Delta Conservation Framework

Section III

Contents

III. Value and Need for Delta Ecosystem Conservation

Contemporary Delta ecosystems are threatened by an array of pressures including ongoing changes in land uses, freshwater flow diversions, poor water quality, reduction in sediment supply, and increased nonnative invasive species abundance, which are expected to be exacerbated by impending climate change (see Section IV for more information).[1] Regaining ecological function in the Delta is crucial to sustaining native wildlife, supporting persistence and recovery of special status species, and improving and sustaining the ecosystem services –the direct and indirect contributions of ecosystems to human well-being– to Delta residents and Californians.[2,3] These services directly or indirectly support our survival and quality of life. With continuing pressures, there remains uncertainty about how effectively conservation efforts will reestablish ecological processes and improve resilience in today's Delta (also see Section IV).[4,5,6] Therefore, it is critical the impacts of our conservation actions be considered and evaluated over the long term, as part of an adaptive management framework, to help guide long-term management for reaching specified goals (see Section IV for more information).

It is essential for all Delta stakeholders to recognize that benefits of restoring healthy ecosystems will also serve the best interest of Delta agriculture and community members.

The Delta Conservation Framework underscores the importance of fostering ecosystem function to better integrate human uses with supporting the persistence of native plants and animals over the long term, instead of attempting to achieve a Delta that resembles a pre-development, "pristine" state.[3] Delta stakeholders should work together to effectively plan and implement conservation, because healthy Delta ecosystems will also support agriculture and local communities.

This section of the Delta Conservation Framework provides a historical overview of changes in Delta ecosystems over the past 300 years, and highlights conservation strategies that promote ecological function on a landscape scale.[2] It also offers an overview of the specific Delta ecosystem types targeted for conservation, and Goal D with a series of relevant strategies and objectives for the conservation of ecosystem function and promoting listed species recovery.

***CONSERVATION** is defined here as a means to achieving system-wide multi-benefits by integrating protection, enhancement, reestablishment, and reconciliation of ecological function of Delta ecosystems with watershed and agricultural sustainability, flood protection, recreation, and other drivers.*

Historical Change in Delta Ecosystems and Human Uses

Before the 1800s, the Delta was home to a number of Native American tribes (primarily Miwok and Wintun).[7] Native American Delta residents relied primarily on fishing, hunting, and foraging. Although they did not practice agriculture, they managed the landscape with fire and other tools to favor the plants they used.[8] Population estimates in the Delta before European arrival are between 3,000 and 15,000, with most native villages situated on natural levees on the edges of the eastern Delta, typically containing around 200 residents in each.[7]

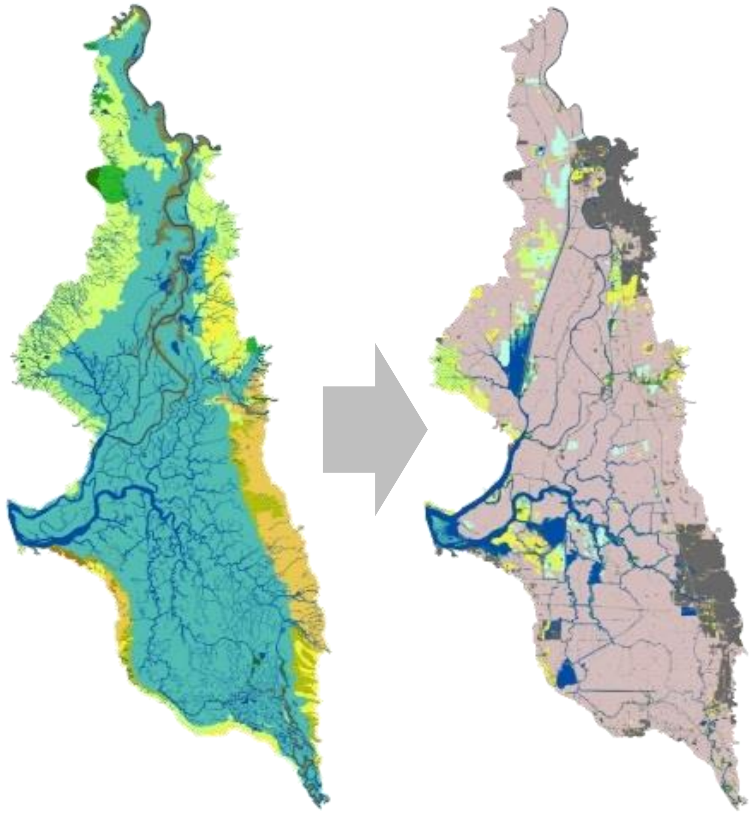

Figure 3.1: Delta waterways historically (left) and current (right). Historical channels depict the "capillary-like" distributary channel networks, now largely missing. Aqua green (left) depicts wetlands; pink (right) depicts agricultural landscapes.[3]

