DRAFT

APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Delta Plan Amendments

May 2020

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Contents

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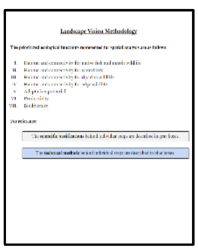
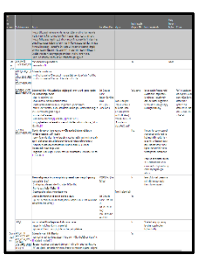
Introduction

This technical report describes the steps taken to rapidly develop a list of complementary opportunities for landscape-scale restoration in the Sacramento-San Joaquin Delta. It was designed to support Delta Stewardship Council staff who are actively developing an Ecosystem Amendment to the Delta Plan and is based upon the guide to science-based ecological restoration in the Delta previously developed by SFEI (A Delta Renewed, SFEI-ASC 2016). Taken together, the opportunities described and mapped in these materials represent a step towards the development of a Delta-wide landscape vision for supporting a holistic suite of desired ecological functions based on the strategies, guidelines, and recommendations put forth in the Delta Renewed report. Please note that work is still evolving; many of the opportunity types described below would benefit from further development and analysis.

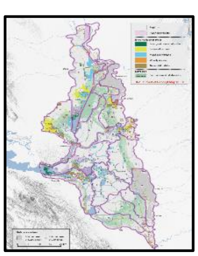
The landscape opportunities are described across several documents:



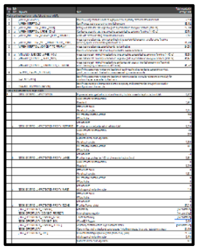
Methodology – a detailed description of the processes, analyses, and criteria used to identify, map, and quantify the opportunities for landscape-scale restoration. The methodology includes the reasoning behind each class or "type" of opportunity and the methods used to actually locate these opportunities on the landscape. The methodology introduces "codes" for the different types of opportunities that are then utilized in the other materials.



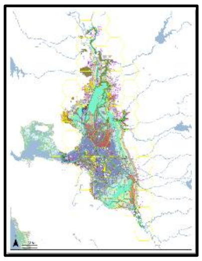
Opportunities Table – a description of opportunities for landscape-scale restoration in the Delta, organized by region. Spatially explicit opportunities are referenced with numbers that correspond to those used in the "Opportunities Map." By referencing the methodology document, the opportunity type codes used in the table can be used to look up the scientific justifications and technical methods that supported the inclusion and mapping of the specific opportunities in the table.



Opportunities Map – a map of the specific restoration opportunities described and numbered in the "Opportunities Table." Maps of individual layers that spatially represent each step in the methodology are also available as a separate package of layers accessible in GIS software.



Opportunities Summary – a numerical summary of conservation and restoration opportunities (as described and coded in the Methodology document). The summary quantifies, by type, the approximate total acreage of the opportunities described conceptually in the Methodology document.



GIS Map Package – a set of spatial data layers representing steps of the methodology. Map package contains organization of layers that is parallel to the ordering of steps and codes within the methodology. As described below in page 3, not all steps have spatially explicit data.

Methodology

The methods for identifying opportunities described below should be thought of as a checklist for conservation planning in the Delta. For this initial rapid analysis, some opportunity types were analyzed in more depth than others. A limited number of analyses associated with certain steps were not performed due to lack of data or time constraints. Overall, analyses were prioritized based on conservation interest (e.g., recovery of native fish populations is of high regional concern), quality of information (e.g., specific tidal marsh quantifications were based on availability in the scientific literature and review from the Delta Landscapes Project reports (Whipple et al. 2012, SFEI-ASC 2014, and SFEI-ASC 2016), and feasibility of analysis (e.g., adaptation potential is a more challenging function to plan for than support for riparian wildlife). Taken together, this information is analogous to a list of ingredients, rather than a recipe. The user must determine priorities for conservation and choose actions or sites accordingly.

The focus of this effort has been to describe kinds of opportunities spatially. To do so, these materials rely heavily on information that has been previously assembled in reports for the "Delta Landscapes Project": the *Sacramento-San Joaquin Delta Historical Ecology Investigation* (Whipple et al. 2012), *A Delta Transformed* (SFEI-ASC 2014), and *A Delta Renewed* (SFEI-ASC 2016). A familiarity with these documents will aid those reviewing the materials contained in this appendix. For example, when identifying opportunities for the conservation and restoration of habitat types, we do not define these habitat types, describe the processes required to sustain them over time, or describe how they differ across different parts of the Delta. Nor do we describe or define the ecological functions that organize the methods. All of this information is provided in the aforementioned reports.

We used the ecosystem functions analyzed in the Delta Landscapes Project reports to organize our methods into seven sections. Since habitat and connectivity for fish and marsh wildlife were the focus of our initial work on this effort, and since there is a high degree of overlap in the kinds of actions that might be taken to support the two functions, the methods used to identify opportunities to support these two functions are lumped. Future versions of this methodology could separate these two functions by:

- Habitat and connectivity for native fish and marsh wildlife
- Habitat and connectivity for waterbirds
- Habitat and connectivity for riparian wildlife
- Habitat and connectivity for edge wildlife
- Adaptation potential
- Productivity
- Biodiversity

For each step in the methods, we include a bracketed "code" in capital letters (e.g., [MARSH_REMNANTS]) that is used to identify opportunity types in the Opportunities Table and associated GIS files. We also include the **scientific rationale** behind each opportunity type and the **technical methods** used to identify opportunities on the map:

Under the technical methods description, we note whether the methods for identifying the opportunity areas were:

A. **[Identified automatically and quantified]** – identified using an automated, thorough, and repeatable GIS methodology. Opportunities that were identified automatically and quantified generally have detailed associated GIS outputs showing the locations of opportunities. These outputs were used to develop the "Opportunities Summary" spreadsheet. There is no extra label displayed in GIS map package layer.

B. **[Identified manually]** – opportunities were evaluated thoroughly, but done so using a manual approach that may not be perfectly repeatable. No associated spatially explicit GIS outputs. Labeled as {IM} in GIS map package layer. These layers may either contain no data or reference data that could be used for more comprehensive future analysis.

C. **[Identified in part]** – opportunities were evaluated in some areas, but not thoroughly, and may still be appropriate in areas where not noted. Generally, there are no associated spatially explicit GIS outputs, though in some cases opportunities that have been explicitly mapped, but not comprehensively added to the opportunities table and map, are characterized as "identified in part." Labeled as {IP} in GIS map package layer. These layers may either contain no data or reference data that could be used for more comprehensive future analysis.

D. **[Not identified]** – due to time constraints or data limitations, no effort was made to identify opportunity areas for these steps; they should still be evaluated at a later date. Labeled as {NI} in GIS map package layer. These layers may either contain no data or contain reference data that could be used to begin future analysis.

Note that many of the assumptions and uncertainties associated with the materials produced for the Delta Landscapes Project have been carried forward into the identification of opportunities in this effort. A notable example of this relates to modeling sea level rise (SLR) in the Delta. As described in more detail in the relevant sections below, the approach employed to map areas potentially subject to tidal inundation with SLR was rudimentary; we simply added a fixed height of 6 feet to the current mean higher high water (MHHW) elevation (as measured at one location in Cache Slough) and identified anything below this new elevation as potentially at the future intertidal elevation range. These methods do not account for spatial variability in either existing tidal elevations or future increases in water surface elevations, which are largely unknown (Council 2018). Opportunity areas could be refined by addressing these uncertainties through improved modeling. In general, we attempt to highlight any major uncertainties associated with the identification of opportunity types in their individual methodology sections.

Habitat and Connectivity for Native Fish and Marsh Wildlife

1. *Identify existing marshes (>1 ha) in need of legal protection, especially remnant historical marshes [MARSH_REMNANTS].*

Scientific Rationale

Many of the Delta's small marsh fragments have existed continuously since the historical period and are important potential reservoirs of native biodiversity. They could potentially serve as sources of propagules for new restoration projects (e.g., Chazdon 2003, Cramer et al. 2008), as "stepping stones" for wildlife dispersal (e.g., Saura et al. 2013), and as windbreaks that help limit fetch and wind-wave driven erosion of other areas in the event of levee failures and large-scale island inundation (e.g., Tonelli et al. 2010).

Technical Methods

Marsh remnants were identified in the GIS by selecting areas classified as freshwater emergent wetland in both the historical habitat types dataset and modern habitat types dataset (SFEI-ASC 2014). "Protected" areas were identified by merging three datasets: (1) the California Protected Areas Database (CPAD 2017), (2) the California Conservation Easement Database (CCED 2016), and (3) a layer containing the footprints of the islands/tracts owned by the Metropolitan Water District of Southern California (MWD), Bouldin Island, Webb Tract, Bacon Island, and Holland Tract. Areas of remnant marsh intersecting any of these datasets were considered protected; those that did not were considered unprotected. Note that we only evaluated that status of marsh areas that were part of marsh patches larger than 1 hectare (ha), as identified by SFEI-ASC (2014). Also note that the analysis overestimates the extent of true remnant marshes, since areas that underwent habitat conversion and subsequent restoration between the historical and modern mapping periods (e.g., Liberty Island) are indistinguishable from true remnants using these methods. **[Identified automatically and quantified]**

2. Identify areas that are currently at intertidal elevation [MARSH_INTERTIDAL].

Scientific Rationale

Large swaths of land in the Delta currently are situated at intertidal elevations but are separated from the tides by levees and other human infrastructure. These areas have the greatest potential to support tidal marshes with minimal management intervention now and into the future because, if connected to tidal action, they would be inundated at a depth and frequency that is appropriate for the establishment and persistence of emergent marsh vegetation. In general, these areas should be prioritized for restoration now, before their elevation becomes less favorable due to subsidence and SLR. In San Francisco Bay, the best available scientific guidance suggests restoring tidal marshes before 2030, since rates of SLR are expected to increase rapidly midcentury and time is needed for marshes to build elevation capital before this occurs (Goals Project 2015).

Technical Methods

Our methods for identifying areas at intertidal elevation were highly simplified. In absence of a comprehensive spatial dataset indicating the elevations of tidal datums across the Delta, we simply selected areas with elevations between a single mean lower low water (MLLW) elevation value (0.64 meter (m) NAVD88) and a single MHHW elevation value (1.95 m NAVD88). Once areas within this elevation range were extracted, we generalized the resulting raster data before converting it to polygonal vector data following methods described in ESRI's ArcGIS 10.5 generalization toolset documentation (Esri 2016). To highlight opportunity areas, we removed any areas classified as marsh or urban development in the modern habitat types dataset (SFEI-ASC 2014). Our source for elevation data was a 2 m Digital Elevation Model (DEM) of the Delta derived from DWR LiDAR data flown in 2007 (Reclamation 2010). The tidal datum elevations were measured at Cache Slough by cbec eco engineering (2010). These methods therefore make the major simplifying assumption that tidal range in the Delta is constant across space and time. We know this assumption is false, and therefore only use this layer to show the approximate location and extent of areas at intertidal elevation now and into the future. The layer should be refined for use in any detailed planning process. A simple visual inspection suggests general agreement with the areas within tidal demarcated by Siegel et al. (2010) using more sophisticated methods that account for spatial variability in the elevation of tidal datums. **[Identified automatically and quantified]**

Specific priorities include:

a Contiguous areas that are large enough to support desired ecological functions [MARSH_INTERTIDAL_LARGE].

Scientific Rationale

All else being equal, we expect larger marshes to support a wider range of desired ecological functions than smaller marshes (see SFEI-ASC 2016). For this analysis we focus on identifying areas that are large enough to potentially support maximum densities of Black rails (approximately 100 ha; N. Nur, personal communication) and areas that are large enough to potentially support a dendritic channel network (approximately 500 ha; SFEI-ASC 2016). These patch-size thresholds are relatively large, and marshes of these size would be expected to be large enough to support a variety of other ecosystem functions.

Technical Methods

Identified by creating patches from the areas at intertidal elevation (following methods developed for A Delta Transformed, SFEI-ASC 2014), then selecting patches larger than either 100 ha or 500 ha. **[Identified automatically and quantified]**

b Areas adjacent to existing marshes to increase patch size and connectivity.

Scientific Rationale

In some places, there are opportunities to restore large marsh patches (see above) by expanding on an existing smaller patch or by connecting multiple existing small patches, rather than restoring an entire new large patch outright.

Technical Methods

Due to time constraints, a detailed connectivity analysis of existing marshes has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

c Areas with remnant blind channel networks (it should be easier to recover complete marsh-channel systems where these channels have not been eliminated) [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL].

Scientific Rationale

Dendritic tidal channel networks that terminate within wetlands contribute to the exchange of energy, materials, and organisms between wetlands and aquatic areas, food-web production, and habitat heterogeneity, among other functions expected to benefit native fish (see SFEI-ASC 2016). Though the vast majority of the Delta's former blind channel networks have been eliminated since the historical period, remnant historical blind channels do still exist in some locations. Though these channels have been highly simplified over time (most have been truncated, straightened, and leveed), areas where they still exist at intertidal elevations offer relatively good opportunities to restore elements of a complete marsh-channel system (e.g., multi-order channels embedded within and hydraulically connected to areas of marsh).

Technical Methods

Identified by selecting "intertidal elevation patches" that intersect (or are within 100 m) of remnant historical blind channels. Remnant blind channels were identified by selecting any reach of modern blind channel (mapped in SFEI-ASC 2014) at least 1.35 kilometer (km) long that fell within 10 m of a historical blind channel (also mapped in SFEI-ASC 2014). **[Identified automatically and quantified]**

d Areas adjacent to tributaries with high inorganic sediment loads.

Scientific Rationale

Inorganic sediment delivery can supplement vertical marsh accretion from the accumulation of organic matter (Drexler 2011) and marshes with high sediment supplies might therefore have enhanced resilience to SLR over time.

Technical Methods

Due to time constraints, a detailed assessment of tributary sediment loads has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

e Areas that are adjacent to nonurbanized uplands to provide tidal-terrestrial transition zone functions (including space for marsh migration space with SLR), especially upland areas with existing terrestrial habitats (see Section IV, 1 below) [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE].

Scientific Rationale

It is important to identify areas where potential marshes have undeveloped uplands that can contribute to the formation of a tidal-terrestrial transition zone because this zone supports important environmental gradients, contributes to high levels of biodiversity, supports a wide range of ecological functions (e.g., high water refuge), and facilitates marsh migration over time with SLR (SFEI-ASC 2016).

Technical Methods

Identified by selecting "intertidal elevation patches" that intersect areas identified as nonurbanized migration space. For the purposes of this analysis, migration space was defined as any area between the elevations of 1.95 and 3.78 m NAVD88, which corresponds to the area within 1.8 m (6 feet (ft)) above present-day MHHW (as measured by cbec eco engineers [2010] at Cache Slough and mapped by SFEI-ASC [2016]). Nonurban areas were those that were not classified as urban/barren in the modern habitat types layer (SFEI-ASC 2014).

This analysis should be updated with a more sophisticated model of current and future tidal datums across the Delta. **[Identified automatically and quantified]**

f Areas that are adjacent to potential woody riparian habitats [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN].

Scientific Rationale

Historically, along the vast majority of their length, the Delta's elevated woody riparian corridors graded down to marshes (SFEI-ASC 2016). Marshes also graded into willow thickets in lower-elevation floodplains (Whipple et al. 2012, see Section II, 3). The existence of an ecotone between woody riparian habitats and marshes provides marsh wildlife with cover, high-water refuge, and alternate food sources (SFEI-ASC 2016). Adjacency between marshes and riparian habitats also benefits species that forage in marshes but roost, nest, or otherwise seek cover in riparian areas (such as colonial nesting birds). Marsh food webs can be supported by an influx of inputs from upstream terrestrial areas, and upstream riparian areas can export sediment and nutrients to support tidal marsh habitat. Landscape-scale restoration should seek to recover some of these lost functions by restoring woody riparian habitats adjacent to tidal and nontidal marshes (SFEI-ASC 2016; also see Section III, 2c, for reference).

Technical Methods

Identified by selecting "intertidal elevation patches" that intersect regions that historically supported woody riparian habitats and could potentially do so again; specifically, the historical footprint of valley foothill riparian, willow riparian scrub/shrub, and willow thicket habitat types (Whipple et al. 2012). See Section III, 1a and Section III, 3 for more information on identifying areas that could potentially support woody riparian habitat types. **[Identified automatically and quantified]**

3. Identify subsided areas that should be prioritized for reverse subsidence. [MINIMALLY_SUBSIDED].

Scientific Rationale

Much of the area that supported tidal freshwater emergent wetland has historically subsided due to the oxidation and compaction of peat soils that occurred as a result of agricultural production (Drexler 2011). "Reverse subsidence" efforts aim to recover lost elevation in these areas through managed wetlands that help to build organic material and trap sediment on site (Miller et al. 2008). These efforts are still in early stages in the Delta, however, reverse subsidence offers the potential to restore lost habitat value in these subsided areas, as well as potentially reducing flood risk over the long term, if these sites are able to regain intertidal elevations. The process of rebuilding peat soils is slow, and therefore the likelihood of achieving intertidal elevations through these methods is likely greatest in minimally subsided areas.

Technical Methods

Minimally subsided areas are lands mapped in A Delta Renewed that would require less than 50 years to reach intertidal elevation assuming constant elevation gains through tule farming of 5 cm per year (without SLR). Once these areas were isolated, we generated patches from the resulting layer following the methods for generating marsh patches described in SFEI-ASC (2016). This analysis would benefit from a more sophisticated model of the time it would take impounded marshes to reach intertidal elevations, taking into account key factors such as inorganic sediment supplies, SLR, and peat compaction (e.g., Deverel et al. 2014). **[Identified automatically and quantified]**

Specific priorities include:

***a	Areas that are both minimally subsided and large enough to support desired ecological functions (e.g., larger than approximately 100 ha for maximum densities of Black rail or 500 ha to support a dendritic channel network) [MINIMALLY_SUBSIDED_LARGE].***

Scientific Rationale

See Section I, 2a above.

Technical Methods

Large areas were identified by selecting minimally subsided patches larger than either 100 ha or 500 ha. **[Identified automatically and quantified]**

***b	Areas that are minimally subsided and are adjacent to potential woody riparian habitats on natural levees [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN].***

Scientific Rationale

See Section I, 2f above.

Technical Methods

Identified manually by locating minimally subsided areas that intersect natural levee features (historical woody riparian habitat type polygons). Could be automated, quantified, and refined in future phases. **[Identified manually]**

***c	Areas that are contiguous with areas at intertidal elevation and if restored would improve site hydrology and the potential for coherent dendritic tidal channel network development [SUBSIDED_HYDROLOGIC_BENEFITS].***

Scientific Rationale

On leveed tracts that are at intertidal elevation at their higher end but are subtidal at their lower end, breaches would result in permanently flooded habitats between the existing channel network and any new marshes that form in the intertidal area. This habitat configuration would prevent the formation of dendritic channel branches directly off of the original channel network. Carrying out reverse subsidence in the subtidal area (e.g., as is planned as part of the Dutch Slough restoration) could allow for the development of a coherent dendritic channel network.

Technical Methods

Identified manually by locating tracts that have significant areas at intertidal elevation at their higher end but are subtidal at their lower end. Could be automated, quantified, and refined in future phases. **[Identified manually]**

d Areas that would meaningfully improve marsh patch connectivity at the landscape scale (see Section I, 4, and 5).

4. Identify the approximate number and locations of large tidal marshes with dendritic channel networks needed to support the survival, growth, and movement of native fish, as represented by juvenile salmonids [SALMON_REARING_NETWORK].

Scientific Rationale

This exercise is based on Delta Renewed guidelines concerning marsh patch size and nearest neighbor distances. The guiding principle is that restoration efforts should create a network of high-quality rearing habitats (particularly marshes with dendritic channels) that are distributed at regular intervals along key salmon migratory corridors. More specifically, if outmigrating juvenile salmon travel during the night and hold/forage in low-velocity refugia habitats during the day, we hypothesize that fish should benefit from gaps between marshes with dendritic tidal channels that are less than the distances they typically travel over a 24-hour period.

Technical Methods

Michel et al. (2013) observed Chinook salmon smolt mean successful migration movement rates (MSMMR) ranging from 14.3-23.5 km/day for different release groups. A mean of all release groups (weighted by the number of fish in each group) yields an average MSMMR of 19.3 km/day. Based on this research, we used location-allocation GIS tools to optimally locate rearing sites along migratory routes so that each site is within 19.3 km of another (the tool determines the minimum number of sites needed to provide complete coverage).

