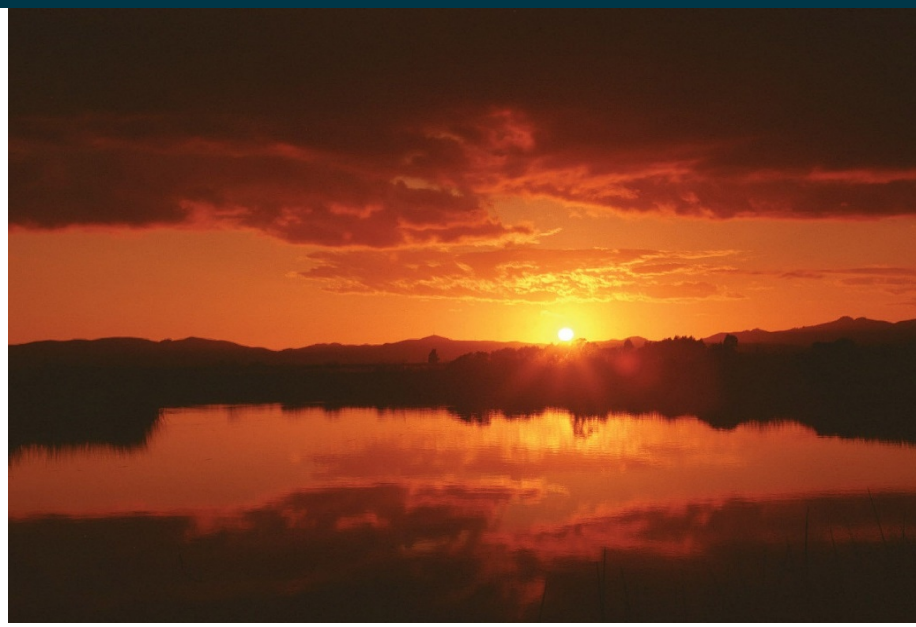
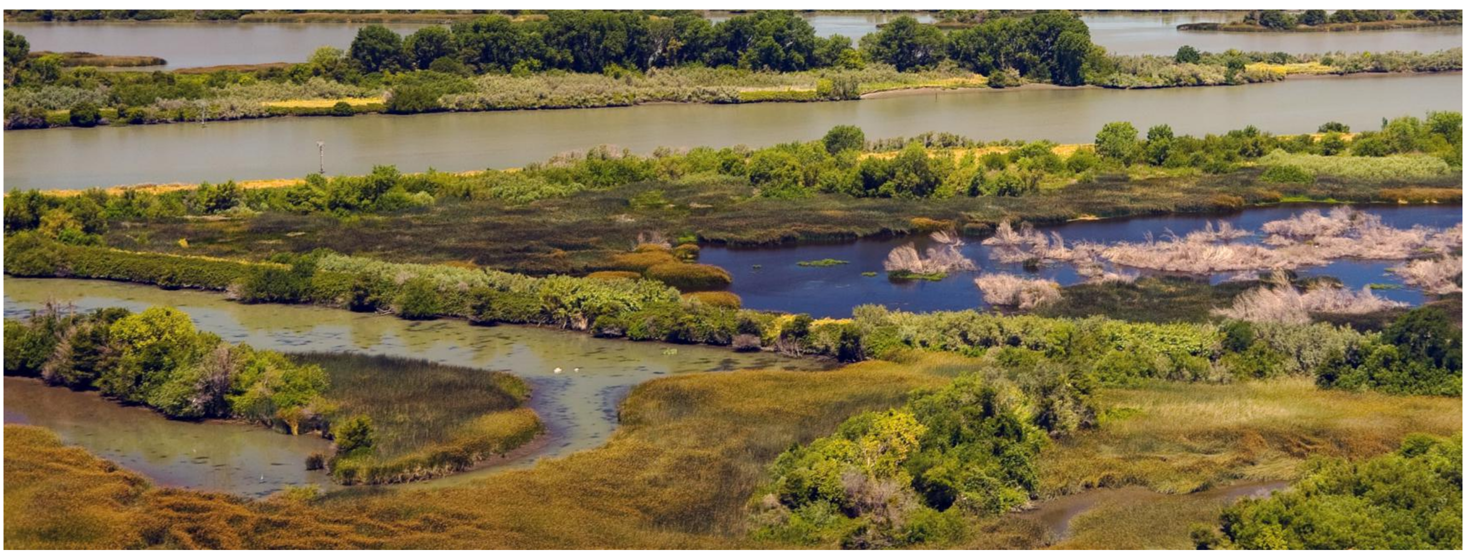
PRELIMINARY DRAFT CHAPTER 4

Protect, Restore, and Enhance the Delta Ecosystem





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About This Chapter

While significant progress has been made in implementing restoration projects since adoption of the Delta Reform Act in 2009, the Delta ecosystem continues to decline. There remains an urgent need to expand and expedite major changes to the Delta landscape, and to align state and federal priorities to hasten the creation of new opportunities to protect, restore, and enhance the Delta ecosystem. Additional research and scientific information will be needed to guide management decisions as climate change accelerates and as new opportunities for restoration arise within the Delta and its watershed.

This chapter presents **five core strategies** to achieve the coequal goal of protecting, restoring, and enhancing the Delta ecosystem, as set forth in the Delta Reform Act:

1. Create more natural, functional flows
2. Restore ecosystem function
3. Protect land for restoration and safeguard against land loss
4. Protect native species and reduce the impact of nonnative invasive species
5. Improve institutional coordination to support implementation of ecosystem protection, restoration, and enhancement

These core strategies form the basis for the six policies and fifteen recommendations pertinent to the coequal goal of protecting, restoring, and enhancing the Delta ecosystem, which are found at the end of this chapter.

Relevant Legislation

The coequal goals for the Delta (California Water Code section 85054) are relevant to ecosystem restoration:

> *"Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.*

Eight objectives in California Water Code section 85020 are inherent in the coequal goals, and three are relevant to this chapter (Section 85020(a), (c), and (e)):

> *85020 The policy of the State of California is to achieve the following objectives that the Legislature declares are inherent in the coequal goals for management of the Delta:*
>
> > *(a) Manage the Delta's water and environmental resources and the water resources of the state over the long term.*
> >
> > *(c) Restore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem.*
> >
> > *(e) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

The coequal goals and inherent objectives seek broad protection of the Delta. Achieving these broad goals and objectives requires implementation of specific strategies. California Water Code sections 85022 and 85302 provide direction on the implementation of specific measures to promote the coequal goals and inherent objectives related to the Delta ecosystem restoration. Those relevant to this chapter are:

85022(d) The fundamental goals for managing land use in the Delta are to do all of the following:

> *(1) Protect, maintain, enhance, and, where feasible, restore the overall quality of the Delta environmental and its natural and artificial resources.*
>
> *(2) Ensure the utilization and conservation of Delta resources, taking into account the social and economic needs of the people of the state.*
>
> *(5) Develop new or improved aquatic and terrestrial habitat and protect existing habitats to advance the goal of restoring and enhancing the Delta ecosystem.*
>
> *(6) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

85302(a) The implementation of the Delta Plan shall further the restoration of the Delta ecosystem and a reliable water supply.

85302(b) The geographic scope of the ecosystem restoration projects and programs identified in the Delta Plan shall be the Delta, except that the Delta Plan may include recommended ecosystem projects outside the Delta that will contribute to achievement of the coequal goals.

85302(c) The Delta Plan shall include measures that promote all of the following characteristics of a healthy Delta ecosystem:

> *(1) Viable populations of native resident and migratory species.*
>
> *(2) Functional corridors for migratory species.*
>
> *(3) Diverse and biologically appropriate habitats and ecosystem processes.*
>
> *(4) Reduced threats and stresses on the Delta ecosystem.*

> *(5) Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations.*

85302(d) The Delta Plan shall include measures to promote a more reliable water supply that address… the following:

> *(1) Meeting the needs for reasonable and beneficial uses of water.*

> *(3) Improving water quality to protect human health and the environment.*

85302(e) The following subgoals and strategies for restoring a healthy ecosystem shall be included in the Delta Plan:

> *(1) Restore large areas of interconnected habitats within the Delta and its watershed by 2100.*

> *(2) Establish migratory corridors for fish, birds, and other animals along selected Delta river channels.*

> *(3) Promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm from invasive species.*

> *(4) Restore Delta flows and channels to support a healthy estuary and other ecosystems.*

> *(5) Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals.*

> *(6) Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds.*

CHAPTER 4

Protect, Restore, and Enhance the Delta Ecosystem

The Delta Stewardship Council (Council) works to achieve the goal of protecting, restoring, and enhancing the Delta ecosystem (California Water Code section 85054). Inherent in that goal is the objective to “restore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem” (California Water Code section 85020[c]). This chapter presents core strategies, policies, and recommendations for protecting, restoring, and enhancing the Delta ecosystem, based on current scientific understanding of opportunities and constraints, to achieve that coequal goal, and to benefit both the Delta ecosystem and native resident and migratory species (see highlighted section on the next page, “What Does It Mean to Achieve the Goal of Protecting, Restoring, and Enhancing the Delta Ecosystem?”).

The Delta: A Unique Ecological Resource

The Delta and Suisun Marsh are part of the largest estuary on the west coast of the Americas. The Delta’s system of channels, bays, and sloughs connects the upper watersheds of the Sacramento Valley, the foothills of the Sierra Nevada Mountains, and the great Central Valley to the San Francisco Bay and marine environments of the Pacific Ocean. The ecosystems supported by the Delta and its watersheds are an integral component of the California Floristic Province, one of 25 biodiversity hotspots of global importance for conservation of species (Myers et al. 2000, Healy et al. 2016). Because it is located at the confluence of California’s two largest rivers, the Delta serves as a key migration corridor for many fish and wildlife species. All Central Valley anadromous fish species migrate through the Delta, as adult fish return to their home rivers and streams to spawn, and juveniles migrate out to the ocean. The Delta also serves as important juvenile fish rearing habitat. For example, Chinook salmon and steelhead juveniles depend on the Delta as transient rearing habitat while they migrate to the ocean. The juvenile anadromous fish can remain in the Delta for several months, feeding in marshes, tidal flats, and sloughs. Other fish species, including the native delta smelt, longfin smelt, and Sacramento splittail, are year-long Delta residents. The Delta also serves as a critical link between Sacramento Valley and San Joaquin Valley terrestrial wildlife populations. The Delta and its watershed provide a unique habitat resource for more than 200 species of marine and freshwater fish, as well as millions of migratory waterfowl and other migratory and resident birds (Council 2018, Appendix Q4). Delta waterways help support California’s $1.5

billion commercial and recreational fishing industries (TNC 2017). Maintaining the Delta ecosystem is critical for supporting the 80 percent of commercial fishery species that migrate through or live in the Delta (Water Education Foundation 2019).

WHAT DOES IT MEAN TO ACHIEVE THE COEQUAL GOAL OF PROTECTING, RESTORING, AND ENHANCING THE DELTA ECOSYSTEM?

Achieving the coequal goal of ecosystem protection, restoration, and enhancement means successfully establishing a resilient, functioning estuary and surrounding terrestrial landscape capable of supporting viable populations of native, resident and migratory species with diverse and biologically appropriate habitats, functional corridors, and ecosystem processes (23 California Code of Regulations section 5001[h][2]).

As defined in the Delta Plan, the term *restoration* means:

> *"the application of ecological principles to restore a degraded or fragmented ecosystem and return it to a condition in which its biological and structural components achieve a close approximation of its natural potential, taking into consideration the physical changes that have occurred in the past and the future impact of climate change and sea level rise" (California Water Code section 85066, see also 23 CCR section 5001[bb]).*

Restoration actions may include restoring interconnected habitats within the Delta and its watershed, restoring more natural Delta flows, or improving ecosystem water quality (23 CCR section 5001[bb]). This, in turn, can lead to species recovery.

Protection means "*preventing harm to the ecosystem, which could include preventing the conversion of existing habitat, the degradation of water quality, irretrievable conversion of lands suitable for restoration, or the spread of invasive nonnative species*" (23 CCR section 5001[z]).

Enhancement means "*improving existing desirable habitat and natural processes*" (23 CCR section 5001[o]). For example, enhancement includes flooding the Yolo Bypass more often to support native species or to expand or better connect existing habitat areas. Enhancement also includes many fish and wildlife management practices, such as managing wetlands for waterfowl production or shorebird habitat, installing fish screens to reduce entrainment of fish at water diversions, or removing barriers that block migration of fish to upstream spawning habitats (23 CCR section 5001[o]).

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The Delta's Historical Ecology

The pre-1849 Delta and Central Valley supported extensive wetland, riparian, and grassland ecosystems which provided habitat for more than 750 species of plants, fish, and other wildlife (Healy et al. 2008, Healy et al. 2016). These ecosystems produced significant organic carbon through a process known as primary production, providing energy to support the Delta food web (The Bay Institute 1998). The dynamic nature of salinity within the Delta supported a resident fish community which included both brackish-water and freshwater species (The Bay Institute 1998).

Through the early 1800s, 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 (see Figure 4-1). Delta river and tidal channel flows varied by season and year to year, sometimes pouring from the Sierra in great floods whose fresh waters overflowed wetlands and floodplains, and at other times declining as droughts shriveled rivers and brackish tidewaters pushed inland. The Delta's historical landscape also varied from north to south. In the north Delta, flood basins occurred where the Sacramento River intertwined with tidal channels. A vast area of freshwater wetlands dominated by tules transitioned into tidal wetlands. Shallow perennial ponds and lakes, broad riparian forests along natural levees, and seasonal wetlands at the upland edge were also common. The central Delta was characterized by large, tidal islands that flooded during spring tides, or more frequently, were intersected by networks of branching tidal channels. Low channel banks were covered by the willows, grasses, sedges, and shrubs that also grew in island interiors. The south Delta contained a complex network of channels formed predominantly by riverine processes. The floodplain was comprised of emergent wetlands, perennial and seasonal ponds, willow thickets, and seasonal wetlands. Driftwood and other woody debris, from riparian forests along the rivers, filled some channels.

Historical records describe a rich and complex Delta with habitats supporting diverse and abundant native plants and animals (Grossinger et al. 2010, Whipple et al. 2010, San Francisco Estuary Institute (SFEI) 2012). Some fish, including delta smelt, schooled in the open waters of bays and channels in the western Delta, moving east when brackish water intruded from San Francisco Bay. Other resident wildlife and plants also prospered: native birds such as rails in tidal and tule marshes; giant garter snakes in freshwater wetlands and ponds; and riparian brush rabbits and riparian woodrats in willow thickets and riparian forests. Each fall, salmon and steelhead, drawn by the swelling Sacramento and San Joaquin Rivers, migrated inland from the ocean and navigated upstream to spawning areas in tributaries. As river flows receded, their offspring, emerging from the tributaries' spawning gravel, would return downstream and shelter in driftwood-lined eddies or undercut riverbanks, feeding in Delta sloughs, marshes, and floodplains before returning to the sea. Waterfowl, cranes, and shorebirds migrated through the Delta along a north-south route stretching from the Arctic to Mexico or beyond. Songbirds followed a similar path through connected riparian woodlands from the Sacramento Valley through the Delta to the San Joaquin Valley.

Indigenous peoples have lived in the Delta for thousands of years, and they made use of many Delta plant, animal, and mineral resources (Helzer 2015). Research over the past several decades has revealed extensive indigenous knowledge of the use of burning to manage the Delta landscape. Indigenous peoples used burning to maintain grassland cover and forage for animals, to improve seed and acorn access, to aid in hunting small game, to control chaparral distribution, and to reduce pathogens and parasites such as ticks (Anderson 2005, Keeley 2002). Euro-American settlement of the Delta had a devastating effect on the area's tribes, and led to the 1833 epidemic, which, according to some estimates, may have resulted in the death of 75 percent of the region's indigenous peoples (Castillo 1978, Cook 1955). This loss of native populations on the land effectively ended wide-scale indigenous landscape management by the mid-nineteenth century. However, indigenous peoples continue to maintain strong relationships with Delta lands, waters, and organisms (Hankins 2018).

EXAMPLES OF HISTORICAL DELTA ECOSYSTEMS

While the Delta will never be restored to historical conditions, a few examples still exist of the historical Delta ecosystem that support native species and that are functioning similarly today as they did historically. These remnants have been protected, restored and/or enhanced, and they provide examples of what restored Delta landscapes may look like:

- **Tidal wetlands** at Rush Ranch possess a largely intact prehistoric marsh form, high levels of hydrogeomorphic complexity, habitat for rare and endemic plants, and a gradual transition between the marsh and undeveloped upland grasslands (Whitcraft et al. 2011). These wetlands have branching channels that support native tidal vegetation. Although an estimated 27 percent of the current estuarine wetland plants at Rush Ranch are nonnative (Whitcraft et al. 2011), the site provides habitat for several rare plant species including Suisun thistle, Suisun marsh aster, and Jepson's Delta tule pea. Rush Ranch is owned and managed by the Solano Land Trust.
- **Riparian floodplain** at the Tall Forest on the Cosumnes River is an example of a late-successional riparian forest with a canopy height of up to nearly 100 feet. This 100-acre parcel is one of the few areas that to some extent resembles the pre-European Central Valley riparian forests. Most of the forest is about 75 years old. Over 200 bird species have been recorded in this area and a high bird-species diversity is well-documented (Nur et al. 2006). The Tall Forest is owned by The Nature Conservancy and managed by the Bureau of Land Management as part of the Cosumnes River Preserve.
- **Vernal pool grasslands** at Jepson Prairie in the northwest Delta provide an example of a Delta landscape that still has largely intact topography, hydrology, and soils. Although the upland grassland is now mostly dominated by nonnative plant species, the numerous vernal pools support a high diversity of native plant species, and provide habitat for unique, rare and imperiled plant and wildlife species, such as Solano grass, Colusa grass, the Delta green ground beetle, and Conservancy fairy shrimp. The Jepson Prairie Preserve is owned and managed by the Solano Land Trust.

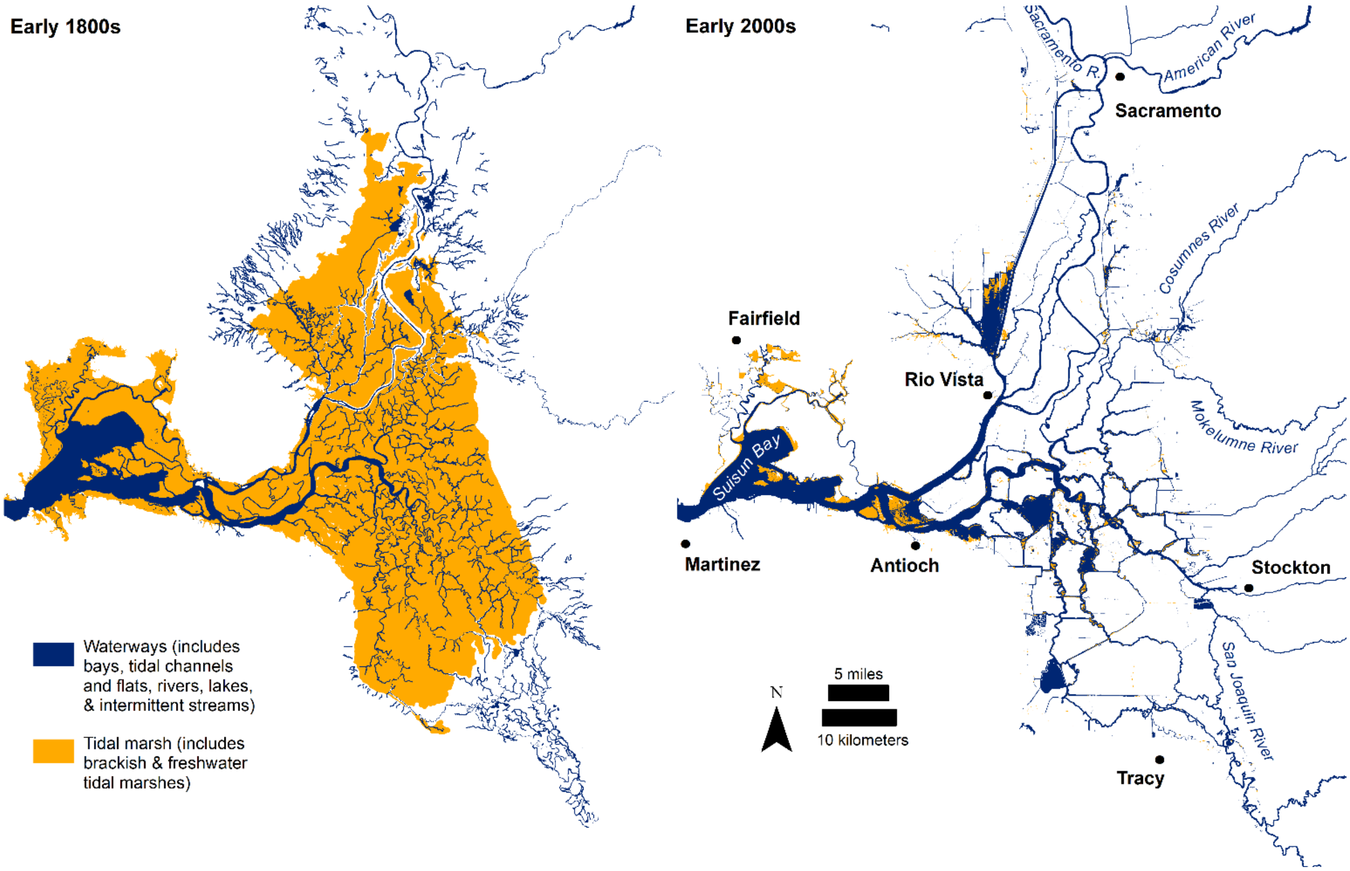

Figure 4-1. Comparison of Historical (Early 1800s) and Modern Delta Waterways

Figure 4-1 shows two maps side by side. The map on the left depicts the extent of the historical Delta (early 1800s) waterways and tidal marsh habitat; the map on the right depicts the extent of the modern Delta (early 2000s) waterways and tidal marsh habitat. These side-by-side maps compare the historical (early 1800s) and modern (early 2000s) Delta waterways and tidal marsh habitat. The waterways are depicted in dark blue and the tidal marsh habitat is depicted in orange. Both maps cover the same territory, extending 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. Depicted waterways include bays, tidal channels and flats, rivers, lakes, and intermittent streams. Depicted tidal marsh habitat includes brackish and freshwater tidal marshes. The historical Delta map shows that through the early 1800s, 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. The modern Delta map shows major changes to the waterways and tidal marsh habitat, such as channel widening, meander cuts, cross levees, and loss of within-island channel networks and tidal wetlands. The historical Delta map shows that historical tidal wetland extended over the majority of the Delta. The modern Delta map shows that modern tidal wetland extent is limited to scattered patches, with the largest patches located in the Suisun Marsh and western Delta. Please contact the Delta Stewardship Council with any questions regarding this figure.