Prior to European settlement, large areas of the Delta were subject to seasonal flooding, and nearly 60 percent was submerged by daily tides, occasionally flooding it entirely during "spring" tides (see text box).[7] Water within the interior Delta remained primarily fresh, although most of the Delta was a tidal wetland, with early explorers reporting saltwater intrusion during the summer months in some years.[9] The historical Delta contained a massive network of small distributary or "capillary-like" channels with natural levees that created floodplains, marshes, and riparian forests and served as an extensive fluvial-tidal interface (Figure 3.1). The upland edges of transition zones from the wetlands were composed of alkali seasonal wetlands, grassland, oak savannas, and oak woodlands. Gently sloping sand mounds around the marshes provided high-tide refugia for terrestrial species[3].

> *A **spring tide, popularly known as a "King Tide**," refers to the 'springing forth' of the tide during new and full moons. The term King Tide is therefore used to describe an especially high spring tide, occurring a few times every year. In contrast, a neap tide, occurring seven days after a spring tide, refers to a period of moderate tides when the sun and moon are at right angles to each other. When King Tides coincide with extreme storms or floods, water levels can rise significantly, potentially causing damage to levees, infrastructure, and other property.*[10,11]

The San Francisco Estuary, and in particular the Delta, supported an extraordinary diversity and abundance of endemic, resident, and migratory wildlife within a wide array of native animal and plant communities.[3] Before European arrival, the Delta teemed with birds and wildlife such as Tule elk (*Cervus canadensis nannodes*), deer (*Odocoileus* spp.), and California grizzly bear (*Ursus arctos californicus*).[7] Few traces of this rich native culture, wildlife, and earlier plant life remain in the Delta today, and we recognize that the historic Delta is gone forever. It no longer functions—to the extent it used to—as a delta distributing water and sediment from rivers and bay tides across wetlands, floodplains, and riparian forests.[3] Instead, it is now largely a system of interconnecting confined channels that protect communities and agricultural land and convey water (Figure 3.1). Water entering the Delta is used to irrigate agricultural fields there; is diverted by the state and federal water projects for delivery to municipalities or irrigated agriculture in the San Francisco Bay Area, the San Joaquin Valley, the Central Coast, and southern California; and flows out into the San Francisco Bay to meet water quality standards and endangered species requirements.[12]

Beginning in the mid-1800s, mining, reclamation, agricultural practices, and urbanization by European immigrants dramatically changed the Delta landscape and function.[3,7] Agriculture has been the mainstay of economic life and culture in the Delta since then, serving as the backbone of contemporary Delta communities. Close to 80 percent of all farmland in the Delta is classified as Prime Farmland, with annual economic value of approximately $702 million from crop-based agricultural operations and $93 million from animal production.[13] Delta ecosystems and their historic ecological and biophysical functions were significantly altered to support this impressive agricultural economic growth over the past 160 years. Agricultural practices and urbanization cleared most forested areas, and levee upgrading removed most trees and vegetation from the natural levees.[7] Land reclamation and subsequent flood protection improvement activities built steep riprapped levees, straightened meandering channels, eliminated small distributary "capillary" channels, increased interconnectivity by connecting blind channels, and converted vast and fertile floodplains for cultivation, where lush riparian forests used to be.[3] As a result, the ability of Delta ecosystems to support native California fish, wildlife, and plant species and communities is now severely degraded or absent entirely.[1,12,14,15]

> "*Before modern development, almost half of California's coastal wetlands were found in the Sacramento-San Joaquin Delta. The Delta supported the state's most abundant salmon runs, the Pacific Flyway, and endemic species ranging from the Delta smelt to the Delta tule pea. In the region's Mediterranean climate, the Delta's year round freshwater marshes were an oasis of productivity during the long dry season. Until reclamation, the Delta stored vast amounts of carbon in its peat soils. Today the Delta functions very differently, having undergone a massive and continuing transformation. Despite the dramatic changes, however, many native species are still found in the Delta, albeit in greatly reduced numbers. Some are threatened by extinction, and others may be soon*."[3]

Most of the former marshlands of the Delta are reclaimed and support a thriving agricultural economy. Many are now highly subsided and dependent upon levees vulnerable to seismic events and sea level rise.[16,17] A number of California native and Delta endemic species are on the brink of extinction. Remnant, degraded ecosystems are often functionally disconnected, dominated by nonnative invasive species, and impacted by pollution, diminishing their resilience to climate change and other anthropogenic impacts.[18,19,20,21,22,23,24]