At the points identified by the location-allocation analysis as important, we generated 500 ha circles, the approximate area of marsh needed to support a full channel network (Whipple et al. 2012, SFEI-ASC 2016). The resulting spatial dataset serves as a rough visual guide to the number, size, and location of large marshes needed across the landscape to provide habitat and connectivity for native fish. It can then be modified and refined based on other criteria. **[Automated]**

5. Identify the approximate number and locations of marshes needed to provide habitat and connectivity for marsh wildlife, as represented by Black rails [RAIL_NETWORK].

Scientific Rationale

Marsh patches of at least approximately 1 km2 are needed to support maximum densities of Black rails (N. Nur, personal communication). In order to maintain connectivity and metapopulation viability, marsh patch nearest-neighbor distances should not exceed normal Black rail dispersal distance (5.58 km; Hall 2015). Since Black rail presence is positively correlated with tidal influence (Tsao et al. 2015), these patches would ideally be hydraulically connected, though benefits would also be expected through the creation of impounded marshes in subsided areas. It is possible that productivity from these nontidal wetlands could subsidize aquatic food webs through water management and other indirect pathways.

Technical Methods

To visualize what a connected landscape is with marsh patches that follow the above size and distance guidelines, we generated an idealized network of circular marshes, each 1 km^2 in size and located 5.58 km from at least three other patches (a hexagonal grid). The resulting spatial dataset serves as a rough guide for determining where additional marsh restoration is needed to provide habitat and connectivity for marsh wildlife at the landscape scale. **[Automated]**

6. Identify opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts. [CHANNEL_RECONFIGURATION].

Scientific Rationale

Channel cuts have very likely contributed to decreased aquatic habitat heterogeneity at the landscape scale (Lund et al. 2007, Enright 2008, Whipple et al. 2012, Safran et al. 2016). Changes in network topology that increase the connectivity of a system, such as channel cuts, can also make it easier for disturbances to be transmitted through the network, resulting in more tightly correlated extinction risks for organisms in different parts of the system (Jones et al. 2000 as cited in Grant et al. 2007). It is conceivable, for example, that increased hydrologic connectivity in the Delta has facilitated the spread of invasive aquatic organisms like the overbite clam and Brazilian waterweed. It may be possible to reduce the over-connectedness of aquatic habitats and to regain some level of habitat heterogeneity through the careful use of physical barriers. These could be positioned at the sites of channel cuts, effectively limiting the influence of artificial hydrologic connections that were created during the reclamation era. Finally, the reconfiguration channel networks through physical barriers also have the potential to reduce entrainment of organisms in water export facilities (e.g., Ateljevich and Nam 2017).

Technical Methods

Identified manually by reviewing historical channel cuts highlighted in Delta Transformed (SFEI-ASC 2014). Future efforts should model actual hydrodynamic changes expected from these actions. **[Identified manually]**

7. ***Identify opportunities to create water temperature refugia through vegetative shading and by increasing the connectivity of channel networks to groundwater sources.***

Scientific Rationale

Cooler water refugia are important for alleviating stressors for marsh wildlife, particularly native fish. Increasing connectivity of channel networks to groundwater sources can sustain channel and wetland complexes throughout different times of the year. As these opportunity types pertain much to riparian wildlife, these types of opportunities are discussed in more detail in Section III.

Technical Methods

Opportunities to increase shade from woody riparian vegetation are captured in section, Habitat and Connectivity for Riparian Wildlife). Opportunities for riparian shading specifically for fish have not yet been comprehensively evaluated or incorporated into the vision. The same is true of opportunities to increase cold-water refuge through groundwater connections. **[Identified in part]**

8. ***Identify tidal-fluvial transition zones with strong inverse relationships between inflow and juvenile salmon survival, where habitat restoration might be prioritized [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT].***

Scientific Rationale

In the Delta, the location where flows in channels shift from tidally dominated (bidirectional) to fluvial-dominated (unidirectional) moves in response to the magnitude of freshwater inflow. These zones have a variety of unique physical and biological characteristics that make them important to wildlife and native fish. During high-flow periods the influence of the tides is “pushed” to the seaward end of the zone. This reduction in the spatial extent of tidal action partially accounts for the increase in survival of juvenile salmon during high-flow periods. Salmon would be expected to benefit from the restoration of channel edge and off-channel habitats that improve survival and growth within these zones (Cavallo et al. 2013, Perry et al. 2018).

Technical Methods

North Delta tidal-fluvial transition zones were mapped from Perry et al. (2018). San Joaquin River fluvial zone was mapped from Cavallo et al. (2013). Restoration opportunities in these zones were then manually identified and noted in the landscape vision. However, due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Identified in part]**

9. ***Identify remnant topographic low points at the sites of former lakes and flood basins, which could support long-duration inundation [TOPOGRAPHIC_LOWS_LONG_TERM_INUNDATION].***

Scientific Rationale

In the Delta, historically topographic low points supported long-duration inundation, to provide spatial and temporal heterogeneity in habitat. That is, these area provided open water habitat in certain areas and times when other places were dry. Particularly, in the North Delta, flood basins, running parallel to the river, accommodated large-magnitude floods, which occurred regularly, with inundation often persisting for several months. They consisted of broad zones of nontidal marsh that had very few channels and transitioned to tidal wetland towards the central Delta. Dense stands of tules over 3m tall grew in these basins. Large lakes occupied the lowest points in these flood basins (SFEI-ASC 2016).

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

Habitat and Connectivity for Waterbirds

1. Identify existing wetland, aquatic, and connected terrestrial habitat types in need of legal protection.

Scientific Rationale

Support for waterbirds is provided by a diversity of wetland types. While opportunities for waterbirds were not specifically analyzed for this effort, many of the recommendations for other functions would also benefit waterbirds. Specifically, the creation of large marsh areas, woody riparian habitats adjacent to marshes, and terrestrial areas that support seasonal wetlands all would be expected to support waterbirds. Agriculture also can play a key role in supporting waterbirds in the Delta. Analyses that consider how the landscape configuration of managed and unmanaged wetlands and wildlife-friendly agriculture support waterbirds should be addressed in future work, and have been to some degree already (e.g., Reynolds et al. 2017). Overall, protecting areas of persistent habitat type, particular habitat value and restoring large unprotected areas of the habitat types described above are important in providing ecological support for habitat and connectivity for waterbirds.

Technical Methods

To perform this basic analysis, methods describing protecting each of the above-described habitat types has, for the most part, been addressed in other sections. For marshes, see Section I. For woody riparian forest, see Section III. For vernal pools and seasonal wetlands, see Section IV. Open water (e.g., lakes) and floodplain habitat types may be addressed by future analyses. In summary, due to time constraints, opportunities for this type of action have either been evaluated for other functions in other sections, or have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

a. Identify existing habitats of significant value to specific populations.

i. Sandhill crane roosting sites.

Scientific Rationale

Sandhill cranes have high site fidelity for roosting sites. Protecting these sites are of particular importance, especially given that they are a species of conservation concern.

Technical Methods

Due to time constraints and data availability, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

ii. Remnant riparian habitat likely to support old-growth woody riparian forests.

Scientific Rationale

Particular trees can have an outsized ecological impact, with single trees containing dense concentrations of colonial nesting birds. In the long run, protecting and maintaining woody riparian forest habitats in general is an important consideration, as these habitats will sustain processes to provide future habitat for such focal bird species.

Technical Methods

Due to time constraints and the fine-scale resolution of data required for this analysis, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision, but the conservation of remnant riparian habitats is captured in Section III, 1a. **[Not identified]**

b Identify other existing important habitats to support a diversity of waterbirds.

Scientific Rationale

Protecting a diversity of wetland and aquatic habitat types can promote a diversity of waterbirds. Wetlands with vegetation of different heights (such as short-stature vegetation like wet meadows and complex emergent wetlands typical of the historical south Delta), as well as wetlands with varying water depths and inundation timing, support different niches of birds and at different times of the year. It is important to include marshes, riparian forests, seasonal wetlands, floodplains, and lakes to address aspects of habitat and food-web support for all waterbirds. Floodplains in the Yolo Bypass and along the Cosumnes and San Joaquin Rivers would support shorebirds and dabbling ducks. Riparian and riverine habitats on the Sacramento, San Joaquin, and Cosumnes Rivers, as well as on smaller tributaries, would support Wood ducks, mergansers, herons, and egrets. Lakes are important for supporting large numbers of waterfowl, and vernal pools and seasonal wetlands are important for cranes and shorebirds. Wildlife-friendly agriculture throughout the Delta can benefit various waterbirds, depending on crop types and flooding patterns. The areas along the periphery of the Delta are more likely to be sustainable for waterbird support in the long term as sea level rises. Terrestrial habitats also provide support for some waterbirds during different times of the year—shorebirds use vernal pools, while various waterbirds such as cranes utilize seasonal wetlands (SFEI-ASC 2016).

Technical Methods

See Section II, 1 for more details. **[Not identified]**

2. Identify opportunities for restoring wetland, aquatic and connected terrestrial habitat types.

a Diversity of wetland and aquatic habitats.

Scientific Rationale

Restore and maintain a diversity of wetland and aquatic habitat types including marshes, riparian forests, seasonal wetlands, lakes, and floodplains. Include wetlands with short-stature vegetation, including wet meadows and complex emergent wetlands typical of the south Delta, historically.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

i. Restore wetlands of large size to support adequate food production for large flocks of waterbirds.

Scientific Rationale

Large wetlands should be created and managed to support large flocks of overwintering waterfowl. Prioritization of large tidal marshes based on other functional thresholds are described under Section I. For instance, 500 ha marshes provide significant habitat heterogeneity by allowing the development of a full dendritic channel network. Marshes of this size should also contribute substantial primary productivity for waterbird uptake. However, full analysis of these functional benefits of primary productivity are still in progress. As such, particular recommended acreage thresholds are not available at this time. Restoring various wetland habitat types can provide different types of primary productivity. Overall, large-scale wetland habitat type restoration is recommended to support food webs.

See Section VI for more on productivity.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

b Restore and maintain connected terrestrial habitats around the periphery of the Delta, including vernal pools for shorebirds and seasonal wetlands for other waterbirds.

Scientific Rationale

Terrestrial habitats are important for waterbirds for two primary reasons. First, areas along the periphery of the Delta are more likely to be sustainable for waterbird support in the long term as sea level rises and shifts habitat on elevational and various other environmental gradients. Secondly, terrestrial habitats provide support for some waterbirds during different times of the year than other habitat types in other locations—allowing shorebirds to use vernal pools and various waterbirds such as cranes to utilize seasonal wetlands (SFEI-ASC 2016).

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

c Restore and maintain riparian forest habitat near marshes to support colonial roosting and cavity nesting birds.

Scientific Rationale

See Section IV, 1b-ii for explanation as well as supporting information in Section I, 2f and Section III, 2c.

Technical Methods

Due to time constraints and the fine-scale resolution of data required for this analysis, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision, but areas that could potentially support riparian habitats adjacent to marshes are identified in Section I, 2f and Section III, 2c. **[Not identified]**

3. Identify opportunities to integrate waterbird habitat into human land uses.

a Wildlife-friendly agriculture.

i. Manage a network of foraging habitats in the form of short-stature managed wetlands or seasonally flooded agricultural fields (particularly for cranes).

Scientific Rationale

Restoring a network of seasonally flooded habitats could take many forms, including primarily rain-fed seasonal wetland complexes, nontidal freshwater emergent wetlands, managed wetlands, and/or seasonally flooded agricultural fields.

Restoring wetland habitat types that can be sustained by natural processes (such as floodplain habitat) and are not managed or managed with low intensity is desirable. Where process-based restoration is not feasible, a more managed approach is possible through cultivating managed wetlands and managed flooding in farm fields.

Given that most of the modern Delta is under agricultural with heavily variable and managed water operations, perhaps the most potential for habitat modification lies here.

Delta Transformed (SFEI-ASC 2014) also suggested general metrics around monitoring and planning for waterbirds by measuring and evaluating ponded area in summer by depth/duration and wetted area by type in winter. The variance in depth and timing of water in space across the Delta is important to plan strategically to support sandhill cranes as well as a suite of other waterbirds.

While more analysis and research is potentially needed for this topic, some literature has established some management guidance specifically for sandhill cranes. Given their relatively long dispersal distance and large biomass, cranes can be used as an umbrella species for many other waterbirds. This research suggests new roosting habitat should be established as close as possible to the original site, or within 5 km of foraging habitats. This 5 km radius comes from analysis for sandhill cranes (Ivey et al. 2015). However, some shorebirds may prefer shallower depths on agricultural fields, and waterfowl will prefer greater depths.

The Nature Conservancy has already done significant analysis around this topic for a variety of shorebirds, in further detail, at both finer resolution and greater scale (for instance, see Reynolds et al. 2017) to target supplying water on fields when and where it is most needed to support this ecological function.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. See Reynolds et al. 2017 and other similar efforts by The Nature Conservancy for more detailed planning analyses in the Central Valley, including the Delta. **[Not identified]**

ii. Offset lost agricultural waterbird habitat (from tidal marsh restoration) in other areas.

Scientific Rationale

Flooded agricultural fields currently provide critical support to migratory waterbirds. Planned tidal marsh restoration in agricultural areas that currently support waterbirds may displace species that prefer more open, deeper water, short-stature vegetation and agricultural grain fields to mudflats and taller vegetation. Offset foraging or roosting habitat then should be designed to accommodate a diversity of species, with strategic managed flooding of variable timing, depths, and locations.

See Section III, 3a-i for more details on characteristics of wildlife-friendly agricultural habitat for sandhill cranes.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. See Reynolds et al.

2017 and other similar efforts by The Nature Conservancy for more detailed planning analyses in the Central Valley, including the Delta. **[Not identified]**

b Integrate habitat improvements in urban areas.

Scientific Rationale

Creating and improving the habitat quality of urban wetlands, ponds, and lakes—including improving water quality and quality of surrounding terrestrial habitat—could potentially benefit resident and migratory waterbirds and, by connecting people to wildlife, help to foster an understanding and appreciation for stewardship and conservation efforts.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

Habitat and Connectivity for Riparian Wildlife

1. Identify existing patches of woody riparian vegetation in need of legal protection [RIPARIAN_EXISTING_UNPROTECTED].

Scientific Rationale

Existing woody riparian habitats provide a wide range of functions to support riparian wildlife in the Delta (see SFEI-ASC 2016). Even small patches have the potential, for example, to serve as sources of propagules for new restoration projects (e.g., Chazdon 2003, Cramer et al. 2008) and as "stepping stones" to facilitate wildlife dispersal (e.g., Saura et al. 2013). However, many areas of existing woody riparian habitat in the Delta lack meaningful legal protection. Since the functional benefits and future resilience of woody riparian patches vary widely across the Delta (for instance, woody riparian vegetation directly connected to riverine flows at the upstream edges of the Delta probably has a higher functional value to wildlife and long-term resilience to change than woody riparian habitat on the landward side of an artificial levee in the central Delta), in the sections below we highlight the importance of protecting woody riparian habitats that are historical remnants, are hydrologically connected to streams, or have an appropriate natural landscape position (located within the fluvial or tidal-fluvial transition zone).

Technical Methods

Protection opportunities for existing woody riparian vegetation were identified by using a composite of modern woody riparian habitat types from the contemporary habitat type layer (SFEI-ASC 2014). Specifically, the modern woody riparian habitat types layer is formed from the valley foothill riparian, valley foothill alliance, willow thicket, willow riparian scrub/shrub, and willow scrub/shrub alliance habitat types (see SFEI-ASC 2014 for more information on the modern habitat type layer). Unprotected parcels were identified by intersecting the modern woody riparian habitat types with a protected areas dataset, developed by merging the California Protected Areas Database (CPAD 2017), the California Conservation Easements Database (CCED 2016), and a layer containing the footprints of the islands owned by MWD ,Bouldin Island, Webb Tract, Bacon Island, and Holland Tract). **[Identified in part]**

Specific priorities include:

a Existing woody-riparian patches that are historical remnants [RIPARIAN_EXISTING_UNPROTECTED_REMNANT].

Scientific Rationale

Historical remnants are potential pools of native biodiversity and are likely connected to the physical processes necessary to sustain the habitat over time (or could potentially be reconnected to these processes). Since they are very likely adjacent to other areas that could potentially support woody-riparian habitats, historical remnants are also likely to be critical components of any future riparian corridors.

Technical Methods

Woody riparian remnants were identified by using the intersect tool to find the overlap of the historical and modern woody riparian habitat types mapped by SFEI-ASC (2014). These areas of overlap were then intersected with the protected areas dataset (see above) to isolate unprotected remnants. Note that the analysis overestimates the extent of true remnant woody riparian vegetation, since areas that were cleared and have subsequently revegetated between the historical and modern mapping periods (e.g., trees growing on engineered levees) are indistinguishable from true remnants using these methods. Not all mapped opportunities have been highlighted in the opportunities table/map. **[Identified in part]**

b Existing woody riparian habitats that are hydrologically connected [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED].

Scientific Rationale

Hydrological connectivity is an important consideration for woody riparian habitat conservation because periodic deliveries of water and sediment are required to maintain the environmental conditions (e.g., moisture gradients and groundwater levels) and geomorphic surfaces (e.g., natural levees and point bars) that sustain woody riparian habitats and their associated functions over time (SFEI-ASC 2016). Note that the potential value of hydrologically disconnected woody riparian vegetation and opportunities for its conservation are discussed elsewhere (see Section III, 2g).

Technical Methods

For this analysis we selected woody riparian areas determined by SFEI-ASC (2014) to have some sort of hydrologic connection (areas classified as “valley foothill riparian,” “willow riparian scrub/shrub,” and “willow thicket,” but not areas classified as “valley foothill alliance” or “willow scrub/shrub alliance”). These hydrologically connected woody riparian areas were then intersected with the protected areas’ dataset (see above) to isolate areas of hydrologically connected but unprotected woody riparian vegetation. Not all mapped opportunities have been highlighted in the opportunities table/map. **[Identified in part]**

2. Identify remnant natural levees where woody riparian vegetation (both riparian forest and riparian scrub) could potentially be restored if reconnected to adjacent streams. [RIPARIAN_POTENITAL_ON_NATURAL_LEVEES].

Scientific Justification

Natural levees historically supported the majority of woody riparian vegetation along streams in the historical Delta, but have since largely been cleared, elevated, and armored over time with the construction of engineered levees (Whipple et al. 2012, SFEI-ASC 2014). Process-based restoration of these features would entail removing or regrading the engineered levees to allow for the reestablishment of woody riparian vegetation that is hydrologically connected to the adjacent stream and subject to associated natural processes (e.g., seasonal flooding, sediment scour and deposition, seed dispersal and seedling establishment). Natural levees are located within the Delta's fluvial zones, with relatively high freshwater flows, rates of sediment delivery, and proportions of well-drained mineral soils, which are all factors that would be expected to promote the establishment and survival of woody riparian vegetation (Griggs 2009). Restoration along natural levees should seek to restore vegetation across the complete gradient of fluvial influence, with larger natural levees supporting riparian forest upstream grading down to smaller natural levees supporting riparian scrub further downstream (Whipple et al. 2012, SFEI-ASC 2014, SFEI-ASC 2016).

Technical Methods

As an initial method for rapidly identifying remnant natural levees that could potentially support woody riparian vegetation in the Delta, we simply selected the historical footprint of valley foothill riparian and willow riparian scrub/shrub (Whipple et al. 2012). This methodology makes the simplifying assumption that areas that historically supported woody riparian vegetation could still do so today, at least with modifications to engineered levees that currently limit connections between streams and the adjacent land. Future phases of this work should refine this analysis, evaluating the actual present-day topographic, edaphic, and hydrologic conditions. As a first step towards refining the historical woody riparian vegetation footprint, we subtracted areas that have undergone urban development (as identified in the modern habitat type layer, SFEI-ASC 2016), based on the assumption that these developed areas are not good potential sites for woody riparian vegetation restoration. To isolate opportunities for restoration, we also subtracted areas of existing hydrologically connected, woody riparian habitats (those classified in the modern habitat type layer [SFEI-ASC 2014] as valley foothill riparian of willow riparian scrub-shrub). The methodology here potentially underestimates opportunity in areas that did not historically support woody riparian vegetation but could today, given changes in environmental conditions (e.g., along new channel courses such as Paradise Cut). These areas are the focus of Section III, 5. **[Identified automatically and quantified]**

Specific priorities include:

a ***Areas expected to enhance connectivity between existing wide patches of woody riparian habitat (prioritize restoration of gaps in existing riparian corridors) [RIPARIAN_EXISTING_GAPS].***

Scientific Justification

In the fluvially dominated areas along streams, riparian corridors in the Delta were largely continuous swaths of woody vegetation, transitioning from tall valley foothill riparian forests upstream to willow riparian scrub downstream. In the contemporary corridor, these corridors have numerous and sizeable gaps and existing patches of riparian vegetation are often quite isolated (SFEI-ASC 2016). This is problematic, because connectivity between riparian habitats is important for sustaining ecological processes and functions. In terms of wildlife, gap sizes of varying distances can reduce probability or capacity of movement between riparian forest patches for such riparian wildlife as songbirds and mammals (see A Delta Renewed). These gaps can thus create barriers to movement and consequently, potentially reduce resilience and persistence of populations (e.g., Cecala et al. 2014). Connectivity of riparian habitats would also be expected to help facilitate pollination, dispersal, and gene flow within and between riparian plant populations.

