefit wildlife by increasing habitat quality and quantity and promoting species diversity. Incentive programs can be designed to address a diversity of objectives and species groups with implementation that ranges from short-term habitat enhancements to long-term management agreements. The flexibility of private landowners and the availability of incentive programs has been critical to creating and enhancing habitat conditions for migratory birds, especially during drought cycles. Furthermore, funding for incentive programs often includes financial support for monitoring activities, which provides a unique opportunity to collect data on wildlife response and address knowledge gaps on the importance of various habitat types and the ability to provide multi-species benefits.

4.1 Understand costs and incentives to landowners

Question(s):

1. Costs of programs and practices: What is the cost of implementing beneficial practices and maintaining and improving incentive programs?
2. Incentive models: What are the best incentive program models for both landowners and funders (annual incentives vs. multi-year programs, state/fed vs. private implementation, and fixed rates vs. bids)? Which ones provide the greatest habitat benefits and encourage the most enrollment?
3. Landowner incentives: Regionally and by commodity type, what level of monetary incentive do landowners need in order to provide wildlife habitat? What are the barriers of participation? How do barriers differ between private landowners and farmers? How do payment structures or administrative burden impact participation in incentive programs?
4. Financial impact of incentive programs on maintaining land ownership: Do programs like the Presley program or others that financially incentivize wildlife-friendly management practices contribute to maintaining privately owned and managed lands?

Expected Outcomes (across all questions):

- Maintained and improved incentive programs. Survey results that gauge participation, assess program drawbacks, and highlight constructive aspects to build on further improvements.
- An understanding of landowner incentive preferences and which rates provide the best return on investment. A review and evaluation of past and current

incentive programs and associated rates that provide the greatest habitat benefits and encourage the most enrollment.
- An understanding of how incentive programs help maintain private ownership and management of lands. This information will help inform the implementation and development of effective incentive programs that increase landowner participation in maintaining conservation lands.

4.2 Habitat goals: Tracking temporary enhancements

Question(s):

1. How can the CVJV best track temporary enhancements in real time and/or on an annual basis? How does this relate to the CVJV objective of providing 340,000 acres of flooded ricelands and other habitat objectives? How does this relate to the CVJV annual wetland enhancement objective? How do temporary enhancement costs compare to permanent conservation and restoration?

Expected Outcome(s):

- An assessment of how temporary enhancements assist in reaching annual CVJV habitat objectives. The costs associated with providing this habitat could be brought to the legislative committee to take to lawmakers and decision makers.
- An assessment of when it might be more cost-effective to work with willing landowners to put wetlands under (permanent) conservation easement and manage them for habitat and other co-benefits compared to temporary enhancements.

4.3 Multiple benefits: Increase benefits to non-target species of existing incentive programs

(see also Section 5)

Question(s):

1. How can existing programs be used to accommodate other bird groups? For example, how can the Presley program summer water duration accommodate both breeding waterfowl, shorebirds and waterbirds?

Expected Outcome(s):

- An increase in conservation impacts and expanded funding sources for habitat programs.

Conservation Easements

Rationale:

The CVJV 2020 Implementation Plan has explicit acreage objectives for the permanent protection of wetland, riparian and agricultural habitats. While public ownership and protection may be the best option in some instances, there is limited funding and support for public acquisition and management. Given that approximately 66% of wetlands and almost all agricultural land in the Central Valley is privately owned, it is imperative that conservation entities work cooperatively with private landowners to protect habitat. Conservation easements provide an important tool that enable conservation organizations to work collectively with landowners to purchase development rights that permanently protect habitat while maintaining properties in private ownership and management. Easements ultimately enable the conservation organization to protect habitat at a lower cost, while allowing the landowner continued management, use and enjoyment of the land. While easements have been successfully purchased by multiple organizations for many years, there is still not a comprehensive tracking system that provides acreage and locations of protected and unprotected habitats. In addition, there are questions regarding the effectiveness of some easements in protecting bird habitat and providing habitat requirements for multiple bird groups. This information could provide meaningful guidance to better prioritize easement acquisition and inform easement criteria.

4.4 Track easement protection: Tracking privately owned bird habitats protected and unprotected by conservation easements.