Source: SFEI 2012

The State of the Modern Delta

The current state of the Delta ecosystem has been severely affected by loss of natural communities, loss of land-water connections, and alteration of hydrology. These stressors have caused a loss of ecosystem function, imperiling many native species and decreasing their resilience to other stressors such as nonnative invasive species, predation, and climate change. A full list of endemic and native species of concern is provided in Appendix Q4. Major causes for ecosystem decline discussed in this section include: large-scale conversion of wetlands to other land uses, widespread construction of levees, simplification of open water habitat, land subsidence, decline in primary productivity and food-web structure, invasive species, predation, decline of native species, and deterioration of water quality.

Loss and Modification of Natural Communities

Humans have physically transformed the Delta landscape over the past 160 years, resulting in the near total conversion of wetland, riparian, and floodplain ecosystems. Large-scale levee construction, draining of wetlands, forest clearing, and grazing began in the early 1850s. Many of the levees were raised to keep floodwaters from entering uplands, even though the subsequent higher flood levels resulted in increased flooding of unprotected lands (Gilbert 1917). As a result, approximately 95% of the native ecosystems and vegetation communities were lost in the late 1800s and early 1900s (Thompson 1957, Bay Institute 1998, SFEI 2014). The loss of natural land cover has limited the capacity of the landscape to meet the life history requirements of fish and wildlife populations. The loss of riparian and wetland vegetation, and construction of fish migration barriers have significantly limited the space on the landscape which can serve as species habitat (DWR 2014, SFEI 2016).

Draining and farming the Delta's historical wetlands also exposed the Delta's peat soils to oxidation, compaction, and wind erosion, resulting in widespread land subsidence. Soil oxidation in the Delta is a major land-based contributor to carbon emissions in California (ARB 2018). Because of historic and ongoing subsidence, much of the Delta lies substantially below mean sea level—by as much as 26 feet in the interior Delta (Mount and Twiss 2005). Land elevations that are below sea level, combined with the future impacts of sea level rise, make much of the Delta vulnerable to catastrophic flooding. Current elevations also limit opportunities to reconnect historical tidal plains to channels, because wetland plants will only become established when land elevations fall within the tidal range. Many Delta islands lie well below intertidal elevation and, if flooded, would become deepwater habitat (as happened with Franks Tract and Mildred Island) instead of tidal marsh. The widespread conversion of the Delta's natural communities has had several interrelated consequences for the Delta ecosystem. Those consequences include: 1) a reduction in habitat extent, 2) loss of habitat diversity, 3) loss of connectivity within and among habitat types, 4) degradation of habitat quality, and 5) disconnection of habitats from the physical processes that form and sustain them (SFEI 2014).

Tidal wetlands in the modern Delta no longer span broad continuous gradients; instead they persist as isolated narrow patches (Figure 4-1). The small size of these existing tidal wetland patches severely limits the wildlife populations that can be supported. The few remaining wetland patches are often quite isolated from one another, creating challenges for marsh-dependent species to move between patches. The habitat quality of these marsh patches is also further degraded by the effects of invasive species, impaired water quality from urban and agricultural runoff, and a decline of sediment input from the upper watershed as a result of dams (SFEI 2014).

The area of valley foothill riparian forest in the modern Delta has been estimated to be reduced by more than 70 percent compared to the historical Delta, consequently leading to a substantial decline of the ecological functions provided by large, interconnected riparian corridors. A key factor in the decline of riparian forests in the Delta is that they are often physically disconnected from rivers by constructed levees, and they are thereby isolated from the physical processes that created and sustained them. The riparian communities in the Delta that remain are now largely narrow, isolated patches, representing a loss in connected corridors that are important for movement and migration of many wildlife species (SFEI 2014). Wildlife living in most woody riparian patches is subjected to the effects of diminished patch size, severed connections, and increased threats from the surrounding landscape (Weins et al. 2016).

The geometry of the Delta's main tidal channels has also been highly modified since the mid-1800s (Figure 4-1). Most of the channels in the modern Delta are lined with steep, constructed levees armored with bank protection (e.g., riprap) which isolate the channel from adjacent habitats and prevent the channel from naturally meandering and shifting course over time. The large channels of the Delta were straightened with meander cutoffs, as well as dredged and widened to facilitate navigation through the Delta. These modifications created channel networks with more homogenized abiotic conditions (e.g., salinity, temperature, nutrients, etc.) which reduced the ability for native fish to find and remain within areas with preferred habitat conditions (SFEI 2014). The altered geometry of the Delta channels also tends to flush water through the Delta more quickly, compared to historical conditions when water slowed down within highly sinuous channels and regularly overflowed laterally onto tidal wetlands and seasonal floodplains. These changes often contribute to higher average velocities and lower residence times, consequently inhibiting primary productivity of the aquatic food web.

While estuarine ecosystems are typically associated with high rates of primary productivity, a function of the variable freshwater-marine interface, the estimated amount of phytoplankton production in the modern Delta ranks among the lowest 15 percent of the world's estuaries (Cloern et al. 2014). The reduction of flow and land-water connectivity in the modern Delta, coupled with the landscape-scale loss of wetland and riparian vegetation communities, has greatly reduced the function of the base of the Delta food web (Cloern et al. 2016). Most shallow aquatic habitat in the Delta is now distributed along the edges of large channels and flooded islands—adjacent to large areas of deep water—in contrast to the shallow, branching channels and tidal wetlands that characterized the historical Delta (SFEI 2014). This arrangement has created an aquatic environment with lower residence time and higher velocities of water, resulting in lower phytoplankton primary productivity and lower food web support. Lack of primary production has been identified as one cause of decline for the endangered delta smelt population (Cloern et al. 2016). Lack of primary production has been identified as one cause of decline for the endangered delta smelt population (Cloern et al. 2016). The gradual transition zone between marsh and terrestrial habitats, which supported many species, has been lost. The transition zone has been replaced by fragmented and narrow patches of terrestrial habitat on the Delta's edge that provides fewer opportunities for foraging, cover, and movement of fish and wildlife species (SFEI 2014, Cloern et al. 2016).

The impact to the Delta's aquatic food web from changes in the Delta landscape has been compounded by the introduction of two nonnative invasive clam species—the overbite clam (*Potamocorbula amurensis*) and Asian clam (*Corbicula fluminea*). Both species are documented to be such effective filter feeders that they can greatly reduce phytoplankton biomass, thereby shrinking the base of the food web for the entire aquatic ecosystem. The effect of these two nonnative species is contributing to decreased populations of many previously common fish species—both native and introduced—a phenomenon known as the Pelagic Organism Decline (POD) (Sommer et al. 2007).

Alteration of Delta Hydrology

In addition to land elevation, water flows and associated water levels are key drivers of habitat conditions and species dynamics within the Delta landscape. Within the northern, eastern, and western Delta, along the major river channels, high flows and resulting high water levels can seasonally inundate floodplains, temporarily converting terrestrial habitats into aquatic habitats. Freshwater flows are also a major source of sediment input to the system, which helps build up and maintain tidal marshes. Additionally, flows influence salinity in the Delta, especially in the central and western Delta, which directly influences where many species are found.

Delta ecosystem health is strongly tied to water supply management in the Delta watershed. The Sacramento and San Joaquin Rivers' flows are highly managed to support agricultural and urban water supply, maintain water quality, and reduce flood risk (see Chapters 3 and 7). Management practices that control releases from upstream reservoirs, for water exports, reduced average annual outflow by approximately 48 percent between 1986 and 2005 (SWRCB 2017). Long-term flow modifications, reflected in these recent management actions, together with highly modified Delta channel geometry, have altered the seasonal flow, salinity, and sediment regimes in the Delta (Wright and Schoellhamer 2004, Enright and Culberson 2010) to the detriment of native species. Natural seasonal and year-to-year variability of river flows has given way to more stable, artificially regulated conditions.

Flows have been modified at the expense of maintaining natural estuarine processes. For example, low winter-spring flows disrupt turbidity and salinity cues for migrating fish (Grimaldo et al. 2009), reduce access to spawning and rearing habitats in tributaries and floodplains (Sommer et al. 1997, Feyrer 2004, Feyrer et al. 2007), and limit success for young fish that are unable to follow natural migration patterns (Feyrer and Healy 2003). The dams used to regulate flows for water supply and flood management purposes also create fish migration barriers and block access to spawning areas critical to salmonids, Sacramento splittail, and other native fish.

Less variable flow conditions also create improved habitat conditions for nonnative invasive species. Introducing nonnative species directly and indirectly affects native species populations through predation and competition for limited resources (NMFS 2009, Buchanan et al. 2013, Healey et al. 2016). While most new species introduced to the Delta system arrive unintentionally, nonnative species have also been intentionally introduced in the past. For example, many nonnative fishes were introduced into the Delta ecosystem for sport fishing, as forage for sportfish, for human food use, and due to the release of aquarium species (Moyle 2002). Nonnative invasive plants in stream channels, wetlands, and riparian areas have also contributed to losses in biodiversity, ecosystem function, and habitat quality (Blank and Young 2002, Reynolds and Boyer 2010, SFEI 2014). Reduced variability of salinity has also allowed for nonnative species to thrive in areas where they were not historically dominant (Nobriga et al. 2008.

In addition, flow paths through the Delta have been highly simplified because of channel cuts, channel straightening, and widening (also described as “over-connectedness”). As described previously, the altered channel geometry reduces overall residence time of tidal flow and diversity of flow patterns and water quality. The South Delta diversions also cause reverse flows in the Old and Middle River, causing entrainment of fish and other aquatic organisms at the export pumps. Lastly, the large dams at the rim of the Central Valley disconnect anadromous fish from their historical spawning habitats above the dams, greatly curtailing their opportunities to spawn in the river.

Ecosystem Resiliency and Climate Change Adaptation

Climate change will have major implications for the future of the Delta ecosystem. It will lead to increased temperatures, changing precipitation and runoff patterns, increased frequency of extreme weather events, and rising sea levels (see “Climate Change” section on page 4-15 for specifics on how climate change will influence the Delta). As described in Chapter 3, these climatic trends must be accounted for in both water management and ecosystem sustainability strategies to improve system robustness and resiliency (Jenkins et al. 2004, Opperman et al. 2009, Cahill and Lund 2013, Kiparsky et al. 2014, Null et al. 2014, Lund 2015, Dettinger et al. 2015, Dettinger 2016).

Although climate change will affect many of the Delta's resources, a restored Delta can provide future climate change refugia in California's Central Valley, buffering climate change impacts in a manner that enables the persistence of valued physical and ecological resources (Morelli et al. 2016). Because of its proximity to the ocean, the Delta is projected to be one of the coolest regions in the Central Valley, cooler than average by about 2°F (Dettinger et al. 1995, Cal-Adapt 2017). In fact, inland warming may enhance the Delta's cooling breezes (Lebassi et al. 2009). Since wetlands and riparian areas possess higher water content compared to most upland areas, they absorb relatively more heat and can buffer against extreme high temperatures (Seavy et al. 2009).

Tidal wetland restoration is expected to increase the availability and quality of food resources for native fish. Improved prey availability and diet quality can effectively increase the optimal growth temperature and thermal tolerance range for fish. Increasing the extent of riparian habitat throughout the Delta, specifically large woody riparian vegetation which overhangs and shades water from direct sunlight, would also help to lessen the effects of climate change on increasing water temperatures (Davenport et al. 2016). Additionally, riparian habitat helps to recharge groundwater, and the reemergence of cooler groundwater into warmer surface waters creates important microhabitats of cooler water temperatures (Seavy et al. 2009).

The locations and extent of tidal marshes in the Delta will inevitably shift as sea levels rise. Tidal marshes respond to rising sea levels by accreting soil matter to build up the elevation of the marsh. It is currently uncertain how long tidal marsh accretion rates in the Delta will be able to keep pace with future rates of sea level rise. If accretion does not build sufficient material to keep pace, marshes can migrate to adjacent areas of higher elevation. However, in the current Delta landscape many existing marsh patches are blocked from migrating upland by levees, roadways, or other infrastructure (Orr and Sheehan 2012, Dettinger et al. 2016). Species that depend on tidal marshes, such as the saltmarsh harvest mouse in Suisun Marsh or black rail in the Delta, are therefore at risk of losing their habitat due to sea level rise.

Inundation of seasonal floodplains was historically tied to large precipitation events or spring snowmelt. With climate change, floods in the Delta are likely to increase in frequency and intensity of peak flows but decrease in total duration. The construction of flood management infrastructure, such as dams, levees, and weirs, reduced floodplain inundation width and extent, increased floodplain depth, and shortened inundation duration. The vast historical floodplains of the Sacramento and San Joaquin Rivers and their tributaries provided native species with an extensive, connected landscape with opportunities to access suitable floodplain habitat and refuge from high flow conditions. With the disconnection of floodplains from channels, the access to suitable floodplain habitat has become much more limited. This limitation will be magnified with increased and more frequent flood flows resulting from climate change, making opportunities to access shallow, low-velocity floodplain habitat and refuge from high flow conditions even more limited. Reduced frequencies of long-duration inundation of the floodplain is expected to reduce the spawning success of native floodplain-dependent species like Sacramento splittail. Floodplain restoration would improve access for native species to low-velocity floodplains and flood refugia habitats, making the ecosystem more resilient to increased flooding by allowing native species to adjust to changes in water levels. Restoring seasonal floodplain functions would help to lessen the impact of more frequent extreme floods anticipated from climate change that can potentially damage downstream habitats.

Climate change is likely to result in salinity intrusion inland into the Delta because of sea level rise and net reductions in freshwater inflow. In addition to rising sea levels, the amount of ideal low-salinity habitat for native fish such as the longfin and delta smelts will be affected by changes in runoff timing and intensity. All of these factors will alter the location and the extent of the area in the Delta and Suisun Marsh where habitat is suitable for fish species with specific salinity needs or tolerances.

Native fish species which require cold water (below 71.6°F) may suffer as a result of climate change as water temperatures rise, because they exhibit lower physiological tolerances for elevated water temperatures compared to nonnative fish species introduced from areas where temperatures are warmer than those found in the Delta (Davis et al. 2019). Restoration planning may warrant opening up more downstream (seaward) habitat, where water temperatures are naturally cooler and could potentially be less favorable to nonnative fish that have limited tolerance for higher salinity (e.g., largemouth bass). Maintaining the viability of Chinook salmon and steelhead in Central Valley rivers in the face of climate change may require re-establishing connectivity to cold water habitats in upper watersheds that are currently blocked by major dams since there may be less future flexibility to operate reservoirs to manage flow releases that protect downstream populations of native fish. Larger storms may force flow releases for flood safety purposes and smaller winter snowpacks caused by warmer, wetter winter storms may reduce the ability to replenish reservoirs during the dry season.

Warmer water temperatures will likely prompt more frequent blooms of the freshwater cyanobacteria Microcystis, which produces toxins harmful to fish. It is also expected to lead to more rapid growth of certain undesirable nonnative plants, such as water hyacinth, which grows more rapidly in warmer temperatures. For land-based wildlife and vegetation communities, higher air temperatures could lead to drier soil conditions, change plant community composition, and even disrupt timing between pollinators and plants. Past modifications and ongoing stressors have reduced the resilience of the Delta ecosystem and limited its ability to adapt to the anticipated effects of climate change.

CLIMATE CHANGE

The effects of climate change will have major implications for the future of the Delta ecosystem. Climate change is expected to have the following four effects on the Delta ecosystem: increased temperatures, altered precipitation and runoff patterns, increased frequency of extreme weather events, and sea level rise. The implications for the Delta ecosystem are summarized below:

Increased Air and Water Temperatures

- Increased moisture loss from evaporation and transpiration by plants, contributing to decreased river inflows, especially during summer
- Increased frequency of summer heat stress on cold water-adapted species
- More hospitable habitat for nonnative species adapted to warmer climates

Altered Precipitation Patterns

- Runoff earlier in the wet season, and decreased dry-season flow from reduced snowpack
- Decreased duration of peak flows
- Reduced occurrence of long-duration seasonal floodplain inundation

Increased Frequency of Extreme Weather Events

- Increased frequency of larger, warmer storms
- Increased frequency of floods and droughts
- Increased sedimentation from extreme flood events and decreased water quality during droughts

Sea Level Rise

- Increased tidal water levels
- Increased salinity intrusion into the Delta
- Reduction in freshwater Delta habitat and an increase in saline Delta habitat
- Reduced growth rate of submerged vegetation

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A Call for Action

The rapid and drastic transformations of the Delta landscape in the mid-1800s had significant effects on the native fish and wildlife species within the Delta and its watershed. Some modifications occurred in the past, such as agricultural and urban development, channel modification, and construction of levees and water management infrastructure. Other factors are ongoing, such as the proliferation of nonnative species in the Delta and Suisun Marsh, and degradation of water quality due to pesticide use and nutrient inputs. Still other factors are expected to increase stress on the Delta in the future, such as new and emerging contaminants, sea level rise, and other consequences of climate change. These changes demand that successful habitat restoration focuses on providing greater habitat resiliency, allowing native species to maintain thriving populations in the face of these environmental changes.

Although projects are underway to alleviate some of these stressors (e.g., improved wastewater treatment at the Sacramento Regional Wastewater Treatment Plant and large-scale habitat restoration projects), the challenges faced by the Delta's native species are expected to continue into the foreseeable future. More than 230 species within the region are special-status species (DWR 2013a). Large-scale habitat loss or degradation likely has resulted in extirpation of regional native species populations from the Delta, such as the Sacramento perch (Moyle 2002), and especially of species that are habitat specialists; while some species could face extinction in the wild (e.g., delta smelt and winter-run Chinook salmon). This has led to protections for scores of plant and wildlife species under federal and state laws and regulations. Past species-specific conservation efforts (e.g., what has largely occurred with implementation of the federal endangered species act) have been extremely effective at preventing extinction of species placed under its protection, but limited in prompting recovery of these same species (Taylor et al. 2005, Schwartz 2008). In recent decades, the focus for conservation efforts have broadened beyond single-species management to specifically considering benefits of managing entire communities and ecosystems for broader benefits.

A portfolio of approaches is necessary to manage ecosystems in highly altered and changing landscapes (Hobbs et al. 2014). These approaches include protecting existing ecosystems, restoring ecosystems, and enhancing working or urban landscapes that provide habitat resources to select species (Bay Institute 1998, Moyle et al. 2012, SFEI 2016). These approaches have varied potential to reestablish ecological processes in natural communities at a sufficient scale (and with connectivity, complexity, and diversity) to be resilient to land conversion and climate change. Given the urgency to improve the ecosystem, restoration should be prioritized in locations where it is possible to restore ecosystem function, while ecosystem protection and enhancement activities continue in other locations (Appendix Q3). Restoration involves the process of assisting the recovery of an ecosystem that has already been degraded, damaged, or destroyed, and works in tandem with ecosystem preservation by expanding ecological functions of the preserved ecosystems (Society for Ecological Restoration International 2004, McDonald et al. 2016). Whether implemented as the primary purpose of a project or as mitigation, restoration activities should be planned and designed to contribute effectively to restoring ecosystem function within the Delta. Preservation requires reserving space on the landscape to protect the ecological processes and natural communities which remain present. Unfortunately, given how altered the Delta landscape is, few opportunities for preservation remain.