Technical Methods

Gaps in existing patches of riparian vegetation along the Cosumnes, Mokelumne, and San Joaquin Rivers' systems were identified manually using spatial data developed for A Delta Transformed (SFEI-ASC 2014). Specifically, we reviewed the map of modern riparian width transects (pg. 67), which were generated wherever existing hydrologically connected, woody riparian vegetation is wider (laterally) than 100 m, and manually identified any longitudinal gaps in these wide habitats greater than 100 m. There was no maximum gap distance, but we only identified gaps in areas that historically supported woody riparian vegetation along natural levees (see above), which did impose an effective maximum gaps size. Future efforts should expand this analysis to other streams (especially the Sacramento River and its tributaries) and generate methods to identify gaps in an automated and repeatable fashion. **[Identified in part]**

b Areas that could potentially support woody riparian patches that are large and wide.

Scientific Rationale

Woody riparian corridors should be as wide as feasible, since the functions supported by woody riparian corridors generally increase with their width, and wide corridors have been disproportionately lost in the Delta over time (see SFEI-ASC 2016). Though relatively narrow corridors can provide some functions (e.g., corridors at least 5-25 m wide are needed to ensure leaf litter inputs to streams), many functions are only achieved at greater widths (e.g., optimal nesting habitat for Western yellow-billed cuckoo is at least 600 m wide). Wide corridors are also more likely than narrow corridors to support complex riparian habitats, with different vegetation zones influenced by lateral gradients in elevation, moisture, inundation frequency, and edaphic conditions (SFEI-ASC 2014).

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. It could be done in the future by intersecting the historical riparian width transects (mapped in SFEI-ASC 2014) with the layer of undeveloped areas that historically supported woody riparian habitats on natural levees (see above). This would allow one to measure the width of the remaining opportunity areas and to identify areas wider than a particular threshold. **[Not identified]**

c Areas that are adjacent to existing or potential marshes.

Scientific Rationale

Historically, along the vast majority of their length, the Delta’s elevated woody riparian corridors graded down to marshes (SFEI-ASC 2016). The existence of an ecotone between woody riparian habitats and marshes provided riparian wildlife with access to wetland habitats for foraging and adjacent marshes can also help dissipate flood waters that move through riparian habitats, reducing flood heights within the riparian corridor and associated mortality of terrestrial animals like riparian woodrat and riparian brush rabbits (SFEI-ASC 2016). Landscape-scale restoration should seek to recover some of these lost functions by restoring woody riparian habitats adjacent to tidal and nontidal marshes (SFEI-ASC 2016).

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. It could be done in the future by selecting potential areas for woody riparian habitats that are within a certain distance of areas deemed appropriate for marsh restoration (see Section I, 2f). **[Not identified]**

3. Identify areas near the mouths of Delta tributaries that could potentially support willow thickets.

Scientific Rationale

In the historical Delta, large willow thickets were located at the mouths of multiple Delta tributaries where the water carried by these streams dissipated into the Delta’s flood basins through distributary channel networks. The willow thickets that formed at these sites (known historically as “sinks”) are notable, in part, because they were sustained by a different suite of physical processes than woody riparian habitats on natural levees and, as a result, had a different form and function (willow thickets were perennially wet and occupied lower-elevation floodplain positions relative to riparian forest habitat types). Since this unique habitat type has been effectively extirpated from the Delta, it’s worth assessing areas near the mouths of Delta tributaries to determine if willow thickets could potentially be restored. Willow thickets, as treated here, are different from the willow-fern swamps of the central Delta, which are the subject of Section III, 4 below.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. As an initial method for identifying opportunity areas for restoring willow thickets, future analyses could map the areas that historically sustained these features (Whipple et al. 2012), minus the portions that have since undergone urban development (mapped in SFEI-ASC 2014). It is important to note that Whipple et al. (2012) only mapped large and well-defined expanses of willow: smaller patches of willow thickets were found elsewhere. A more refined analysis would evaluate the actual present-day topographic, edaphic, and hydrologic conditions to determine where willow thickets might be supported. **[Not identified]**

4. Identify locations in the central Delta that could support willow-fern swamps.

Scientific Rationale

Whipple et al. (2012) describe the historical presence of willow patches ("willow-fern swamps") embedded within the freshwater tidal marshes of the central Delta. Though willow-fern swamps were less connected than woody riparian habitats along natural levees, willow-fern swamps offered the only significant areas of woody vegetation in the central Delta, contributed to the heterogeneity of riparian habitats at the landscape scale, and likely supported riparian wildlife—particularly breeding riparian birds (Whipple et al. 2012, SFEI-ASC 2014).

Outright restoration of this plant community should be considered as part of tidal marsh restoration projects in appropriate parts of the central Delta (see below). Additionally, it may also be feasible to support willow groves in subsided portions of the central Delta, either as a component of impounded nontidal wetlands or in other landside areas where reconnection is not possible given water surface/land surface elevations. Sizeable willow groves are located on Sherman, Twitchell, Bradford, Webb, and Venice Islands/Tracts and indeed have been documented to support riparian wildlife (R. Melcer, personal communication). An important caveat is that the long-term sustainability of willow groves in subsided areas is threatened by continued SLR and the potential for levee failure. Such restoration efforts could be viable and provide benefits to riparian wildlife over shorter timescales, especially when coupled with subsidence reversal projects.

Willow-fern swamps are thought to have been most common historically within Sherman, Bradford, Webb, Venice, and Mandeville Islands; areas coincident with areas of cooler temperatures due to the maritime influence and tule fog (Whipple et al. 2012). The vegetation community is also thought to have occurred on Bethel, Franks, Holland, Quimby, Medford, Bacon, Orwood, Palm, Veale, and Hotchkiss Islands/Tracts. The full region—across which willow-fern swamps are thought to have occurred historically, and thus where it might make sense to prioritize their restoration today—is mapped in figure 4.50 in Whipple et al. (2012). An early map suggests there were approximately 7 patches of willow-fern swamp per 10,000 ha of land, each with an average size of approximately 16 ha

(SD = 12 ha, SFEI-ASC 2014). In absence of other information, projects might strive for restoring willow groves in this general configuration.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. As an initial method for identifying broad areas of opportunity for restoring willow-fern swamps, we simply have highlighted the region across which the vegetation community historically occurred (Whipple et al. 2012). Future phases of work could refine this analysis, evaluating the actual present-day topographic, edaphic, and hydrologic conditions to determine where willow-fern swamps might be supported. Efforts could also be made to visualize the historical size/distribution of willow patches across this area for reference during conservation planning efforts (see Section I, 5 for a similar example). **[Not identified]**

5. *Identify areas that did not historically support woody riparian vegetation, but could now, due to environmental changes.*

Scientific Rationale

The opportunity types identified above for supporting riparian wildlife emphasize recovering woody riparian habitats in areas where they were historically supported. This makes sense for identifying high-level opportunities for process-based restoration, but fails to account for areas where physical processes have been altered and “new” areas that could support woody riparian vegetation over the long term. Due to creation of new channels or changes in channel morphology, elevation, flows, or water control structures, there are areas that did not historically support extensive woody riparian habitats that could potentially support them now and into the future. Good examples of this include Paradise Cut in the south Delta and portions of the Yolo Bypass in the north Delta.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. A first cut at methodically identifying these areas could be accomplished by using the historical and contemporary channel layers to isolate new channel courses and then selecting those new courses that fall within the fluvial zone (And are thus potentially subject to the physical processes that support woody riparian vegetation over time). **[Not identified]**

6. *Identify opportunities to increase support for riparian species in urban areas, through the restoration and buffering of urban creeks.*

Scientific Rationale

Opportunities exist to improve riparian habitat along urban creeks and tributaries. Waterways in urban areas may be of particular importance in drought years for wildlife, as the waterways are often supplemented by artificial irrigation from urban landscaping and gardening operations (e.g., Solins et al. 2018). Further, creeks in urban areas have the potential to support regional corridors for connectivity (Urban et al. 2006) and can export nutrients and sediment downstream (Paul and Meyer 2001). These areas also provide convenient places for humans to connect with nature and can foster an understanding and appreciation for stewardship and conservation efforts (e.g., Standish et al. 2013).

In addition to restoration of areas within existing stream-area footprints, daylighting streams to improve hydrological and ecological connectivity is also an option, as is reconfiguring the sewershed network.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

7. Identify opportunities to increase support for riparian species in agricultural areas.

Scientific Rationale

There are a variety of well-established best management practices for supporting riparian wildlife in agricultural landscapes. The Riparian Habitat Joint Venture (2004) recommendations for managers include (1) use groundcover in orchards and vineyards to discourage foraging by Brown-headed cowbirds, (2) either avoid mowing through the nesting season or maintain the layer to 6 inches in height to discourage use by nesting birds, (3) use integrated pest management or organic production as an alternative to pesticide use, (4) eliminate, reduce, or closely manage grazing in spring and during the breeding season (April-July) to maximize the understory habitat value to wildlife and minimize foraging habitat for cowbirds, and (4) if grazing must occur in riparian zones, establish wide pastures and move cattle often to avoid the devastating impacts of year-round grazing. They also recommend planting hedgerows at field margins and managing nonnative plants and animals. These could be particularly useful to increase landscape connectivity in key areas where process-based woody riparian restoration is not feasible.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

Habitat and Connectivity for Edge Wildlife

Scientific Rationale

Terrestrial habitat types (including seasonal wetlands, vernal pool complexes, alkali wetlands, oak woodland/savannah, grassland, and stabilized interior dune vegetation) that were historically found along the periphery of the Delta are important to a wide range of terrestrial or "edge" wildlife species (defined in A Delta Renewed) and can provide crucial areas of connectivity and exchange in the tidal-terrestrial transition zone. These terrestrial habitats are considered together here because of their similar landscape position and because they support overlapping ecological functions. While these habitats were largely limited to the Delta periphery historically, today they often occur in deeply subsided areas of the Delta, behind levees, where they are less sustainable and do not provide the full suite of processes and functions expected.

Terrestrial habitat types occurring at appropriate elevations are most likely to persist over time, and the range of "appropriate" elevations is expected to shift with sea level rise. To most conservatively identify what terrestrial habitats may persist in tomorrow's Delta, protection and restoration of potential terrestrial habitat cover should focus on areas above current MHHW, plus 6-feet (1.8 m) projected SLR. Areas above this elevation should be less vulnerable to SLR.

Terrestrial habitat protection in urban areas is assumed to be a low priority because of the degree of fragmentation and stressors in urban areas.

Thus, the footprint that develops to prioritize restoration of terrestrial habitat types is those lands above the MHHW plus 6-feet (1.8 m) elevation, minus lands currently urbanized.

Technical Methods

The terrestrial upland layer was developed by extracting areas from the DEM (Reclamation 2010) higher than 3.78 m NAVD88, which corresponds to the area at least 1.8 m (6 ft) above current MHHW, as measured by cbec eco engineers [2010] at Cache Slough and mapped by SFEI-ASC (2016). This land, predictably, falls mostly on the periphery of the Delta. For more information on identifying tidal-terrestrial transition zone areas, see Section I, 2e. Nonurbanized areas were isolated by subtracting any areas classified as urban/barren in the modern habitat types layer (SFEI-ASC 2014). **[Automated]**

1. ***Identify areas of existing terrestrial habitat types in need of legal protection. [EDGE_EXISITING_UNPROTECTED].***

Scientific Rationale

Though agriculture is the dominant land cover in the Delta, and much of the existing native habitat types are protected, opportunities remain to protect remnant, persistent or otherwise extant habitat types. Areas of high-quality habitat that are not yet protected should be the highest priority for acquisition or easement, as these likely harbor the highest biodiversity.

Technical Methods

Existing unprotected terrestrial habitat types were identified by the following process: taking the modern habitats layer (not including open water, agriculture or urban/barren lands) and subtracting current protected areas, and then intersected with the terrestrial upland zone. The protected areas were taken from a merged dataset of the CPAD 2017, the CCED 2015, and a layer containing the footprints of the islands owned by MWD, Bouldin Island, Webb Tract, Bacon Island, and Holland Tract. These lands collectively represent lands owned in fee or protected for open space purposes by many nonprofits and government agencies. Please note that this protected areas' layer utilizes an older (2015) version of the CCED database than other analyses identifying existing habitats in need of legal protection (e.g., Section I, 1 and Section III, 1); in future phases of work the analyses should be re-run with the latest 2016 version. **[Identified automatically and quantified]**

Specific priorities include:

a Protect as many remnant areas of high-quality habitat as possible. [EDGE_EXISITING_UNPROTECTED_PRIOITY_REMNANT].

Scientific Rationale

Habitats of historical persistence are of interest as they represent areas of unique genetic diversity and likely represent pools of native biodiversity that could colonize new areas and serve as high-quality habitats to link to broader landscape connectivity (Chazdon 2003). Restoration often may only "restore" a subset of the habitat features, processes and species historically present, so emphasizing these areas is of particular importance.

Technical Methods

Remnants are identified in the GIS by selecting areas with the same historical and modern habitat type classifications. The CPAD and CCED databases are then used to determine which remnants are in need of formal protection. As a technical note, grassland remnants in particular are difficult to classify accurately, as persistent native plant cover may be low given the invasion of European Mediterranean annual grasses. **[Identified automatically and quantified]**

b Protect largest, least-isolated existing habitat patches first. [EDGE_EXISITING_UNPROTECTED_PRIOITY_LARGE].

Scientific Rationale

Large patches are more likely than small patches to support high levels of species diversity and support the physical and biological processes needed to sustain desired ecosystem functions over time (Rosenzweig 1995, Peterson et al. 1998). Large patches are also likely the most resilient to future disturbances, including climate change, since they have more contiguous space available for the movement of populations and communities. Fifty hectares could be used as a threshold for identifying a minimum size for a “large” terrestrial patch, given its threshold support for biodiversity for terrestrial habitat (Helzer and Jelinski 1999).

Identifying and protecting less isolated patches can assist population resilience by improving metapopulation health, where patches close to others can harbor source populations for emigration, and immigration to new sites in part as a function of distance. Isolation also matters in terms of daily or seasonal movement, as terrestrial species have various thresholds of crossing distance between patches. Protecting patches that are close together, and especially those with proximity to large patches, should benefit biodiversity.

Technical Methods

The largest areas of high-quality habitat can be identified from basic acreage tabulations from the unprotected modern habitat layer. Identifying areas that are less isolated was done informally, though it could be automated using the near tool or similar proximity analysis in GIS. Large patches over 50 ha were selected and identified in a separate layer. **[Identified automatically and quantified]**

c Protect existing rare habitat types on landscape. [EDGE_EXISITING_UNPROTECTED_PRIORITY_RARE].

Scientific Rationale

There are several habitat types historically present in the Delta that now exist in in very small acreages. Interior dune, alkali seasonal wetlands, oak woodlands and willow thickets all have suffered net areal losses of more than 95 percent (SFEI-ASC 2014). Considering such steep declines, these habitat types should be a priority for protection.

Technical Methods

Rare habitats were identified using simple selection of the above-described habitat types from the unprotected modern habitat type layer. **[Identified automatically and quantified]**

d Protect existing habitat within current tidal-terrestrial transition zone. [EDGE_EXISITING_UNPROTECTED_PRIOITY_TZONE].

Scientific Rationale

The tidal-terrestrial transition zone supports valuable environmental gradients, high biodiversity and other ecological benefits, such as capacity for marsh migration with SLR (SFEI-ASC 2016). Understanding where existing marshes and terrestrial habitat are located in relation to each other is key to developing adequate protection and support for these functions. An upland buffer of 290 m from intertidal elevation is predicted to provide a suite of ecological functions (Semlitsch and Bodie 2003). This functional width likely would provide a variety of benefits, including a sufficient distance for movement and resources for herpetofauna and some small mammals (see A Delta Renewed).

Technical Methods

Areas that can contribute to the t-zone are identified by intersecting a layer of existing modern edge habitats with the polygon of the current intertidal elevation buffered by 290 m (explained above) to determine what lands can serve as current or future tidal-terrestrial transition zone. **[Identified automatically and quantified]**

2. Identify opportunities for restoration of "new" areas of terrestrial habitat types. [EDGE_OPPORTUNITY].

Scientific Rationale

In addition to protecting existing habitats, consideration should be given to restoration potential of lands converted to human land uses from historical habitat types. Potential for edge opportunities are based on historical ecological evidence, but consideration of contemporary variables, such as groundwater and soil conditions, is also important.

Technical Methods

The total opportunity area for protection and restoration was identified by taking the "edge" area described in the intro to Section IV, intersecting it with the modern habitats layer from A Delta Transformed (SFEI-ASC 2014) and dissolving adjacent parcels. The remaining landscape block(s) represents the contiguous areas that can be further analyzed for regional opportunities for specific conservation priorities. **[Identified automatically and quantified]**

Specific priorities include:

a Identify opportunities for restoring habitat connectivity. [EDGE_OPPORTUNITY_CONNECT].

Scientific Rationale

Supporting connectivity is a fundamental goal of conservation efforts, to allow for movement and dispersal between geographic areas for species, and to link and sustain physical processes across gradients and landscapes that support various habitat types and biodiversity generally. Connectivity can be both defined in a variety of ways, as expressed below in the following components.

Technical Methods

Connectivity can be measured in a number of different ways, dependent on the definition. Connectivity here is defined mostly in terms of structural connectivity and thus is measured close proximity of habitats, or based on California Department of Fish and Wildlife (CDFW) landscape connectivity analyses (see below). However, more detailed assessments of opportunity types were not given here due to some constraints explained in later text various sections.

Areas to prioritize include:

i. ***Those that increase intra- and inter-habitat connectivity among existing modern habitats and protected areas. [EDGE_OPPORTUNITY_PROTECT].***

Scientific Rationale

Connecting existing habitats can provide key corridors to movement and exchange of resources between patches, as well as supporting biodiversity generally by expanding cumulative patch size in of itself.

Prioritizing connections among and to protected habitats is of obvious additional importance, as restoration and habitat quality improvements are often most accessible and feasible on these lands.

Terrestrial habitat types are inherently a mosaic and depend on management and many environmental gradients. As these gradients will change with changing climate and management, promoting within-habitat connectivity is a valuable goal, particularly for species that depend on rare, fragmented habitat types such as interior dunes or vernal pools. Increasing habitat connectivity between different habitat types is important for species that might rely on resources specific to multiple different habitat types or vegetation communities.

These areas were identified manually, though software programs or more sophisticated tools such as Linkage Mapper could identify connectivity opportunities in a more thorough and finer-grained way in future analyses.

Technical Methods

These areas were identified manually, by observing areas with protected or existing habitat in close proximity. More sophisticated technical tools such as Linkage Mapper could identify connectivity opportunities in a more thorough and finer-grained way in future analyses [Identified manually].

ii. ***Those that contribute to tidal-terrestrial transition zones and facilitate marsh migration [EDGE_OPPORTUNITY_CONNECT_TZONE].***

Scientific Rationale

This category is highlighted to explicitly call out acquiring lands to preserve for future t-zone habitat— lands between both existing terrestrial habitats and protected areas and future projected marshes, rather than just protecting existing transition zone habitat. See also Section IV, 2a under edge wildlife and Section I, 2f under native fish and marsh wildlife.

For edge habitat species, this tidal-terrestrial transition zone should extend a significant distance upslope of the marsh. This specific distance may depend on desired ecological functions, but 1,000 m was used to identify of terrestrial habitat beyond marshes provides a threshold that encompasses many ecological functions, inclusive of distance within which the amount of emergent wetland most strongly influences heron and egret colony site selection, but also encompassing the smaller threshold distances that provide ecological functions including the terrestrial buffer preserved upslope of wetlands to maintain terrestrial resources for herpetofauna (290 m), the distance California voles move into terrestrial habitats from marshes during the wet season (100 m), the preferred distance between Tree swallow nesting sites and foraging sites in the marsh (100 m), and the distance that California ground squirrels leave terrestrial habitats into marshes to forage (20 m) (SFEI-ASC 2016).

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. [Not identified]

iii. Those that enhance connectivity to areas outside of the Delta, e.g., to Suisun Marsh, Coast Range, Foothills. [EDGE_OPPORTUNITY_CONNECT_REGIONAL].