Question(s):

1. What are the acreages and locations of the following in protected and unprotected conservation easements: private wetlands, ricelands, private riparian forest, private Sierra meadows, and grasslands and oak savannah?

    Expected Outcomes(s):
    - An assessment of the protection status of key bird habitats and accomplishments in meeting CVJV 2020 Implementation Plan habitat protection objectives.
    - An understanding of where easement priorities should be focused to meet habitat protection objectives and/or address threats.

4.5 Easements as bird habitat: Determine if existing easement conditions meet the habitat needs of birds.

Question(s):

1. Do existing easement requirements meet the needs of multiple bird groups/species using privately-owned habitat?
2. Do existing easements adequately protect the land as bird habitat? In which cases do they function as habitat corridors?

    Expected Outcome(s):

- An understanding of whether the needs of multiple bird groups/species are being met on private lands protected with easements and/or which easements may be serving as habitat corridors.
- As assessment of whether additional easements are needed on land to ensure adequate protections for birds (e.g., agricultural easements with no crop restrictions may require an additional easement to require wildlife friendly crops).
- Additional incentive programs that can help meet management objectives for multiple bird groups on easement properties (e.g., incentive programs can be used to promote semi-permanent wetlands for breeding waterfowl, shorebirds, and waterbirds on wetland easement properties).

4.6 Easements as bird habitat: Develop specific habitat criteria to meet the needs of multiple bird groups/species on new easements

Question(s):

1. What are specific easement criteria needed to address habitat requirements of multiple bird groups (e.g., waterfowl, shorebirds, waterbirds, riparian landbirds) in various habitats?

Expected Outcome(s):

- An assessment of easement criteria that can be used in Wildlife Conservation Board and other easement funding programs.
- Language incorporated into new conservation easements on habitat criteria and management obligations to benefit birds.

Restoration & Enhancement

Rationale:
Habitat restoration comes in many forms and can target a myriad of specific issues and outcomes. Restoration projects may involve the conversion from one land-use type to another such as the conversion of agricultural lands to wetlands or simply the enhancement of existing land cover value to reach targeted goals. Restoration projects integrate engineering, habitat planning, species conservation, and ecosystem function into their design and implementation. Successful restoration projects include long-term management and operational objectives in order to ensure restoration goals can be sustained over the long term as well as an adaptive management component which can guide modifications and future restoration efforts. Restoration efforts have been a critical component of the CVJV's conservation efforts since its inception and will likely be a major factor contributing to CVJV success into the future.

4.7 Determine bird response to restoration

Question(s):

1. Grassland and oak savannah restoration: How do focal species populations and/or densities change with habitat restoration and enhancement? How do focal species respond to recommendations in the plan to remove invasive plants and encourage bunch grasses and blue oaks?

    Expected Outcome(s):
    - An evaluation of restoration and enhancement methods, including project-level responses, for improving focal species populations, densities, and/or population objectives. This will result in improved restoration targets and enhancements.

2. Riparian habitat restoration:
    - How do focal species densities change with habitat restoration projects? How does bird community structure and diversity change with habitat restoration projects, by season and with age since restoration? How does the bird community structure and diversity at restored sites compare to other areas in California?
    - How can monitoring of multi-species groups indicate the success of riparian restoration, and does it provide additional insight or value compared to evaluating each focal species separately?
    - How much do bird responses to restoration depend on the surrounding landscape context, including floodplain or groundwater connectivity, the extent, structure, and diversity of the adjacent riparian vegetation, and the surrounding land use/land covers?

    Expected Outcome(s):
    - An evaluation of restoration and enhancement methods, including project-level responses, for improving focal species populations, densities, and/or population objectives. This will result in improved restoration targets and enhancements.
    - An assessment of project-level responses beyond focal species (i.e., including the broader community structure and diversity, such as wintering species) linked to broader biodiversity monitoring across the state. This will guide project management and monitoring programs.
    - A document that reviews multi-species approaches for monitoring and evaluating restoration project success and makes recommendations for tracking multi-species headline indicators for use by the CVJV. Also, a review that helps demonstrate which monitoring type is appropriate in which circumstance and a protocol for implementing multi-species indices to measure and easily communicate the success of CVJV riparian habitat projects over time.