Further, as described in Chapter 3, there are conflicts between water operations for ecosystem management (temperature and flow variability), water quality (both in-Delta and for water exported from the Delta), and water supply reliability. These conflicts are magnified during critically dry periods and periods of lower flow—when the ecosystem is already stressed, and water suppliers are most vulnerable to shortages. Implementation of Delta Plan recommendations related to improved water conveyance and storage infrastructure and operational flexibility (addressing the timing of water movement through the Delta), combined with investments in regional self-reliance, are important parts of the portfolio of actions needed to support ecosystem restoration in the Delta.

A key component of effective restoration is reestablishing fundamental physical processes (e.g., geomorphic, chemical) which are key drivers of ecological functions such as vegetation succession or food-web function (Larsen and Greco 2002; Greco et al. 2007, Cloern et al. 2016). Reestablishing both physical and biological processes is commonly termed *process-based-restoration*, and is key to the composition and structure of vegetation communities and meeting habitat needs of sensitive species. In areas where process-based restoration is not feasible (e.g., deeply subsided areas of the Delta), there can be opportunities to enhance conditions on working landscapes, such as farmland, to benefit certain native species. For example, flooding grain crop residues during the winter, following harvest, can produce beneficial habitat conditions for migrating sandhill cranes.

Within the restoration science community there is an emerging emphasis on the importance of implementing process-based restoration because such actions address the fundamental causes of degradation of the ecosystem, rather than the symptoms (Beechie et al. 2010, Greco 2013, Wiens et al. 2016). Part of the motivation for that shift is a recognition that past restoration actions relied too heavily on engineered solutions to provide specific habitat features for particular species (e.g., placing gravels in reaches to expand salmon spawning habitat) and often provided limited benefits because they ignored larger environmental drivers (e.g., the reason why the reach did not already have spawning gravels) (Beechie et al. 2010). Process-based restoration requires input from experts in a wide array of science and engineering disciplines (such as hydrology, geomorphology, geology, and botany). Active adaptive management that incorporates explicit experimentation should be a key component of process-based restoration projects. Although restoration in the Delta has been planned for decades, implementation of large-scale, process-based restoration projects has only been initiated recently, which underscores the importance of monitoring and adaptively managing those projects.

The Delta Reform Act requires that the ecosystem be protected, restored, and enhanced in a way that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place (California Water Code section 85054). Discussions regarding the future management of the Delta have often been unproductive because of a perceived conflict between social and ecological objectives, due to differing cultural perspectives on the value of nature (Milligan and Kraus-Polk 2017). While some perspectives believe that nature should be protected simply because it has intrinsic value, or because there is a sacred or cultural connection with the land (Yocha Dehe Wintun Nation 2015), others, such as utilitarian perspectives, only value the raw materials and resources that can be extracted from nature. Yet even utilitarian perspectives must recognize that the natural environment produces tangible social benefits, and that humans depend directly on the biological integrity of our natural landscapes to provide ecosystem services (Costanza et al. 1997, Postel and Carpenter 1997). Ecosystem services are the economic benefits that society derives from ecosystem processes, including pollination (which supports food production), primary production (which supports fisheries), soil formation (which builds land elevation and sequesters carbon), and water storage and regulation (which can mitigate flood peaks) among other relationships (Costanza et al. 1997). The Delta's agricultural economy, and cultural and recreational traditions, depend on these processes derived from the continued functioning of the Delta and its connected ecosystems. The meaningful benefits that society gains from a healthy ecosystem should inform decision-making concerning tradeoffs between land use and economic growth (Suding et al. 2015, Wiens et al. 2016).

Vision for a Restored Delta Ecosystem

Achieving the coequal goal of ecosystem protection, restoration, and enhancement means successfully establishing a resilient, functioning estuary and surrounding terrestrial landscape capable of supporting viable populations of native resident and migratory species with diverse and biologically appropriate habitats, functional corridors, and ecosystem processes. Ecosystem function, in this context, represents the full range of physical and biochemical processes that sustain an ecosystem over time and space (Naeem and Wright 2003), including the processes that sustain a native species assemblage in a particular area over time. Ecosystem functions include not just biological processes, such as biomass production, food web support, and biodiversity support, but also biogeochemical processes, such as nutrient cycling.

The Delta Reform Act's definition of restoration recognizes that the ecosystem will be dynamic, changing in response to restoration actions and future climate change (California Water Code section 85066, Healey et al. 2008, Delta ISB 2011).

The Delta Reform Act calls for the Delta Plan to provide a long-term vision for restoring interconnected habitats within the Delta and its watershed by 2100 (California Water Code section 85302[e][1]). The Council envisions a future in which the Delta ecosystem has the following characteristics:

- Native species, including algae, plants, invertebrates, fish, birds, and other wildlife, are self-sustaining and persistent.
- The tidal channels and bays in the Delta and Suisun Marsh connect with tidal wetlands, freshwater creeks, upland grasslands, and woodlands. The Sacramento and San Joaquin Rivers and other Delta tributaries include reaches where streams are free to meander and connect seasonally to functional floodplains.

- Habitats for native resident and rearing migratory fish, birds, and upland wildlife are connected by aquatic and terrestrial migratory corridors, including areas with high-quality plant cover and feeding opportunities.
- More natural variations in water flows and conditions make aquatic habitats, tidal marshes, and floodplains more dynamic; encourage survival of native species; and resist invasions by weeds and animal pests.
- The ecosystem is resilient enough to absorb and adapt to current and future effects of multiple stressors without significant declines in ecosystem services.
- The Delta will provide more reliable water supplies, in part because survival of its wildlife, fish, and plants do not require extraordinary regulatory protection.
- Californians recognize and celebrate the Delta's unique natural resource values through wildlife observation, angling, waterfowl hunting, and other outdoor recreation.

A restored Delta ecosystem depends on a future in which large-scale interconnected natural communities, characterized by land-water connections and natural vegetation, support productivity and biodiversity of native species that persist over long periods of time. This occurs at a scale needed to meet or exceed the goals in existing species recovery plans and state and federal goals with respect to doubling the population of salmon (California Water Code section 85302[c][5]). Restored habitat and agricultural landscape elements will coexist within an evolving landscape whose course of gradual change depends on their location. This vision depends on effective contributions from all restoration activities, including mitigation and recovery plans. Currently 14 recovery plans, conservation strategies, and species-specific resiliency plans provide specific guidance on the level of ecosystem restoration needed (Council 2018, Appendix Q4). These strategies and plans collectively address 121 of the most imperiled species, and considered together, provide the best available understanding of an ecosystem-based restoration target (PPIC 2013). It is currently estimated that it will take approximately 60,000-80,000 acres of net new functional, diverse, and interconnected habitat to achieve the fully restored Delta landscape envisioned in the Delta Reform Act. This estimate is comprised of multiple landforms and vegetation communities, and is based on a review of current planning and management efforts, including recovery plans, conservation strategies, and species-specific resiliency plans intended to benefit conditions for native species found in the Delta.

The future Delta will differ both from the Delta that greeted the first Californians and from the current ecosystem. Not every native species or natural area now found in the Delta may persist through the changes ahead, including climate change. The survival and recovery of native species, and the level of benefits provided by the Delta ecosystem, are dependent in part on the actions that Californians are willing to take to restore the Delta ecosystem.

WHAT COULD A RESTORED DELTA LOOK LIKE?

The Delta Reform Act calls for the Delta Plan to provide a long-term vision for restoring interconnected habitats within the Delta and its watershed by 2100 (California Water Code section 85302[e][1]). But this vision, and how it is achieved, may vary within different regions of the Delta.

The Cosumnes River Preserve, which partially overlaps with the northeastern portion of the Delta, provides a case study for the potential outcome of a concerted effort to preserve and restore large patches of natural lands over the course of multiple decades. The Nature Conservancy and Ducks Unlimited established the Cosumnes River Preserve in 1987 to protect more than 1,000 acres of riparian habitat along the Cosumnes River corridor, which has uniquely large stands of remnant valley oak riparian forests and an intact flow regime. The Preserve now consists of over 50,000 acres of wildlife habitat and agricultural lands that are owned by seven different Preserve Partners: U.S. Bureau of Land Management (BLM), California Department of Fish and Wildlife, California Department of Water Resources, California State Lands Commission, Sacramento County Regional Parks, The Nature Conservancy, and Ducks Unlimited. The long-term vision of the partnership is to establish the permanent protection of a continuous riparian corridor extending from the Cosumnes River headwaters to the Delta, including adjacent floodplain and wetland habitats and a vast vernal pool grassland complex.

The Preserve Partners work together to implement conservation measures that preserve and restore natural lands in a manner that integrates agricultural lands and practices. Six of the Preserve Partners are signatories to a Cooperative Management Agreement, which defines the process through which they coordinate ownership and management activities, and the authority each has to do so. For example, the Cooperative Management Agreement commits the BLM to providing a wetland manager position and a preserve manager position to coordinate all restoration and land management activities, funded jointly by multiple Preserve Partners. Much of the area along the lower 14 miles of the Cosumnes River is protected within the Cosumnes River Preserve, including approximately 70 percent of the existing riparian forest, and about 45 percent of the total existing and restorable riparian habitat. Many of the habitat improvements along the Cosumnes River have resulted from a combination of significant levee breaches that have occurred both naturally or intentionally. For example, in 1985, flooding resulted in an unintended breach of a levee two miles downstream of Twin Cities Road. The breach resulted in a substantial deposition of sand onto the floodplain and in the establishment of the “accidental forest” which now consists of a rich mosaic of riparian trees. Over time, the Cosumnes River Preserve partners have also conducted intentional breaches of levees to achieve similar results. More recent efforts have focused on restoring tidal wetlands and seasonal floodplains within the lower Cosumnes River, including the Cougar Wetland Restoration Project, the Grizzly Slough Restoration Project, and the McCormack-Williamson Tract Project.

The levee breaches reestablished the connection between channel and floodplain, which, because the Cosumnes River is not regulated by a major dam, has restored the ecological processes of sediment deposition and riparian plant community colonization; allowing native fish species to utilize floodplains and neotropical song bird species to colonize the newly established riparian habitat.

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Figure 4-2. Simulation of Restored Future Delta Landscape

This figure is a simulation of what a restored future Delta landscape might look like. It shows an aerial view of an agricultural landscape interspersed with riparian forest and floodplains that are connected to river channels. Please contact the Delta Stewardship Council with any questions regarding this figure.

Source: SFEI 2016

Core Strategies

The Delta Reform Act calls for the Delta Plan to include strategies to assist in guiding state and local agency actions related to the Delta (California Water Code section 85300[a]). The core strategies described below take a balanced approach to ecosystem protection, restoration, and enhancement by identifying changes that are required of the physical environment to reestablish ecological processes, at large scales, and within complex and diverse natural communities that are connected across the landscape, and that are resilient to threats associated with climate change and other factors. These strategies are interconnected and support one another; they should be implemented in combination with each other to make progress in achieving the objectives for the Delta ecosystem set forth in the Delta Reform Act.

The core strategies describe how successful implementation of restoration actions depends on the ability of local, state, and federal agencies, as well as stakeholders, to coordinate and align activities. The five core strategies described in this section leverage decades of research, recovery planning, and restoration activities to lay out a path forward, increasing coordination and working towards a common vision for a restored Delta ecosystem.

Core Strategy 1: Create More Natural, Functional Flows

The effects of managing the flow of the Sacramento and San Joaquin Rivers vary according to season and region. Low winter-spring flows disrupt turbidity and salinity cues for migrating fish (Grimaldo et al. 2009), reduce access to spawning and rearing habits in tributaries and floodplains (Sommer et al. 1997, Feyrer 2004, Feyrer et al. 2007), and limit success for young fish trying to follow natural migration patterns (Feyrer and Healy 2003). Reverse flows (i.e., net flows traveling upstream) in the southern Delta, due to pumping at the federal Central Valley Project (CVP) and State Water Project (SWP) export facilities, draw fish toward the southern Delta and result in increased entrainment, predation, and ultimately, mortality of endangered or threatened fish species (Grimaldo et al. 2009). Existing flow management practices have also led to more stable hydrological conditions conducive to certain nonnative species. By contrast, native fish communities evolved with seasonal and interannual variations in flows which were formerly present throughout the Delta watershed.

Restoring Delta flows and channels is one the Delta Reform Act’s subgoals to support a healthy ecosystem (Water Code section 85302[e][4]). However, the highly altered landscape in the Delta and its upstream watershed make restoring historical natural flows—similar to those that would have occurred without human development of land and water supply—infeasible (SWRCB 2017). The focus now is on using best available science to understand the functions that flows provide to native species and to manage flows to support the needs of these species throughout their lifecycle. This approach would result in establishment of functional flows that would make the Delta aquatic environment more amenable to native species. A functional-flows approach relies on an understanding of how changes in water movement affect the surrounding landscape and the species that rely on it, such as large floods that scour and maintain channels; flows that create and maintain floodplain connectivity that supports spawning, food production, and rearing; and predictable rates of decline in flow resulting from snowmelt recession (Yarnell et al. 2015, Poff 2017).

KEY COMPONENTS TO A FUNCTIONAL FLOW APPROACH

Recent research (Yarnell et al. 2015) suggests that there are five key components of flow regimes that should be considered as part of a functional flow approach: 1) wet-season initiation flows, 2) peak magnitude flows, 3) spring recession flows, 4) dry seasonal low flows, and 5) interannual variability. Each of these components is described briefly, below.

1. **Wet Season Initiation Flows**. The timing of first increased flows of the wet season, which coincide with storm events in the late fall to early winter period within the Delta watershed, functions to signal the start of an annual shift in riverine conditions. The magnitude of these initiation flows should be able to reestablish connectivity with the riparian zone and to flush out organic matter accumulated in the channel substrate (Yarnell et al. 2015). The first pulse of these increased flows often has higher suspended sediment concentrations because sediment on hillsides and in channels is flushed downstream. This sediment pulse is often an important life-history cue for species (e.g., delta smelt spawning migration). Altering the timing of, or eliminating, this key flow event can be detrimental to the life-history strategies of native species (Yarnell et al. 2015).
2. **Peak Magnitude Flows**. High-magnitude peak flows during the flood season transport a large proportion of a river's annual sediment load and help to restructure the channel and floodplain. These processes are important to trigger a reset in natural processes, such as scouring vegetation that has encroached in the channel, dispersing seeds and fragments of riparian vegetation, enhancing channel and floodplain variability by redistributing sediment, and eliminating nonnative species that are not adapted to such a disturbance regime. Large-magnitude peak flows also facilitate inundation of seasonal floodplains and backwaters for a duration long enough to allow for blooms of phytoplankton, and in turn zooplankton, and successful spawning by floodplain-dependent species.
3. **Spring Recession Flows**. The transition from high flows to seasonal low flows is an important life history cue for many native aquatic species. Gradually receding flows can also be important in redistributing sediments mobilized by high peak flows. They allow for continued sediment movement in deeper channels and gradual deposition within shallower areas. The gradual recession from high flows to low flows also supports completion of biological processes, such as hatching of fish and amphibian eggs in shallow water areas, or germination of riparian plants, before the waters completely recede and the habitat dries out.
4. **Dry Season Low Flows**. A period of seasonal low flows is important to promote habitat variability. Native species which have evolved in the highly variable inter- and intra-annual hydrologic regime that is so common in California are at an advantage compared to nonnative species introduced from systems with more stable conditions. If flows stay constant for too long, it can lead to silt accumulation in the channel bed and less complex channels with a reduced diversity of structural features preferred by native fish and other aquatic organisms.
5. **Interannual Variability**. Variability in the magnitude, timing, and duration of peak and low-flow events regulates aquatic food webs and supports riparian vegetation recruitment and succession. Native aquatic and riparian species are adapted to interannual variability of flows, which supports greater species diversity and resilience to continued alterations in land uses and changing climate conditions.

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More natural flow patterns will not be effective in a channelized and leveed landscape because flow must connect to and interact with land in order to create floodplain habitat and support aquatic primary production. Management of flow patterns must work in tandem with habitat restoration to produce diverse and interconnected food webs, refuge options, and spawning habitat (Carlisle et al. 2010). The large-scale approach to restoration of land-water connections described in Core Strategy 2 would improve the effectiveness of more natural, functional flows in recovering special-status species that depend on marsh and floodplain habitat. As described by the Delta Independent Science Board (ISB), "flow is but one factor affecting fishes" (Delta ISB 2015). As such, a functional-flows approach needs to consider the various components which make up flow, and to evaluate how those flows interact with other environmental factors in particular habitat conditions across the landscape. These factors are balanced using flow objectives for individual waterways to address their unique hydraulic characteristics, public trust values, and specific beneficial uses of water. Development, implementation, and enforcement of new and updated flow objectives for the Delta and high-priority tributaries are key to achieving the coequal goals.

Implement and Regularly Update Flow Guidance

Effectively managing flows to both restore the Delta ecosystem and improve water supply reliability is challenging, because flow-related stressors are likely to increase as population grows and the climate changes. The State Water Resources Control Board (SWRCB) is responsible for preserving, enhancing, and restoring the quality of the state's water resources for the protection of the environment, public health, and beneficial uses. Under this responsibility, the SWRCB prepares and updates the Bay-Delta Water Quality Control Plan (Bay-Delta Plan), which establishes water quality control measures and flow requirements needed to provide reasonable protection of beneficial uses in the watershed (SWRCB 2019). It also places regulatory requirements on water project operations to control salinity levels (caused by saltwater intrusion, municipal discharges, and agricultural drainage) in the system. The SWRCB periodically updates the Bay-Delta Plan to ensure that its flow and water quality standards remain protective of the aquatic ecosystem and also meet human needs, based on the latest data and scientific research.

In keeping with the SWRCB's primary responsibility to protect the quality and beneficial uses of waters of the state, the Bay-Delta Plan primarily focuses on flow-related issues. The SWRCB recognizes that other actions, including habitat restoration, are also important steps to protect the ecosystem, and that alternative management approaches, such as implementing use of a temperature control device to regulate water temperatures released downstream of a dam (rather than use of flow alone), may be equally or more effective than flow management. As a result, the SWRCB has set broad flow objectives, and has encouraged stakeholders to continue to develop voluntary agreements to support environmental objectives through a broad set of tools while protecting water supply reliability (SWRCB 2018). Voluntary agreements would incorporate a mix of flow-based and non-flow-based measures that also protect fish and wildlife beneficial uses (SWRCB 2018). Voluntary agreements would remain subject to consideration and analysis by the SWRCB to determine whether the agreements meet environmental objectives required by law and are identified in the SWRCB's update to the Bay-Delta Plan.

While the Council does not have a direct role in setting flow objectives, Delta Plan regulations require covered actions that could affect flow in the Delta to demonstrate consistency with the Bay-Delta Plan flow objectives (see Ecosystem Restoration Policy [ER P]1). In addition, the Delta Science Program advises the SWRCB regarding best available science and adaptive management related to Delta flow objectives, primarily by facilitating independent advisory and review panels (see Ecosystem Restoration Recommendation [ER R]1).

As described above, flow interacts with the surrounding landscape and affects native species habitat. Therefore, several Delta Plan regulatory policies and recommendations promote protecting, restoring, and enhancing riparian floodplains and tidal marshes in a manner that allows space for functional flows to access them. Ecosystem protection, restoration, and enhancement projects, including mitigation, resulting from voluntary agreements may be covered actions required to demonstrate consistency with applicable Delta Plan policies. When implemented in combination with more natural, functional flows, ecosystem restoration has the potential to improve water supply reliability.

Through a combined effort to create more natural, functional flows and restore land-water connections in low-lying areas in the Delta, floodplain and tidal marsh habitats can support recovery of native species. This means that, ideally, the frequency and duration of inundation in the Yolo Bypass would be sufficient to support native migratory fish spawning and rearing (see Performance Measure [PM] 4.2A); that pulse flows on the Sacramento River would be large enough, and the recession rate slow enough, to support habitat formation and maintenance (see PM 4.2B); that more natural functional flow patterns would be created, allowing for natural variability in water year types (see PM 4.2C and PM 4.2D); and that areas physically capable of supporting flood flows would be inundated on a periodic basis (see PM 4.15). When management actions use natural, functional flows, efforts to create a more reliable water supply can work together with ecosystem protection, restoration, and enhancement.