Scientific Rationale

Large-scale connectivity is important for movement of large mammals such as bobcats, whose home ranges average around 2,638 ha (Zezulak and Schwab 1979 in CWHR), and connections of populations, as well as exchange of materials and resources on the scale of the watershed or larger. These connections are also expected to facilitate the movement of plants and animals both towards and away from the Delta over multiple time-scales (from seasonal to decadal).

Technical Methods

Areas where habitat restoration might improve regional connectivity from a conservation biology perspective are identified using CDFW's essential connectivity (ECA) layer (from Spencer et al. 2010), which identifies areas of important connections throughout the state. Intersecting polygons of the CDFW layer with the undeveloped, unprotected terrestrial edge layer yields suggested areas of protection/restoration that match with broader aims of connectivity. Also, areas of regional connectivity may also be identified by general landscape observation of the relationship between the Delta periphery and surrounding large landscape habitat blocks. **[Identified automatically and quantified]**

iv. Those that enhance connectivity within, to and among natural landscape blocks from existing habitat and protected areas. [EDGE_OPPORTUNITY_CONNECT_BLOCKS].

Scientific Rationale

Connectivity to and among large scale landscape blocks is important for the same reasons described in Section IV, 2a-iii.

Technical Methods

Areas for connectivity within, to and among blocks can be identified in two ways:

1) Areas of large natural landscape blocks sourced from CDFW's Essential Connectivity project (Spencer et al. 2010) can be intersected with the footprint of undeveloped, unprotected areas, to highlight all of the areas that currently represent contiguous landscape blocks but are not protected, and could potentially benefit from restoration.

2) As an additional, finer-scale form of analysis, these blocks could be buffered based on the average distance separating nests of a focal terrestrial species, such as Swainson's hawk, 1,450 m based on averages reported in Dunkle 1977 and Bloom 1980 in CDFW's California Wildlife Habitat Relationships (CHWR). All areas that intersect the undeveloped, unprotected footprint, then, are areas that could be restored and improved to link closely to these large landscape blocks.

CDFW's ECA layer set is comprised in part of existing natural landscape blocks, which is based on an Ecological Condition Index (Davis et al. 2003, 2006 and Spencer et al. 2010), using inputs of degree of land conversion, residential housing, roads, forest structure, degree of conservation protection, mapped critical habitat and endemism hotspots. [Not identified]

b Restoring rare or lost habitat types [EDGE_OPPORTUNITY_RARE].

Scientific Rationale

There are several habitat types historically present in the Delta that now exist in in very small acreages. Interior dune, alkali seasonal wetlands, oak woodlands and willow thickets all have suffered net areal losses of more than 95 percent (SFEI-ASC 2014). Considering these steep declines, these habitat types should be a priority for restoration. Historical land cover type is a helpful consideration for where restoration of these rare habitat types might be possible; however, groundwater depletion, surface hydrological modification, agricultural practices and other management choices may have altered precise opportunities for recreation of some of these habitat types.

Technical Methods

These opportunities were mapped simply by selecting the modern habitat types layer and intersecting it with the edge opportunity layer described in the introduction of Section IV, 2. **[Identified automatically and quantified]**

c Restoring undeveloped areas, particularly areas large enough to support desired ecosystem functions (derived from Delta Renewed guidelines). [EDGE_OPPORTUNITY_LARGE_METRICS].

Scientific Rationale

As discussed above, the footprint we developed for terrestrial restoration corresponds to lands higher than 3.78 m NAVD88 (an approximate current MHHW elevation plus 1.8 m [6 ft] SLR), minus portions that are currently urbanized. Thus, these areas are those that are potentially appropriate for long-term terrestrial habitat restoration with projected future climatic and SLR changes.

However, more specific consideration of species requirements and other ecological thresholds related to habitat patch size can help further prioritize areas for restoration. The Delta Renewed report provides landscape configuration guidelines for certain terrestrial edge habitat types, including grasslands, vernal pools and wet meadow/seasonal wetland. For instance: 129 ha represents the minimum recommended giant garter snake patch size for wet meadow/seasonal wetlands, 336 ha for a minimum Swainson's hawk home-range size in grasslands, and 1,375 ha for a breeding population of tiger salamanders for vernal pools.

Further literature review gives a few suggested benefits for other habitat types, such as 5.2 ha as a potential home range size for kit foxes, representing use of habitat types such as alkali seasonal wetland complexes (Koopman et al. 2000); 2 ha representing habitat benefits for butterfly species associated with small patches, representing stabilized interior dune habitat (Longcore and Osborne 2015), and 2,638 ha for home range size of bobcats, representing use of habitat types such as oak woodland (Zezulak and Schwab 1979 in CWHR).

This is not to say that ecological benefits will not be provided in smaller areas -- ecological functions can be provided even in small patches surrounded by agricultural land use (e.g., Tscharntke et al. 2002). Further, these exact home ranges are not perfect estimates, as they are approximations or averages from the literature, and actual use of the landscape, even among restored patches, will of course depend on local resource availability, existing population distributions, barriers to movement in the landscape, and other similar factors. Also, the mosaic of habitat types should be acknowledged; many species utilize multiple habitat types within their home ranges and thus it is difficult to establish precisely the appropriate acreages per species per habitat type.

Nonetheless, the metrics suggested above provide rough outlines of potential benefits provided for various restoration targets. These metrics help establish potential approximate floors for consideration of a suite of ecological functions that benefit a variety of taxa.

For rare habitats (terrestrial habitats with greater than 95 percent loss) with relatively small historical distribution in total (i.e., stabilized interior dune, alkali seasonal wetland complex and willow thickets), it is recommended that restoration target acreages and distribution targets match general historical conditions. The acreage of interior dune scrub and alkali seasonal wetland complex were small enough in extent historically that exact thresholds for restoration may not be necessary—all potentially suitable areas should probably be considered for restoration.

For habitats with larger historical distribution (i.e., wet meadow/seasonal wetland, oak woodland and grassland), it is recommended that the targets listed above are referenced to set objectives for habitat restoration and/or land acquisition.

Oak woodland in particular is nearly entirely gone from the Delta periphery. However, large swaths of undeveloped land exist in the eastern Delta north of Stockton where much of oak woodlands were historically located. Opportunities for agroforestry or integration with rangelands could also exist in this area (see Habitat and Connectivity for Edge Wildlife section for more on this topic). Consideration should also be given to the connectivity and feasibility, as discussed previously.

Technical Methods

These opportunities described above were identified using simple acreage tabulations from the historical ecology map layers from A Delta Transformed (SFEI-ASC 2014) overlaid with the undeveloped, above-SLR projection opportunity layer. The intersection of the “opportunity layer” described in the beginning of the edge section and the historical ecology layer yields at a coarse scale opportunities for restoration. Applying the ecological metrics listed above, this intersected layer was then subsetted by selecting contiguous areas of the given patch size thresholds. This produced a set of data layers demonstrating areas where restoration to match historical habitat types is still possible, and where these opportunities are contiguous and sizeable enough to potentially support ecological functions of interest. For instance, these analyses showed where areas in which large enough vernal pools could be restored in the historical footprint to support a breeding population of tiger salamanders. **[Identified automatically and quantified]**

d Integrate ecological processes with human land uses by: [EDGE_HUMANLU].

Scientific Rationale

Urban land and agricultural cover now take up roughly four-fifths of the contemporary legal Delta, representing the largest land use cover types by acreage. These human-dominated land uses provide opportunities to integrate support for ecological functions into the landscape. Restoring terrestrial corridors in urban and agricultural areas, such as greenways and the upland portions of riparian areas, can provide ecological connectivity for terrestrial species. Restoring edge habitats in urban areas can be targeted in urban open spaces, such as public parks. Recovering some functions of oak woodlands, grasslands and willow thickets can be achieved through street tree and green infrastructure programs. Further, integrating and expanding wildlife-friendly agricultural practices can provide a variety of benefits for fauna in a somewhat hostile matrix environment.

Technical Methods

Due to time constraints, a detailed assessment of these opportunity types has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

Adaptation Potential

Scientific Rationale

SFEI-ASC (2014) defines “wildlife adaptation potential” as the potential ability of native plant and animal populations to adapt to changing conditions. Wildlife adaptation potential encompasses adjusting to new or increased disturbances and stressors, utilizing newly available resources, and moving as the locations of suitable conditions shift. Wildlife adaptation potential is particularly important in the face of climate change, SLR, and changing water management in the Delta. Species distributions, habitat associations, and life-history strategies are likely to change over time in ways that are difficult to predict.

Promoting wildlife adaptation potential at the landscape scale can help to manage for an uncertain future. Adaptation potential is supported by large wildlife populations with high genetic and phenotypic diversity, which in turn generally require extensive, heterogeneous habitats. The ability of species to move along physical gradients (in elevation, salinity, and other parameters) as conditions change requires habitat connectivity.

An important next step in this analysis is to identify areas of potential climate refugia within the Delta. The Delta in general is of particular conservation importance regionally, as due its lower elevation and closer proximity to the coast and potential future greater cooling breezes, temperatures are likely to rise less quickly than other parts of the Central Valley. In this way, the Delta may serve as an area of temperature refuge for many species (Cal-Adapt 2017, Council 2018). Factors that may aid in identifying climate refugia potentially include areas of environmental stability, microclimate heterogeneity, large size, connectivity/accessibility (Keppler 2015). Some more particular examples of such types of places include areas with canopy cover that can buffer local temperature maximums and areas near or in large deep lakes have a high heat capacity and will likely warm more slowly. Areas with inputs to groundwater recharge are also of high importance, as they provide lower stream temperature somewhat independently of air temperature. Valleys may harbor cool air pockets and inversions, unlinked to regional circulation processes, while terrain with significant variability in topography can provide many different microclimates, some that are expected to experience slower rates of change in key environmental variables with climate change (e.g., Morelli et al. 2016).

Considering these thoughts, riparian restoration may be a priority given its high adaptation potential and strong natural resilience (Seavy et al. 2009). Also highlighted is the importance of considering and prioritizing management of flood basins and historical lakes. Finally, locating areas of groundwater recharge potential can provide multiple functions including refugia. Areas with high topographic variability, can be formed to some degree by vernal pool habitat restoration (see Section IV, 1c and 2b). South-facing slopes and valleys can be found more in terrestrial habitat types, such as the relatively unprotected rangelands at the edge of the east Delta.

More analysis needs to be done to more comprehensively identify these opportunities, with a basis for improving the other ecological functions discussed here. Sections I-IV can be used for the focal taxa groups to formulate and evaluate planning for climate adaptation and refugia planning. Example frameworks for how to conceptualize and manage climate refugia can be found in such papers as Keppler et al. 2015 and Morelli et al. 2016.

Technical Methods

While adaptation potential was not specifically analyzed for this effort, this effort did identify opportunities to support large and connected habitat types for tidal marsh, riparian, and terrestrial habitats. Analysis for adaptation potential might consider how opportunities span across specific environmental gradients including salinity and microclimate. Protecting species at the edge of their range may be important for maintaining species across environmental gradients. For Delta species where distinct populations have been identified (e.g. Chinook salmon, giant garter snake) opportunities should be across areas that support these different populations.

Analyses for determining climate refugia are addressed to some degree in other sections but were not evaluated comprehensively at this time due to time constraints. **[Not identified]**

Productivity

Scientific Rationale

Primary production, the supply of food, energy, and biochemicals provided by plants and algae, helps to set the capacity of ecosystems to support wildlife populations. One key goal of wetland restoration in the Delta is to increase primary production in the Delta to provide additional food resources for native fish. A study currently in progress is using data from the Delta Landscapes Project to estimate how landscape change has altered primary production (Cloern et al. 2016). Insights from that project may be useful for better understanding the effects of wetland size and configuration on the magnitude of primary production.

Technical Methods

While we did not analyze opportunities to increase primary production in this effort, some of the opportunities highlighted to support other ecological functions would increase the amount of primary production or its export from wetland to open water habitat (e.g., large marsh areas, channel reconfiguration). Primary production in the Delta is influenced by the hydrodynamics of the Delta as well as wetland extent and configuration. In, addition, identifying beneficial actions to support primary production is complicated by invasive species (aquatic plants and clams) that affect whether increases in primary production will benefit target native species. **[Not identified]**

Biodiversity

Scientific Rationale

A Delta Renewed (SFEI-ASC 2016) recommends a systematic conservation planning approach for biodiversity which considers: communities and ecosystems, abiotic and physical features, and key species likely to be missed by the first two categories. In the steps above, in our approach for life-history support functions, we address communities and ecosystems, and physical features. Here we address the final category: key species likely to be missed by the first two categories. These include imperiled, threatened, or endangered species; endemic species; focal species that are area-limited, dispersal-limited, resource limited, or limited by ecological process (e.g., natural flow regime); and keystone species. These analyses generally consider existing species distributions based on direct observations or modelling, though in some cases, they also consider support for potential habitat.

1. Identify areas that are critical to species covered in the Bay Delta Conservation Plan (ICF International 2013).

Technical Methods

We considered species covered in the Bay Delta Conservation Plan (BDCP) and used maps in the species accounts from Appendix 2A of BDCP to make sure areas critical to key species are being covered. For species found in only a limited portion of the Delta these areas are identified. As part of the BDCP appendix, these maps were not georeferenced and thus not available in the GIS layers package. **[Identified manually]**

a Identify areas of modeled vernal pool habitat, or degraded vernal pool habitat [BIODIVERSITY_VERNAL_POOL].

Scientific Rationale

Vernal pool associated "covered species" that could be supported in these areas include Legenere, Heckard's peppergrass, dwarf downingia, Boggs Lake hedge-hyssop, alkali milk-vetch, vernal pool tadpole shrimp, vernal pool fairy shrimp, mid-valley fairy shrimp, longhorn fairy shrimp, Conservancy fairy shrimp, California linderiella, and California tiger salamander.

b Identify areas in the west Delta that could support species not found in other parts of the Delta. [BIODIVERSITY_WEST_DELTA].

Scientific Rationale

The range of several species found in the lower estuary extend into the westernmost part of the Delta. These species include soft bird's beak, Suisun song sparrow, California least tern, and salt marsh harvest mouse. In addition to increasing biodiversity within the Delta, preserving these areas may also support the adaptation potential of these species by maintaining habitat at the edge of their ranges, and supporting their distribution across important environmental gradients (e.g., salinity, temperature).

c Identify areas of the south Delta that support unique riparian species. [BIODIVERSITY_SOUTH_RIPARIAN].

Scientific Rationale

Species supported in this area include slough thistle, Delta button celery, riparian woodrat, riparian brush rabbit.

d Identify areas of the northwest Delta periphery that support covered species. [BIODIVERSITY_SOUTHWEST_TERRESTRIAL].

Scientific Rationale

Species supported in this area include red-legged frog, San Joaquin kit fox, also: heartscale, brittlescale. Note that there's overlap with potential vernal pool areas.

e Identify areas important for covered species with limited ranges within the Delta that are not already covered by the steps above. [BIODIVERSITY_SKULLCAP], [BIODIVERSITY_LEAST_BELLS_VIREO], [BIODIVERSITY_CARQUINEZ_GOLDENBUSH].

Scientific Rationale

Covered species with limited ranges in the Delta that are not already covered by the steps above include: side flowering skullcap, Least Bell's vireo and Carquinez goldenbush.

f Identify other patterns in supporting covered species in the Delta [BIODIVERSITY_CENTRAL_MARSH].

Scientific Rationale

Several covered species had fairly broad distributions within the Delta that somewhat align with Central Delta Public Lands corridor: Suisun marsh aster, Delta tule pea, Delta mudwort, Mason's lilaeopsis, western pond turtle, Yellow-breasted chat, Black rail.

2. Identify opportunities for very large areas of continuous habitat to support wide-ranging endemic and generalist species, including habitat diversity at a large scale. Restoration and protection of large natural areas should be coordinated in Sections I-VII to provide contiguous, large scale blocs of diverse habitat that provide support for and integrate across ecological functions.

Scientific Rationale

Very large areas could support wide ranging species that use multiple habitat types, including tule elk (Cobb 2010). These areas would provide additional benefits to wildlife at the population and community level, as larger areas are associated with larger population sizes and more complex community structure, supporting increased biodiversity relative to smaller areas (Rosenzweig 1995, Peterson et al. 1998). Habitat heterogeneity, in combination with large areas, can also help support biodiversity (Carpenter and Brock 2004, Standish et al. 2014). In the Delta, this would mean coordinating large contiguous restoration and protection of habitats across gradients, from wetland to terrestrial, lowland to upland, upstream to downstream, that can provide the greatest gradients of physical processes and thus support for diversity of habitat types, communities, and ultimately species. Other recommendations in this document relate to this goal, such as prioritizing areas in the tidal-fluvial zone, areas where marsh is adjacent to riparian, areas where marsh is adjacent to undeveloped lands that could support tidal-terrestrial transition zone and marsh migration space, and protecting and restoring areas near existing habitats.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 1 – Opportunities Table

Delta Plan Amendments

May 2020

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Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region