3. Sierra meadows restoration:
    - How do individual restoration projects contribute to population objectives? To what degree does restoration and enhancement of degraded meadows increase breeding bird densities? How do restoration outcomes differ among meadow

types, climatological gradients, and restoration techniques? How does post and pre-restoration livestock management affect restoration outcomes?
- What physical conditions provide the best habitat for complex aquatic invertebrate communities with staggered emergence periods across the avian breeding season.

Expected Outcome(s):
- An evaluation of restoration and enhancement methods, including project-level responses, for improving focal species populations, densities, and/or population objectives. This will result in improved restoration targets and enhancements.
- Improved prioritization of meadow restoration projects. An improved understanding of desired post-restoration conditions that promote insect prey availability for birds, to inform restoration methods.

4. Wetland habitat restoration: How can restoration assessments be developed which identify the appropriate balance of wetland types and habitat components to meet conservation objectives (tidal vs managed wetland components, etc.)? How can monitoring of successful outcomes be integrated into restoration design that allows for adaptive management (i.e., how do the target species respond to the restoration action)?

Expected Outcome(s):
- An evaluation of restoration and enhancement methods, including project-level responses, for improving focal species populations, densities, and/or population objectives. This will result in improved restoration targets and enhancements.
- An assessment of shorebird, waterfowl, and waterbird response to new or different wetland (including agricultural wetlands and small montane wetlands) restoration and enhancement practices. This could utilize advanced animal movement monitoring techniques to evaluate bird response to wetland restoration activities.

4.8 Determine best practices for restoration

Question(s):

1. Grassland and oak savannah: What are the best ways to enhance grassland and oak savannah for the focal species?

Expected Outcome(s):
- An understanding of restoration opportunities. Improved restoration and/or enhancement practices.

2. Riparian: How can riparian restoration be conducted (e.g., diversified planting palettes, sourcing plants from similar climates, or restoring soil microbiota) to provide

more habitat for more species given projected conditions in climate and hydrology? What are the appropriate riparian plant communities to use in restoration by planning region?

Expected Outcome(s):
- An understanding of restoration opportunities. Improved restoration and/or enhancement practices.
- Restoration experiments to test the effectiveness of alternative restoration designs/methods and ultimately, riparian restorations that are more climate-smart, providing habitat to more species under a wider range of conditions.

3. Sierra meadows: What restoration techniques and physical conditions are needed for optimal habitat restoration for germination and recruitment of multiple age classes of willow in Sierra meadows?

Expected Outcome(s):
- An understanding of restoration opportunities. Improved restoration and/or enhancement practices.
- A determination of the places and techniques for optimal restoration and recruitment of willows.

4.9 Understand opportunities associated with land retirement

Question(s):

1. Where is land retirement resulting from recent groundwater management laws (SGMA) likely to occur and how do these places intersect with priorities for restoration? With planned land retirement in San Joaquin Valley, are there opportunities and adequate water supplies for restoration of riparian, wetland and upland habitats?

Expected Outcome(s):
- Projections for land retirement and restoration opportunities. Land retirement could represent an opportunity for habitat restoration (mostly for grassland and At-risk species).

Understanding land owners and managers

Rationale:
Landowners and managers play a pivotal role in promoting conservation and sustainable land management practices within the Central Valley, making them essential components of successful conservation efforts. Without the engagement of landowners and managers, the Central Valley would not be able to support one of the largest migrations of waterfowl and shorebirds in the world. Understanding the perspectives, motivations, and challenges that landowners and managers face is crucial to ensuring that they are engaged in future

conservation and land management efforts. Most restoration efforts, land procurements, easements and incentive programs rely on the participation of private landowners since 66 percent of wetlands and essentially all the agricultural lands are under private ownership in the Central Valley. In summary, understanding the perspectives, motivations, and challenges of landowners and managers, and what they need to facilitate their participation, is essential for promoting their engagement in future conservation and land management efforts in the Central Valley. It is also important to understand under-represented and/or marginalized groups of landowners (e.g., beginning or small farmers, economically disadvantaged). By adopting a collaborative and inclusive approach that recognizes the diversity of stakeholders and contexts within the region, conservationists can foster meaningful partnerships, achieve shared conservation goals, and secure the long-term sustainability of this vital landscape.