Core Strategy 2: Restore Ecosystem Function

The Delta Reform Act specifies a subgoal to restore large areas of interconnected habitats within the Delta and its watershed by 2100 (California Water Code section 85302[e][1]). The Delta Reform Act identifies diverse and biologically appropriate habitats and ecosystem processes, functional corridors for migratory species, and viable populations of native species as characteristics of a healthy Delta ecosystem (California Water Code section 85302[c]). The

Delta Reform Act requires that the Delta Plan include measures to promote conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations (California Water Code section 85302[c][5]). An evaluation of existing species recovery plan and conservation plan targets indicates that it will be necessary to reestablish tens of thousands of acres of functional, diverse, and interconnected habitat (Council 2018, Appendix Q4). The magnitude of this need dictates a change in existing approaches to protecting, restoring, and enhancing the Delta ecosystem.

Although implementing the Delta Plan will help to achieve the specific objectives set forth in recovery plans and the salmon doubling goal, the Delta Plan is not intended to be constrained by or limited to objectives that focus only on a subset of the Delta's native species. Restoring ecosystem functions by establishing large areas of interconnected habitat—along with the other four strategies identified in this chapter—will help increase the likelihood that the objectives of recovery plans and salmon doubling are met, and will also benefit a broader array of native Delta species.

Decades of efforts aimed at improving aquatic and terrestrial ecosystems of the Delta and Suisun Marsh have failed to prevent declining species populations. Many of these efforts are limited to single-species conservation, recovery, or mitigation projects. Best available science supports an emphasis on restoring ecosystem function over single-species management (SFEI 2016, Council 2018). However, agencies charged with stewardship and restoration of the Delta ecosystem have limited ability to change these practices due to permitting requirements and restrictions on the amount and use of public funds. Information gaps also prevent more systematic planning and adaptive management of these activities and investments (additional information is discussed in Core Strategy 5). Ecosystem protection, restoration, and enhancement are not just about adding up the acres of restored habitat, but also about landscape-scale ecosystem attributes, such as connectivity, complexity, diversity, and scale (SFEI 2016).

Priority Attributes

The Delta ecosystem is naturally dynamic in response to a variable climate and variable river flows. A sustainable Delta ecosystem needs to be large, diverse, and structurally complex in order to accommodate this variability and sustain native species communities. Best available restoration science identifies the following priority attributes that maximize the effectiveness of individual ecosystem protection, restoration, and enhancement projects:

1. restore hydrological, geomorphic, and biological processes
2. be large-scale
3. improve connectivity

4. increase native vegetation cover
5. contribute to the recovery of special-status species

Each of these attributes is discussed below.

Restore Hydrological, Geomorphic, and Biological Processes

Ecological processes consist of the physical, chemical, and biological processes that connect organisms and their environment, such as nutrient cycling, erosion, sedimentation, and accretion. Reestablishing these processes requires reestablishing land-water connections (e.g., floodplains, river channels, tidal channels, and marsh plains). Ecological processes function to sustain the natural ecosystem, including its native species, communities, and habitats within the Delta over time (Beechie et al. 2010, Greco 2013, Wiens et al. 2016).

Be Large-Scale

The ecological processes described above occur over varied scales and time periods (Palmer et al. 2016, SFEI 2016). Larger-scale protection, restoration, and enhancement projects implemented over long periods of time can accommodate ecosystem processes more effectively, compared to small-scale projects. Similarly, larger-scale projects are expected to create natural systems that are more capable of sustaining desired functions in uncertain future environmental conditions (Peterson et al. 1998, SFEI 2016).

Improve Connectivity

Connected habitats are important for sustaining species populations and biological diversity across increasingly fragmented landscapes. Connectivity requirements are specific to each species and how it uses the landscape. For example, certain mammal species may require adjoining corridors of suitable habitat to be able to move from one area to another. By contrast, habitat patches separated by miles are functional connections for many bird species. Various aspects of connectivity are crucial to riparian and wetland systems' ability to support biodiversity (Vannote et al. 1980, Poff et al. 1997). This heightens the importance of such ecosystems, in light of ecological adaptation and a rapidly changing climate (Naiman et al. 1993, Seavy et al. 2009, SFEI 2016).

Increase Native Vegetation Cover

The loss of native vegetation cover has greatly reduced habitat complexity in the Delta over the last 160 years, completely altering aquatic and intertidal food-web dynamics (Moyle et al. 2010, SFEI 2012). Restoration of complex ecosystems will require reestablishment of native vegetation communities, and the underlying processes that support their recruitment, disturbance regimes, and community succession. Restoring a variety of native vegetation cover types can promote ecological resilience and enhance native biodiversity by providing a range of habitat options for species, thus expanding the types and numbers of species that a landscape can support.

Contribute to the Recovery of Special-Status Species

Many native plant, fish, and wildlife species in the Delta are imperiled by human activities, and they are at varying degrees of risk of elimination from the Delta landscape or outright extinction. Habitat loss and degradation and the resulting impacts on food-web dynamics have been a major cause of the special status of these species (Suding 2011, Palmer et al. 2016). Restoring ecological functions is an important requirement for the recovery of these species.

Improve Project Design

Ecosystem protection, restoration, and enhancement actions that have all five priority attributes will be most effective in restoring ecosystem function. Actions with only one or two of these attributes would be less effective, although they would still contribute toward the goal.

In locations where conditions in the landscape allow for ecosystem protection, restoration, and enhancement actions that would achieve most, if not all, of the priority attributes, the focus should be on ensuring that such projects are designed to achieve as many of these attributes as feasible. It is inappropriate to implement ecosystem protection, restoration, or enhancement actions (whether for mitigation, recovery, or other objectives) that can only achieve one or two of the priority attributes in locations that could potentially support four or more of these attributes, since such areas are extremely limited within the Delta. Areas of the Delta that can only support projects that achieve one or two of the priority attributes are much more commonplace (e.g., areas which are too subsided to ever support tidal wetland restoration). The incremental benefits to ecosystem function achieved by implementing a singular action with a very limited number of the priority attributes may be modest, but given that there are ample opportunities to implement these actions throughout the Delta, wide-scale implementation of such projects can make meaningful contributions to ecological functions.

To increase transparency and information concerning public investments in restoration, certifications of consistency for all covered actions that consist of or include components of environmental protection, restoration, or enhancement—including implementation of recovery plans and mitigation projects—must describe the priority attributes the project would provide (see New ER Policy “A”). There are several examples of restoration projects that include restoration of ecological processes, and all or most other priority attributes. These include the Dutch Slough Tidal Marsh Restoration Project, the West Sacramento Southport Setback Levee Project, and the Lindsey Slough Tidal Marsh Restoration Project. Each of these projects is large-scale and has been designed to restore land-water connections, improve habitat connectivity, reestablish native vegetation communities, and benefit special-status species. Planning and implementation of these projects required collaboration among multiple jurisdictions, and support from multiple funding sources. Continued progress toward projects that restore ecological processes and most other priority attributes will require continued focus on interagency collaboration, new funding sources, and prioritizing funding for such projects in the future (see New ER Recommendation “A” and PM 4.14).

Numerous economic and financial trade-offs are involved in Delta ecosystem protection, restoration, and enhancement projects. State and local decision-making also should consider and recognize the social and economic value a functioning ecosystem would provide to the Delta, its residents, and the state as a whole. To this end, certifications of consistency for covered actions that include environmental protection, restoration, or enhancement—including implementation of recovery plans and mitigation projects—must also describe the cultural, recreational, agricultural, and natural resource benefits expected to result from the action.

Successful ecological restoration in the Delta must also include a well-coordinated and collaborative approach with Delta residents, agricultural interests, and other stakeholders. Protection, restoration, and enhancement projects should consider the surrounding land-use context, and integrate it with the surrounding environment. Project proponents should use the California Department of Water Resources (DWR) Good Neighbor Checklist (in Appendix Q2) when planning and designing restoration projects, in order to demonstrate that the project avoids or reduces conflicts with existing uses (see New ER Recommendation “B”).

Functional Floodplains

Restoring ecological processes is both challenging and complex. Environmental planning and implementation actions undertaken to meet different policy objectives, funding requirements, and statutory and regulatory obligations often result in missed restoration opportunities. For example, agencies charged with improving levees to protect Delta communities must meet stringent standards, at high cost, and with tight timelines. These agencies are primarily charged with providing flood protection and, therefore, have an incentive to maintain, repair and rehabilitate levees in-place and to mitigate vegetation removal off-site. Such an approach streamlines permitting requirements and keeps costs low and assessments affordable. Unfortunately, along most of the Sacramento and San Joaquin Rivers, levees are near the water’s edge, leaving little room for habitat features, which often are provided only by trees growing immediately adjacent to or on the levees themselves.

Floodplains provide important opportunities to restore ecosystem processes in the Delta. Projects that expand floodplains at a sufficient scale have the potential to feature all five restoration priority attributes. Natural floodplain processes of erosion, bank cutting, and sediment deposition could be restored. Setting back or removing levees within the floodway would provide lateral connectivity for aquatic and riparian species to access shaded riverine habitat, and would increase important floodplain rearing habitat for juvenile salmon. As described in Core Strategy 1, native fish do particularly well when flows through expanded floodplains follow more natural patterns.

YOLO BYPASS AND COSUMNES RIVER FLOODPLAINS

The Yolo Bypass and Cosumnes River floodplains offer good illustrations of ecosystem and flood risk-reduction projects working together. These areas provide migratory and rearing habitat for salmon, and important habitat for other native fish, birds, and bats. The California Department of Fish and Wildlife (CDFW) manages the Vic Fazio Yolo Wildlife Area, a 16,000-acre public-private restoration project in the Yolo Bypass, to promote waterfowl and other bird populations. The Cosumnes River Preserve consists of over 50,000 acres jointly owned and operated by the Bureau of Land Management, California Department of Fish and Wildlife, California Department of Water Resources, California State Lands Commission, Sacramento County Regional Parks, The Nature Conservancy, and Ducks Unlimited.

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There are limited locations in the Delta where land use, land elevation, and primary fish migration corridors are conducive to physically expand floodplains. To ensure that these opportunities are not foreclosed, new flood control works and capital improvement projects to existing flood control works in these priority locations (Figure 4-3, which is also Appendix 8A) must evaluate the feasibility of setting back or removing existing levees in order to physically expand the width of the channel (see ER P4). By engaging in this evaluation early in project planning, before funding decisions are made, reclamation districts and flood control agencies can build partnerships and projects that both reduce flood risk and restore ecosystem function.

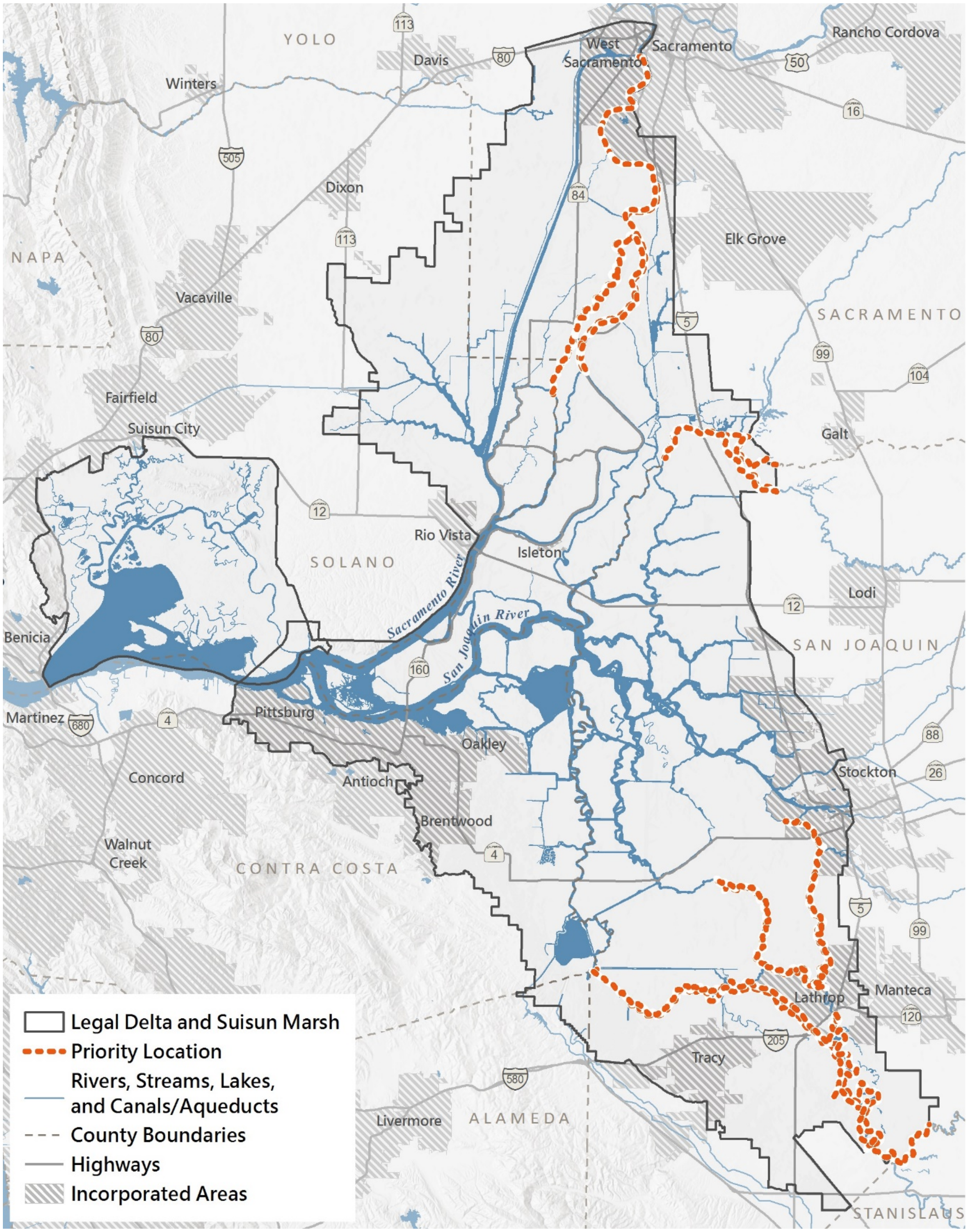

Figure 4-3. Priority Locations to Evaluate Physical Expansion of Floodplains

Figure 4-3. Priority Locations to Evaluate Physical Expansion of Floodplains (contd.)

Figure 4-3 is a map that identifies the Priority Locations to Evaluate Physical Expansion of Floodplains within the Legal Delta and Suisun Marsh, corresponding to the requirements of Ecosystem Restoration Policy 4 (ER P4). The map shows an outline of the Legal Delta and Suisun Marsh in black. The priority areas are shown within the Legal Delta in orange dotted lines. The map shows unlabeled rivers, streams, lakes, and canals/aqueducts within the Legal Delta and Suisun Marsh colored in a solid blue. County boundaries are depicted in gray dotted lines. Major highways are depicted in gray solid lines, labeled by highway number. Incorporated areas are shown in gray hatching.

The priority areas are:

- the Sacramento River between the Deepwater Ship Channel and Steamboat Slough, including urban levees in West Sacramento and Sacramento;
- Elk Slough;
- Sutter Slough, from Miner Slough to Elk Slough;
- the Cosumnes River and the Mokelumne River, from the boundary of the Legal Delta to the confluence with Snodgrass Slough;
- the San Joaquin River from the Stanislaus River confluence to Rough and Ready Island, including urban levees in Stockton and levees that run through Lathrop;
- the portion of the Stanislaus River that is within the boundary of the Legal Delta;
- Middle River, from the Old River confluence to the midpoint between Howard Road and Tracy Boulevard;
- Old River, from the San Joaquin River confluence to Hammer Island, including levees that run through Lathrop; and
- Paradise Cut.

This map is also Appendix 8A. Please contact the Delta Stewardship Council with any questions regarding this figure.

The opportunity to restore ecological processes may be physically constrained in many levee locations. However, thoughtful planning can enable levee projects in these areas to provide other restoration priority attributes, such as improved habitat complexity that supports the recovery of native species. To that end, new flood control works and capital improvements to existing flood control works must evaluate the feasibility of alternatives to increase levee waterside habitat (see ER P4). Waterside habitat could include riparian vegetation, large woody debris, or complexity of bank materials and configurations.

Other state agencies have an active role in ensuring no net loss of riparian and aquatic habitat on levees. The California Department of Fish and Wildlife (CDFW) is charged with ensuring that flood control plans in the Delta provide a net long-term habitat improvement and have a net benefit for aquatic species (California Water Code section 12314). DWR has made significant progress in developing a long-term habitat management program to implement this objective. Through this program, DWR contracts with resource conservation districts (RCD) and other Delta land management entities to maintain riparian habitat enhancement and mitigation sites associated with its special projects and subventions program expenditures.

Transitioning ecosystem restoration efforts toward a more complete ecosystem-based approach is expected to result in improved function and connectivity of restored floodplain, riparian, and tidal marsh habitat throughout the Delta. By 2050, the Delta Plan envisions restoration of more than 30,000 acres of new tidal wetland, more than 13,000 acres of new oak woodland and other upland ecosystems, and nearly 20,000 acres of upland and lowland river floodplain habitat. Restoration of more than 16,000 acres of willow and riparian vegetation communities is envisioned within or adjacent to the restored floodplain habitat. Thus, the Delta Plan envisions a total of approximately 60,000 to 80,000 acres of restored habitat (see PM 4.16). These restored habitat patches will be functionally connected for the native species that depend on them, and well-integrated with surrounding land uses. Ecosystem protection, restoration, and enhancement projects will provide recreational opportunities, and will support the cultural and natural resource values of Delta communities.

Core Strategy 3: Protect Land for Restoration and Safeguard Against Land Loss

Land reclamation has claimed more than 90 percent of wetlands in the Delta since the 1850s (SFEI 2014). Much of the land that once supported intertidal wetlands is now subsided deeply below intertidal elevations. Loss of land elevation due to subsidence is ongoing, and in some portions of the Delta, more than an inch of land elevation may be lost per year. Some portions of the central Delta now lie more than 25 feet below sea level. In general, the further land lies below sea level, the less feasible it is to reestablish intertidal habitat, and the greater the risk of permanent inundation and land loss.

Climate change will exacerbate this problem. The California Ocean Protection Commission recommends preparing for 2.4 to 10.2 feet of sea level rise at the Golden Gate Bridge by 2100 (OPC 2018). Regardless of whether sea levels rise to the lower end of current projections or the higher end, lands that are currently at intertidal elevations are at risk of sinking too far below the tidal range to support restoration of tidal marsh habitat due to ongoing subsidence. Sea level rise will add pressure on Delta levees, further increasing the risk to people, property, and managed habitats located on subsided islands (Deverel et al. 2016).

Infrastructure and urban development limit the natural ability of marsh vegetation and marsh-dependent species to migrate upland as tides rise (Orr and Sheehan 2012, Dettinger et al. 2016). Tidal marsh habitat that cannot migrate upland and cannot accrete soil matter at a rate fast enough to keep pace with sea level rise will, over time, be lost (Tsao et al. 2015). Urbanization also constrains opportunities to reconfigure and reconnect floodplains to their stream channels. The extent of urban land use in the Delta increased by nearly 50 percent between 1990 and 2014, and it continues to expand. Chapter 5 of the Delta Plan includes a regulatory policy requiring new commercial, residential, and industrial development in the Delta to be located wisely (see Delta as Place Policy [DP P]1); however, land conversion for agriculture-related uses—including the expansion and development of processing facilities, retail establishments, and mining—poses ongoing challenges.

Land conversion, subsidence, and sea level rise pose threats to the Delta ecosystem, especially in the western, central, and southern Delta where subsidence rates are highest. Urgent action is needed to protect land for restoration and safeguard against further land loss.

Protect Land for Restoration

The Delta Reform Act requires that the Delta Plan include subgoals and strategies for restoring large areas of interconnected habitats within the Delta and its watershed (Water Code section 85302[e][1]). In order to accomplish restoration at this scale, there must be sufficient land available to restore. Restoration opportunities in the Delta are constrained by land elevation, which determines the potential to reestablish land-water connections that create and sustain tidal marsh, wetland, and floodplain habitat. In the modern Delta, only a limited amount of land remains at elevations physically capable of supporting intertidal restoration. The best way to safeguard lands currently at intertidal elevations is to reconnect those lands to regular inundation of water that may support the buildup of land through sediment and soil deposits. Tidal marshes in the Delta naturally accumulate sediment and produce organic material. This allows them to either maintain or raise the land elevation (Drexler et al. 2009).

The locations and extent of tidal marsh in the Delta will inevitably shift with sea level rise. Tidal marsh vegetation can adapt to rising sea levels by either building up a marsh’s base elevation with soil, or by migrating onto adjacent uplands. Restoring natural geomorphic processes, along with more natural functional flows, should increase the potential for intertidal areas in the Delta to keep pace with anticipated levels of sea level rise (Swanson et al. 2015, Schile et al. 2014). In Suisun Marsh, organic material accumulates more slowly, so elevation gain relies more on sediment inputs to marshes. Because infrastructure separates streams from their basins throughout the Sacramento-San Joaquin River watersheds, sediment loads are lower than the historical rates. This means that in Suisun Marsh, simply reconnecting tidal marshes may not be enough to adapt to sea level rise (Callaway et al. 2012, Schile et al. 2014). For these reasons, proponents of projects that include tidal marsh protection, restoration, and enhancement in the Delta—and especially in the Suisun Marsh—should design and protect space in upland areas sufficient to allow tidal marsh to migrate onto adjacent uplands under anticipated levels of sea level rise.