Region#[1]	Name[2]	Opportunity Types (codes)[3]	Description[4]	Ecological Restoration[5]	Ecological Restoration Notes[5]
Central Delta					
1	Central Delta	[MARSH_REMNANTS] [BIODIVERSITY_CENTRAL_MARSH]	**Protect and enhance existing remnant marshes** ↳ examples labeled with 1A	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [BIODIVERSITY_CENTRAL_MARSH]	**Restore marshes in subsided areas** ↳ minimally subsided areas at least 100 ha in size include parts of eastern Liberty Island and parts of western Twitchell Island ↳ minimally subsided areas at least 500 ha in size include Sherman Lake and Frank's Tract	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[SALMON_REARING_NETWORK] [BIODIVERSITY_CENTRAL_MARSH] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore a network of large (>500 ha), well-distributed, and hydrologically connected wetlands capable of supporting juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites include Sherman Marsh ↳ planned sites include Sherman Island [1D], Twitchell Island [1C], and Frank's Tract [1H] ↳ a strategically located site would still be needed in the general vicinity of the Mokelumne-Georgiana confluence (e.g., South end of Staten Island [1B]), which is also located within a tidal-fluvial transition zone	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
			Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations ↳ at least 4 additional sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, additional sites may not be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects, but potentially include Bouldin Island [1F] and Staten Island [1E] (Staten Island is also located along a tidal-fluvial transition zone)	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
			Between these large nodes consider channel margin improvements to increase the length of vegetated edges (may not require full setbacks) ↳ Channel margin habitat type enhancements between Franks Tract and MWT/Staten Island. ↳ Restore tidal habitats along Seven Mile Slough [1G]	No	Levee modification projects to create channel margin habitat type have reduced ecological integrity and long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
1 (contd.)	Central Delta (contd.)	[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ e.g., at Fisherman's Cut [1J] and at Frank's Tract in combination with marsh restoration (to create tidal flows primarily in and out of False River with limited flow through Frank's Tract to Old River) [1I]	No	Reliance on water control diminishes long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting of hedgerows)	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
27	East Delta	[MARSH_REMNANTS]	**Protect and enhance existing remnant marshes** ↳ examples labeled with [27A]	Yes	
		"[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_TRANGRESSION_SPACE]	**Restore marshes on lands at intertidal elevation** ↳ the area at intertidal elevation in this region is large enough to support a dendritic channel network (>500 ha), is adjacent to remnant blind channel networks, and has extensive undeveloped migration space.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ opportunity to restore a large (>500 ha) marsh in existing minimally subsided area ↳ restoring subsided areas at Brack, Terminous, Rio Blanco, Bishop, Shim, and Wright-Elmwood Tracts could improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development (building off of remnant blind channels)	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the surrounding network of marshes by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 4 sites would be needed in this region to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Explore potential benefits of channel barriers to re-establish blind channel geometry and hydrodynamics** ↳ e.g., isolating cuts between White Slough and Disappointment Slough **[27D]** and cut between Disappointment Slough and Fourteenmile Slough **[27E]**	No	Reliance on water control diminishes long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
27 (contd.)	East Delta	[EDGE_EXISTING_UNPROTECTED] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS]	**Enhance and expand appropriate terrestrial habitat types (primarily seasonal wetlands and oak woodlands) at upper edge of tidal zone, especially ones with direct connections to restored tidal marshes** ↳ protect any existing terrestrial habitats without protections in place, e.g., along and north of White Slough. ↳ seasonal wetland restoration, particularly in former alkali wetland areas located above the SLR zone with remnant alkali soil types (e.g., near W. Peltier Road east of I5 [27B], near Thornton Road north of Stockton [27C]) ↳ Opportunities for large patches of oak woodland restoration on eastern side.	Yes	
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
19	West Delta	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 19Q	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE]	**Restore marshes on lands at intertidal elevation** ↳ at least 3 sites could support marsh patches larger than 100 ha in size and also feature undeveloped migration space. These include Byron Tract [19J & 19K], eastern Veale Tract [19D], and Eastern Hotchkiss Tract [19C]. Some of these sites are adjacent to remant blind channel networks. All are contiguous with undeveloped migration space. Byron Tract [19J & 19K] is contiguous with existing terrestrial habitat types to form tidal-terrestrial transition zones.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ minimally subsided areas in this region such as north-eastern Hotchkiss Tract [19E], western Veale Tract [19F], Holland Tract [19G], Quimby Island [19H], and Byron Tract [19L] could support marsh patches larger than 500 ha ↳ reverse subsidence in these areas would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development ↳ priority sites include areas around remnant stabilized interior dunes to restore associated marsh-terrestrial transition zones (see below)	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Protect, prepare, and, restore SLR accommodation space and tidal-terrestrial transition zones of current and planned marshes** ↳ e.g., areas without urban development above Big Break [19A] and above Dutch Slough [19B]	Yes	
			Restore connections between tributaries and wetlands ↳ potential for spring-fed creeks to deliver sediment to marshes, increase local turbidity, and potentially increase cool-water conditions within wetland complexes; also potential to restore associated seasonal wetlands and woody riparian vegetation ↳ e.g., Marsh Creek [19M], Brushy Creek [19N], Frisk Creek [19O], Kellogg Creek [19P]	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
19 (contd.)	West Delta (contd.)	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 4 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible less than 4 additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [19S]	No	Reliance on water control diminishes long-term sustainability.
		[BIODIVERSITY_VERNAL_POOL] [BIODIVERSITY_SOUTHWEST_TERRESTRIAL] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_EXISTING_UNPROTECTED_PRIORITY_RARE] [EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_CONNECT_TZONE] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_REGIONAL] [HUMAN_LU]	**Protect and restore terrestrial habitat types** ↳ protect persistent alkali seasonal wetland complexes at Byron and Veale Tracts. ↳ protect wet meadows, large patches of grasslands, and nontidal marshes not currently protected at Bryon and Veale Tracts, including those to connect to larger protected areas, e.g., near Marsh Creek. ↳ protect and restore modeled vernal pool habitat type near [19P], an opportunity expected to support many sensitive species. ↳ perform active restoration to increase extent of and connectivity among terrestrial habitat types. ↳ protect and connect habitat along Antioch urban fringe (waterfront by Carquinez Strait), including rare unprotected dune habitat type and other terrestrial habitat types for multi-benefit urban greening (particularly for t-zone adaptation) e.g., near Lake Alhambra and [19R]. ↳ opportunities to acquire and restore large terrestrial mosaic of habitat types, in part for t-zone connectivity, particularly with large patches of dunes and oak woodlands. ↳ acquire and restore terrestrial habitats types to connect to large landscape blocks (ex. Diablo foothills, Vasco Caves, toward Altamont) from Clifton Court Forebay and Southwest of Old River.	Yes	
		[EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT]	**Restore stabilized interior dune habitat type at remnant sites** ↳ e.g., at eastern Jersey Island [19I], at Dutch Slough [19B], at western Veale Tract [19F] ↳ couple with marsh restoration to create marsh-terrestrial transition zone	Yes (but see note)	Some uncertainty about processes needed to sustain habitat types over long term. Potential for reduced ecological integrity and long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
31	Southern Central Delta	[MARSH_REMNANTS]	**Protect and enhance existing remnant marshes** ↳ examples labeled with 31A	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
31 (contd.)	Southern Central Delta (contd.)	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ strategically located sites would still be needed along Old River and Middle River (e.g., general location of Bacon Island [31B]), along the San Joaquin River, (e.g., general location of Lower Roberts Island [31D]), and near the distributaries' confluence (e.g., general location of Medford Island [31C])	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 7 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 3 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [31E]	No	Reliance on water control diminishes long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
16	Cache-Sherman Corridor	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 16A	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN]	**Restore marshes in subsided areas** ↳ minimally subsided areas at the northwest end of Brannan Island **[16B]** could support a marsh patch >100 ha and is also adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
16 (contd.)	Cache-Sherman Corridor (contd.)	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region, though these are both accounted for in adjacent regions (see Cache Slough Complex and Central Delta Corridor) ↳ sites here should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation in large parts of this region ↳ in the interim period these areas could still provide nontidal marshes for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites include Sherman Marsh [see 1D] ↳ a strategically located site is still needed in the vicinity of Little Egbert Tract [see 12E]	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 2 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 0-1 additional site would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects, but potentially include Brannan Island [16D], the North side of Sherman Island [16C], or Tomato Slough	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Increase the extent and connectivity of woody riparian vegetation** ↳ opportunities exist in this area to restore hydrologically connected, woody riparian habitats on natural levees	Yes	
		[EDGE_EXISTING_UNPROTECTED_PRIORITY_RARE] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_OPPORTUNITY_REGIONAL]	**Protect and restore edge habitat type fragments off Sacramento mainstem [16E]** ↳ particularly rare alkali seasonal wetland complex fragments, persistent freshwater emergent wetlands and future t-zone habitat fragments ↳ support conservation efforts between Grizzly Island and Sherman Island as part of the local CDFW Essential Connectivity Area [16F]	Yes	
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
30	Sacramento	[EDGE_HUMANLU]	**Urban greening in Sacramento** ↳ in urban settings, aim to promote multi-benefit urban greening, which may involve: 1) restored riparian areas along urban stream corridors for habitat and flood control; 2) restored oak woodland, grassland and willow thickets in public open spaces; 3) green infrastructure using native plants, and oak and riparian tree incorporation into native street tree programs. ↳ protect, restore and connect fragmented terrestrial habitat along Morrison Creek.	No	Urban greening projects generally have reduced ecological integrity and long-term sustainability.
18	Upper Sacramento River	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN	**Restore marshes on lands at intertidal elevation** ↳ one area at intertidal elevation [18D] is >100 ha in size, has undeveloped migration space, and is adjacent to potential woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
18 (contd.)	Upper Sacramento River (contd.)	[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Restore significant nodes of woody riparian vegetation in "nodes" along the mainstem north of Clarksburg** ↳ target should be riparian vegetation >200 m wide ↳ opportunities to improve woody riparian vegetation at riverside parks ↳ opportunity for more substantial, continuous and wide woody riparian vegetation along Sacramento River between confluences with Shipping Channel and Babel Slough (including Southport Setback Levee Project [18A]) and in vicinity of Sacramento Airport [18B]	Yes	
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region along the Sacramento River ↳ in this region these sites should be seasonal floodplains	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 2 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, additional sites may not be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
18 (contd.)	Upper Sacramento River (contd.)	[EDGE_EXISTING_UNPROTECTED_PRIOITY_REMNANT] [EDGE_OPPORTUNITY]	**Protect and restore key terrestrial habitat types** ↳ fill gaps in terrestrial connectivity adjacent to Yolo Bypass Essential Connectivity Area. ↳ protect small but persistent wet meadow fragments and large contiguous terrestrial habitat patches near the Yolo/Sacramento county borders	Yes	
			Improve fish passage along river ↳ implement project to allow adult salmonids (and sturgeon) from the Sacramento Deep Water Ship Channel (SDWSC) to pass the channel gates [18C] and enter the Sacramento River	No	Reliance on water control and fish passage structures diminishes long-term sustainability.
7	Sacramento Basin	[MARSH_REMNANTS]	**Protect and enhance existing remnant marshes** ↳ examples labeled with [7F]	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ one significant area at intertidal elevation along Snodgrass Slough between MWT and Stone Lakes [7D] is large enough to support a dendritic channel network (>500 ha), is adjacent to a remnant blind channel network, and has undeveloped migration space. ↳ tidal marsh in this area would also enhance connectivity between MWT and Stone Lakes for terrestrial wildlife by minimizing the distance between marshes at these sites ↳ at least 4 sites (all labeled [7G]) could support marsh patches larger than 100 ha in size and also feature undeveloped migration space. Some of these are also adjacent to potential woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
North Delta					
7 (contd.)	Sacramento Basin (contd.)	[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN]	**Restore marshes in subsided areas** ↳ the Pearson District features a large (>500 ha) minimally subsided area around the former site of Secret Lake [7C] that is also adjacent to potential woody riparian vegetation ↳ a >100 ha minimally subsided area is located at [7H]	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the surrounding network of marshes by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 1 site would be needed in this region to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [7I]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [TOPOGRAPHIC_LOWS_LONG_TERM_INUNDATION]	**Re-establish aspects of flood-basin inundation regime and habitat type features** ↳ one or more water control structure to allow Sacramento River high flows to activate floodplain e.g., [7A] ↳ re-establish woody riparian vegetation on remnant natural levee topography [7B] ↳ re-establish nontidal wetlands at topographic lows from remnant lake topography [7C] ↳ since these actions would divert fish from Sacramento River to the interior Delta, they may be contingent on improving conditions in the interior Delta. Until survival though the interior Delta is at acceptable levels, it might be beneficial to control access from the river to the interior Delta (e.g., through a nonphysical barrier at the head of Georgiana Slough [2T])	No	Reliance on a water control structure diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
7 (contd.)	Sacramento Basin (contd.)	[BIODIVERSITY_VERNAL_POOL] [EDGE_EXISTING_UNPROTECTED_PRIOITY_REMNANT] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_PROTECT]	**Protect and restore key terrestrial habitat types** ↳ protect existing rare unprotected vernal pool wetland complexes, persistent grasslands and surrounding grassland habitat types near Stone Lakes for broader landscape connections (ex. [7E]). ↳ protect and restore unprotected lands as part of the Stone Lakes ECA and between protected areas for broad scale connectivity. ↳ protect unprotected habitat types along and near Morrison Creek to connect patches of larger protected areas. ↳ opportunities exist in the eastern portion of this planning unit to support large patches of seasonal wet meadows and grasslands.	Yes	
2	Cosumnes-Mokelumne	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN] [BIODIVERSITY_SKULLCAP]	**Restore marshes on lands at intertidal elevation** ↳ areas that are large enough to potentially support a dendritic channel network (>500 ha) include McCormack-Williamson Tract [2E] and the tract to the southeast [2S]. ↳ both sites are adjacent to natural levee topography that could potentially provide transitions to woody riparian vegetation. ↳ MWT is also adjacent to a remnant blind channel network and, if restored, would enhance connectivity between existing small marsh patches at at Delta Meadows [2G] and MWT's east end [2H]. ↳ the land at intertidal elevation at [2S] is contiguous with undeveloped upland areas. ↳ Delta Meadows and surrounding area supports side-flowering skullcap and mash skullcap [2G]	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore marshes in subsided areas** ↳ large minimally subsided areas include the land along Georgiana Slough [2A & 2B], North Mokelumne River [2B & 2C], and South Mokelumne River [2C & 2D] ↳ all of these areas are adjacent to potential woody riparian vegetation and located along tidal-fluvial transition zones ↳ restoring the minimally subsided area east of South Mokelumne River [2D] could improve site hydrology and the potential for coherent dendritic tidal channel network development ↳ restoring the minimally subsided area at the base of MWT [2F] could also improve improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development on the tract	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**Restore a network of large (>500 ha), well-distributed, and hydrologically connected wetlands capable of supporting juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks or seasonal floodplains ↳ substantial reverse subsidence efforts would be required to bring land surfaces up to intertidal elevation in portions of the region ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites include the Cosumnes Preserve ↳ planned sites include the McCormack-Williamson Tract [2E] ↳ a strategically located site would still be needed along the Mokelumne River (e.g., in the vicinity of Thornton [2O])	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
2 (contd.)	Cosumnes-Mokelumne (contd.)	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 additional site would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
			Prepare existing public lands and acquire other lands along Mokelumne-Cosumnes courses to create a continuous corridor for tidal marsh migration through SLR zone ↳ remove lateral and longitudinal barriers to tidal flows ↳ e.g., elevate I5 [2J], alter or remove levees to restore hydrological connectivity at Grizzly Island [2N]	Yes	
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [2U]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Remove levee along Mokelumne to restore wide corridor of woody riparian along south edge of tract [2I]** ↳ remnant natural levee topography could be reoccupied to support a woody riparian corridor that is >100 m wide and >5 km long	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Enhance connection between riparian vegetation at MWT and Cosumnes Preserve** ↳ notable gap around I5 (to have gap <100 m, break should not be much wider than highway itself) [2K]	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Work to enhance riparian corridor between large/wide patches at Cosumnes Preserve and Tracy Lake** ↳ artificial levee setbacks to allow riparian vegetation to reoccupy remnant natural levee topography (200- 600 m wide corridor) [2O]	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Enhance connectivity between woody riparian vegetation of Cosumnes Preserve and Mokelumne River** ↳ levee setbacks to allow riparian vegetation to reoccupy remnant natural levee topography on west edge of Cosumnes River Mitigation Bank [2L] ↳ upstream connection to Mokelumne River at Cosumnes Floodplain Mitigation Bank [2M] ↳ similarly, connect terrestrial lands along Dry Creek.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
2 (contd.)	Cosumnes-Mokelumne (contd.)	[EDGE_EXISTING_UNPROTECTED] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_PROTECT]	**Restore and expand woody riparian, nontidal marshes, seasonal wetlands and nearby terrestrial habitat types along Cosumnes River [2R]** ↳ continuous transitions from perennial to seasonal wetlands ↳ low-stature seasonal wetlands for long-term crane roosting (outside of tidal zone) ↳ protect and connect existing wet meadow/seasonal wetland fragments to larger protected areas near and off the Cosumnes. ↳ acquire, restore and connect terrestrial habitat types as part of the Cosumnes area Essential Connectivity Area and large landscape blocks to the northeast. ↳ restore large historical willow thicket habitat type in the proximity of [2R]. ↳ opportunities exist to restore large patches of oak woodland habitat type in undeveloped areas on the eastern edge of this region.	Yes	
		[EDGE_OPPORTUNITY]	**Re-oak upland areas** ↳ in agricultural areas plant oaks for hedgerows, shade trees, landscaping ↳ dedicated oak savannah restoration in protected areas (e.g., McFarland Unit [2Q] and Grizzly Island [2P])	Mixed	
17	Lower Sacramento River & Distributaries	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ at least 2 sites (both labeled [17K]) could support marshes larger than 500 ha. Both also feature some undeveloped migration space and are adjacent to potential woody riparian vegetation.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN	**Restore marshes in subsided areas** ↳ large (>500 ha) and minimally subsided areas are located at Ryer Island, the margins of Grand Island, and Shutter Island ↳ these areas are adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks or seasonal floodplains ↳ substantial reverse subsidence efforts would be required to bring land surfaces up to intertidal elevation in large parts of region ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ planned sites include Prospect Island (degrade levee on west side [17G], construct new cross-levee [17H]) ↳ strategically located sites would still be needed in the general vicinity of the Elk Slough confluence [17F], Sutter Island [17I], and Grand Island [17J] ↳ the Sutter Island [17I] and Grand Island [17J] sites are both located along tidal-fluvial transition zones	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
17 (contd.)	Lower	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 7 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 3 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Reconnect natural levees to distributaries to create wide and functional woody riparian corridors** ↳ e.g., at Miner Slough along east side of Prospect [17A]: based on historical ecology, riparian habitat types grade from 100+ m wide at N end of Prospect to emergent wetlands at S end ↳ e.g along East-West portion of Miner [17B]: some existing narrow riparian on inside of levee. ↳ e.g along Sutter [17C]: existing narrow riparian on inside of levee, none wide. ↳ e.g along Elk [17D]: existing narrow riparian on inside and outside of levee, none wide. Historically 300+ m. Functional riparian habitat types would require reconnection of Elk to Sacramento River [17F]. ↳ e.g along Babel Slough at historical splay [17E]: protect and improve remnant oaks on sediment splay near Reamer Farms, expand towards Sacramento ↳ particularly to match local Essential Connectivity Area (areas discussed above, also along mainstem Sacramento and along Winchester Lake).	Yes	
			Elsewhere explore opportunities for wildlife-friendly agriculture to improve habitat and connectivity for riparian wildlife and to improve water quality along key migratory corridors for fish ↳ agricultural re-oaking or hedgerows might increase connectivity between Reamer Farms and Elk Slough ↳ best practices to improve water quality very important in this area because it is a key fish corridor	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
10	Yolo Bypass	[MARSH_REMNANTS]	**Protect and enhance existing unprotected remnant marshes** ↳ examples labeled with [10L]	Yes	
			Increase the extent, duration, and frequency of Bypass inundation and improve fish passage as called for in the Yolo Plan ↳ Lower Elkhorn and Sacramento Bypass levee setbacks and Sacramento Bypass Weir Extension [10A] ↳ Upper Elkhorn levee setback [10B] ↳ Tule Canal riparian and instream restoration [10B] ↳ Fremont Weir extension and improved fish passage [10C] ↳ Wallace Weir improvements [10D] ↳ Lisbon Weir improvements [10E]	No	Reliance on water control and fish passage structures diminishes long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
10 (contd.)	Yolo Bypass	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks or seasonal floodplains ↳ substantial reverse subsidence efforts would be required to bring land surfaces up to intertidal elevation in large parts of region ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites located at Liberty Island ↳ planned sites include Lower Yolo [10K] ↳ strategically located sites would still be needed along the length of the Bypass	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 9 sites would be needed in this region. Counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 6 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Increase the extent and connectivity of woody riparian vegetation** ↳ opportunities exist at north end of this area to restore hydrologically connected woody riparian habitats on natural levees of Sacramento River	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_LEAST_BELLS_VIREO]	**Improve functioning of eastside tributaries (e.g., Cache Creek [10G], Willow Slough [10H], Willow Slough Bypass [10I], and Putah Creek [10J])** ↳ improve connection of creeks with wetlands, increasing extent, duration, and frequency of associated inundation ↳ improve protection of lands along South Fork Putah Creek to enhance connectivity and floodplain management capacity. ↳ promote associated habitat types at creek mouths, including nontidal wetlands and willow thickets ↳ opportunity to restore woody riparian habitats on remnant natural levees along Putah Creek ↳ opportunity expected to help support Least Bell's Vireo, observed [10P]	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
10 (contd.)	Yolo Bypass	[BIODIVERSITY_VERNAL_POOL] [EDGE_EXISTING_UNPROTECTED] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS]	**Manage Bypass to create additional seasonal and managed wetlands, particular in the transition-zones upslope of perennial wetland habitat types** ↳ protect existing, particularly persistent seasonal wetland habitat types around the protected areas of the Yolo Bypass, ex. [10M]. ↳ protect and connect large terrestrial habitat type fragments around [10I and 10N]. ↳ promote connection of wetlands protection and restoration to promote connectivity mapping to local Essential Connectivity Area. ↳ restore large willow thicket fragments that existed historically, such as on South Fork Putah Creek and Willow Slough. ↳ protect and connect seasonal wet meadow fragments near Cache Creek [10G], and connect protected terrestrial fragments along the mainstem Sacramento. ↳ opportunities for supporting large-scale wet meadow/seasonal wetland restoration towards Davis and west of the Sacramento [10O].	Mixed	Managed wetlands and have reduced ecological integrity and long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
12	Cache Slough	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ e.g., Watson Hollow marshes near airport/Liberty Island Road [12F], southeast of Calhoun Cut Ecological Preserve [12G], and within Cache Slough [12P]	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE]	**Restore marshes on lands at intertidal elevation** ↳ at least 3 areas of land located at intertidal elevation--including Liberty Farms/Lookout Slough [12A and 12B], Hastings Tract [12C], and Egbert Tract/Little Egbert Tract [12D and 12E]--could support marsh patches larger than 500 ha. These sites are all also adjacent to remnant historical blind channels (Cache Slough and Lindsey Slough) and are contiguous with undeveloped migration space. ↳ one additional site at Peters Pocket [12R] could support a marsh patch larger than 100 ha, is adjacent to remnant historical blind channels, and is contiguous with undeveloped migration space.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore marshes in subsided areas** ↳ minimally subsided areas at the lower edge Egbert [12H], Little Egbert [12I], and Hastings [12J] could support a marsh patch >500 ha ↳ restoration of these areas would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development (building off of Lindsey and Cache slough remnant blind channels) ↳ Little Egbert is also adjacent to potential woody riparian vegetation and along the tidal-fluvial transition zone ↳ reverse subsidence at the base of Liberty Farms [12S] could also improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development (building off of the Cache Slough remnant blind channel)	Yes (but see note)	Long-term restoration of marshes at intertidal elevation with dendritic channel networks constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
12 (contd.)	Cache Slough Complex (contd.)	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 1 site needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation in large parts of this region ↳ in the interim period these areas could still provide nontidal marsh habitat type for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ a strategically located site is needed in the vicinity of Little Egbert Tract [12E], which intersects migratory pathways along the lower Sacramento River and its distributaries	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 2 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects, but potentially include sites described under "Restore marshes on lands at intertidal elevation" above	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[BIODIVERSITY_VERNAL_POOL] [BIODIVERSITY_CARQUINEZ_GOLDENBUSH] [EDGE_EXISTING_UNPROTECTED] [EDGE_EXISTING_UNPROTECTED_LARGE] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_EXISTING_UNPROTECTED_PRIORITY_TZONE] [EDGE_OPPORTUNITY_CONNECT] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_REGIONAL]	**Enhance and expand seasonal wetlands at upper edge of tidal zone, especially ones with direct connections to tidal marshes** ↳ protect existing terrestrial habitat types without protections in place, e.g., seasonal wetlands, grasslands, and managed wetlands between Calhoun Cut Ecological Preserve and Rio Vista Municipal Airport [12K], grasslands northwest of Duck Slough [12L], large patches of persistent vernal pool and alkali seasonal wetland complex habitat [12O] and assorted potential t-zone areas around ex. [12D, 12G, 12O, 12A] ↳ seasonal wetland restoration and wildlife-friendly agriculture to enhance connectivity between existing and planned habitat type patches, e.g., in spaces between Jepson Prairie, Dickson Creek, Duck Slough, and Lower Yolo [12M]; connect large grassland fragments near Cache Slough and mainstem Sacramento, and spaces between Jepson Prairie, Rio Vista Airport, and River Road [12N]; opportunities for supporting large-scale vernal pool and wet meadow restoration between [12P and 12Q], particularly also to connect to large landscape blocks to the east of Jepson Prairie. ↳ evaluate potential to restore connections between small tributaries and seasonal wetlands, e.g., Watson Hollow, Ulatis Creek network. ↳ expanding seasonal wetlands here could benefit Carquinez goldenrod, which has a population at the Jepson Prairie [12T]	Yes	
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ e.g., Hastings Cut [12O]	No	Reliance on water control diminishes long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
29	Netherlands	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE]	**Restore marshes on lands at intertidal elevation** ↳ this region contains the largest contiguous area of land at intertidal elevation. It greatly exceeds the 500-ha threshold needed to support a dendritic channel network and is adjacent to potential woody riparian vegetation along Elk, Sutter, and Miner Sloughs ↳ opportunity enhanced by presence of Duck Slough, which could potentially be reconnected to Miner Slough to restore tidal flows to portions of tract, including Medora Lake (but would require targeted reverse subsidence for coherent channel network development, see [29A] below)	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ minimally subsided areas at lower edge of the region [29A] could support a marsh patch >500 ha and would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development ↳ the area is also adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation with dendritic channel networks constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the surrounding network of marshes by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 1 site would be needed in this region to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
South Delta					
23	Old River-Paradise Cut	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 23E	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ at least 2 areas, including Fabian Tract [23F] and across Old River to the south [23G] could support marsh patches larger than 500 ha. Both have connections to undeveloped migration space and are adjacent to potential woody riparian vegetation. ↳ one additional site south of Old River [23H] could support a marsh patch larger than 100 ha, is contiguous with undeveloped migration space, and is adjacent to potential woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
23 (contd.)	Old River-Paradise Cut (contd.)	[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ one very large minimally subsided area also spans the Middle River and San Joaquin River-north regions and could support multiple marsh patches larger than 500 ha ↳ portions of this area are adjacent to potential woody riparian vegetation ↳ reverse subsidence at the lower end of Fabian Tract [23I] and the lower end of Union Island [23J] would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks and seasonal floodplains ↳ planned sites include the Paradise Cut Bypass [23A] ↳ a strategically located site would still be needed along Old River (e.g., in the vicinity of Fabian Tract [23F])	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [23K]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_SOUTH_RIPARIAN] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Increase the extent and connectivity of woody riparian vegetation** ↳ there is a near-complete lack of wide woody riparian vegetation along Paradise Cut between the Southern Pacific Railroad Bridge and head of Union Island [23A]. Smaller, but still prominent gaps in wide woody riparian vegetation can be found at locations marked with [23C]. ↳ prominent gaps in wide woody riparian vegetation can be found between Old River to Mountain House Creek at locations marked with [23D] ↳ opportunities expected to help support riparian brush rabbit, which has been observed near [23A] to [23C] ↳ preserve and protect terrestrial patches near Tom Paine Slough and Paradise Cut to link gradients across future t-zone to woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
23 (contd.)	Old River-Paradise Cut (contd.)	[EDGE_EXISTING_UNPROTECTED]	**Protect and restore terrestrial habitat types** ↳ protect persistent grassland patches south of Old River. ↳ opportunities for alkali seasonal wetland complex restoration and large patches of wet meadow/seasonal wetland southeast of Clifton Court Forebay.	Yes	
24	Middle River	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 24D	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ one very large area at intertidal elevation is shared with the San Joaquin River- North region [24G and 25E] and could support marsh patches larger than 500 ha. This area has connections to undeveloped migration space and is adjacent to potential woody riparian vegetation. ↳ one additional site [24H] could support a marsh patch larger than 100 ha, is also contiguous with undeveloped migration space, and is adjacent to potential woody riparian vegetation.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ one very large minimally subsided area also spans the Old River and San Joaquin River-north regions and could support multiple marsh patches larger than 500 ha ↳ portions of this area are adjacent to potential woody riparian vegetation ↳ reverse subsidence on portions of Union Island [24I] and Drexler Tract [24J] would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**↳ at least 2 sites needed within this region** ↳ sites here should be tidal marshes with dendritic channel networks and seasonal floodplains ↳ strategically located sites would be along Middle River at its head [24C] and downstream in the vicinity of Howard Road [24F] ↳ note the area along the San Joaquin River near the head of Middle River [24C] was identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region. Counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 or fewer additional site would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [24K]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
24 (contd.)	Middle River (contd.)	[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Increase the extent and connectivity of woody riparian vegetations along Middle River** ↳ especially along the north side of Steward Tract **[24A]** and east side of Union Island **[24B]**, where there is very limited wide woody riparian vegetation ↳ opportunities to combine with woody riparian restoration to create marsh-riparian edge	Yes	
			Evaluate head of Old River barrier [24C] operations to identify and then implement the best alternative for maximizing survival of juvenile steelhead and spring-run Chinook salmon emigrating from the San Joaquin River ↳ functional floodplains and riparian vegetation would require flows to be restored along Old River	No	Reliance on water control diminishes long-term sustainability.
24 (contd.)	Middle River (contd.)	[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds ↳ particularly along/near Middle River.	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
25	San Joaquin River- North	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with [25C]	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore marshes on lands at intertidal elevation** ↳ one very large area at intertidal elevation is shared with the Middle River region [25E and 24G] and could support marsh patches larger than 500 ha. This area has connections to undeveloped migration space and is adjacent to potential woody riparian vegetation. ↳ one additional site [25F] could support a marsh patch larger than 100 ha and is also contiguous with undeveloped migration space. ↳ both areas are also located along the San Joaquin River tidal-fluvial transition zone	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN]	**Restore marshes in subsided areas** ↳ one very large minimally subsided area also spans the Old River and Middle River regions and could support multiple marsh patches larger than 500 ha ↳ portions of this area are adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks and seasonal floodplains ↳ strategically located sites would be along the San Joaquin River near the split with Middle River [see 24C] and downstream of Howard Road (in the vicinity of [25F]) ↳ note the area along the San Joaquin River near the head of Middle River [24C] was identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
25 (contd.)	San Joaquin River- North (contd.)	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 2 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_SOUTH_RIPARIAN] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Increase the extent and connectivity of woody riparian vegetations along the San Joaquin River between Howard Road and Old River Head** ↳ Howard Road [25A] represents the approximate downstream extent of woody riparian vegetations historically ↳ today there is extremely limited existing wide woody riparian along this reach [25B], which has been identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area ↳ the area is also located along the San Joaquin River tidal-fluvial transition zone ↳ opportunities would be expected to help support riparian brush rabbit, which has been observed near [26B] to [25B]	Yes	
		[EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Restore terrestrial habitat types** ↳ opportunities for large alkali seasonal wetland complex restoration east of the San Joaquin River ↳ opportunities for t-zone and floodplain restoration along the San Joaquin	Yes	
26	San Joaquin River- South	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ example labeled with [26C]	Yes	
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be seasonal floodplains that support a mosaic of woody riparian vegetation, nontidal marsh, and upland seasonal wetlands ↳ majority of reach identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area [26A]	Yes	
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
26 (contd.)	San Joaquin River- South (contd.)	[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_SOUTH_RIPARIAN]	**Increase the extent and connectivity of woody riparian vegetation** ↳ prominent gaps in wide woody riparian vegetation can be found at locations marked with [26B] ↳ opportunities expected to help support riparian woodrat population along the Stanislaus River at Caswell State Park [AR1] ↳ opportunities expected to help support riparian brush rabbit, which has been observed near [26A], near [23A] to [23C], and near [26D] to [25B] ↳ opportunities expected to help slough thistle populations observed near [26D], with modeled habitat all along San Joaquin River in this region	Yes	
		[EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_REGIONAL]	**Restore terrestrial habitat types** ↳ protect and restore large oak woodland habitat type patches, and alkali seasonal wetland fragments adjacent to existing habitat type patches. ↳ opportunities to connect further to large landscape blocks to the south end of 26 towards upstream San Joaquin River.	Yes	
28	Stockton-Lathrop	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 28A	Yes	
		[EDGE_HUMANLU] [EDGE_EXISTING_UNPROTECTED_RARE] [EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Urban greening in Stockton-Lathrop** ↳ in urban settings, aim to promote multi-benefit urban greening, which may involve: 1) restored riparian areas along urban stream corridors for habitat and flood control; 2) restored oak woodland, grassland and willow thickets in public open spaces; 3) green infrastructure using native plants, and oak and riparian tree incorporation into native street tree programs. ↳ protect and restore oak woodland habitat around Bear Creek, Calaveras River, Duck Creek and French Camp Slough where possible in urban environment. Consider oak street trees where not possible. ↳ protect seasonal wet meadow and terrestrial habitat type complexes for t-zone capacity, floodplain connectivity and flood protection along Mormon and French Camp Sloughs, protect and connect lands near the junction of French Camp and Walker sloughs. ↳ protect/restore small alkali seasonal wetland complex parcel south of French Slough	No	Urban greening projects generally have reduced ecological integrity and long-term sustainability.