4.10 Determine landowner motivation and perceptions

Question(s):

1. Farmers:
    - What factors affect the decisions of farmers in applying conservation management actions? For example, factors to investigate could include benefits to crops (e.g., nitrogen fixing cover crops), risks (real or perceived), administrative burden, neighbor's opinions, past experience, incentive payments/programs, desires to pursue "green" practices, and/or barriers/limitations to implementing best management practices and the perceived efficacy of different practices).
    - How are publicly-available characteristics of farms and farm ownership (whether a farmer is owner, long-term lessee, annual renter, and/or annual share-cropper) correlated to farmers' ability and interest in annual vs. short-term (3-10 year) vs. long-term (30-year or perpetual easements) conservation programs?
    - What impacts farmers' interest and ability in participating in conservation work beyond familiar practices such as winter flooding and into new activities (e.g., flooding during shoulder seasons, providing cover crops, hedgerows, no-till, longer-term contracts, government programs)?

        Expected Outcome(s):
        - An understanding of the factors that influence decision-making for conservation on farms. These new understandings could relate to practices (how risky, duration, difficulty [level of knowledge]), or to program implementation (administrative burden, price point, duration, etc.) and can inform conservation organizations on how to better tailor messaging or education on practices or how best to craft incentives to encourage adoption and long-term persistence.
        - An understanding of the relationship between length or status of land ownership, publicly available farm characteristics, and conservation decisions. This will aid in focusing outreach for habitat programs to farmers who are able and willing to participate.

2. Past experiences with programs: How do farmer or landowner experiences participating in specific programs (governmental [e.g., Natural Resources Conservation Science Regional Conservation Partnership Program, California Department of Fish and Wildlife Presley Program] vs. private [e.g., Bid4Birds, BirdReturns, Salmon]) impact their willingness to persist in these activities after payments end and/or participate in future new programs?

   Expected Outcome(s):
   - An assessment of the impact of previous experience on the durability of the conservation impacts of the program, which can help prioritize how programs are designed in the future so they have lasting benefits

3. Water use: How can the JV partners effectively communicate to promote landowner participation in programs to address water use by agricultural producers? [specific programs of interest to study to be identified]

   Expected Outcome(s):
   - [specific programs of interest to study to be identified]

4. Wetland manager perceptions: What influences private wetland managers' willingness to conduct conservation practices and management for non-game species (e.g., waterbirds, shorebirds, other wildlife/fish on their wetlands)? What data do wetland managers use in their decision-making? What formats do they like for additional information? Is the availability or awareness of information the bottleneck of their capacity to use existing information?

   Expected Outcome(s):
   - A better understanding of wetland manager perceptions and how they impact their willingness to conduct management practices. A better understanding of how to deliver data to wetland managers so it can inform their decisions and fill gaps in the data they are already using.

4.11 Determine barriers and constraints for landowners to provide habitat

Question(s):

1. Private wetlands:
   - What is the average annual cost of maintaining (water costs, infrastructure maintenance, vegetation management, etc.) an acre of privately owned and managed wetland in each planning region? Is there a cost threshold where landowners will no longer flood and manage their wetlands in the different regions? Are there other components besides costs, such as hunting quality, hunting season length, environmental regulations or social constraints, that influence investment in habitat management?
   - Are there other ways to incentivize alternative management on private wetlands than direct payments? What role does cost, habitat management/maintenance actions, habitat goals, and landowner perceptions/education play in a

landowner's desire to provide habitat for breeding ducks? Does that vary between regions?
- How many duck clubs exist in each planning region and what are their ownership type(s) and water rights/resources?

Expected Outcome(s):
- An understanding of landowner costs for maintaining managed wetlands in different regions. An understanding of landowner needs to provide habitat, including the necessary funding to support privately managed wetlands. Projections for privately managed wetlands that may be at risk due to costs and other factors. An understanding of the needed actions and locations for breeding duck management programs.
- A catalog of duck clubs by region, including their ownership type(s) and water rights.