Because of ongoing changes in land uses, freshwater flow diversions, contaminants, reduction in sediment supply, increased nonnative invasive species abundance, and projected climate change impacts, future Delta ecosystems will not resemble historical or contemporary conditions. The lost ecosystem processes that sustain habitats for wildlife also provide services to humans, related to open space, improvements to water and land quality, and public enjoyment opportunities. The integrity of Delta ecosystems, including "wildlife-friendly" agricultural ecosystems, is dependent on improved and sustained ecological and biophysical processes. As a result, conservation planning should focus on restoring or improving processes, such as reconnecting flows of water and sediment, streams and rivers, and floodplains and tidal marshes; maintaining and reestablishing connections between aquatic and terrestrial habitats; and improving the spatial arrangement of natural and agricultural ecosystems across the landscape to provide wildlife habitat and movement corridors.

Landscape-Scale Conservation with a Long-Term Perspective

The central challenge for Delta conservation is to create and maintain resilient "landscapes that support desired ecological functions while retaining the overall agricultural character and water-supply service of the region."[2,25] Landscape-scale conservation is a concept that departs from a focus on restoration or enhancement of a particular site or parcel. It takes a holistic approach to planning conservation, which considers large-scale connectivity, biodiversity, and resilience to climate change in the context of local economies, agriculture, ecotourism, geodiversity, and the health and social benefits of the environment to humans.[26]

The Delta Conservation Framework provides landscape-level guidance by offering strategies for conservation based on the latest insights from scientific and historical ecology investigations.[2,3,27,28] From a landscape perspective, thriving wildlife populations depend on functional ecosystems where biological and physical processes, or groups of processes, link different elements together—e.g., the energy transfer in food chains (a biotic process) or tidal water flow (an abiotic process) that support them—with large patches of interconnected habitats. This includes agricultural or "working" landscapes, in which ecological processes (the physical, chemical, and biological actions or events that link organisms and their environment, such as decomposition, production [of plant matter], nutrient cycling, and fluxes of nutrients and energy) can occur. Fragmentation and habitat loss threaten the degree to which a landscape facilitates the movements of organisms and their genes.[29] For example, reduced connectivity between upland and wetlands can degrade habitat suitability for giant garter snake (*Thamnophis gigas*), since uplands are required for hibernation and cover[30] and wetlands are required for foraging and reproduction. Reduced connectivity can diminish the size and quality of available habitat, disrupt wildlife movement among habitats, and affect seasonal migration patterns. These changes can lead to detrimental effects on populations and species, including decreased carrying capacity, loss of genetic variation, and ultimately species extinction.[3,25,29] While these dynamics generally apply to all wildlife species, they may serve as stronger stressors on special status species present in the Delta (e.g., giant garter snake),[31] since small populations are more sensitive to isolation and reduced genetic diversity that may affect their resilience and long-term fitness.[32,33,34]

Landscape Connectivity can be broken down into '*structural connectivity*' and '*functional connectivity*.'

"*Structural connectivity* refers to the physical relationship between landscape elements, whereas functional connectivity describes the degree to which landscapes actually facilitate or impede the movement of organisms and processes.

Functional connectivity is a product of both landscape structure and the response of organisms and processes to this structure. Thus, functional connectivity is both species- and landscape-specific.

Distinguishing between these two types of connectivity is important because structural connectivity does not imply functional connectivity. In general, when we use the term 'connectivity' we are using the functional definition."

Source: Meiklejohn, et al. 2009: https://www.wildlandsnetwork.org/sites/default/files/terminology%20CLLC.pdf

Planning for conservation at larger scales therefore allows consideration of animal movement for foraging or other life history needs, migration and rearing opportunities for wildlife populations, sufficient genetic diversity, and movement of wildlife to upland refugia during high tides and storm events as sea levels rise. A landscape-scale approach also gives the opportunity to balance the pros and cons of implementing many smaller, widely spaced projects with fewer, larger, and less spatially distributed conservation projects.[25] As a result, many conservation efforts focus on protecting and enhancing landscape-scale connectivity and ecosystem resilience to potential threats by establishing interconnected reserve networks, or in case of the Delta, mosaics of conservation areas (for more information see subsection on *Protecting Ecosystems and Improving Connectivity* below) .[29,35]