Notes:
[1] Region #'s correspond with those on the Opportunity Map.
[2] Geographic area covered by the Region #.
[3] This field provides codes that link to the Methodology document, which provides the ecological justification for taking steps as well as the technical methods to identify the opportunities.
[4] This column identifies key action items in bold, followed by location guidance for implementing opportunities, restoration considerations and specifications. Numbers in brackets correspond with the locations of spatially explicit opportunities on the Opportunity Map.
[5] These fields indicate whether the described opportunity/opportunities qualify as "ecological restoration" as defined by Suding et al. 2015 (Science Magazine, volume 348, issue 6235). If not, we explain our reasoning in the notes field.

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 2 – Opportunities Map

Delta Plan Amendments

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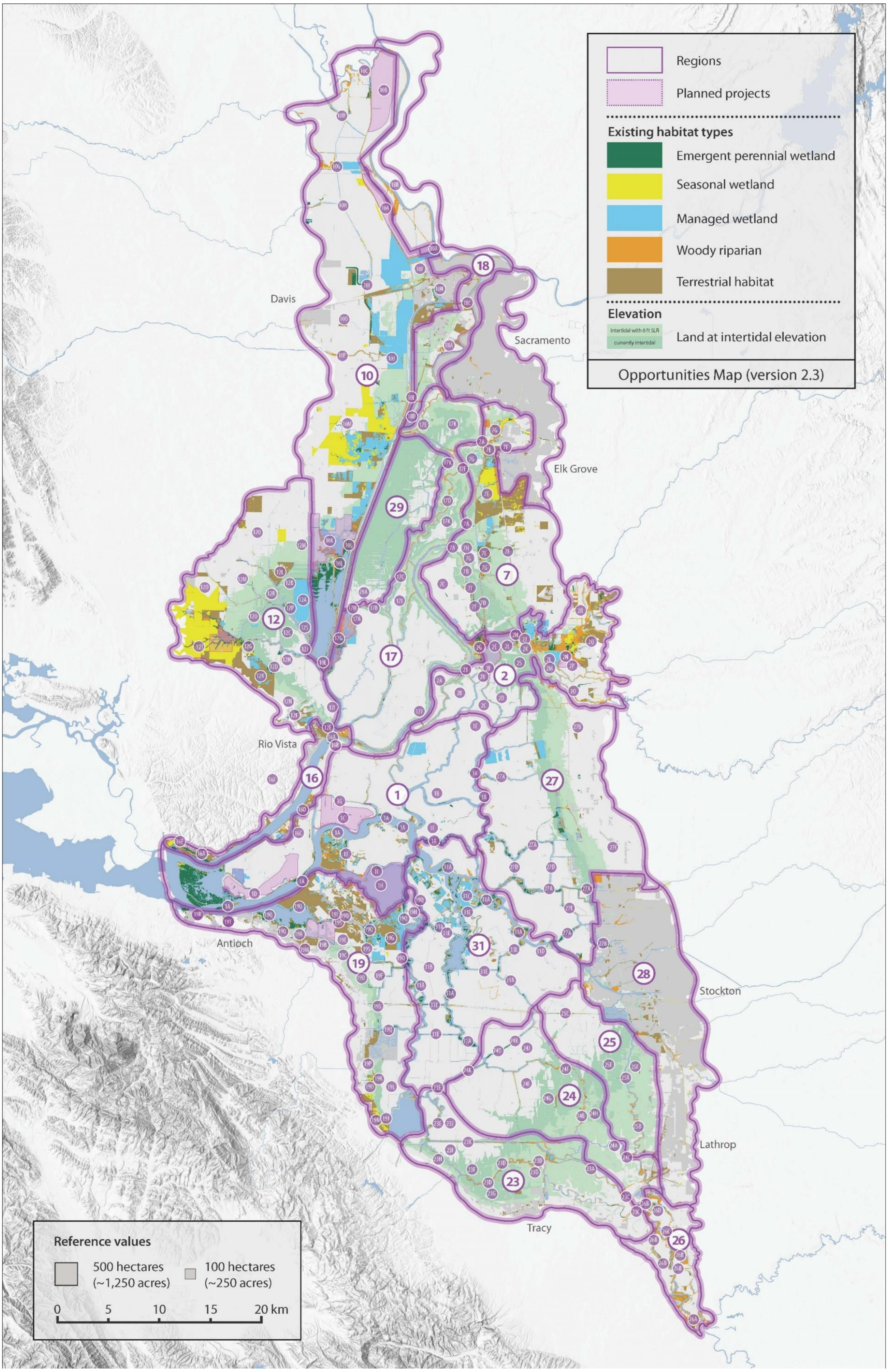

Opportunities Map

This map illustrates the approximate locations of restoration opportunity sites throughout the Delta, corresponding to the restoration opportunities listed in Table 1-1. This map depicts the location of planned restoration projects and opportunities for ecological restoration in the Sacramento-San Joaquin Delta. The map extends from the eastern edge of Suisun Bay on the west, to present-day Stockton in the east; and from Fremont Weir State Wildlife Area in the north, to the lower San Joaquin River in the south.

The existing habitat types depicted include emergent perennial wetland, seasonal wetland, managed wetland, woody riparian, and terrestrial habitat. Existing emergent perennial wetland habitat is concentrated mostly in the central Delta and Yolo Bypass regions. Existing seasonal wetland habitat is concentrated in Cache Slough Complex and Yolo Bypass regions. Existing managed wetland habitat is concentrated in the Yolo Bypass region. Existing woody riparian habitat is concentrated mostly in the Consumnes-Mokelumne region. Existing terrestrial habitat is concentrated in west Delta, Cache Slough Complex, Consumnes-Mokelumne, and Sacramento Basin regions. The map also depicts land that is currently at intertidal elevations, and land that is projected to be at intertidal elevations with future sea level rise.

The map divides the Delta into numbered regions, corresponding to those listed in Table 1-1. The map also depicts opportunities for ecological restoration. These opportunities are labeled using a combination of a number and letter; the number corresponds to the region in which the opportunity is located, and the letter corresponds to the type of project. For example, there are 17 project opportunities shown in the central Delta region. Eight of these are labeled as 1A, representing opportunities to protect and enhance existing remnant marshes. Other project opportunity areas in the central Delta region include 1D, 1C, and 1H which are associated with Sherman Island, Twitchell Island, and Frank's Tract respectively, representing restoration of large, well-distributed, and hydrologically-connected wetlands capable of supporting juvenile salmonid rearing and movement. All other project opportunities depicted in this map are listed in Table 1-1.

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 3 – Opportunities Summary

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Opportunities Summary v2.3 FINAL DRAFT July 2018

#	step	Step code	Step	Total opportunity acreage (ha)
Habitat and connectivity for native fish and marsh wildlife				
1		[MARSH_REMNANTS]	Identify existing marshes in need of legal protection, especially remnant historical marshes	2,110
2		[MARSH_INTERTIDAL]	Identify areas that are currently at intertidal elevation	33,452
2	a	[MARSH_INTERTIDAL_LARGE_500ha]	Contiguous areas that are large enough to support desired ecological functions (>500 ha)	27,060
2	a	[MARSH_INTERTIDAL_LARGE_100ha]	Contiguous areas that are large enough to support desired ecological functions (>100 ha)	30,703
2	c	[MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL]	Areas with remnant/existing blind channel networks	8,597
2	e	[MARSH_INTERTIDAL_WITH_MIGRATION_SPACE]	Areas that are adjacent to nonurbanized uplands to provide tidal-terrestrial transition zone functions (including space for marsh migration with SLR)	31,203
2	f	[MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	Areas that are adjacent to potential woody riparian vegetations	24,093
3	a	[MINIMALLY_SUBSIDED_LARGE_100ha]	Areas that are both minimally subsided and large enough to support desired ecological functions (>100 ha)	43,553
3	a	[MINIMALLY_SUBSIDED_LARGE_500ha]	Areas that are both minimally subsided and large enough to support desired ecological functions (>500 ha)	41,447
Habitat and connectivity for riparian wildlife				
2		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	Identify remnant natural levees where woody riparian vegetation (both riparian forest and riparian scrub) could potentially be restored if re-connected to adjacent streams [historical footprint of woody riparian habitats minus existing hydrologically connected woody riparian habitats and areas that have been subject to urban development]	12,928

Opportunities Summary v2.3 FINAL DRAFT July 2018 (contd.)

Step #	Sub-step	Step code	Step	Total opportunity acreage (ha)
Habitat and connectivity for edge wildlife				
1		[EDGE_EXISTING_UNPROTECTED]	Unprotected existing edge habitat - identify existing habitats in need of legal protection (total)	8,222
			Alkali seasonal wetland complex	110
			Grassland	5,901
			Interior dune scrub	1
			Vernal pool complex	1,751
			Wet meadow/Seasonal wetland	459
			Willow thicket	2
			Oak woodland	0
1	a	[EDGE_EXISTING_UNPROTECTED_PRIOITY_REMNANT]	Prioritize remnant edge terrestrial habitats (total)	2,055
			Alkali seasonal wetland complex	90
			Grassland	389
			Stabilized interior dune vegetation	1
			Vernal pool complex	1,395
			Wet meadow/Seasonal wetland	107
			Willow thicket	0
			Oak woodland	73
1	b	[EDGE_EXISTING_UNPROTECTED_PRIOITY_LARGE]	Prioritize large patches (ex. >50 ha) of terrestrial habitats (total)	3,981
			Alkali seasonal wetland complex	0
			Grassland	2,659
			Interior dune scrub	0
			Vernal pool complex	1,321
			Wet meadow/Seasonal wetland	0
			Willow thicket	0
			Oak woodland	0

Opportunities Summary v2.3 FINAL DRAFT July 2018 (contd.)