2. Public Lands: What are management costs on public lands (actual cost of habitat) and how do they compare with the costs determined by BirdReturns survey results, i.e., how much financial support do willing landowners accept via a reverse auction to provide habitat and how does that compare to actual costs incurred?

Expected Outcome(s):
- A comparison of actual management costs on public lands to what landowners accept via a reverse auction format to provide habitat (using BirdReturns survey results). This can support budget increases for public lands.

3. Rare/Endangered Species: To what extent does the presence of rare or endangered species (or the perceived risk of this) limit participation in habitat restoration programs? To what extent do safe harbor agreements address these issues?

Expected Outcome(s):
- An understanding of whether the potential for rare and endangered species presence on a property limits restoration opportunities. Identified programs (Safe Harbor, Cutting the Green Tape) that can help provide assurances to landowners.

4.12 Future projections and landowners

Question(s):

1. Loss of private wetlands:
   - With private wetland owners aging, what is the projection for future ownership and management of these lands?
   - Hunters as future landowners: are there enough waterfowl hunters being recruited and retained to take on the financial responsibility of owning and managing protected private wetlands in the future?

- What type of policy design would help wetland managers to ensure continued management of private wetlands for breeding and non-breeding waterfowl, shorebirds and waterbirds?

  Expected Outcome(s):
  - A better understanding of the relationship between losses of private wetlands and future projections of ownership and management. This will help the CVJV plan future policy and programs that help maintain private ownership and wildlife-friendly management.
  - An understanding of the demographics of the waterfowl hunting community and the impacts this may have on the long-term ownership and management of private wetlands. This will help inform programs that continue to retain and recruit waterfowl hunters that will support private wetlands.
  - An understanding of the opportunities for policy to ensure private wetland managers continue to manage private wetlands for breeding and non-breeding waterfowl, shorebirds and waterbirds.

Community Interests

Rationale:
Within the Central Valley, non-hunting recreationists and urban residents are an important component for conservation action. Non-hunting recreationists, including bird watchers and wildlife photographers, represent the largest user group of National Wildlife Refuges in the Central Valley. This group has been shown to financially support habitat protection and are a strong constituency for conservation policy. In addition, as many as 95% of California residents now live in urban areas, primarily outside the CVJV boundary, and represent an enormous constituency that has a huge political impact on conservation policy. Understanding non-hunting recreationists' and urban residents' current level of awareness in conservation as well as how they participate in conservation efforts is important for conservation planning. It is important for the CVJV to understand both how these groups support conservation and what barriers and limits may exist for promoting conservation among them. With this knowledge, the CVJV can better engage and educate non-hunting recreationists and urban residents to gain direct support for habitat protection and conservation policy. Additionally, it is important to understand opportunities with Joint Ventures outside the CVJV boundary and collaborative work that could benefit birds within the Central Valley.

4.13 Engage urban residents in bird conservation

Question(s):

1. What is the current awareness level and attitude of urban residents towards wildlife conservation, including wildlife water needs, and how do urban residents define ‘conservation’?

2. How can the CVJV quantify the value of habitat in and around urban areas and neighborhood conservation projects in meeting conservation objectives?
3. How can the CVJV encourage and support urban planning and local stewardship of urban habitats (e.g., managing garbage, cats, and lighting, planting native plants, and/or encouraging wildlife gardening and community gardens) that benefit birds, regardless of resident's motivations?

Expected Outcomes (across all questions):

- Identified approaches and communication tools that can be used to engage and motivate urban residents regarding bird conservation (i.e. to visit ecological preserves and refuges as well as state and federally managed wildlife areas, to participate in citizen science, to engage in hunting).
- An understanding of what local stewardship activities urban residents are engaged in already, and how the CVJV can support the activities that benefit birds in urban areas.
- Residents with motivation, pride, and a sense of responsibility in maintaining and improving habitat in and around urban areas.

4.14 Identify opportunities for non-hunting outdoor recreationists to assist in conservation funding

Question(s):

1. How can the CVJV best engage non-hunting recreationists in bird conservation and water policy and management (e.g., in birding and wildlife viewing, hiking and other "non-consumptive" recreation, and/or citizen science)? How does the CVJV recruit and retain non-hunters to financially support habitat protection and management (e.g., through donations, licenses, tags, validations and stamps)?
2. How does the CVJV better engage non-hunting recreationists to garner political support for bird and water conservation? Is there both public and political support for legislation that taxes outdoor equipment similar to the Pittman Robertson Act?