SEA LEVEL RISE ADAPTATION PLANNING

Senate Bill (SB) 379, approved in 2015, requires local governments to include the following in their general plans: a climate change vulnerability assessment, measures to address vulnerabilities, and comprehensive hazard mitigation and emergency response strategy in the safety element of their general plans (Gov. Code section 65302[g][4]). For coastal jurisdictions, this means planning for sea level rise.

The California Office of Emergency Services publishes the California Adaptation Planning Guide to assist local jurisdictions in addressing the unavoidable consequences of climate change. Potential strategies for adapting to sea level rise include preserving undeveloped land, sealing and protecting existing infrastructure, and strategic retreat of roadways and development from areas expected to be impacted by sea level rise (p. 38).

The California Governor's Office of Planning and Research publishes general plan guidelines, which provide local governments with guidance on SB 379, among other requirements. The guidelines direct local jurisdictions to use the process in the California Adaptation Planning Guide, and as reflected in referenced tools such as Cal-Adapt, to assess the climate change vulnerabilities of their community and to identify feasible methods to avoid or minimize climate change impacts associated with new uses of land.

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In parts of the Delta that are currently less than 8 feet below low tide, and parts of the Suisun Marsh that are less than 4.5 feet below low tide, subsidence reversal followed by tidal reconnection would restore ecosystem function. Managed wetlands in the Delta have shown capacity to reverse subsidence at a rate of 1.6 inches (4 centimeters) per year (Miller et al. 2008). Managed wetlands in Suisun Marsh tend to accumulate organic material and gain elevation more slowly because saline conditions slow organic growth. Nonetheless, Suisun Marsh offers important opportunities to raise land elevations through subsidence reversal because the existing landscape is less subsided than in much of the Delta.

As described in Chapter 5 of the Delta Plan, much of the land in the Delta has subsided to elevations that are too far below sea level to restore its original ecological functions as tidal marsh channels and plains without considerable expense. Providing terrestrial and wetland habitat for native species on deeply subsided Delta lands is expensive and requires intensive, ongoing management. Such lands offer few opportunities to recover native ecosystem forms and functions. However, deeply subsided islands are appropriate locations for managed wetlands for waterfowl and for wildlife-friendly agriculture (Elphick 2000, Shackelford et al. 2017). Actions at these locations that halt soil oxidation, prevent soil-based carbon emissions, reverse subsidence, and improve migratory bird habitat are especially valuable (Deverel et al. 2016).

The Delta Plan's approach to restoring Delta ecosystem functions is to implement restoration projects in the right places at the right elevations. It is important that investments to improve the Delta ecosystem consider the long-term flood risk associated with the landscape, and where possible, to reduce that risk by reversing or halting subsidence. State and local agencies funding, approving, or building ecosystem protection, restoration, or enhancement actions in the Delta—including recovery and mitigation actions—must ensure the durability of their investments by demonstrating that they are at appropriate elevations, in the context of ongoing subsidence and projected sea level rise (see ER P2 and Figure 4-4). Investments in tidal marsh protection, restoration, and enhancement should focus on areas that are, or will be, exposed to tidal action. Ecosystem protection, restoration, and enhancement investments on deeply subsided islands should be made with caution and awareness of the risk of future inundation.

Figure 4-5 illustrates the appropriate elevations for the protection, restoration, and enhancement of different classes of natural communities, as well as other activities that support native species recovery and the recovery of critical ecosystem processes. Subsidence reversal for the purpose of reestablishing tidal processes is only appropriate in the shallow subsided elevation band. Subsidence reversal may be appropriate in more deeply subsided areas when implemented to achieve other project objectives, such as carbon sequestration. Wildlife-friendly agriculture is most appropriate within the deeply subsided islands. The full range of these activities, in appropriate locations, are necessary to support the vision of a restored Delta ecosystem.

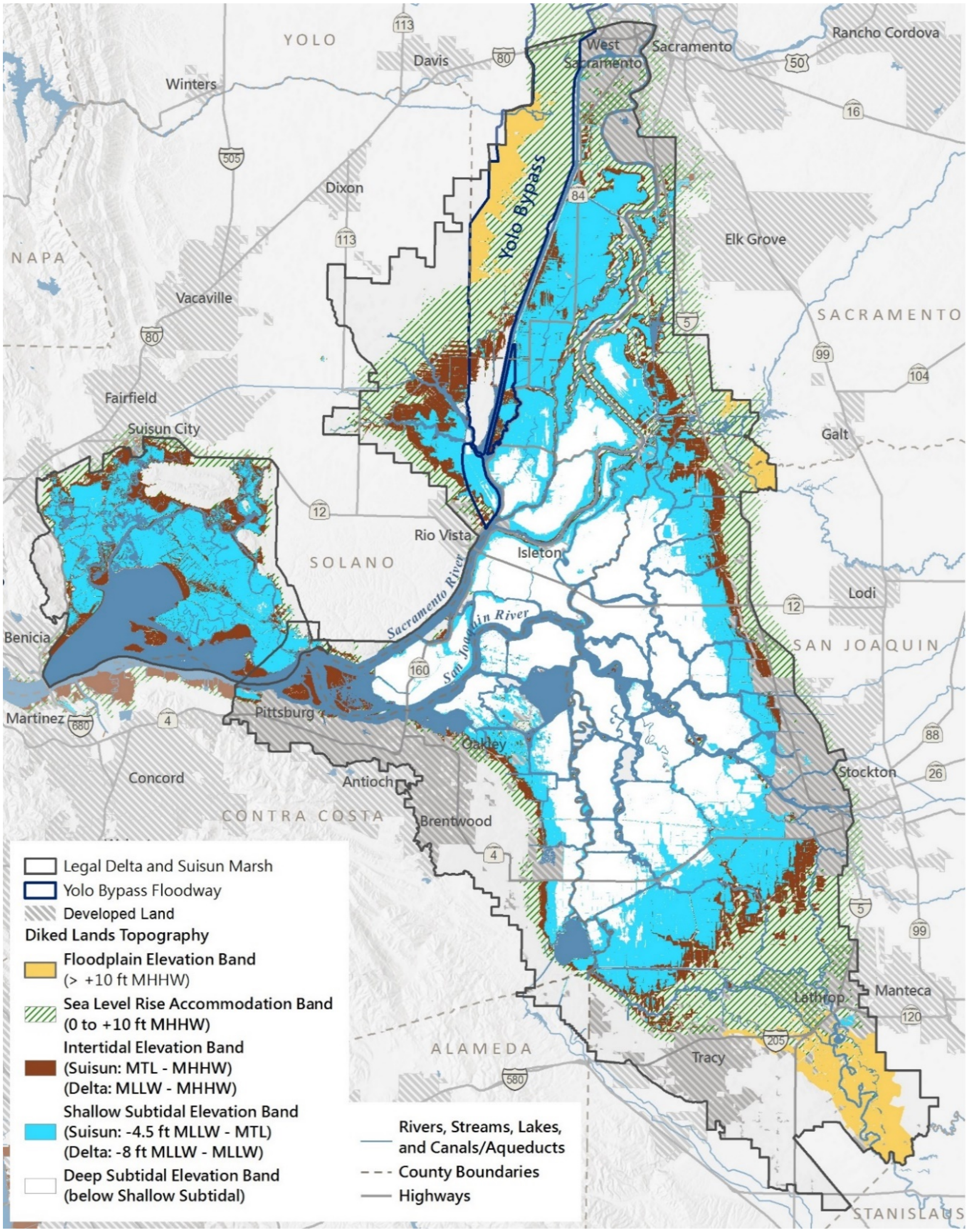

Figure 4-4. Elevation Bands for the Protection, Restoration, and Enhancement of Different Classes of Natural Communities

Figure 4-4. Elevation Bands for the Protection, Restoration, and Enhancement of Different Classes of Natural Communities (contd.)

Figure 4-4 is a map that illustrates Elevation Bands within the Legal Delta and Suisun Marsh, shown with existing tidal marsh extent. The map shows an outline of the Legal Delta and Suisun Marsh in black. The map shows unlabeled rivers, streams, lakes, and canals/aqueducts within the Legal Delta and Suisun Marsh colored in a solid blue. County boundaries are depicted in gray dotted lines. Major highways are depicted in gray solid lines and labeled by highway number. Developed land is shown in gray hatching. The Yolo Bypass is outlined in a solid dark blue line.

Elevation Bands depicted are:

- The Floodplain Elevation Band is depicted in solid yellow, and consists of land at elevations that are greater than or equal to 10 feet Mean Higher High Water;
- The Sea Level Rise Accommodation elevation band is depicted in green hatching, and consists of land at elevations that are between 0 to 10 feet Mean Higher High Water;
- The Intertidal elevation band is depicted in solid brown, and consists of land at elevations between Mean Tide Level and Mean Higher High Water in Suisun Marsh, and between Mean Lower Low Water and Mean Higher High Water in the Delta;
- The Shallow Subtidal elevation band is depicted in solid cyan, and consists of land at elevations between 4.5 feet below Mean Lower Low Water and Mean Tide in Suisun Marsh, and between 8 feet below Mean Lower Low Water and Mean Lower Low Water in the Delta; and
- The Deep Subtidal elevation band is depicted in white and consists of land at elevations that are below the Shallow Subtidal elevation band.

The Floodplain Elevation Band is the least extensive among those shown in the map. Land areas within the Floodplain Elevation Band are concentrated as follows: on the western side of the Yolo Bypass; two small areas west of the City of Galt along the Cosumnes and Mokelumne Rivers; and a conical shaped area at the southeastern tip of the Legal Delta, along the San Joaquin River, south of the City of Lathrop.

The Sea Level Rise Accommodation Band includes: a narrow strip of land at the northern boundary of Suisun Marsh, small patches of land at the eastern edge of Suisun Marsh; a wide swath of land at the western edge of Cache Slough that continues into much of Yolo Bypass; waterside levee area along the Sacramento River and adjacent channels and sloughs; a strip of land at the eastern boundary of the Legal Delta along Highway 5, between Stockton and Sacramento; a wide swath of land north of Tracy and Lathrop at the base of the San Joaquin River floodplain; and a narrow strip of land extending from Tracy west to Clifton Court Forebay, and northwest to Oakley.

Existing tidal wetlands in Suisun Marsh and western Delta islands near Pittsburg are located in the Intertidal Elevation Band. Other concentrated land areas located within the Intertidal Elevation Band are within Cache Slough and in the south Delta. There are narrow strips of land located in the Intertidal Elevation Band at the edges of the Sea Level Rise Accommodation Band, extending along Highway 5 between Stockton and Sacramento, and from Tracy to Oakley. Scattered patches of land in the Intertidal Elevation Band are also present on Decker Island, Prospect Island, Merritt Island, Pearson District, McCormack Williamson Tract, and New Hope Tract.

The Shallow Subtidal and Deep Subtidal Elevation Bands are the most extensive. The Shallow Subtidal Elevation Band consists of: the majority of Suisun Marsh; the southeastern corner of Cache Slough; land between the Sacramento River Deep Water Ship Channel and the Sacramento River in the north Delta; the majority of the Pearson District; a strip of land along the eastern edge of the Delta, adjacent to and west of the Intertidal Elevation Band; land south of Highway 4 and adjacent to the Intertidal Elevation Band, in the south Delta; and a narrow strip of land running north from Clifton Court Forebay to Oakley.

The Deep Subtidal Elevation Band consists primarily of land areas on islands in the central and western Delta, from Sherman Island in the west to Rindge Tract in the east, and from Victoria Island in the south to Liberty and Grand Islands in the north.

The elevation bands illustrated in this map are the same as the elevation bands identified in Appendix 4A, which is the regulatory appendix for Ecosystem Restoration Policy 2 (ER P2). Please contact the Delta Stewardship Council with any questions regarding this figure.

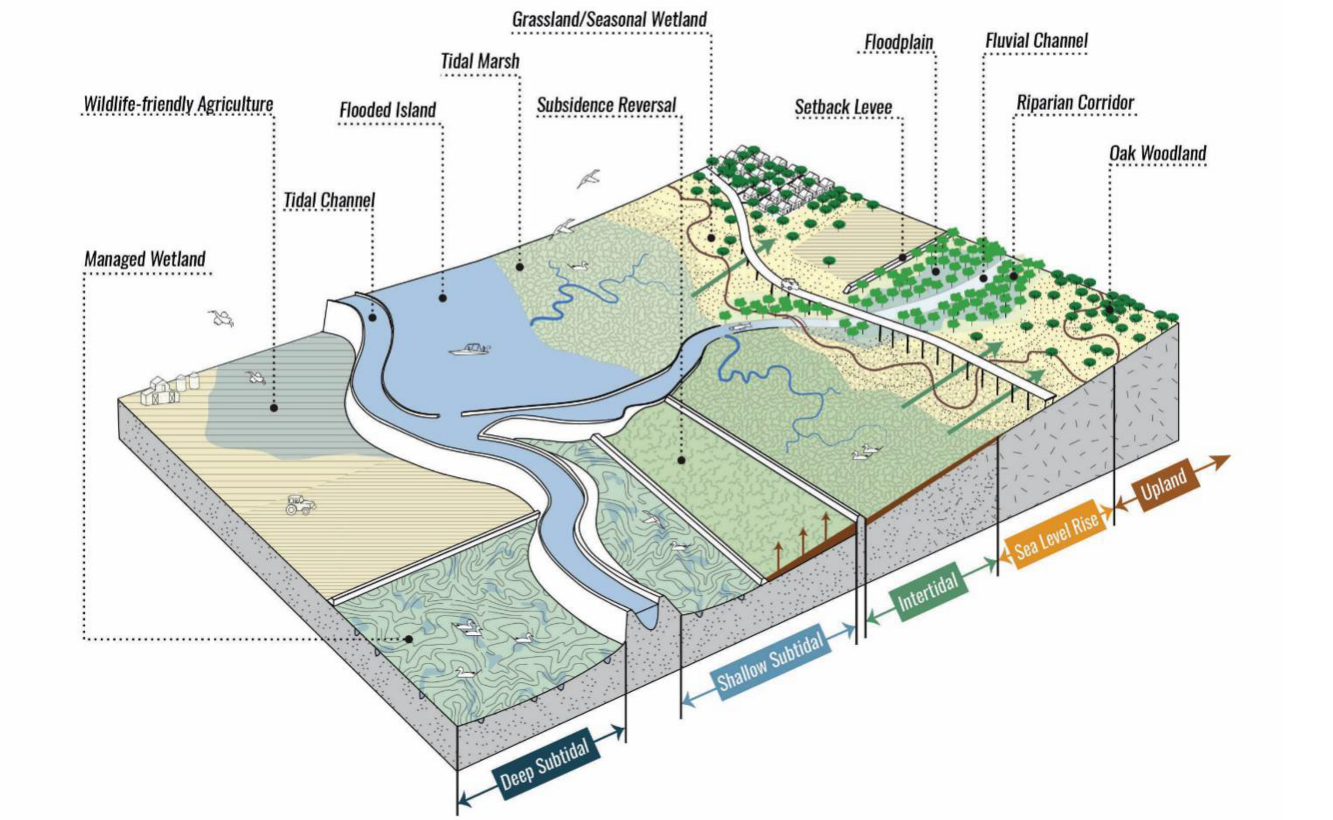

Figure 4-5. Section Diagram of Protected, Restored, and Enhanced Ecosystems at Appropriate Elevations, Including Subsidence Reversal and Wildlife-Friendly Agriculture

The ecosystem, urban development, and infrastructure shown in this diagram are resilient to projected sea level rise. Protection, restoration, and enhancement activities can be integrated into, and supportive of, the surrounding agricultural context of the Delta.

Source: SFEI 2019

State and local agencies must also protect the few remaining areas in the Delta and Suisun Marsh that present opportunities to reestablish land-water connections. The less-subsided flood basins, river corridors, and reclaimed marshes on the Delta's perimeter offer the most promising restoration opportunities. Accordingly, the Delta Plan identifies six Priority Habitat Restoration Areas (Figure 4-6):

- **Yolo Bypass, from the Fremont Weir south toward the Delta.** Winter and spring flooding of the Yolo Bypass provides substantial benefits for spawning and rearing of Sacramento splittail and rearing of salmon (Sommer et al. 2001, Moyle et al. 2007). Restoration of the Yolo Bypass can create conditions that promote enhanced growth and survival of juvenile spring- and winter-run salmon, among other species, and can benefit other migrating salmon.

- **Cache Slough Complex, southwest of the Yolo Bypass.** The flood basins entering the Cache Slough Complex are located at the interface between river and tidally influenced portions of the Delta. Habitat restoration at Cache Slough can create conditions that help recover delta smelt and that benefit migrating salmon.
- **Cosumnes River-Mokelumne River confluence.** While most of the riparian forests of the Central Valley have long been lost, the Cosumnes River floodplain possesses exceptionally large stands of remnant valley oak riparian forests, as well as an intact flow regime because the Cosumnes River is not regulated by a major dam. Restoring seasonal floodplains and tidal wetlands in this area can benefit migrating salmon and provide food-web support.
- **Lower San Joaquin River floodplain between Stockton and Manteca.** Historically, the south Delta and its connection to the lower San Joaquin River contained a complex network of channels with low natural berms, large woody debris, willows, and other shrubs with upland areas supporting open oak woodlands. Restoring this area to a mix of tidal marsh, riparian habitats, and wildlife-friendly agriculture could create conditions to recover riparian brush rabbits and Swainson's hawks, benefit migrating salmon, and serv to reduce the risks from flooding in urban areas.
- **Suisun Marsh.** The Suisun Marsh is the largest wetland area on the West Coast of the contiguous United States; however, it is mostly managed for waterfowl, with levees that disconnect its wetlands from the estuary. Restoration of tidal marsh and associated habitats here can aid the recovery of longfin smelt and spring- and winter-run salmon, and support Suisun song sparrows and saltmarsh harvest mice.
- **Western Delta/Eastern Contra Costa County.** Some islands and tracts at appropriate elevations may be desirable sites for restoration of tidal marsh and channel margins to provide food-web support and habitat for native species.

These six Priority Habitat Restoration Areas have been highly altered by more than a century of human use and exposure to multiple stressors. Reestablishing geomorphic processes and habitat for native species in these areas requires a careful assessment of opportunities and challenges that maintains focus on long-term ecological outcomes when making short-term land-use decisions. Covered actions must demonstrate that they would not prevent, impede, or constrain future opportunities to restore habitat in the six Priority Habitat Restoration Areas (see ER P3). Protecting these areas will contribute sufficient land area, at the appropriate elevations and in appropriate locations, to restore critical Delta habitat types and to achieve the vision of a restored Delta ecosystem.

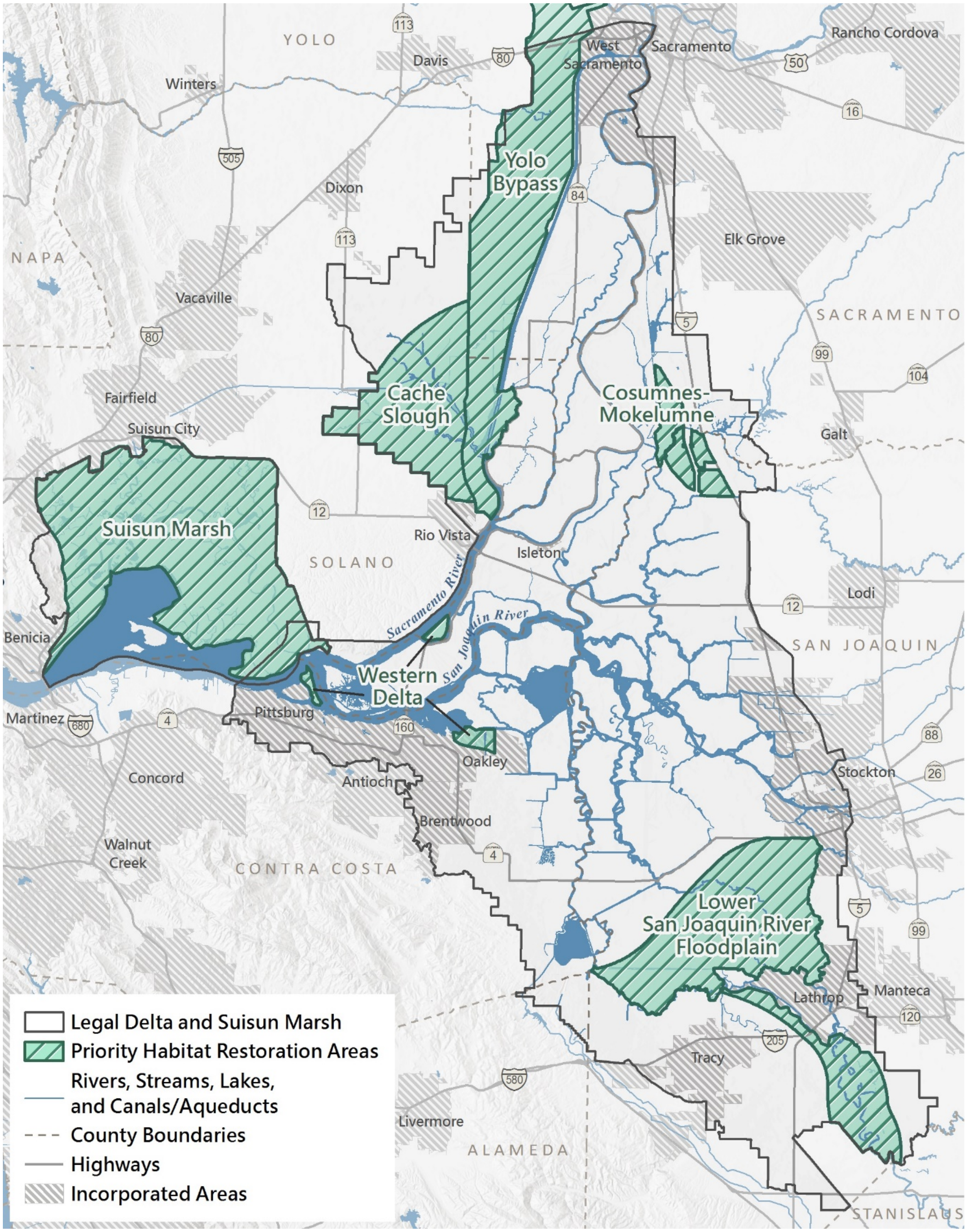

Figure 4-6. Priority Habitat Restoration Areas

Note: The Priority Habitat Restoration Areas are the same as those depicted in Appendix 5.