Step #	Sub-step	Step code	Step	Total opportunity acreage (ha)
Habitat and connectivity for edge wildlife (contd.)				
1	c	[EDGE_EXISTING_UNPROTECTED_PRIOITY_RARE]	Alkali seasonal wetland complex	110
			Interior dune scrub	1
			Willow thicket	2
			Oak woodland	0
1	d	[EDGE_EXISTING_UNPROTECTED_PRIOITY_TZONE]	Prioritize T-zone habitat	27,516
2	aiii.	[EDGE_OPPORTUNITY_CONNECT_REGIONAL]	Within ECA footprint	6,469
2		[EDGE_OPPORTUNITY]	Opportunities: total undeveloped edge acreage (including protected lands and restoration projects)	121,466
2	b	[EDGE_OPPORTUNITY_RARE]	Historical habitat types [now very rare (>95% loss)] (total)	21,034
			Alkali seasonal wetland complex	6,474
			Stabilized interior dune vegetation	427
			Willow thicket	3,382
			Oak woodland	10,751
2	c	[EDGE_OPPORTUNITY_LARGE_METRICS]	Historical habitats with footprints large enough to support DL thresholds (total)	55,023
			Alkali seasonal wetland complex - 5.2 ha for San Joaquin kit fox	2,452
			Grassland - 336 ha for Swainson's hawk	4,646
			Interior dune scrub – 2 ha for butterfly conservation	68
			Vernal pool complex - 1375 ha for tiger salamanders	6,841
			Wet meadow/seasonal wetland - 129 ha for California giant garter snake	26,979
			Willow thicket - 80 ha for Western yellow-billed cuckoo	3,291
			Oak woodland - 2630 ha for bobcat	10,748

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 4 – GIS Map Package

Delta Plan Amendments

May 2020

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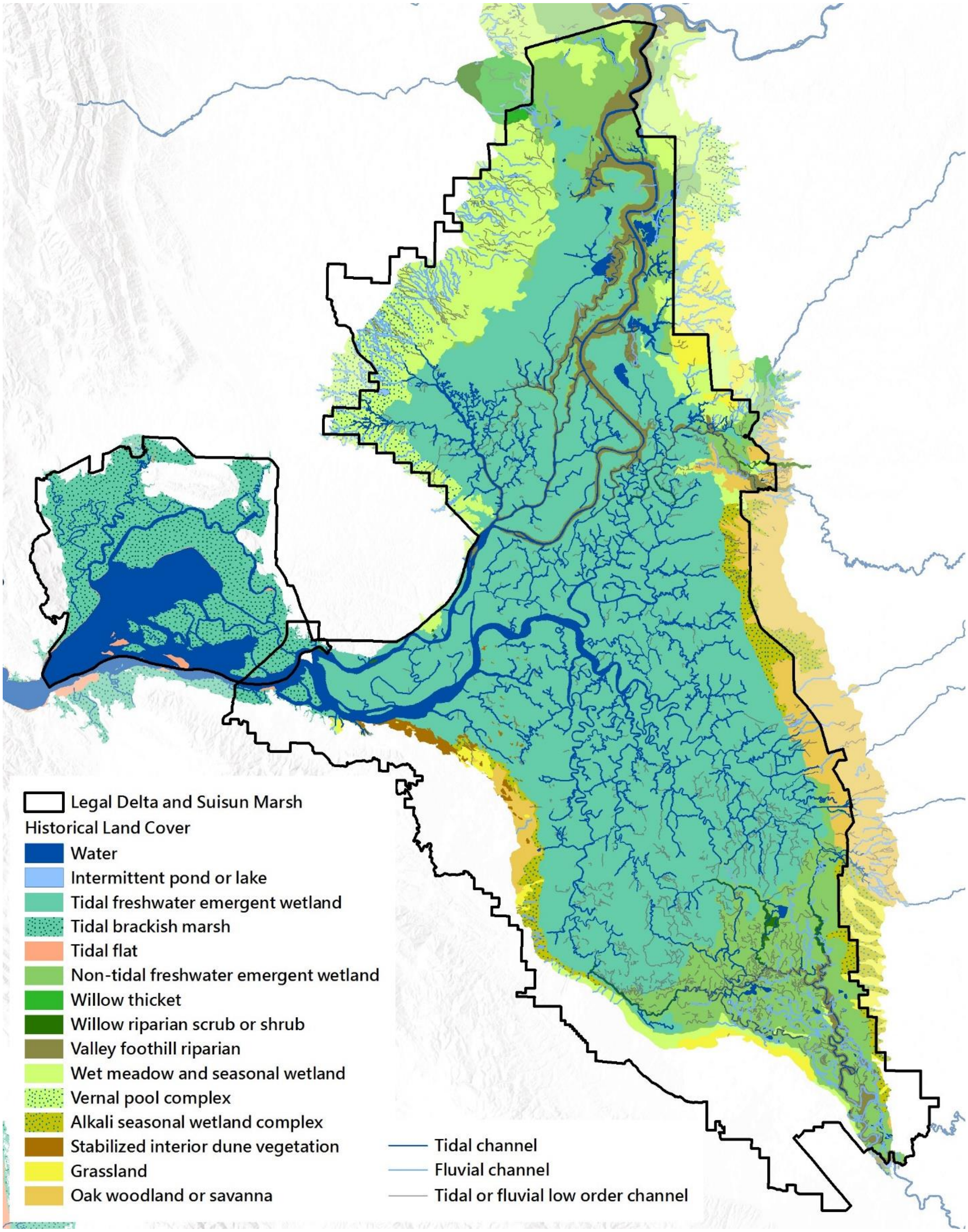

Figure 4-1. Delta Historical Ecology

Figure 4-1. Delta Historical Ecology (contd.)

This map illustrates the Delta's historical (early 1800s) ecology. This map reconstructs the patterns of habitat types in the Delta region prior to the significant modification of the past 160 years. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. Historical land cover types include water, intermittent pond or lake, tidal freshwater emergent wetland, tidal brackish marsh, tidal flat, nontidal freshwater emergent wetland, willow thicket, willow riparian scrub or shrub, valley foothill riparian, wet meadow and seasonal wetland, vernal pool complex, alkali seasonal wetland complex, stabilized interior dune vegetation, grassland, oak woodland or savanna, tide channel, fluvial channel, and tidal or fluvial low order channel.

This map of the historical Delta (early 1800s) depicts how rivers traversed approximately 400,000 acres of tidal wetlands and other aquatic habitats in the Delta, connecting with several hundred thousand acres of nontidal wetlands and riparian forest. Extensive tidal wetlands and large tidal channels are seen at the central core of the Delta. Riparian forest extends downstream into the tidal Delta along the natural levees of the Sacramento River, and to a certain extent on the San Joaquin and Mokelumne Rivers. To the north and south, tidal wetlands grade into nontidal perennial wetlands. At the upland edge, an array of seasonal wetlands, grasslands, and oak savannas and woodlands occupy positions along the alluvial fans of the rivers and streams that enter the valley. Habitat types in Suisun Marsh were dominated by water, tidal brackish marsh, and tidal flat habitat.

Alternative formats of this map are available upon request.

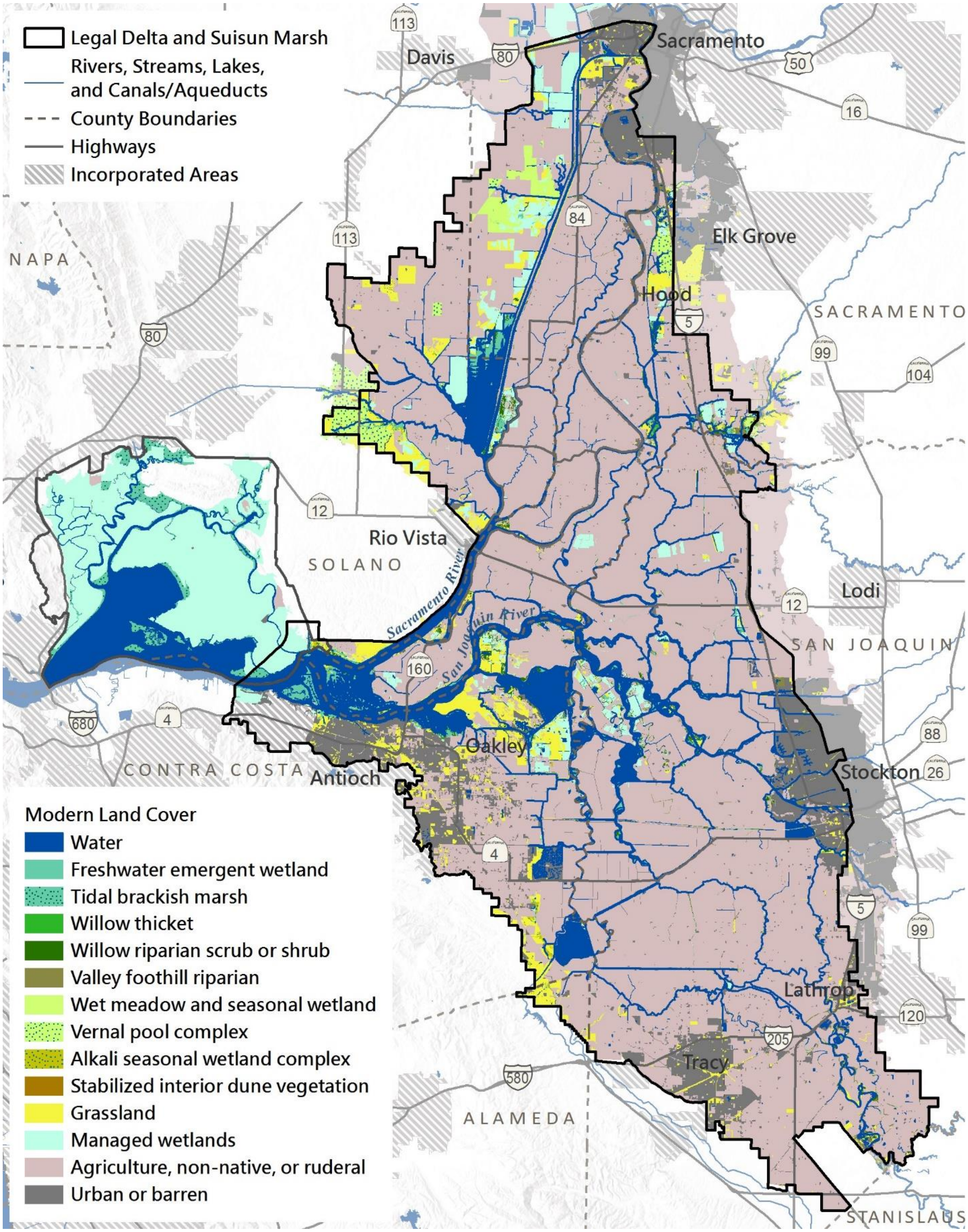

Figure 4-2. Delta Transformed

Figure 4-2. Delta Transformed (contd.)

This map illustrates the ecology of the modern Delta and Suisun Marsh. Compared to Figure 4-1 (map of the Delta's historical ecology), this map illustrates how humans have greatly transformed the Delta's ecology since the 1800's. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. Modern land cover types that are also historical land cover types include water, freshwater emergent wetland, tidal brackish marsh, willow thicket, willow riparian scrub or shrub, valley foothill riparian, wet meadow and seasonal wetland, vernal pool complex, Alkali seasonal wetland complex, stabilized interior dune vegetation, and grassland. Modern land cover types that are not historical land cover types include managed wetlands, agriculture, nonnative, and ruderal cover, and urban or barren cover. Historical land cover types that are not depicted in this map include tidal freshwater emergent wetland, tidal flat, nontidal freshwater emergent wetland, oak woodland and savanna, and channels (tidal, fluvial, and tidal or fluvial low order channels).

The modern state of the Delta ecosystem has been severely affected by the loss of natural communities. Widespread levee construction and large-scale conversion of wetlands to other land uses have severed land-water connections across much of the Delta landscape. As a result, the extent of important seasonal floodplain, tidal wetland, and riparian corridor natural communities has been sharply reduced compared to the pre-reclamation era. The few remaining wetland patches are isolated from one another. The modern Delta landscape is characterized mostly by agriculture, nonnative, or ruderal land cover, rather than the historical distribution of tidal freshwater emergent wetland habitat. Suisun Marsh has been transformed from a tidal brackish marsh to a managed wetland.

Alternative formats of this map are available upon request.

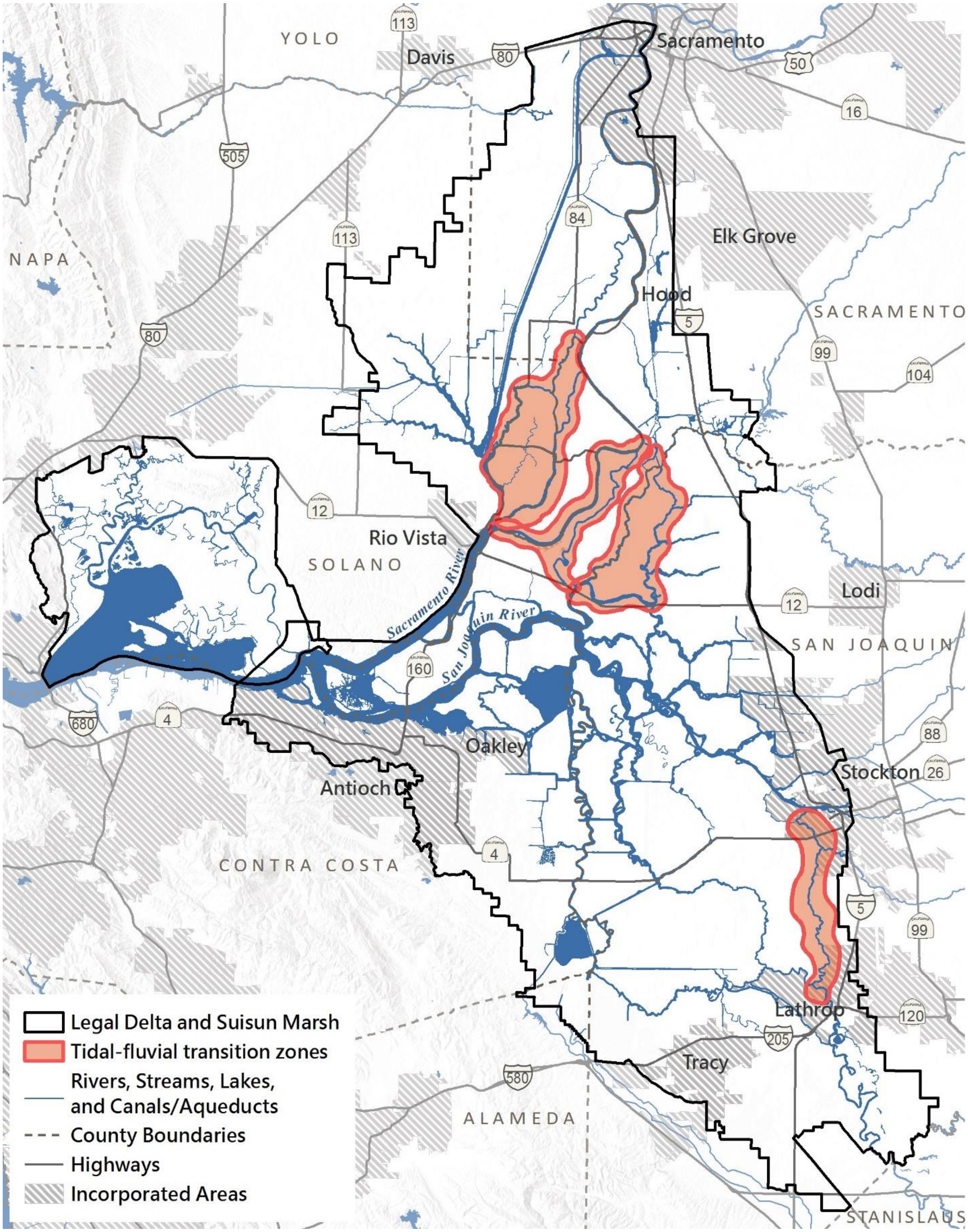

Figure 4-3. Tidal-Fluvial Transition Zone

Figure 4-3. Tidal-Fluvial Transition Zone (contd.)

This map illustrates the tidal-fluvial transition zones within the Delta and Suisun Marsh. Tidal-fluvial transition zones are shown as an orange overlay on a subset of waterways. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; they are not labeled, except the Sacramento and San Joaquin Rivers. In the north-central Delta, tidal-fluvial transition zones are located along sections of Miner Slough, Steamboat Slough, Sutter Slough, Georgiana Slough, North Fork Mokelumne River, and South Fork Mokelumne River. These tidal-fluvial transition zones include areas of Prospect Island, Ryer Island, Sutter Island, Grand Island, Tyler Island, Staten Island, New Hope Tract, Dead Horse Island, Brannan-Andrus Island, Bouldin Island, Terminous Tract, Canal Ranch Tract, and McCormack Williamson Tract. In the south-east Delta, a tidal-fluvial transition zone exists along the San Joaquin River, extending north to south from Rough and Ready Island to Lanthrop, and includes areas of Rough and Ready Island, Boggs Tract, Middle Roberts Island, Upper Roberts Island, and Stewart Tract.

Alternative formats of this map are available upon request.

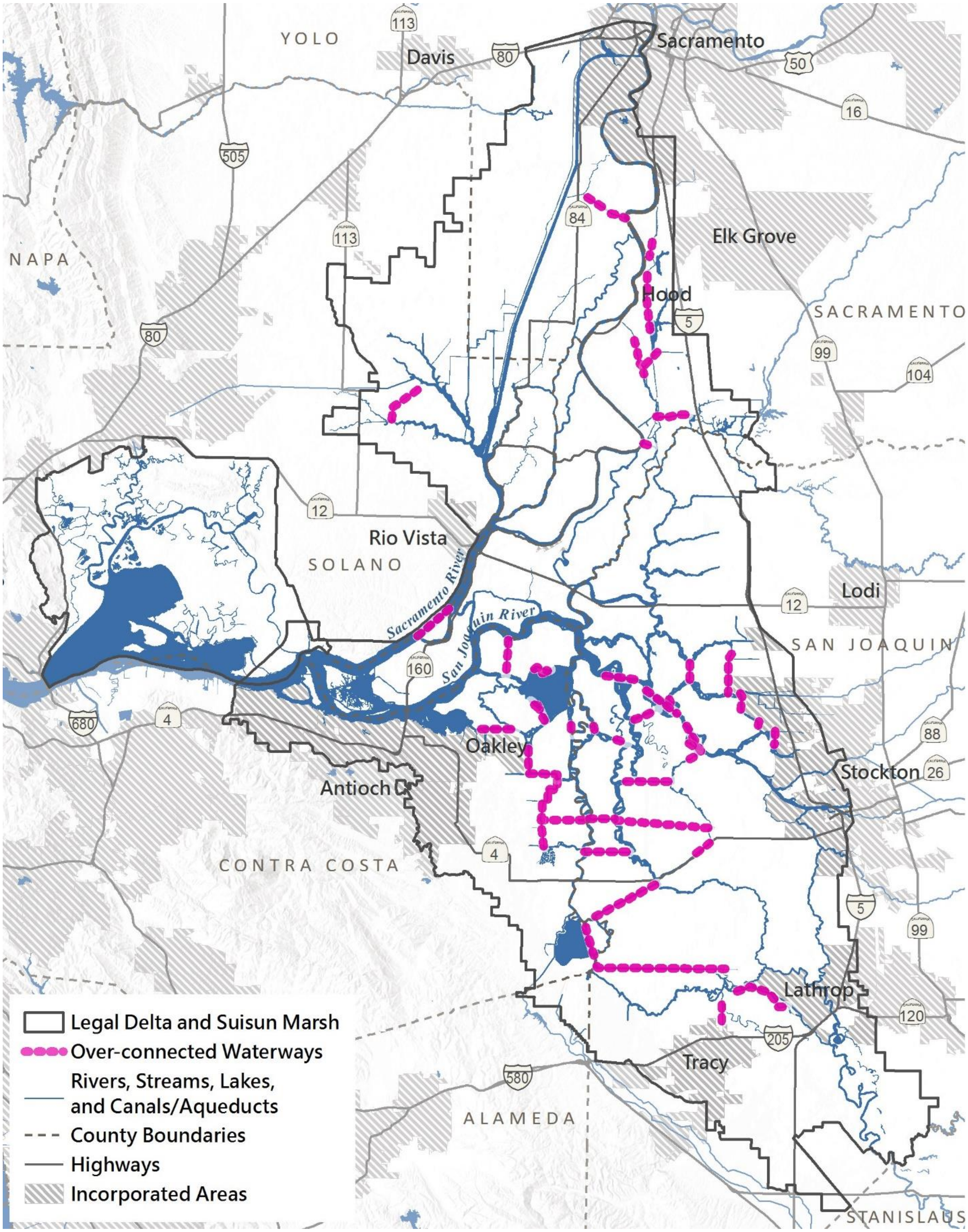

Figure 4-4. Over-Connected Waterways

Figure 4-4. Over-Connected Waterways (contd.)

This map illustrates over-connected waterways within the Delta. Over-connected waterways are highlighted in pink. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; they are not labeled, except the Sacramento and San Joaquin Rivers. Many artificial hydrologic connections were created during the reclamation era, and are conceived to facilitate the spread of invasive aquatic organisms. This map illustrates the high number of over-connected waterways in the Delta, including sections of Hastings Cut, Winchester Lake, Snodgrass Slough, Lost Sough, Delta Cross Channel, section of Sacramento River near Decker Island, Fishermans Cut, False River and Piper Slough near Franks Tract, Dutch Slough, Holland Cut, section of Old River along Bacon Island, Palm Tract, Fay Island, Orwood Tract, and Woodward Island, Rock Slough, Woodward Canal, West Canal, Victoria Canal, Trapper Slough, Grant Line Canal, Tom Paine Slough, Paradise Cut, Empire Cut, Turner Cut, San Joaquin River Deep Water Ship Channel, Columbia Cut, Disappointment Slough, White Slough, Bear Creek, and Fourteen Mile Slough.