Expected Outcomes (across all questions):

- Identified approaches and communication tools that can be used to engage and educate non-hunting recreationists. This will encourage funding through recreation or other avenues and create buy-in and support for hunters and conservation that can lead to increases in funding and social support for hunting and conservation.
- An understanding of opportunities and potential mechanisms for non-hunting outdoor recreationists to financially support conservation. This could provide more funding for conservation and advocacy for increased public funds to support protected habitat

Hunters

Rationale:
Traditionally, hunters have provided financial support for waterfowl and wetland conservation through the purchase of federal and state duck stamps as well as excise tax contributions (via the Pittman-Robertson Act) to support the operation and maintenance of wetlands and wildlife habitat. Hunters also contribute to scientific knowledge of waterfowl and other migratory game birds by participating in wing-bee, harvest and body condition surveys. Hunters and hunting can incentivize private landowners to flood wetlands and manage their property for the benefit of waterfowl and other bird species. Hunter-supported nonprofit conservation organizations also perform important work that assists the Department of Fish and Wildlife and U.S. Fish and Wildlife Service in achieving conservation objectives. It is critical to understand how participation in hunting supports wetland and waterfowl conservation.

4.15 Understanding hunter contribution to conservation and hunting opportunities

Question(s):

1. What role do the number of waterfowl hunters play in maintaining and improving lands for waterfowl? Does this vary by region?
2. What will happen to habitat if hunters decline? How will conservation funding (habitat maintenance, research and education) be impacted?
3. Are there equitable opportunities that reduce barriers to hunter participation on both public and private land?

Expected Outcomes (across all questions):

- An economic analysis determining the direct and indirect financial benefits of waterfowl hunting (e.g., benefits to smaller economies throughout the Central Valley through travel and tourism, and how license, validation and stamp sales benefit actual conservation work being done in the field). Statewide information (i.e., the number of jobs supported, overall economic activity/sales, and tax revenue) can be used to show legislators and the public how much economic activity is produced annually by waterfowl hunting.
- Identification of areas or geographical regions most susceptible to changes in hunting participation by habitat type (e.g., managed wetlands and rice), land ownership (i.e., public or private), and region (e.g., Sacramento Valley, Suisun Marsh, Delta, Grasslands, Tulare Basin). This information will be used to identify which areas are experiencing declines in hunting and where resources should be applied to address that, as well as where the greatest opportunities are to expand hunting.
- An understanding of all public and private lands accessible within the region along with costs and demographics for hunting those lands, and an equity analysis on waterfowl hunting. An equity analysis could be used to identify

underserved populations using available data and help to make informed decisions of recruiting, retaining and/or reactivating diverse populations to participate in waterfowl hunting. This could inform the management of hunting programs on public and private lands.

4.16 Determine hunter satisfaction and barriers to participation

Question(s):

1. What roles do regulation complexity and legislative issues (e.g., ammunition laws) play in hunter participation?
2. What role do age, physical ability, lack of a mentor, and public and private land access play in hunter participation?
3. What is hunter satisfaction and how can it be obtained?
4. What can government agencies do to assist in removing barriers to participation?

Expected Outcomes (across all questions):

- An understanding of barriers to the retention and recruitment of hunters. Determining barriers to recruitment is important for regulation development, public land management, and hunter recruitment programs by CDFW and non-governmental organizations.
- An understanding of hunter satisfaction and limitations. This may impact the regulations developed, how public and private lands are managed, and how hunting is portrayed in messaging.