Figure 4-6. Priority Habitat Restoration Areas (contd.)

Figure 4-6 is a map that delineates Priority Habitat Restoration Areas (PHRA) within the Legal Delta and Suisun Marsh. The map shows the Legal Delta and Suisun Marsh outlined in black. The PHRAs are shown as crosshatched green areas. The PHRAs are depicted as located in Suisun Marsh, Cache Slough, Yolo Bypass, Cosumnes/Mokelumne, Western Delta, and the lower San Joaquin River floodplain. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; the Sacramento and San Joaquin Rivers are labeled. County boundaries are depicted in gray dotted lines. Major highways are depicted in gray solid lines and labeled by highway number. Incorporated areas are shown in gray hatching.

Suisun Marsh PHRA is located at the western edge of the Delta, south of Fairfield and Suisun City, and east of Benicia. It encompasses nearly the same area as the Suisun Marsh boundary, except that the PHRA does not extend west beyond Highway 680, nor into the developed portion of Suisun City.

The Yolo Bypass PHRA is located in southern Yolo County and eastern Solano County, adjacent to Cache Slough, which is located entirely within eastern Solano County (north of Rio Vista). The Yolo Bypass PHRA encompasses the same area as the Yolo Bypass, and extends north beyond the boundary of the Legal Delta to Fremont Weir. The Cache Slough PHRA extends from the boundary of the Legal Delta on the south and west to Yolo Bypass on the east.

The Cosumnes/Mokelumne PHRA is located at the western edge of Highway 5 between Elk Grove and Lodi. The Western Delta PHRA consists of three separate areas: one on Sherman Island, one on Browns Island (in Pittsburg) and one to the east of Big Break in the City of Oakley. The Lower San Joaquin River Floodplain PHRA is located south of Highway 4 between Interstate 5 and 205, including the southwestern portions of Stockton and western side of Lathrop.

The PHRAs shown on this map are also the same as the PHRAs shown in Appendix 5, the regulatory appendix for policy ER P3. Please contact the Delta Stewardship Council with any questions regarding this figure.

Safeguard Against Land Loss

Alongside, but separate from, actions to protect ongoing investments and opportunities for restoration, the current rapid pace of subsidence must be reduced, halted, and reversed. The ongoing loss of land due to subsidence and sea level rise is a critical stressor that threatens the livelihood of those who live and work in the Delta, statewide water supply reliability, and critical habitat for native species. Models accounting for ongoing subsidence and 2.6 feet of sea level rise (OPC 2018) indicate that 3,500 acres of nontidal area at intertidal elevation in the legal Delta, and 3,000 acres of nontidal area at intertidal elevation in Suisun Marsh, will be lost within 10 years.

The same process that causes subsidence also works against the state's carbon neutrality goal, declared in state Executive Order B-55-18. The majority of soil carbon loss in California is attributed to oxidation of organic soils in the Delta (ARB 2018). The Natural and Working Lands Climate Change Implementation Plan was developed to implement this executive order by identifying land-based methods to sequester carbon and setting a target of restoring 2,500-2,800 acres of Delta wetlands per year to stop carbon losses associated with soil oxidation (California Natural Resources Agency et al. 2019). These restoration activities would also have the benefit of helping stop subsidence and reversing it over time.

WORKING LANDS PROGRAMS

Supporting biodiversity on working agricultural lands has been a focus of many conservation funding programs within the Central Valley. This approach generally involves modifying the management of agricultural lands to provide ancillary benefits to a particular wildlife species or a group of species with similar habitat needs. For example, flooded rice fields can provide surrogate wetland habitats for species such as the giant garter snake (*Thamnophis gigas*). Many crops and some annually cultivated crops provide important foraging habitat for raptors, including Swainson's hawk (*Buteo swainsoni*), and winter-flooded croplands provide essential foraging and roosting habitat for greater sandhill crane (*Antigone canadensis tabida*) along with other waterfowl and shorebird species (SFEI 2016, Dybala et al. 2017, Strum et al. 2017).

Partnerships with farmers, to achieve ecological objectives, take advantage of farmers' experience managing large areas of land (e.g., controlling for pests, keeping away trespassers). These partnerships also enable private landowners to maintain ownership of their property, ensuring a stable tax base for local governments and maintaining the agricultural heritage of the Delta.

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Public agencies own more than 35,000 acres of deeply subsided lands in the Delta and Suisun Marsh, and they play a critical role in halting and reversing subsidence. State agencies should not enter into leases that contribute to subsidence on state-owned lands (see Delta as Place Recommendation 7). Rather, state and local agencies should take proactive steps to evaluate the feasibility of subsidence-reversal projects, and update applicable management plans that identify land management goals; identify appropriate public or private uses for that property; and describe the operation and maintenance requirements needed to implement management goals, to incorporate actions that reduce, halt, and reverse subsidence (see New ER Recommendation "E").

Subsidence reversal activities support multiple, diverse goals, from protecting the state's water supply to reducing flood risk and sequestering carbon in order to mitigate greenhouse gas emissions. Some subsidence reversal approaches also support migratory birds by providing food sources and seasonal wetland habitat. In less-subsided portions of the Delta and Suisun Marsh, subsidence reversal could also raise land elevations to sea level, and create opportunities to reestablish connections to the tidal regime. State agencies should articulate clear objectives when investing in subsidence-reversal projects and should target subsidence-reversal investments to appropriate locations (see New ER Recommendation "C").

The Sacramento-San Joaquin Delta Conservancy (Delta Conservancy) has been working closely with local agencies, nonprofit organizations, universities, and private landowners to develop pilot projects and to inform policies that halt or reverse subsidence for carbon sequestration. This collaboration led to the development of the American Carbon Registry protocol for voluntary carbon offsets for wetland creation and rice cultivation in the Delta. If offsets are approved to be sold in the cap-and-trade compliance market, higher prices for carbon offsets could incentivize participation among private landowners, and more widespread adoption of practices to halt and reverse subsidence in the Delta. The Delta Conservancy and its partners should continue efforts to develop incentive programs that encourage land management practices that halt and reverse subsidence (see New ER Recommendation “C”).

The RCDs and other Delta land stewardship entities should identify best practices to halt subsidence and support native species on working lands within their respective jurisdictions. RCDs are locally governed special districts of the state that are dedicated to conservation and stewardship of agricultural and natural resources and are therefore well-suited to improve agricultural land management practices in a manner that benefits species and allows for continued agricultural productivity, while avoiding unintended consequences for nearby landowners. Many RCDs are actively engaged in implementing projects in accordance with carbon protocols for grasslands, and the California Department of Conservation provides financial assistance to RCDs for staff and capacity building. State agencies should pursue new funding sources to support RCDs and other partners to develop and implement practices that safeguard against land loss and support native species (see New ER Recommendation “D”).

Collaborative efforts of state, local, and private partners can prevent and, in limited cases, reverse subsidence to the extent that habitat can be restored in locations throughout the Delta and Suisun Marsh. Accordingly, the number of carbon sequestration projects and acres of subsidence reversal should accelerate in the next decade. By implementing 3,500 acres of subsidence reversal in the Delta and 3,000 acres in Suisun Marsh, by or before 2030, projected loss of land at elevations suitable for tidal restoration could be reversed (see PM 4.12). Encouraging subsidence-reversal projects in less-subsided areas of the Delta and Suisun Marsh will help to ensure no net loss of intertidal wetland restoration on the landscape through 2100. These projects will also contribute to the broader Delta Plan goal to implement subsidence-reversal projects on 30,000 net new acres in the Delta and Suisun Marsh by 2030 (see PM 5.2).

Core Strategy 4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

Native species evolved in the varied, complex floodplains, marshes, and other habitats of the historical Delta. Channelizing waterways, altering riparian vegetation structure, stabilizing flow patterns, and impairing water quality have all contributed to conditions that favor nonnative invasive species. Nonnative species now affect virtually all components of the Delta ecosystem. Nonnatives can take over physical space, compete for food and nutrients, alter food webs, modify the physical habitat structure, or prey upon native species (CDFW 2014). Thus, nonnative species are both symptomatic and a cause of widespread ecosystem degradation.

Promoting self-sustaining, diverse populations of native and valued species by reducing risk of take and harm from invasive species is one of the Delta Reform Act's subgoals for restoring a healthy ecosystem (Water Code section 85302[e]). Large-scale ecosystem restoration supports recovery of native species, in part by removing conditions favored by nonnative species. However, there is also a need to ensure the immediate survival of native species populations within the current, degraded conditions of the Delta ecosystem. Specifically, some native fish populations require targeted interventions and active management to sustain and increase their numbers to a threshold at which they are self-sustaining. Major species' fisheries management actions include removing migration barriers, restoring and managing migration corridors, managing hatcheries, and identifying and tracking salmonid fish and other native species.

Prevent Introduction of Nonnative Invasive Species and Manage Nonnative Species Impacts

Nonnative species in the Delta fall broadly into the following four categories:

1) **Naturalized Species:** These nonnative species were intentionally introduced to the Delta, often to provide some economic benefit (e.g., striped bass recreational fishery), and now have established self-sustaining populations.
2) **Widespread and Unmanaged Species:** These nonnative species are widespread and known to cause problems (e.g., invasive Asian clams that rapidly deplete plankton from the water column), but they are not currently being actively managed-typically because of lack of feasible control options.
3) **Widespread and Managed Species:** These species are known to be major challenges and significant investments are being made to keep their abundance and distribution in check (e.g., water hyacinth, giant reed). Given how widespread and well-established these species are in the Delta ecosystem, the focus of management for these species is to control their abundance rather than to fully eradicate them from the Delta.
4) **Emerging Species of Concern**: These nonnative species have been recently found (e.g., nutria) or have a high potential to invade the Delta in the near future (e.g., quagga mussels), and their presence poses a major threat to the Delta ecosystem and/or human infrastructure. If already in the Delta, they are the focus of eradication efforts, and if not already in the Delta, they are the focus of invasive species prevention efforts.

Some nonnative species are also invasive. Invasive species are nonnative species whose introduction is likely to cause or causes economic or environmental harm, or harm to human health. A variety of nonnative invasive species are prevalent within the Delta. Nonnative invasive aquatic weeds in the Delta include water hyacinth, Brazilian waterweed, water pennywort, Eurasian water milfoil, and parrot feather. These weeds flourish across wide areas where they act as powerful *ecosystem engineers* by altering ecosystems, sometimes creating dense mats or thickets that displace native plants, reduce food-web support, reduce turbidity, interfere with water conveyance and flood control facilities, and hinder boating (Jones et al. 1994, Breitburg et al. 2010). Nonnative invasive aquatic vegetation also provides favorable habitat conditions for nonnative invasive predatory fish species, including largemouth bass (Ferrari et al. 2014, Conrad et al. 2016).

Nonnative invasive invertebrate species also profoundly affect the aquatic food web in the Delta. Nonnative invasive overbite clams contribute to the reduction of algae and some invertebrates in the Delta, especially in Suisun Bay (Kimmerer 2006). This represents a loss at the base of the food web, contributing to the decline of delta smelt and other open-water fish (Sommer et al. 2007). The introduced Asian clam is abundant in freshwater parts of the Delta and in the mainstems of the Sacramento and San Joaquin Rivers. This species can alter channel bottoms and competes with native freshwater mussels for food and space (Claudi and Leach 2000). In addition, introduced zooplankton, which are linked to a decrease in nutritional value for fish, have almost completely replaced native zooplankton (Winder and Jassby 2011).

Future invasions by new nonnative species, like zebra and quagga mussels, are likely. Neither has been observed in the Delta yet, but they have proven to be highly invasive and can colonize in high densities that affect water flow and quality through canals and pipes. Once introduced, nonnative invasive species are difficult and expensive to control, and often impossible to eradicate. Therefore, preventing introduction of new nonnative species is a priority.

Aquatic invertebrates mainly enter the estuary in the ballast water of ships and on their hulls. California requires vessels arriving from outside the United States Exclusive Economic Zone to manage ballast water either through retention, mid-ocean exchange, or discharge to a shore-based treatment facility. The California State Lands Commission (CSLC) sets limits for allowable concentrations of living organisms in discharged ballast water. In 2018, the Council completed an independent scientific review for the CSLC, evaluating the feasibility of shore-based ballast water reception and treatment in California. A shore-based barge solution was determined to be the most cost-effective option to reduce the potential for conflicts with land-use restrictions and permitting requirements.

MANAGING INVASIVE SPECIES IN THE DELTA

Several federal and state agency programs detect and manage invasive species in the Delta, often in collaboration with nonprofit organizations, universities, and other stakeholders.

- The Sacramento-San Joaquin Delta Conservancy has organized a Delta Interagency Invasive Species Coordination Team to foster communication and collaboration among agencies that detect, prevent, and manage invasive species and to restore invaded habitats in the Delta. The team includes participants from six state agencies, three federal agencies, and the University of California, Davis.
- The California Invasive Plant Council (Cal-IPC), a nonprofit organization, produces an inventory of invasive plants present in California. The Cal-IPC list guides planning processes by identifying which invasive plants are more likely to be threats.
- The California Department of Food and Agriculture is the lead agency for the control of noxious weeds in California.
- The Delta Region Areawide Aquatic Weed Project is a group comprised of university researchers, public agencies, and resource managers that help management agencies optimize long-term sustainable control methods for various aquatic weeds, including water hyacinth and giant reed. The group supports research by the U.S. Department and Agriculture and University of California, Davis scientists to test new herbicides and integrated control methods.

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The Delta Plan encourages an increased focus on nonnative invasive species in the Delta and Suisun Marsh and continued collaboration among agencies to address and manage such species (see ER R7). To protect the Delta ecosystem, covered actions that have a reasonable probability of introducing new nonnative invasive species, or improving habitat conditions for nonnative invasive species, must fully consider and avoid or mitigate such potential (see ER P5). To measure progress, the Delta Plan tracks the establishment of new nonnative invasive species of fish, plants, and invertebrates; and the large-scale treatment and reduction of nonnative invasive plant species. By 2030, these actions are expected to reduce the land area covered by nonnative invasive plant species by half (see PM 4.10).

NUTRIA: AN EMERGING THREAT IN THE DELTA

The discovery that nutria, an invasive species of rodent, have reestablished in California has sparked immediate alarm, because nutria infestations in other portions of the country have resulted in widespread destruction of emergent wetland habitat. Failing to address the nutria threat may result not only in devastating impacts to the limited and fragile remaining wetlands in the Delta and the state but also increased flood risk to farms, houses, and infrastructure as nutria burrowing habits undermine levees. In response to the nutria threat, the interagency Nutria Response Team was convened and includes representatives from California Department of Fish and Wildlife, California Department of Food and Agriculture, California Department of Parks and Recreation, Department of Water Resources, U.S. Department of Agriculture, U.S. Fish and Wildlife Service, and county agricultural commissioner offices. This team is in the process of developing an eradication plan, which will include determining the full extent of the nutria infestation in California.

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Improve Fisheries Management

The Delta serves as a migration corridor for all anadromous fish species in the Central Valley as they return to their natal rivers to spawn, and during juvenile outmigration downstream to the ocean. The Delta Reform Act requires that the Delta Plan include measures to promote functional corridors for migratory species and conditions conducive to doubling salmon populations (Water Code section 85302[c]). The Delta Plan's primary mechanism for achieving these goals is restoring ecosystem function, as described in Core Strategy 2. However, some endemic and migratory fish populations are so threatened that they require active management in order to sustain current population levels until large-scale ecosystem function is restored.

A major obstacle affecting the function of streams and rivers for fish migration is instream, man-made structures (DWR 2014). Barriers to migration can negatively affect survival of anadromous fish by limiting access to refuge habitat, spawning and rearing grounds, and contributing to stressors that adversely affect overall species survival (NMFS 2009, 2014).

The most formidable barriers are located upstream on the Sacramento and San Joaquin Rivers and their tributaries, especially the many large and small dams associated with reservoirs, including Shasta, Folsom, and Millerton Lakes and Lake Oroville. Other physical barriers in the Delta that interrupt fish migration include structures with ledges and drops, such as bridge pilings, boat docks, narrow channels with riprapped edges, or the intakes of the SWP and CVP pumps, which entrain out-migrating juvenile salmonids and create attractive spots for predatory fish to feed on migrating species.

In the Central Valley, less than one-fifth of the historical spawning habitat is still accessible to Chinook salmon and steelhead (Reynolds et al. 1993, Yoshiyama et al. 2001). Juvenile salmon (or smolts) leaving the Sacramento River and entering the interior Delta through the Delta Cross Channel or Georgiana Slough have significantly lower survival rates than fish that stay in the Sacramento River (Newman 2008, Perry et al. 2015). There are around 3,000 unscreened water diversions operating throughout the entire Delta watershed, almost all of which are small agricultural intake pipes. The overwhelming majority of the larger intakes in the Delta watershed have been screened as part of initiatives undertaken in recent decades to reduce entrainment loss of native juvenile fish.

Removing fish passage barriers would enable native Chinook salmon and Central Valley steelhead to access their natural spawning habitat in the upper Delta watershed. Due to limited resources and the large number of known barriers and unscreened diversions in the Delta and upstream watersheds, priority should be given to resolving the most important barriers (see New ER Recommendation “H”). For the purposes of the Delta Plan, priority barriers are those identified in the Fish Migration Opportunities Analysis (DWR 2014), Appendix K to the Central Valley Flood Protection Plan Conservation Strategy (DWR 2016), National Marine Fisheries Service (NMFS) Biological Opinions, and lists of priority barriers and priority unscreened diversions that CDFW maintains and updates on an annual basis (see PM 4.13). These include Lisbon Weir in the Delta and several others located within the lower Sacramento River Basin just outside the Delta (e.g., Sacramento Weir, Fremont Weir, Cache Creek Settling Basin Weir, and five Tule Canal agricultural crossings).

State and federal agencies should also fund and implement projects that improve habitat conditions and reduce predation risk for juvenile salmon along the priority migration corridors identified in Figure 4-7 (see New ER Recommendation “I”). Expanding floodplains by removing or breaching existing levees, improving waterside habitat, managing nonnative aquatic weeds, and augmenting sediment could improve survival of juvenile salmon, among other strategies (Moyle et al. 2012, SFEI 2016). Additional novel approaches to migration corridor management should be considered, including the use of behavioral fish guidance structures. A bio-acoustic fish fence was tested at Georgiana Slough and demonstrated promise toward guiding fish away from pathways where survival is decreased (Perry et al. 2014).

Until priority barriers are removed and critical migration corridors are restored, maintaining populations of anadromous fish requires the use of hatcheries to ensure reproduction. Hatcheries require careful management to maintain the genetic integrity of the salmonids (Araki et al. 2008, NMFS 2014). Hatchery fish interbreed and compete with wild fish, which can lead to a long-term decline in genetic diversity within the population.