California State Wildlife Action Plan

The 2015 California State Wildlife Action Plan (SWAP) is a region-based strategic conservation plan developed by CDFW[1]. The document provides a blueprint for actions necessary to sustain the integrity of California ecosystems, for their intrinsic values and as natural resources and heritages. The SWAP highlights the Delta as part of the Bay Delta Conservation Unit, within the Bay Delta and Central Coast Province. The conservation target ecosystems for the Bay Delta Conservation unit are freshwater marsh, including nontidal freshwater emergent wetlands; salt marsh, including saline emergent wetlands and tidal freshwater wetlands in the Delta; and American Southwest riparian forest and woodland, which includes the Valley Foothill Riparian natural community in the Delta. The SWAP highlights the pressures in the Delta that make it a prime region for conservation. Targets and conservation strategies were developed by reviewing and synthesizing other planning efforts for more specific guidance, including the Bay Delta Conservation Plan, the Delta Plan, and other planning documents described here. However, planning partnerships and project proponents should consult the SWAP when planning projects for or within target ecosystems and are strongly advised to consult the SWAP if applying for federal funding through the State Wildlife Grant or Endangered Species Act Section 6 program (see Appendix VII for more information on SWAP conservation priorities and species of greatest conservation need for the Delta).

Ecosystem Types

The Delta is composed of a mosaic of interconnected types of aquatic, terrestrial, transitional, and agricultural ecosystems that function as habitats for wildlife according to their various natural history requirements. Improving the function of these ecosystems will benefit not only wildlife species, but also provide services to humans related to open space, including recreation, pollinator services, improved soil and water quality,[36] ecotourism, and control of invasive species. Restoring a diversity of interconnected ecosystem components within the Delta landscape can provide insurance in the form of redundancy.[2,25] Ecological processes and resiliency would also be sustained in case a few components are degraded or lost. Therefore, the main questions to address in effective conservation planning are where and how to reestablish the dynamic natural processes that can support native Delta wildlife and their habitats into the future. The recommended approach is to create an appropriate configuration of ecosystem types at the landscape scale to provide diverse functional wildlife habitats and connectivity between them. Associated monitoring and adaptive management will allow tracking of whether restored ecosystem functions remain resilient over time, as the landscape and climate change.[2,25]

DEFINITIONS

An **ECOSYSTEM** is a community of living organisms interacting as a system in conjunction with the nonliving components of their environment (such as air, water and mineral soil). Each ecosystem is a defined area of varying sizes where biotic and abiotic components are interacting as a system and are regarded as linked together through nutrient cycles and energy flows.[37]

Example: Grassland ecosystems are made up of low herbaceous plants occupying well-drained soils with native forbs and annual and perennial grasses and are usually devoid of trees.

A **HABITAT** is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism. The term typically describes the area in which this organism lives and where it can find food, shelter, protection, and mates for reproduction. It can describe the natural environment in which an organism lives or the physical environment that surrounds a population of a given species.[38]

*Example: In portions of San Joaquin County, native grassland ecosystems provide habitat to the endangered San Joaquin Kit Fox (*Vulpes macrotis mutica*).*

The suite of Delta ecosystem types and their underlying processes (see text box below) support a variety of native wildlife species. They also include wildlife-friendly agricultural, managed, and urban ecosystems that are modified, managed, and influenced by people, yet also provide life history support to wildlife species (also see *Section II*). The ecosystem types listed below are generally aligned with the descriptions of ecosystems and habitats in the Delta Landscapes reports, California EcoRestore, CDFW and Delta Conservancy Proposition 1 funding solicitations, and Delta Stewardship Council performance measures (see Appendix VIII for specific definitions).

Delta Conservation Framework Goal D aims to improve ecological processes in the Delta, with specific focus on improving the function of the following ecosystem and associated wildlife habitat types (see Appendix VIII for specific definitions):

TERRESTRIAL/UPLAND ECOSYSTEM:

- Grassland
- Oak woodland/savannah
- Stabilized interior dune vegetation

- Wildlife-friendly agriculture (associated practices are defined in more detail in Appendix VIII)
- Ruderal/non-native
- Urban

RIPARIAN ECOSYSTEM:

- Valley foothill riparian
- Willow riparian scrub-shrub
- Willow thicket

AQUATIC ECOSYSTEM - Perennial Wetland

- Freshwater emergent marsh/wetland – tidal (intertidal vs. subsided elevations)
- Freshwater emergent wetland/marsh - non-tidal
- Saline emergent wetland/salt or brackish marsh

AQUATIC ECOSYSTEM - Seasonal Wetland

- Vernal pool complex
- Alkali seasonal wetland complex
- Wet meadow and seasonal wetland
- Managed wetland