Underserved communities and tribes

Rationale:
Rural agricultural communities throughout the Central Valley have historically been underserved. These are often low-income communities of color that are dependent on seasonal farm work. Historically, many of these communities have lacked public infrastructure, access to clean drinking water, access to green space and have been prone to flooding. Similarly, there are over 109 federally recognized tribes in California, dozens of which are located within the CVJV boundary, that have traditionally struggled with high levels of poverty, lack of public infrastructure and natural resource issues. Underserved and tribal communities are often embedded in landscapes that the CVJV has prioritized for bird conservation. Engaging these communities in CVJV efforts can bring buy-in and support for bird conservation, while helping empower the communities to improve infrastructure, public health and the local environment (e.g., access to water for communities in Tulare). In addition, collaborating with communities on local projects can also help achieve CVJV habitat objectives. A good example of this would be multi-benefit projects that improve local flood control using “green infrastructure”, such as wetlands and floodplains. These projects can provide public safety, groundwater recharge, and outdoor recreation areas for communities, while helping meet CVJV habitat restoration objectives for various bird groups.

4.17 Engage and collaborate with underserved communities and tribes

Question(s):

1. What shared interests are there between the CVJV and underserved communities and tribes (e.g., protecting a place, water security), and how do these shared interests represent opportunities for bird conservation, either now or in the future?

   Expected Outcome(s):
   - Descriptions of the needs and conservation goals of key underserved communities and tribes.

2. Who and where are the underserved and tribal communities within key CVJV planning regions?

   Expected Outcome(s):
   - Names and locations of key underserved communities and tribes in priority CVJV planning regions, which will enable CVJV partners to identify potential opportunities for collaboration.

3. How can CVJV conservation efforts be designed to incorporate the knowledge (especially Traditional Ecological Knowledge) of these communities?

   Expected Outcome(s):
   - Conservation efforts informed by community knowledge and experience, including Traditional Ecological Knowledge.

4. What existing programs and/or conservation actions align with both underserved community/tribal needs and CVJV interests?

   Expected Outcome(s):
   - Successful methodologies for agencies and conservation groups to use when engaging underserved communities and tribes.
   - Effective programs and conservation actions that can be used when working with underserved communities and tribes.

5. How can the CVJV better collaborate with tribes to manage water and land resources for birds, fish, and other animal and plant species?

   Expected Outcome(s):
   - An understanding of the ability to collaborate with tribes when managing wildlife and natural resources.

Section 5: EXPANDING CONSERVATION BENEFITS AND BUILDING RESILIENCE

Assess multiple-benefit opportunities

Rationale:
Efforts to meet the conservation objectives defined by the Central Valley Joint Venture are likely to provide benefits to other species and human communities within the Central Valley, and because many of these bird populations are migratory, supporting local populations is likely to provide benefits to ecosystems and human communities elsewhere on the Pacific Flyway. By understanding how individual conservation projects can be designed to contribute to CVJV objectives while also providing benefits to other species or human communities, the CVJV can find common interests and identify opportunities to partner with other conservation organizations and community groups. Collaborative, multiple-benefit conservation projects designed to simultaneously benefit human communities, ecosystem function, and habitat for multiple species can be more inclusive of multiple perspectives, more successful in avoiding conflicts and trade-offs across multiple goals, and more compelling to a broader array of funders and constituents.

5.1 Develop integrative science for multi-species management
(see also Section 2B, objective 2)

Question(s):

1. Fish:
   - How can the CVJV provide both fish and bird habitat and integrate wetland and winter rice management with fish needs?
   - How can the CVJV incorporate breeding and non-breeding waterfowl, shorebird, waterbirds and landbird needs into habitat projects that primarily benefit listed anadromous fish?

     Expected Outcome(s):
     - An assessment of where, when, and how to effectively integrate fish management with shorebird, waterbird, riparian landbird, and waterfowl management in riparian areas, wetlands, and winter-flooded rice within floodplains. An integration of this data into large-scale planning processes and management. Improved conservation benefits for multiple species on managed lands.

2. Landbird habitat in agriculture: Evaluate how wildlife friendly agriculture (e.g. rice and cereal grains) and/or wetlands are utilized by landbird species. Identify if there are key management actions at each of these habitat types that impact use by these species (e.g. pesticide applications).

Expected Outcome(s):

- An understanding of how wildlife friendly agriculture and/or wetlands are utilized by landbirds and the effects of key management actions.