The Hatchery Scientific Research Group (2012) recommended a Hatchery and Genetic Management Plan (HGMP) for each California Hatchery Program to ensure the conservation and recovery of listed Evolutionary Significant Units. NMFS also requires hatcheries releasing listed species into the wild to develop and implement HGMPs. Some hatcheries have developed HGMPs (Feather River Hatchery and Nimbus Hatchery), but not others (Coleman National Fish Hatchery and Merced River Hatchery). All hatcheries releasing listed species should continue to develop and implement HGMPs to reduce genetic risk of those species, and CDFW should provide annual updates on the status of those HGMPs (see ER R8).

These interventions are expected to contribute to increased abundance of native fish species, relative to the abundance of all fish species (see PM 4.10). Over time, these management actions will help to sustain native fish populations until large-scale ecosystem restoration can be implemented, and fish populations become self-sustaining. State agencies and academic researchers should coordinate and use best available science and technology to tag fish within the Delta, identify fish migration pathways, estimate survival, and track progress (see ER R9).

PREDATORY FISH MANAGEMENT

Modification of the Delta ecosystem since the early 1850s has resulted in system-wide and localized conditions that favor nonnative predatory fish. The current system of highly interconnected and relatively uniform deep channels provides excellent habitat for nonnative predators, and it lacks the heterogeneous shallow tidal habitat that provides predator refuge and foraging habitat for native fishes. Additionally, nonnative submersed and floating aquatic vegetation provides favorable habitat conditions for many nonnative predatory fish species. Predation hot spots exist in the Delta where predators congregate and consume large numbers of prey that are disoriented by unnatural flow patterns and modified habitat structures, such as water intakes.

Nonnative fish species such as striped bass have been shown to prey on native salmon and smelt. Efforts are underway to evaluate the effectiveness of targeted removal of nonnative fish predators from the Delta for improving native fish survival. Currently, DWR is implementing a robust study to evaluate the effectiveness of various techniques to capture and selectively remove nonnative predatory fish from Clifton Court Forebay, a known predator hot spot. DWR will evaluate whether these predator removal treatments are correlated to improved survival of tagged fish traversing the Forebay. Direct removal of nonnative fish predators alone, though, is unlikely to provide long-term improvements to native fish survival throughout the Delta (Grossman et al. 2016). Other actions such as restoring and enhancing bankside habitat to provide predation refuge and foraging habitat for juvenile salmonids, as well as restoring tidal wetlands and seasonal floodplains, will be crucial components within a range of management actions to reduce the net effect of nonnative fish predators on native fish populations.

The Delta Plan includes recommendations in Chapter 3 for DWR, Reclamation, and local beneficiary agencies to evaluate and implement effective predator control actions, such as fishery management and directed removal programs, to minimize predation on juvenile salmon and steelhead in Clifton Court Forebay and in the primary channel at the Tracy Fish Collection Facility.

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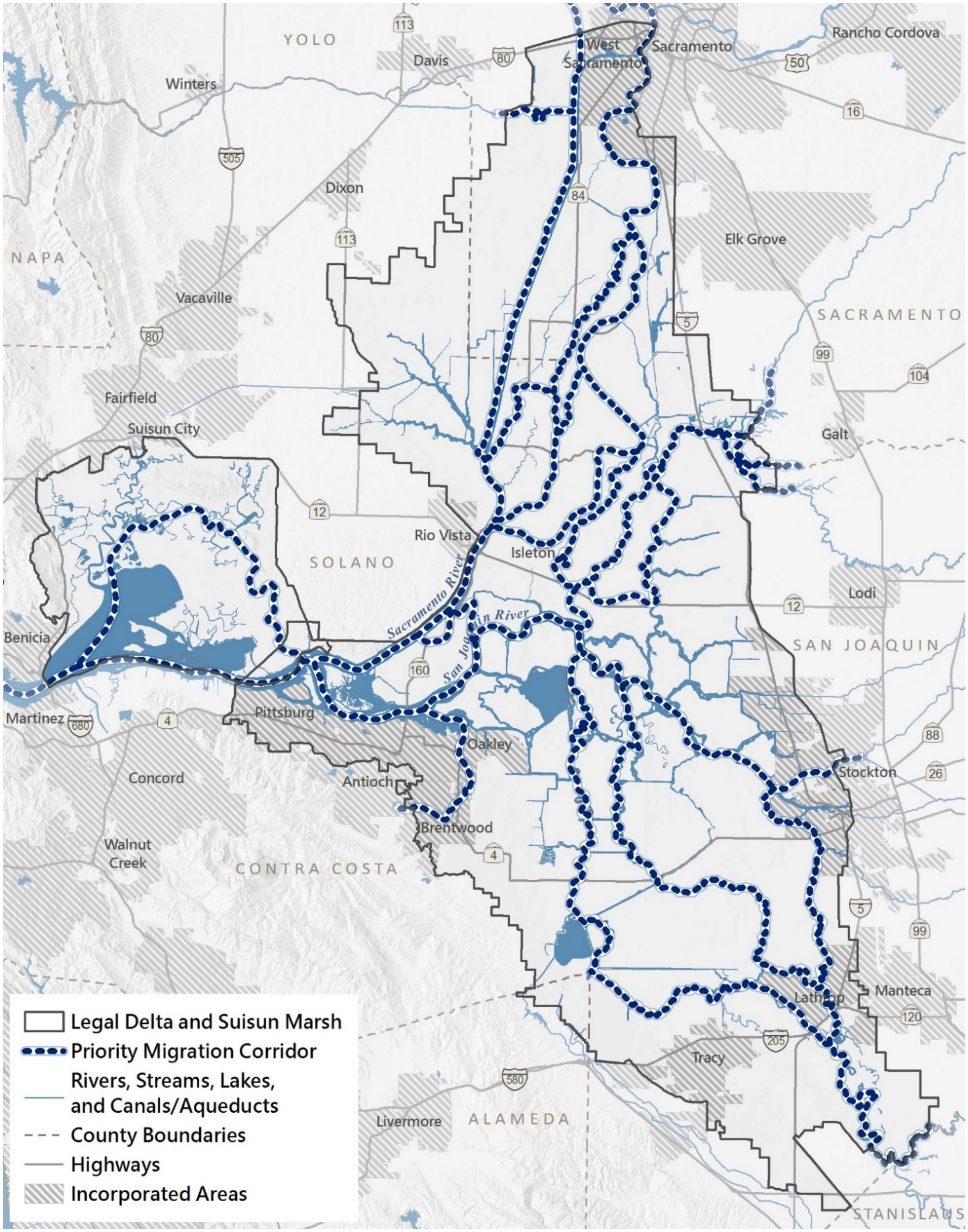

Figure 4-7. Priority Migration Corridors

Figure 4-7. Priority Migration Corridors (contd.)

Figure 4-7 is a map that identifies Priority Migration Corridors for native migratory fish species within the Delta and Suisun Marsh. The map shows the Legal Delta and Suisun Marsh outlined in black. The migration corridors are depicted as dark blue dotted lines. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; the Sacramento and San Joaquin Rivers are labeled. County boundaries are depicted in gray dotted lines. Major highways are depicted in gray solid lines and labeled by highway number. Incorporated areas are shown in gray hatching.

The Priority Migration Corridors depicted in this map are, starting at the northern end of the Delta and moving clockwise: the Sacramento River Deep Water Ship Channel and toe drain, Sacramento River, Elk Slough, Sutter Slough, Steamboat Slough, Georgiana Slough, the Cosumnes River, North and South Fork of the Mokelumne River, Threemile Slough, the San Joaquin River, Burns Cutoff, Paradise Cut, Middle River, Old River, Marsh Creek, Sand Creek, and Montezuma Slough. Priority Migration Corridors are also depicted running through Grizzly Bay and Suisun Bay within Suisun Marsh, and heading west to Carquinez Strait. These Priority Migration Corridors run through and adjacent to the cities of West Sacramento, Sacramento, Isleton, Stockton, Lathrop, Brentwood, Oakley, and Rio Vista.

Please contact the Delta Stewardship Council with any questions regarding this figure.

Core Strategy 5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement

Many state, local, and federal plans, programs, and projects address ecosystem protection, restoration, and enhancement in the Delta. This includes plans to recover and conserve species, programs to distribute public grants and loans, and single- and multi-benefit projects. However, these plans, programs, and projects typically have different objectives and desired outcomes, depending on individual agency missions, legislative direction, or other guidance. As a result, the combined effect of efforts to protect, restore, and enhance the Delta ecosystem has not been equal to the sum of its parts.

Most restoration in the Delta has traditionally been implemented to meet regulatory requirements under a variety of laws and regulations, including the Federal Endangered Species Act (ESA), the Clean Water Act, the California Fish and Game Code, the California Water Code, and others. These laws and regulations may require restoration to compensate for impacts to species and their habitats. Implementation of these laws and regulations provide important benefits to the Delta ecosystem, and established goals and objectives for habitats and species, including Recovery Plans and Habitat Conservation Plans under ESA (Council 2018, Appendix Q4). However, additional progress could be made by coordinating planning efforts among the agencies responsible for implementation.

An existing mechanism for coordination between among the agencies responsible for implementation of ecosystem protection, restoration, and enhancement actions and the Council is the early consultation process for covered action certification. State and local agencies may consult with the Council early in the planning process on the consistency of proposed projects with applicable regulatory policies in the Delta Plan. For ecosystem restoration projects, it is critically important that early consultation occur in the earliest possible stages of the California Environmental Quality Act (CEQA) review process to ensure that Delta

Plan requirements are incorporated as features of proposed projects or as mitigation measures.

Recent planning processes, such as the Delta Conservation Framework (2018) and the Public Land Strategy (2019), have helped identify a conservation vision for regions throughout the Delta. As these planning processes continue, there is a need to align state, local, and federal plans and programs that address ecosystem protection, restoration, and enhancement within the Delta and to accelerate implementation (see New ER Recommendation “G”). This includes promoting the priority attributes described in Core Strategy 2 and detailed in Appendix Q2 across all ecosystem protection, restoration, and enhancement planning, design, and funding efforts, with a focus on achieving the Delta Plan’s vision and the Delta Reform Act’s subgoals and strategies for a sustainable, restored Delta ecosystem.

Although major challenges exist in addressing the historical alteration of the Delta ecosystem, progress toward protecting existing conditions and restoring the Delta ecosystem has been made. Approximately 25,000 acres of habitat restoration is in progress pursuant to existing mandates under federal biological opinions to support native fish species, and an additional 5,000–10,000 acres of habitat restoration and enhancement projects have been funded by state-led programs (e.g., Delta Conservancy grant programs). The pace of progress has also accelerated over recent years due to concerted efforts on behalf of the state administration to support additional resources to align state and federal activities, increase the efficiency of permitting processes, and focus on creating resources to complete projects. Nevertheless, there remains a pressing urgency to restore ecosystem function to ensure the Delta can remain a unique ecological resource and to increase the resiliency of the ecosystem to growing threats from subsidence, land-use changes, climate change, and sea level rise.

Increase Interagency Coordination and Support for Restoration Projects

Known barriers to implementing ecosystem restoration projects include restrictions on the amount and use of restoration funding, complex and time-intensive permitting requirements, and a lack of authority and funding to support long-term ownership and management of restoration projects. Addressing these challenges requires institutional commitment to a single, consolidated restoration forum with agency support and discretion to align strategies. The existing charter of the DPIIC provides a framework for this type of effort, focused on implementing restoration projects (see New ER Recommendation “F”). The roles and responsibilities of relevant agencies, including DPIIC member agencies, for restoration in the Delta are shown in Table 4-1.

Funding

Based on the most recent available studies, the cost of restoring the Delta ecosystem is estimated at over five billion dollars, or several hundreds of millions of dollars annually (DWR 2013b, Medellín-Azuara et al. 2013). These studies estimate the cost of tidal wetland and shallow water habitat restoration (including land acquisition) at 20,000 dollars per acre, although costs can vary widely based on location, ownership, and project features. As of 2013, annual maintenance costs for tidal wetland restoration projects were estimated at 35 to 100 dollars per acre. Estimated capital and operations and maintenance costs for some direct fish management actions, invasive species control measures, and expansion of floodplain habitat, were about 10 million dollars per year; while actions related to changing flow management and reducing discharges ranged between 10 to 100 million dollars per year (Medellín-Azuara et al. 2013).

State agencies should collaborate to develop a comprehensive funding strategy that updates cost estimates and identifies a portfolio of approaches to remove institutional barriers to funding landscape-scale restoration projects within the Delta. Multi-benefit project funding is often limited in scope, and frequently must be used to achieve other project objectives in addition to ecosystem restoration. Bonds and public borrowing have funded the majority of large-scale restoration projects in the Delta to date, but gaps have been left with respect to the long-term management of restored lands. Planning efforts have typically focused on identifying and implementing the most cost-effective actions providing the highest ecological values for the lowest cost. The result of implementing the lowest-cost, highest-value projects is that remaining actions needed in the Delta will largely be of moderate to high cost (Medellín-Azuara et al. 2013). Achieving the Delta Plan’s vision for restoring Delta ecosystem will require different funding strategies and mechanisms than have been applied in the past.

These costs are necessary to achieve the ecosystem restoration goals, subgoals and strategies identified in the Delta Reform Act. Yet it is important to note that such large-scale investments in ecosystem restoration could also provide economic benefits to Delta communities, such as job creation, ecotourism, flood control, improved water quality, and improved commercial and recreational fisheries.

Permitting

Permitting for ecosystem protection, restoration, and enhancement actions in the Delta can be complex, time-consuming, and costly, requiring coordination among multiple local, state, and federal agencies. Strategic partnerships amongst agencies, including continued investment in fostering these relationships on an ongoing basis, will be important to help accelerate progress toward protecting, restoring, and enhancing the Delta ecosystem.

State and federal agencies should coordinate to establish program-level environmental permitting mechanisms that increase efficiency for priority projects, which are defined as projects that have at least four of the priority attributes of ecosystem restoration described in Core Strategy 2 and Appendix Q2. The DPIIC provides an existing forum in which state and federal agencies could coordinate Delta permitting needs and develop agreements to support integrated permitting processes, regional mitigation banking and crediting, and cost sharing. Such coordination would help increase the effectiveness of mitigation, shifting the focus from avoiding jeopardy toward species recovery and resilience, and reducing the time and cost for restoration projects to move to implementation.

Table 4-1. Agency Responsibilities for Restoration in the Delta

Agency	Responsibility
California Department of Fish and Wildlife	Developed Delta Conservation Framework (2018), which is intended to serve as a comprehensive resource and guide for planning conservation in the Delta through 2050; funds ecosystem restoration and habitat conservation projects in the Delta; state permitting agency; implements the Ecosystem Restoration Program, a multi-agency effort aimed at improving and increasing terrestrial and aquatic habitats and ecological function in the Delta and its tributaries.
California Department of Parks and Recreation	Owns and manages State Parks' property for the state, including in the Delta; develops and implements recreation plans; provides grant funding for parks and recreation projects.
California Department of Water Resources	Operates water management facilities within the Delta and Delta watershed; plans and implements multipurpose projects that support ecosystem restoration and habitat conservation in the Delta.
California Natural Resources Agency	Coordinates and oversees the restoration-related activities of numerous state agencies charged with Delta Plan implementation, including California EcoRestore.
California State Lands Commission	Protects California's navigable waterways and submerged lands for public use and enjoyment; works with other state agencies and local and regional governments to assess risk and then plan accordingly.
California Water Commission	Distribution of public funds set aside for the public benefits of water storage projects, including ecosystems and fish and wildlife in the Delta, and developing regulations for the quantification and management of those benefits.
Delta Protection Commission	Manages the newly established Sacramento-San Joaquin Delta National Heritage Area; protects, maintains, enhances, and enriches the overall quality of the Delta environment and economy.
Delta Stewardship Council	Implements the Delta Plan, a comprehensive, long-term, legally enforceable management plan for the Delta ; through the Delta Science Program, provides the best possible unbiased scientific information to inform water and environmental decision-making in the Delta; coordinates and guides adaptive management strategies through the *Delta Science Plan*; identifies funding for projects; produces syntheses and hosts symposia to inform restoration projects; conducts early consultation with project proponents for certification of consistency with the Delta Plan; processes certifications of consistency; hears and decides appeals; coordinates the Delta Plan Interagency Implementation Committee (DPIIC).
National Oceanic and Atmospheric Administration	National Marine Fisheries Service - Develops plans for the conservation and recovery of threatened and endangered anadromous fish; Ecosystem Restoration Program implementing agency; federal permitting agency; NOAA Office for Coastal Management – Collaborates with San Francisco State University and San Francisco Bay Conservation and Development Commission on the San Francisco Bay National Estuarine Research Reserve.
Sacramento-San Joaquin Delta Conservancy	Primary state agency for implementation of ecosystem restoration in the Delta; funds ecosystem restoration and habitat conservation projects in the Delta; has authority to acquire and manage lands and to coordinate with landowners.

Table 4-1. Agency Responsibilities for Restoration in the Delta (contd.)

Agency	Responsibility
San Francisco Bay Conservation and Development Commission	Administers the Suisun Marsh Protection Plan and ensures federal projects and activities are consistent with the plan as the federally designated state coastal management agency for San Francisco Bay.
San Francisco Bay Restoration Authority	Funds shoreline projects that protect, restore, and enhance San Francisco Bay, including Suisun Marsh and portions of Contra Costa and Solano Counties, through the allocation of funds raised by the Measure AA parcel tax.
State Water Resources Control Board	Establishes, implements, and enforces water-rights requirements; state permitting agency; with regional boards, develops and implements water quality standards and control plans, including the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (Bay-Delta Plan), which establishes water quality control measures and flow requirements needed to provide reasonable protection of beneficial uses in the watershed.
U.S. Army Corps of Engineers	Plans and implements multipurpose projects that support aquatic ecosystem restoration in the Delta.
U.S. Bureau of Reclamation	Operates water management facilities within the Delta and Delta watershed; plans and implements multipurpose projects that support ecosystem restoration and habitat conservation in the Delta.
U.S. Environmental Protection Agency	Oversees implementation of Clean Water Act programs and policies delegated to the State of California; published the San Francisco Bay Delta Action Plan in August 2012 and identified priority activities to advance the protection and restoration of aquatic resources and ensure a reliable water supply in the San Francisco Bay Delta Estuary watershed.
U.S. Fish and Wildlife Service	Develops plans for the conservation and recovery of threatened and endangered terrestrial and aquatic species; Ecosystem Restoration Program implementing agency; federal permitting agency.

PERMITTING AND REGULATORY PROCESSES THAT AID ECOSYSTEM RESTORATION

- **Regional Partnerships**. Habitat planning conducted through regional conservation frameworks, such as the California Department of Fish and Wildlife's *Delta Conservation Framework*, provides a means for identifying and reinforcing landscape-scale conservation targets and identifying permitting actions that may be needed at a program level.
- **California Environmental Quality Act**. Program-level coverage under CEQA for ecosystem restoration and related multi-benefit actions in the Delta could provide another tool to streamline implementation. For example, the *Suisun Marsh Habitat Management, Preservation, and Restoration Plan* and its Final Environmental Impact Statement/Environmental Impact Report guide and provide compliance support to implementing agencies in obtaining permits to carry out marsh restoration and management actions.
- **Mitigation Banking**. The California Department of Fish and Wildlife's *Regional Conservation Investment Strategies Pilot Program* moves a step beyond planning by incorporating advance mitigation banking components. Mitigation credit agreements developed under an approved Regional Conservation Investment Strategy provide the basis for tracking mitigation credits when conservation or habitat enhancement actions are implemented. This voluntary, nonregulatory regional planning process is intended to result in higher-quality conservation outcomes, while facilitating regional mitigation.
- **Expedited Permitting**. The *Bay Restoration Regulatory Integration Team* seeks to reduce permitting time for multi-benefit restoration projects via coordinated permitting, while ensuring compliance with all applicable laws. A variety of agency partners have developed a programmatic Biological Assessment for the National Marine Fisheries Service to review, approve, and use to issue a programmatic Biological Opinion. The U.S. Army Corps of Engineers has also embarked on internal efforts to increase the efficiency of its Clean Water Act Section 404 Permit process. Similarly, the multi-agency *Suisun Marsh Adaptive Management Advisory Team* meets regularly to review projects within the Suisun Marsh during early planning, setting the stage for faster permit approvals when projects move into construction.

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Ownership and Management

Improved coordination among public agencies is also needed to develop strategies for acquisition and long-term public ownership and management of lands necessary to achieve large-scale restoration in the Delta. Although the Council does not have the authority to construct, implement, or fund ecosystem protection, restoration, or enhancement actions, the Delta Reform Act created and granted authority to the Delta Conservancy to acquire and manage lands and to coordinate with landowners, among other responsibilities. This authority is critical to implementing restoration in the geographies and at the scale required. The DPIIC also has an important role to play in facilitating the development of cost-sharing agreements and other strategies to support ownership and maintenance of lands used by multiple partner agencies to accomplish restoration, recreation, and other objectives.