Alternative formats of this map are available upon request.

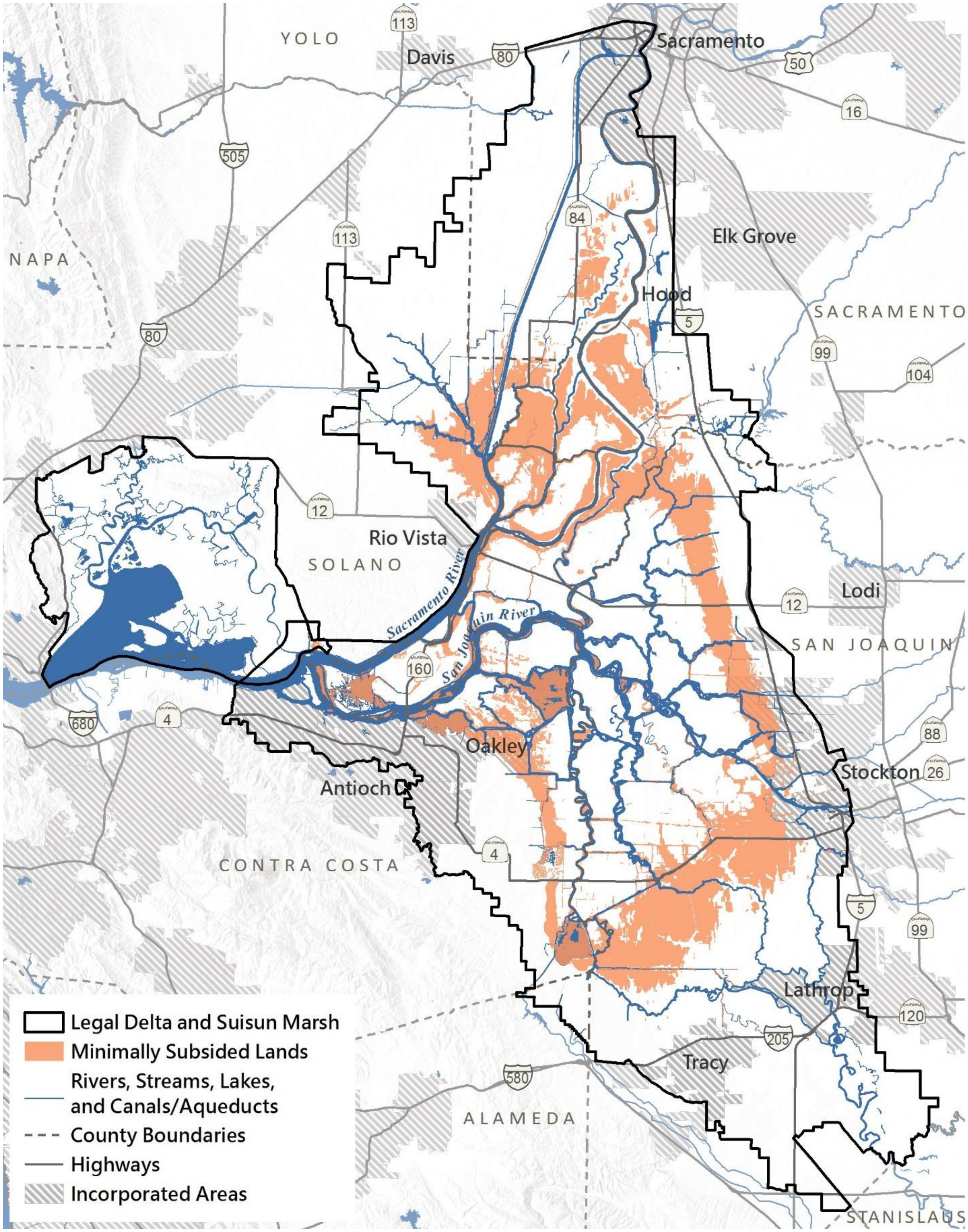

Figure 4-5. Minimally Subsided Lands

Figure 4-5. Minimally Subsided Lands (contd.)

This map depicts areas of minimally subsided lands within the Delta and Suisun Marsh where subsidence reversal activities, ongoing from 2030 to 2100, can produce intertidal elevations by 2100. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; they are not labeled, except the Sacramento and San Joaquin Rivers. Minimally subsided lands are thought to have the greatest likelihood of achieving intertidal elevations through reverse subsidence efforts. Islands at an appropriate elevation to reach elevations that would support potential intertidal restoration by 2100 include: Drexler Pocket, Honker Lake Tract, Brack Tract, Grand Island, Terminous Tract, Merrit Island, Tyler Island, Pearson District, Sutter Island, Shin Kee Tract, Bishop Tract, Little Egbert Tract, Ehrheardt Club, Ryer Island, Upper Andrus Island, Dead Horse Island, Fay Island, Fabian Tract, Shima Tract, Smith Tract (Lincoln Village), Byron Tract, Lisbon Tract, Cache Hass Area, Rio Blanco Tract, Drexler Tract, Wright-Elmwood Tract, New Hope Tract, Canal Ranch Tract, Hotchkiss Tract, Winter Island, Atlas Tract, Egbert Tract, Netherlands, Prospect Island, Glanville, McCormack-Williamson Tract, Maintenance Area 9, Yolo Bypass, Chipps Island, Mein's Landing, Morrow Island, Grizzly Island, Sunrise Club, Honker Bay, Joice Island, Chipps Island South, Union Island, Middle Roberts Island, Lower Roberts Island, Veale Tract, and Hastings Tract, among others. If subsidence reversal activities are implemented by 2030 in these locations, and these activities continue to accrete the land elevation, land elevations are expected to increase to, and maintain, intertidal elevations by 2100.

Alternative formats of this map are available upon request.

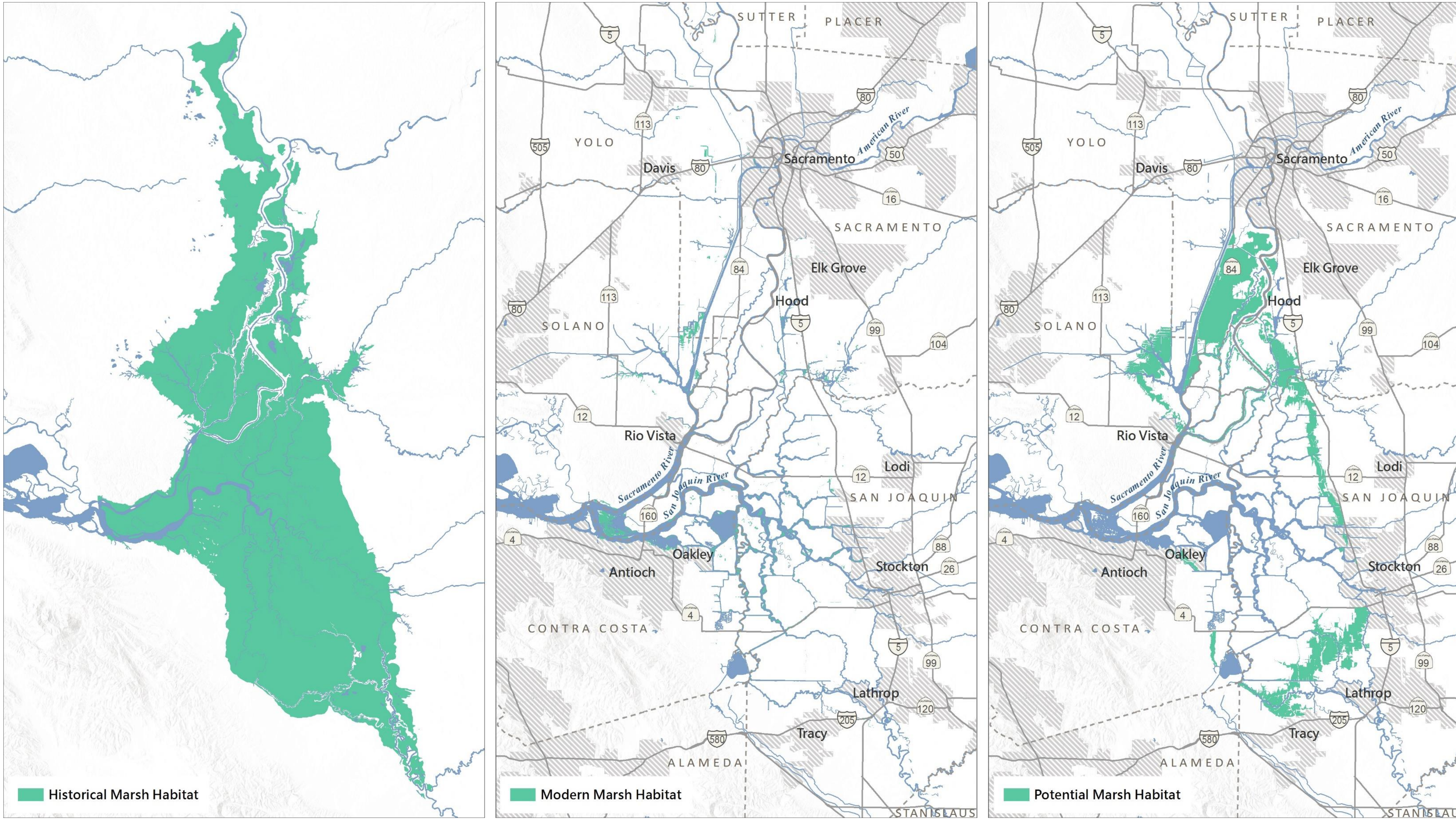

Figure 4-6. Historical, Modern, and Potential Wetland Habitat

Figure 4-6. Historical, Modern, and Potential Wetland Habitat (contd.)

These three side-by-side maps illustrate the historical (early 1800s) marsh habitat, modern (early 2000s) marsh habitat, and potential future marsh habitat within the Delta and Suisun Marsh. The historical Delta map depicts the historical waterways, whereas the modern and potential Delta maps depict the current waterways. The historical Delta map shows that historical marsh habitat extended over the majority of the Delta. The modern Delta map shows that modern marsh habitat extent is limited to scattered patches, with the largest patches located in the Suisun Marsh and western Delta. The map of potential Delta marsh habitat shows that marsh habitat can be greatly expanded throughout the Delta, mostly in the north, east, and southern Delta.

Alternative formats of this map are available upon request.

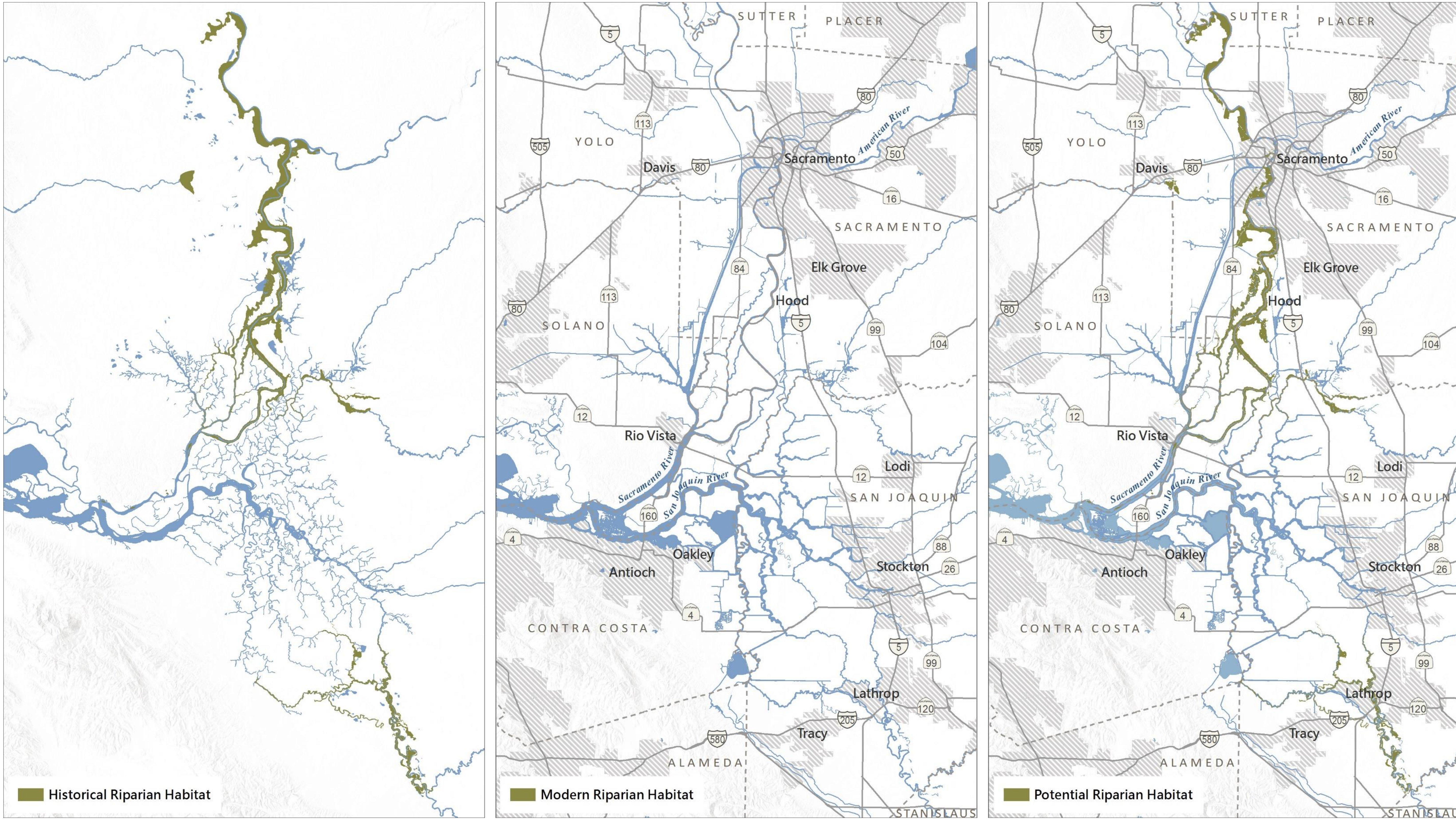

Figure 4-7. Historical, Modern, and Potential Riparian Habitat

Figure 4-7. Historical, Modern, and Potential Riparian Habitat (contd.)

These three side-by-side maps illustrate the historical (early 1800s) riparian habitat, modern (early 2000s) riparian habitat, and potential future riparian habitat within the Delta and Suisun Marsh. The map of historical Delta riparian habitat depicts the historical waterways, whereas the maps of the modern and potential riparian habitat in the Delta depict the current waterways. The map of the historical Delta shows a continuous corridor of riparian habitat, extending downstream into the tidal Delta along the natural levees of the Sacramento River, and to a certain extent on the San Joaquin and Mokelumne Rivers. The modern Delta map depicts a major reduction in the historical riparian habitat extent across the Delta, but also shows the expansion of scattered riparian habitat in the central Delta that historically did not exist. The map of potential riparian habitat (right) shows the potential for riparian habitat to return to a portion of its historical coverage.

Alternative formats of this map are available upon request.

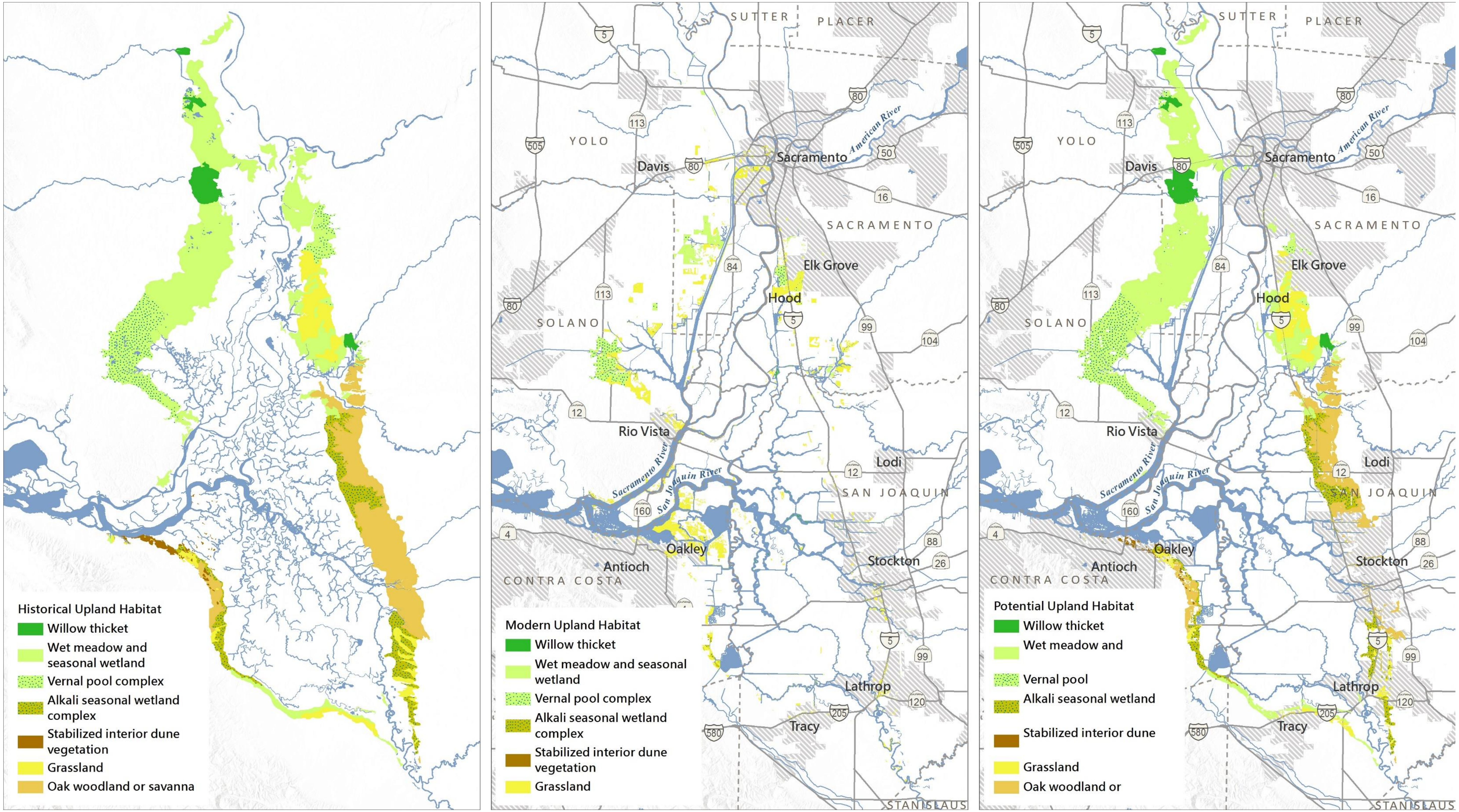

Figure 4-8. Historical, Modern, and Potential Upland Habitat

Figure 4-8. Historical, Modern, and Potential Upland Habitat (cont'd)

These three side-by-side maps illustrate the historical (early 1800s) upland habitat, modern (early 2000s) upland habitat, and potential future upland habitat within the Delta and Suisun Marsh. The map of historical Delta upland habitat depicts the historical waterways, whereas the maps of the modern Delta and potential upland habitat depict the current waterways. Upland habitat types include willow thicket, wet meadow and seasonal wetland, vernal pool complex, alkali seasonal wetland complex, stabilized interior dune vegetation, grassland, and oak woodland or savanna. The map of the historical Delta shows a much greater distribution and diversity of upland habitat compared to the modern Delta. In the historical map, the upland margin of the north Delta was lined primarily by seasonal wetlands, vernal pool complexes, and patches of willow thickets and grassland. The upland margin in the south Delta was lined primarily by alkali seasonal wetland complexes, grassland, and oak woodland or savanna. Upland transitions along the central-western Delta included patches of stabilized interior dune vegetation, alkali seasonal wetlands, grassland, oak woodland and savanna. The central-eastern Delta was characterized by oak woodland and savanna, alkali seasonal wetland complex, and seasonal wetland. The map of modern Delta upland habitat shows a major reduction in the extent of all upland habitat types across the Delta; there are scattered patches of grassland habitat throughout the Delta, and small remaining patches of vernal pool complex and seasonal wetland habitat in the north Delta. The map of potential upland habitat depicts the potential for upland habitat to nearly return to its historical coverage, with the exception of areas that have been urbanized such as south of Sacramento, near Elk Grove, and near Stockton.

Alternative formats of this map are available upon request.