3. Landbirds in breeding waterfowl habitat (upland vegetation): How much upland vegetation cover is available that is used by landbirds such as the At-risk Northern Harrier, the At-risk Short-eared Owl, American Bittern, Red-winged Blackbird *Agelaius phoeniceus*, and Savannah Sparrow *Passerculus sandwichensis*?

Expected Outcome(s):

- An assessment of the value of fallowed rice, cover crops, irrigated pasture and other agriculture for landbird species. An understanding of management needs for different groups of species and At-risk birds (e.g., waterfowl and landbirds).

5.2 Identify multiple-benefit opportunities (beyond birds)

Question(s):

1. Barriers to involvement by bird conservation groups: What are the barriers to bird conservation group involvement in ecosystem services/multiple benefits? What is needed to get bird conservation groups involved in these projects and those developing the projects to engage the bird conservation community?

Expected Outcome(s):

- Increased bird conservation projects, programs, and policy development/ implementation by CVJV partners that includes and values multiple benefit and ecosystem services.

2. Grassland and oak savannah: What co-benefits/multiple benefits do grassland and oak savannah habitats offer? (e.g., evapotranspiration, groundwater recharge, connectivity, recreation, and cultural value)

Expected Outcome(s):

- An understanding of the multiple benefits in grassland and oak savannah habitats. Increased conservation opportunities for grassland and oak savannah habitat

3. Sierra meadows: How do Sierra meadows contribute to multiple benefits like: biodiversity (breeding waterfowl, pollinators, rare plants, bats, deer, beavers, etc.), pollinators, improved hydrology, water quality improvements, carbon sequestration, and cultural benefits?

Expected Outcome(s):

- An assessment of multiple benefits of Sierra meadows. Increased conservation opportunity for Sierra meadows. A better understanding of the

tradeoffs among conservation objectives for multiple resources. Informed prioritizations of meadow conservation.

4. Birds and groundwater recharge in flooded agriculture: What is the potential for synergies/partnerships with groundwater agencies and farmers, and for groundwater recharge projects (supported by SGMA) in crop fields/orchards to be habitat for birds (i.e., providing multiple benefits of bird habitat and groundwater recharge)?

   Expected Outcome(s):
   - Identification of opportunities to create flooded habitat in partnership with on-farm groundwater recharge efforts (i.e., providing multiple benefits of bird habitat and groundwater recharge).

5. Wetlands and flooded agriculture: What are the full suite of benefits to wildlife provided by wetlands and flooded agriculture (e.g., including for non-bird species)? How does this vary depending on land and water management? Where are the best places to achieve multiple-benefits with wetland restoration and enhancement projects?

   Expected Outcome(s):
   - A better understanding of the multiple benefits to wildlife of wetland and flooded agriculture. Maps highlighting different benefits of wetlands and flooded agriculture, taking into account management practices, and areas where the benefit could be expanded.

6. Riparian Forest and floodplain habitat: What co-benefits/multiple benefits do riparian forest and floodplain habitat provide? (e.g. bird conservation, fisheries conservation, flood control, water quality benefits, recreation, and cultural value). Where are the best places to achieve multiple-benefits with riparian and floodplain restoration?

   Expected Outcome(s):
   - An understanding of the multiple benefits to humans and wildlife of riparian forest and floodplain habitat. This could increase conservation opportunities for riparian and floodplain restoration.

Butte Sink. Credit: Mike Peters

Willow Flycatcher. Credit: Steve Emmons

APPENDIX A: Full list of objectives

4.10 Determine landowner motivation and perceptions
4.11 Determine barriers and constraints for landowners to provide habitat
4.12 Future projections and landowners
4.13 Engage urban residents in bird conservation
4.14 Identify opportunities for non-hunting outdoor recreationists to assist in conservation funding
4.15 Understanding hunter contribution to conservation and hunting opportunities
4.16 Determine hunter satisfaction and barriers to participation
4.17 Engage and collaborate with underserved communities and tribes
5.1 Develop integrative science for multi-species management
5.2 Identify multiple-benefit opportunities (beyond birds)

Dunlin and Dowitchers. Credit: Mike Peters

LINK TO REFERENCES

See the Science Needs Library for current list of relevant literature, with a focus on approximately the last 10 years.

Colusa National Wildlife Refuge. Credit: Mike Peters


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