The Council acknowledges that land ownership and management can affect the productivity of existing agricultural operations, and the values of the Delta as an evolving place. Therefore, the Delta Plan contains a regulatory policy to promote ecosystem restoration on existing public lands before privately owned sites are purchased (see Chapter 5 for a detailed description of Delta As Place and DP P2). However, achieving the vision of a restored Delta ecosystem will require restoration on lands beyond those currently in public ownership. Reaching a balance between agriculture and a functioning ecosystem will require working landscapes—agricultural lands managed to support biodiversity and provide habitat resources—as an important part of achieving ecosystem goals in the Delta. Partnership strategies should incentivize the long-term management of working lands for ecosystem services such as seasonal wetland and floodplain habitat, carbon sequestration, and subsidence reversal.

Science Support

The Delta Reform Act requires that the Delta Plan "Include a science-based, transparent, and formal adaptive management strategy for ongoing ecosystem restoration and water management decisions" (Water Code section 85308[f]). Use of best available science and application of a robust, science-based adaptive management plan are essential for moving ecosystem restoration science forward, and for the long-term success of ecosystem restoration in the Delta (see Delta Plan Policy GP 1, subsections [b][3, 4] codified as 23 CCR section 5002[b][3,4]). Proponents of ecosystem protection, restoration, and enhancement projects should consult with the Delta Science Program on the application of best available science and adaptive management.

Adaptive management of restoration projects should incorporate the use of experiments where possible to improve our understanding of restoration approaches and reduce future uncertainty. Lessons learned from adaptive management will be used to improve planning, design, and implementation of similar, future process-based restoration projects. Monitoring and adaptive management of restoration projects should be pursued over time scales that are sufficiently long to observe and adapt to changes in conditions. There may often be long time lags between implementing process-based restoration actions and seeing recovery of ecological processes (e.g., it takes many years for newly planted trees to grow into mature stands of riparian forest and even longer to observe recruitment from those trees) (Beechie et al. 2010). When adaptive management experiments are included in the design of ecosystem restoration projects (e.g., the Dutch Slough Tidal Marsh Restoration Project), future improvement in restoration design can be expected.

The Delta Science Program develops and implements the *Delta Science Plan* and the *Science Action Agenda* to strengthen, organize, and communicate science to provide relevant, credible, and legitimate decision-support for policy and management actions, and to identify priority actions that fill critical gaps in Delta science. The Delta Science Program aims to provide technical guidance, update and increase the accessibility of conceptual models, and develop standardized monitoring tools to facilitate both individual restoration projects and comparability and synthesis across projects (Council 2019).

State and federal agencies should coordinate with the Delta Science Program to align resources for scientific support of restoration efforts, including adaptive management, data tools, monitoring, synthesis, and communication.

Policies and Recommendations

Core Strategy 1: Create More Natural Functional Flows

The volume, timing, and extent of freshwater flows through the Delta directly affect the reliability of water supplies and the health of the Delta ecosystem. More natural functional flows across a restored landscape can support native species recovery, while providing the flexibility needed for water supply reliability. Freshwater flows should be allocated and adaptively managed to more closely resemble the natural volume, timing, frequency, and duration to achieve the desired ecosystem functions.

Implement and Regularly Update Flow Guidance

Problem Statement

The best available science demonstrates that altered or reduced water flows strain the entire Delta ecosystem, as well as the rest of the estuary. The predictability of water exports cannot be improved, and restoration cannot be effectively implemented, without timely State Water Resources Control Board action to update flow objectives. Updates must consider and balance the agricultural, urban, and ecosystem beneficial uses of a finite water supply and use best available science to guide decision-making.

Policy

ER P1. Delta Flow Objectives (NO CHANGE)

(a) *The State Water Resources Control Board's Bay Delta Water Quality Control Plan flow objectives shall be used to determine consistency with the Delta Plan. If and when the flow objectives are revised by the State Water Resources Control Board, the revised flow objectives shall be used to determine consistency with the Delta Plan.*

(b) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, the policy set forth in subsection (a) covers a proposed action that could significantly affect flow in the Delta.*

Recommendation

ER R1. Update Delta Flow Objectives (REVISED)

The State Water Resources Control Board (SWRCB) should maintain a regular schedule of reviews of flow objectives to reflect changing conditions due to climate change. The SWRCB should consult with the Delta Science Program on adaptive management and the use of best available science.

Core Strategy 2: Restore Ecosystem Function

Achieving the Delta Reform Act vision for the Delta ecosystem requires the reestablishment of tens of thousands of acres of functional, diverse, and interconnected habitat. The magnitude of the need dictates a change in existing approaches to restoration in the Delta. State agencies will require new funding sources in order to implement large-scale restoration projects and support multi-benefit projects that go above and beyond mitigation of impacts. An integrated, adaptive approach to ecosystem restoration requires that restoration projects focus on ecosystem function and be designed and located to continue functioning under changing climate conditions. Restoration projects should also be compatible with adjacent land uses and support the cultural, recreational and natural resource values of the Delta as an evolving place.

Improve Project Design

Problem Statement

The loss of over 90 percent of wetlands greatly impacted the Delta ecosystem; further impacts across all ecosystem components (physical, chemical and biological) continue to severely stress the Delta ecosystem. Habitats and migration corridors in the Delta are already shifting with climate-driven impacts such as sea level rise and temperature changes, and these changes are likely to accelerate rapidly in coming decades. Restoration projects must be implemented at scales and in locations with sufficient opportunity to restore land-water connections in order to be resilient to these long-term trends. Currently, many restoration actions in the Delta are limited to single-species conservation, recovery, or mitigation projects. State agencies charged with stewardship and restoration of the Delta ecosystem have limited ability to change these practices due to permitting requirements and restrictions on the amount and use of public funds. Information gaps prevent more systematic planning and adaptive management of these activities and investments.

Policies

New ER Policy “A”. Disclose Contributions to Restoring Ecosystem Function and Providing Social Benefits (NEW)

(a) The certification of consistency for a covered action described in Subsection (b) shall:

1. *Include completed Section 1 (Priority Attributes) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits), and the documentation and information required by Appendix 3A, Section 1, to identify the priority attributes of the covered action and disclose its contribution to the restoration of a resilient, functioning Delta ecosystem, and to identify the ecosystem restoration tier associated with that covered action based on the identified priority attributes.*
2. *Include completed Section 2 (Social Benefits) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits), and the documentation and information required by Appendix 3A, Section 2, to identify and disclose the covered action's cultural, recreational, agricultural, and/or natural resource attributes anticipated to result from project implementation.*

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy applies to a covered action that includes protection, enhancement, or restoration of the ecosystem.

ER P4. Expand Floodplains and Riparian Habitats in Levee Projects (REVISED)

(a) Certifications of consistency for levee projects must provide an evaluation of, and where feasible the levee project must incorporate, alternatives to increase floodplains and riparian habitats.

1. *Levee projects located in the following areas (as depicted in Appendix 8A): (1) The Sacramento River between the Deepwater Ship Channel and Steamboat Slough, the San Joaquin River from the Stanislaus River confluence to Rough and Ready Island, the Stanislaus River, the Cosumnes River, Middle River, Old River, Paradise Cut, Elk Slough, Sutter Slough; and the North and South Forks of the Mokelumne River, and (2) Urban levee improvement projects in the cities of West Sacramento and Sacramento, shall evaluate alternatives which remove all or a portion of the original levee prism in order to physically expand the width of the channel.*

2. *All levee projects located in whole or in part in the Delta shall evaluate alternatives to increase levee waterside habitat.*

(b) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to construct a new flood control work or make capital improvements to an existing flood control work.*

Recommendations

New ER Recommendation "A". Increase Public Funding for Restoring Ecosystem Function (NEW)

New funding sources are needed to achieve the scale of ecosystem restoration envisioned by the Delta Reform Act. Future State funding opportunities for implementing restoration projects in the Delta, including grant and loan programs, should be directed to projects that would achieve Ecosystem Restoration Tier 1 or 2, as defined in Appendix 3A.

New ER Recommendation "B". Use Good Neighbor Checklist to Coordinate Restoration with Adjacent Uses (NEW)

Restoration project managers should use the Department of Water Resources' Good Neighbor Checklist when planning and designing restoration projects, in order to demonstrate that the project avoids or reduces conflicts with existing uses.

ER R4. Exempt Delta Levees from the U.S. Army Corps of Engineers' Vegetation Policy (NO CHANGE)

Considering the ecosystem value of remaining riparian and shaded riverine aquatic habitat along Delta levees, the U.S. Army Corps of Engineers should agree with the California Department of Fish and Wildlife and the California Department of Water Resources on a variance that exempts Delta levees from the U.S. Army Corps of Engineers' levee vegetation policy where appropriate.

Core Strategy 3: Protect Land for Restoration and Safeguard Against Land Loss

As sea levels rise, opportunities for intertidal and floodplain restoration are shifting inland, toward the upland edges of the Delta. Restoration of tidal wetlands should focus on opportunities to create interconnected habitats, where elevations will support intertidal habitats into the future. Lands at elevations suitable for current and future restoration must be protected from development, and restoration projects must be designed and located with rising sea levels in mind. Consistent with State law, local and regional plans in the Delta must consider sea level rise as well as the loss of lands suitable for ecosystem restoration and the need to accommodate these landscape changes. State agencies must take action to reduce, halt, or reverse subsidence; and incentivize agricultural land management practices that support native wildlife and counter subsidence.

Protect Opportunities for Restoration

Problem Statement

The loss of lands suitable for restoration due to sea level rise and development jeopardizes efforts to restore ecosystem functions in the Delta. Levees, roads, and other infrastructure prevent wetland migration, threatening the ability of existing channel margin wetlands to adapt to rising sea levels. The expansion of development and infrastructure in the Delta will constrain opportunities to reconfigure and reconnect floodplains to their channels. Over time, these forces will continue to diminish the extent of land suitable for restoration projects at intertidal elevations, reducing future opportunities to create land-water connections and restore ecosystem function.

Policies

ER P2. Restore Habitats at Appropriate Elevations (REVISED)

(a) The certification of consistency for a covered action described in Subsection (d) must be carried out in a manner consistent with Appendix 4A, which provides guidance on appropriate elevations for particular ecosystem types within the Sacramento-San Joaquin Delta and Suisun Marsh.

1. *The certification of consistency must include a completed Appendix 4A and all of the documentation and information required by Appendix 4A.*
2. *If a covered action is not consistent with the Table 1.1 in Appendix 4A, the certification of consistency shall provide, based on best available science, the rationale for any inconsistency with Table 1.1 and how it is nonetheless consistent with this policy.*

(b) The certification of consistency for a covered action that takes place, in whole or in part, in the Intertidal Elevation Band and Sea Level Rise Accommodation Band shall, based on best available science:

1. *Explain, how the action is designed to accommodate each of the following:*
   - i. *future marsh migration;*
   - ii. *anticipated sea level rise; and*
   - iii. *tidal inundation; and*
2. *If the action does not implicate one or more of the elements set forth in subsection (1) of section (b) of this regulation, for each such element, explain why it does not.*
3. *The information required by this regulation may be included in an adaptive management plan, where required by section 5002 of this Chapter.*

(c) The certification of consistency for a covered action that takes place, in whole or in part, in the Shallow Subtidal Elevation Band or the Deep Subtidal Elevation Band shall explain, based on best available science, how the action is designed to safeguard against levee failure over the design life of the project. This information may be included in an adaptive management plan, where required by section 5002 of this Chapter.

(d) For purposes of Water Code Section 85057.5(a)(3) and Section 5001(j)(1)(E) of this Chapter, this policy applies to a covered action that includes protection, restoration, or enhancement of the ecosystem.

ER P3. Protect Opportunities to Restore Habitat (REVISED)

(a) Within the priority habitat restoration areas depicted in Appendix 5, significant adverse impacts to the opportunity to restore habitat as described in section 5006 of this Chapter, must be avoided or mitigated.

(b) Impacts referenced in subsection (a) will be deemed to be avoided or mitigated if the project is designed and implemented so that it will not preclude or otherwise interfere with the ability to restore habitat as described in section 5006 of this Chapter.

(c) If the impacts referenced in subsection (a) are mitigated (rather than avoided), they must be mitigated to the extent that the project has no significant impact on the opportunity to restore habitat as described in section 5006 of this Chapter.

(d) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions in the priority habitat restoration areas depicted in Appendix 5. It does not cover proposed actions outside those areas.*

Recommendation

ER R5. Update the Suisun Marsh Protection Plan (REVISED)

The San Francisco Bay Conservation and Development Commission should update the Suisun Marsh Protection Plan to adapt to sea level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act, and the Delta Plan, and support local government and districts with jurisdiction in the Suisun Marsh in amending their components of the Suisun Marsh Local Protection Program accordingly.

Safeguard Against Land Loss

Problem Statement

Agriculture has shaped the rich economy and rural culture of the Delta, although it has come at a cost: the loss of land-water connections. Without regular inundation, peat-rich Delta lands experience soil carbon loss and subsidence. The 2018 Natural and Working Lands Inventory attributed the majority of soil carbon loss in California to oxidation of organic soils in the Delta. The ongoing loss of land due to subsidence threatens the Delta Reform Act's vision for a restored Delta ecosystem, the livelihoods of those who live and work in the Delta, and statewide water supply reliability. Urgent action is needed to halt the current rapid pace of subsidence and to promote subsidence reversal activities. Reaching a holistic balance between agriculture and a functioning ecosystem will require working landscapes – agricultural lands managed to support biodiversity and provide habitat resources – as an important part of achieving ecosystem goals in the Delta. State agencies own more than 35,000 acres on deeply subsided lands in the Delta and Suisun Marsh and thus have a critical role to play in halting and reversing subsidence.

Recommendations

New ER Recommendation "C". Fund Targeted Subsidence Reversal Actions (NEW)

(a) *The Delta Conservancy should develop incentive programs for public and private land owners that encourage land management practices that stop subsidence on deeply subsided lands in the Delta and Suisun Marsh.*

(b) *In order to ensure the long-term durability of state investments in restoration, State agencies that fund ecosystem restoration in subsided areas should direct investments to areas that have opportunities to both reverse subsidence and restore intertidal marsh habitat.*

New ER Recommendation "D". Enhance Working Landscapes through Resource Conservation Districts (NEW)

State agencies should be provided with funding in order to provide resources and support to Resource Conservation Districts (RCDs), and other local agencies and districts, in their efforts to improve agricultural land management practices that support native species. State agencies should work with RCDs, and other local agencies and districts, to adaptively manage agricultural land management practices to improve habitat conditions for native species.

New ER Recommendation "E". Develop and Update Management Plans to Halt or Reverse Subsidence on Public Lands (NEW)

For all publicly-owned lands in the Delta or Suisun Marsh, State and local agencies should develop or update plans that identify land management goals; identify appropriate public or private uses for that property; and describe the operation and maintenance requirements needed to implement management goals. These plans should address subsidence and consider the feasibility of subsidence reversal.

Core Strategy 4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

While large-scale ecosystem restoration is the priority approach to support native species recovery, some stressors require more focused interventions. In particular, management actions continue to be necessary to avoid introductions of, and reduce the spread of, nonnative invasive species. In managing native fish populations, reestablishing riparian habitat and in-stream connectivity along migratory corridors supports the reproductive success and survival of native fish. Hatcheries and harvest regulation should employ adaptive management strategies to predict and evaluate outcomes and minimize risks.

Prevent Introduction of Nonnative Species and Manage Nonnative Species Impacts

Problem Statement

Nonnative invasive species are both a symptom of a highly degraded ecosystem and a major obstacle to successful restoration of the Delta ecosystem because they can affect the survival, health, and distribution of native Delta plants and wildlife. Native species are impacted by nonnative invasive species through competition, predation, disease and other interactions. The establishment of new nonnative invasive species is likely within the highly altered landscape of the Delta and could result in further ecosystem effects. Native species are also impacted by ongoing activities that improve habitat conditions for existing nonnative invasive species.

Policy

ER P5. Avoid Introductions of and Habitat Improvements for Invasive Nonnative Species (NO CHANGE)

(a) *The potential for new introductions of or improved habitat conditions for nonnative invasive species, striped bass, or bass must be fully considered and avoided or mitigated in a way that appropriately protects the ecosystem.*

(b) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that has the reasonable probability of introducing or improving habitat conditions for nonnative invasive species.*

Recommendation

ER R7. Prioritize and Implement Actions to Control Nonnative Invasive Species (REVISED)

The Delta Conservancy, Delta Science Program, California Department of Fish and Wildlife, California Department of Food and Agriculture, and other State and federal agencies should develop and implement communication and funding strategies for rapid response to new introductions of nonnative invasive species, based on scientific expertise and research.

Improve Fisheries Management

Problem Statement

Fish migration is impaired by barriers and unscreened diversions within and upstream of the Delta, and these impacts will be compounded with a rapidly changing climate. Aquatic habitat conditions within the Delta support nonnative, predatory fish species, further reducing native fish survival. Hatcheries and harvest regulation are important tools in fisheries management, but they also pose genetic and ecological risks to wild salmon runs, other native species, and the Delta ecosystem. These practices need to employ adaptive management strategies to predict and evaluate outcomes and minimize risks.

Recommendations

New ER Recommendation “H.” Improve Fish Migration within the Delta and Sacramento – San Joaquin Watershed (NEW)

State and federal agencies should implement priority actions to remove barriers to fish migration.

New ER Recommendation "I". Fund Projects to Improve Survival of Juvenile Salmon (NEW)

Public agencies should fund and implement projects that improve aquatic habitat conditions and reduce predation risk for juvenile salmon along the priority migration corridors identified in Chapter 4, Figure 4-7. Projects that could improve survival of juvenile salmon include levee setbacks and waterside habitat improvements, placement of fish guidance structures, and nonnative aquatic weed management.

ER R8. Manage Hatcheries to Reduce Genetic Risk (NO CHANGE)

As required by the National Marine Fisheries Service, all hatcheries providing listed fish for release into the wild should continue to develop and implement scientifically sound Hatchery and Genetic Management Plans (HGMPs) to reduce risks to those species. The California Department of Fish and Wildlife should provide annual updates to the Delta Stewardship Council on the status of HGMPs within its jurisdiction.

ER R9. Coordinate Acoustic Telemetry Program (REVISED)

The California Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, should seek coordination among researchers conducting acoustic telemetry within the Delta waterways to identify fish migration pathways, and survival.

Core Strategy 5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement

A large and diverse array of public agencies and private organizations are engaged in ecosystem protection, enhancement, restoration, and mitigation in the Delta, with roles ranging from regulatory oversight to project implementation and long-term monitoring and management. Improving the efficiency and effectiveness of these efforts will require institutional commitment to a single, consolidated restoration forum with agency support and discretion to guide restoration strategies, plan investments, align individual agency plans and actions, and resolve barriers to implementation.

Increase Interagency Coordination and Support for Restoration Projects

Problem Statement

Broad, landscape scale changes are necessary to restore ecosystem functions in the Delta and Suisun Marsh. While coordination between State, federal and local agencies on ecosystem restoration has dramatically improved through forums such as the Delta Plan Interagency Implementation Committee and the Interagency Adaptive Management and Integration Team, slow progress in protecting and restoring the Delta ecosystem reveals an ongoing need to better coordinate plans and actions that contribute to ecosystem restoration.

Recommendations

New ER Recommendation "F". Support Implementation of Ecosystem Restoration (NEW)

Local, State and federal agencies should coordinate to support implementation of ecosystem restoration, and the Delta Plan Interagency Implementation Committee (DPIIC) should:

(a) *Consider establishing an ecosystem restoration subcommittee.*

(b) *Develop strategies for acquisition and long-term ownership and management of lands necessary to achieve ecosystem restoration consistent with the guidance in Appendix Q2.*

(c) *Develop a funding strategy that identifies a portfolio of approaches to remove institutional barriers and fund Ecosystem Restoration Tier 1 or 2 actions within the Delta.*

(d) *Establish program-level endangered species permitting mechanisms that increase efficiency for Ecosystem Restoration Tier 1 or 2 actions within the Delta and its watershed.*

(e) *Coordinate with the Delta Science Program to align State, federal, and local resources for scientific support of restoration efforts, including adaptive management, data tools, monitoring, synthesis, and communication.*

(f) *Develop a landscape-scale strategy for recreational access to existing and future restoration sites, where appropriate and while maintaining ecological value.*

New ER Recommendation “G”. Align State Restoration Plans and Conservation Strategies with the Delta Plan (NEW)

Agencies should coordinate, and the Delta Plan Interagency Implementation Committee (DPIIC) should consider establishing a subcommittee, to align State, local, or regional restoration strategies, plans or programs in the Delta to be consistent with the priority attributes described in Appendix Q2. These include:

(a) The Delta Conservation Framework;

(b) The CVFPP Conservation Strategy;

(c) The Public Lands Strategy;

(d) Regional Conservation Investment Strategies;

(e) *Regional Conservation Strategies or Partnerships; and.*

(f) *San Francisco Bay and Suisun Marsh Conservation Strategies, Investments and Partnerships, as appropriate.*

Performance Measures

<<See Appendix E>>

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