AQUATIC ECOSYSTEM – Open Water

- Fluvial low order channel
- Fluvial main stem channel
- Fluvial – shaded riverine aquatic
- Fluvial - channel margin habitat
- Freshwater pond/lake
- Freshwater intermittent pond or lake
- Tidal main stem channel
- Tidal low order channel

TRANSITIONAL ECOSYSTEM

- Upland Transitional Corridors
  - Marsh-terrestrial transition zone
  - Marsh to open water edge
  - Floodplain – seasonal, short-term, intermediate recurrence
  - Floodplain – seasonal, long duration, low recurrence, deeper flooding
  - Floodplain – tidal inundation, high recurrence, low duration
  - Floodplain – ponds, lakes, channels, & flooded islands
  - Wildlife-friendly agriculture practices - minimize water quality impacts
  - Wildlife-friendly agriculture practices - minimize water diversion impacts
  - Wildlife-friendly agriculture practices - flexible and responsive agricultural management as surrogate wildlife habitat
  - Wildlife-friendly agriculture practices - agricultural fields managed as seasonal wetland or floodplain

- Wildlife-friendly agriculture practices – hedgerows, trees, and native vegetation within/between agricultural fields
- Wildlife-friendly agriculture practices - minimize distance for wildlife corridors

Delta conservation efforts should focus on the following processes to maximize benefits to native species:[2]

- Fluvial processes along streams, functional channels, river corridors, and tidal floodplains *to benefit resident and anadromous fish and other wildlife species.*
- Tidal marsh processes in areas at intertidal elevations, in subsided areas, in tidal-terrestrial transition zones, and tidal processes in channel and open water areas *to benefit marsh wildlife and the aquatic food web.*
- Connected terrestrial habitats, wildlife-friendly agriculture, and managed wetland operations processes *to benefit migratory birds and other wildlife species.*

Conservation of Ecosystem Function and Related Ecological Processes

There is a pressing need to find ways to reestablish degraded ecological processes by implementing conservation activities on available public lands and existing lands managed for conservation and in collaboration with willing private landowners into the future. The Delta Conservation Framework's overarching goal for improving ecosystem function (Goal D – see Table 3.1) is founded on a landscape-scale approach and directly aligns with *A Delta Renewed*[2]. The goal's associated strategies and objectives, presented in Table 3.1, are intended to serve as starting points for restoring ecosystem function over the next 30 years, in the context of *Delta as an evolving place*. Many of the strategies associated with Goal D are also consistent with climate adaptation strategies that have been identified for biodiversity and habitat.[1,39]

Conserving ecological processes is crucial to ensuring resiliency and adaptability of Delta ecosystems' in the face of non-native invasive species invasions, pollution, the long-term challenges of maintaining the vast Delta levee system, and impending climate change impacts.[40,41] In order to find long-term solutions, alternative future scenarios from current and continued human land uses, different levels of flood protection, levels of floodplain or other restoration, a changing climate, and other ongoing ecosystem pressures need to be considered and evaluated going forward (see Section VI for more information on scenario planning).

Table 3.1: Goal D and related strategies and objectives for implementation.

GOAL D: Conserve ecosystems and their ecological processes to promote function to benefit society and wildlife and enhance resilience to climate change.

Strategy D1: Restore, enhance, and manage ecosystem processes Delta-wide, as identified and specified by existing or emerging *Regional Partnerships,* in *Regional Conservation Strategies* to improve function and life history support for native and migratory wildlife.

- *OBJECTIVE D1-1:* Within 10-30 years, implement conservation actions to reestablish **fluvial processes** along streams to provide resilient habitat and foster life history support for healthy populations of resident and anadromous fish and other wildlife species.
- *OBJECTIVE D1-2:* Within 10-30 years, implement conservation actions to reestablish **functional channels and connections between streams and tidal floodplains** for support of resident and migratory aquatic species.
- *OBJECTIVE D1-3:* Within 10-30 years, implement conservation actions to reestablish **tidal marsh processes in areas at intertidal elevations** to provide resilient habitats and life history support for marsh wildlife.
- *OBJECTIVE D1-4:* Within 10 – 30 years, implement conservation actions to reestablish **tidal marsh processes in subsided areas** to provide resilient habitats and life history support for marsh wildlife.
- *OBJECTIVE D1-5:* Within 10-30 years, implement conservation actions to reestablish **tidal processes in channel and open water areas** (flooded islands) to provide resilient habitats and life history support for marsh wildlife.
- *OBJECTIVE D1-6:* Within 10-30 years, implement conservation actions to reestablish **tidal-terrestrial transition zones** to provide resilient habitats and life history support for wildlife.
- *OBJECTIVE D1-7:* Within 10-30 years, implement conservation actions to restore **connected terrestrial ecosystems of the Delta** and provide resilient habitats and life history support for wildlife and migratory birds.
- *OBJECTIVE D1-8:* Within 10-30 years, implement conservation actions to expand **wildlife-friendly agriculture** and operate **managed wetland processes** to provide resilient habitat and foster life history support for healthy populations of native and migratory wildlife species.
- *OBJECTIVE D1-9:* Within 10-30 years, implement conservation actions to integrate support for native wildlife into **urban areas** to provide supplementary habitat for certain species, increase wildlife connectivity, and provide opportunities for people to connect to nature.

292 **Table 3.1 (continued):** Goal D and related strategies and objectives for implementation.

Strategy D2: Through technical analyses conducted by given *Regional Partnerships,* identify and prioritize available areas to protect Delta ecosystems and transition zones with the potential for providing landscape connectivity and resiliency to ecosystem function.

- OBJECTIVE D2-1: Within 5 years of implementation of a given *Regional Conservation Partnership,* identify and prioritize available areas for conservation of ecosystem types or processes that are most vulnerable to climate change and that also support climate vulnerable (and listed) species for inclusion in the *Regional Conservation Strategy.*
- OBJECTIVE D2-2: Within 20 years of implementation of a given *Regional Conservation Strategy*, protect at minimum 25% of ecosystem types and transition zones prioritized therein as important for ecosystem connectivity and resiliency.
- OBJECTIVE D2-3: By 2050, protect a variety of interconnected functioning ecosystems throughout the Delta as diverse mosaics of complementary habitat types, including wildlife-friendly agriculture, to support a broad suite of ecological processes.

Strategy D3: Improve the connectivity of ecosystems and associated wildlife populations at multiple scales.

- OBJECTIVE D3-1: By 2025, initiate projects to improve connectivity and meandering waterways along selected Delta rivers, sloughs, agricultural channels, or streams, and riverine and riparian migratory corridors for wildlife.
- OBJECTIVE D3-2: By 2025, develop and initiate projects to remove barriers and improve connectivity along terrestrial (overland) movement corridors, including established migratory corridors for birds and other wildlife.
- OBJECTIVE D3-3: By 2025, develop and initiate projects to address priority actions to remove barriers and improve connectivity across transitional zones.

Strategy D4: Create conditions conducive to meeting the goals in existing species recovery plans to maintain or improve the distribution and abundance of listed species supported by Delta ecosystems.

- OBJECTIVE D4-1: By 2024, implement all recommendations in the Delta smelt and Sacramento Valley salmon resiliency strategies to support the recovery of these listed species.
- OBJECTIVE D4-2: By 2050, reestablish Delta ecosystem functional processes according to recommendations in species recovery plans to achieve measurable improvements in conditions that support the distribution and abundance of a majority of listed species in the Delta.

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Table 3.1 (continued): Goal D and related strategies and objectives for implementation.

Strategy D5: Implement conservation actions to improve ecosystem function and support a thriving aquatic food web in the Delta.

- OBJECTIVE D5-1: By 2025, through continued scientific investigations on Delta primary production, determine a suite of priority conservation actions to reestablish a thriving Delta aquatic food web.
- OBJECTIVE D5-2: By 2030, develop, implement and evaluate effects of at least five conservation projects that include one or more priority actions to reestablish a thriving Delta aquatic food web to support native wildlife.

Strategy D6: Support and coordinate proactive approaches for the early detection, rapid response, and long-term control and management of harmful invasive species.

- OBJECTIVE D6-1: By 2020, increase support for Delta County Weed Management Areas (WMAs) and California State Parks Division of Boating and Waterways (DBW), to prioritize implementation of area-wide control of problematic invasive species.
- OBJECTIVE D6-2: By 2030, double the current level of early detection and management of invasive species of concern in the Delta, to reduce negative impacts on ecosystem function, special status species, and Delta community interests and increase ecosystem resilience.

Strategy D7: Balance the benefits of conservation areas for human use with reduced adverse effects on Delta wildlife from human disturbance.

- OBJECTIVE D7-1: By 2020, develop a Public Access Plan for Delta conservation lands, recognizing existing management plans and management objectives to clearly outline a balance between conserving Delta ecosystems and supporting public access and recreation activities.
- OBJECTIVE D7-2: By 2030, double the current capacity for law enforcement and public safety in the context of public access and conservation land management.

Recovering and Restoring Ecological Processes to Improve Delta Ecosystem Function

Recovering degraded or lost ecological functions of Delta ecosystems is critical for providing life history support to native wildlife populations and ensuring continued provision of ecosystem services to people.[2,3] The latest insights from a series of historical ecology investigations focus on the status of Delta ecosystems now in relation to their historical condition, and provide a big-picture perspective on how to reestablish a landscape that functions well for people and native wildlife.[2,3,27] The most recent report from this series, *A Delta Renewed*, provides tools and on-the-ground strategies to reestablish desired ecological functions that will support a productive food web and improve native wildlife populations in different regions of the Delta.[2,25] Region-specific targets should be developed for all objectives within Strategy D1 (Table 3.1) by integrating with broader targets, such as those outlined in the *2016 Central Valley Flood Protection Plan Conservation Strategy*[28]*,* and by aligning with guidelines in *A Delta Renewed.*[2]

Protecting Ecosystems to Improve Connectivity and Resiliency

To maximize functional connectivity and resilience of ecosystems across the Delta landscape, *Regional Conservation Partnerships* should conduct technical analyses to identify potential ecosystem types that would persist over the long term in the area and prioritize available opportunities to protect them (see Strategy D2, Table 3.1). In any of the *Conservation Opportunity Areas,* region-specific targets could be developed based on an assessment of ecological opportunities, existing land uses, and existing plans. These then should also integrate, where possible, with broader-scale plans that pertain to the surrounding landscape; for example, the 2017 *Central Valley Flood Protection Plan Conservation Strategy*, or other relevant planning or regulatory documents (see Appendix VII).

In doing so, two primary approaches to promote connectivity should be employed: 1) protecting areas that *facilitate* movement; and 2) restoring connectivity across areas that *impede* movement (e.g., by removing a fence, aquatic barrier, or building a wildlife-friendly highway underpass).[35] A mosaic of interconnected ecosystem types, including wildlife-friendly agricultural lands and managed ecosystems, will maximize the adaptive capacity of wildlife populations at various scales.[42] A highly connected landscape is crucial for facilitating species movement and accommodating distribution shifts in response to climate change[42] (see Strategy D3, Table 3.1).

Improving Conditions for Species Resiliency and Recovery

The goal focused on protecting Delta ecosystems, and reestablishing ecological processes, also aims to create conditions that meet or exceed the goals of relevant recovery plans for special status species (see Strategy D4, Table 3.1). This includes improving the long-term resiliency and adaptive capacity of ecosystems and wildlife populations to impacts from habitat loss, climate shifts, exotic species invasions, and other pressures. Building on work piloted and championed by many others, the recommended approach is to reestablish natural processes where possible, create an appropriate configuration of habitat types at the landscape scale, and use adaptive management to generate Delta ecosystems that are resilient in the face of climate change.[2] Several special status species, including giant garter snake, greater sandhill crane (*Antigone canadensis tabida*), tricolored blackbird (*Agelaius tricolor*), and

Swainson's hawk (*Buteo swainsoni*), benefit from agriculture in the Delta (See Appendix XI). Conservation implementation and lasting agricultural land stewardship will require communication among Delta stakeholders with a common appreciation for how crop selection and management to support special status species will affect agricultural productivity and how stressors such as sea level rise or salinity intrusion will affect both agriculture and wildlife.

To understand how conservation actions in the Delta improve ecosystem function and benefit special status species, individual projects need to incorporate existing species recovery strategies, such as the ones described below, and incorporate adaptive management (see Section IV for further discussion on adaptive management).

Delta Smelt Resiliency Strategy

> ***"…the Strategy is an aggressive approach to implementing any actions that can be applied in the near term, can be executed by the State with minimal involvement of other entities, and have the potential to benefit Delta Smelt."***

The Delta Smelt Resiliency Strategy (Strategy) addresses both immediate and near-term needs of Delta smelt (*Hypomesus transpacificus*), in order to support their resiliency to drought and future fluctuations in habitat conditions.[43] The Strategy relies on the Interagency Ecological Program's Management, Analysis, and Synthesis Team (MAST) report and conceptual models[44] that outline a suite of actions designed to benefit Delta smelt. These will be implemented within the next few years to address predation, turbidity, and food availability and quality. [43] These management actions include:

- Aquatic weed control,
- North Delta food web adaptive management projects,
- Outflow augmentation,
- Reoperation of the Suisun Marsh salinity control gates,
- Sediment supplementation in the low salinity zone,
- Spawning habitat augmentation,
- Roaring river distribution system food production,
- Coordinating managed wetland flood and drain operations in Suisun Marsh,
- Adjusting fish salvage operations during summer and fall,
- Storm water discharge management,
- Rio Vista Research Station and Fish Technology Center,
- Near-term Delta smelt habitat restoration,
- Franks Tract restoration feasibility study.

Implementation of the Delta Smelt Resiliency Strategy may also include outflow augmentation to improve a suite of habitat conditions such as contaminant exposure, food availability and quality, water temperatures, and salinity.

Sacramento Valley Salmon Resiliency Strategy

> ***"The goal of this Strategy is to promote actions that address specific life-stage stressors and thus significantly contribute to the achievement of overall viability of Sacramento Valley salmonids."***

The Sacramento Valley Salmon Resiliency Strategy outlines a suite of habitat restoration and management actions necessary to improve the immediate and long-term resiliency of Sacramento Valley salmonid species.[45] For each proposed action, the Salmon Resiliency Strategy lays out objectives, linkages to conceptual models that are consistent with existing priorities, estimated costs, funding sources, and timing. Recommended actions relevant to the Delta include:

- Improve Yolo Bypass adult fish passage;
- Increase juvenile salmonid access to Yolo Bypass, and increase duration and frequency of Yolo Bypass floodplain inundation;
- Construct a permanent Georgiana Slough nonphysical barrier;
- Restore tidal habitat in the Delta.

Supporting a Thriving Delta Food Web

Primary production is an essential ecosystem process that limits the quality and quantity of food available for invertebrates, fish, and other secondary consumers, including species of special concern.[2,4,5] Recent research linking changes in primary production over time with reductions in the extent of tidal marshes and associated marsh channel networks has generated a renewed appreciation for the importance of primary productivity in the Delta aquatic food web (see Strategy D5, Table 3.1).[2,4]

An inventory of organic-carbon sources revealed that the Delta is currently a low productivity ecosystem, yet it is unclear whether this was always the case.[4,46] As a consequence, limited productivity causes low availability of high-quality food for consumers such as fish and invertebrates. Researchers have used historical analyses to test the hypothesis that "*the Delta has been transformed from a high-productivity ecosystem largely dependent upon marsh-based production to a low-productivity ecosystem dependent upon production of aquatic plants and algae.*"[4]

Indicators, metrics, and performance measures based on an understanding of ecological processes in the Delta are needed to assess the progress of individual conservation projects and to help gauge the trajectory of ecological recovery throughout the region. Estimates of differences between historic and modern primary production could be used to shape targets and evaluation metrics to track the effectiveness of conservation projects designed to improve ecosystem function.[4] As a baseline, comparisons of primary productivity through time can provide an estimate of how the large-scale conversion of tidal marsh to agriculture has altered the Delta's capacity to produce food for native biota.[4] Future measurements of primary productivity could provide conservation practitioners with a new approach to evaluate the long-term impact of conservation projects on ecosystem function and specific processes that support species of concern.[4,5] Results from recent investigations have highlighted the importance of landscape configuration in determining levels of primary production in the Delta, because interactions between terrestrial and aquatic food webs vary across the current landscape.[4,5]

More work is needed to understand how monitoring primary productivity could inform Delta conservation management and improve food web processes in the future. Implementation of the Tidal Wetland Monitoring Framework for the Upper San Francisco Estuary could help evaluate whether primary productivity assessments could become a measure for better understanding and quantifying the benefits of habitat restoration to aquatic food webs and native wildlife.[4,47] This way, conservation actions that are most likely to improve ecosystem primary production could be prioritized for implementation and tracked over time to assess the course and progress of Delta ecosystem recovery.

Area-Wide Coordination of Invasive Aquatic Plant Species Management

Invasive aquatic plant species are a widespread problem in the Delta and can have multiple adverse effects on native wildlife, recreation, and local agriculture and businesses. Ever-expanding invasive aquatic vegetation is reducing the quality of habitat for native species, impacting recreation and navigation, impeding the flow of water, increasing the cost of pumping, increasing the need for pesticides, decreasing water quality, and harboring pests like mosquitos.[17,48,49,50,52] Over the last decade, three floating aquatic plant species – water hyacinth, water primrose, and Brazilian waterweed – have spread dramatically within the Delta[50]. The DBW aquatic invasive species programs and Department of Water Resources (DWR) Invasive Plant Management Plan (Appendix E of the CVFPP Conservation Strategy) are engaged in the control of floating and submerged invasive aquatic vegetation in the Delta.[28,51] Changing climatic conditions may favor or accelerate the spread of certain invasive species.[2] Early detection and eradication can help to reduce existing ecosystem stressors and increase overall resilience to change.

The DWR Agricultural Lands Stewardship Workgroup (ALS) acknowledges the impacts of invasive terrestrial and aquatic weeds on Delta communities and agriculture, and offers suggested strategies, including prioritizing weeds and other pests for area-wide control and to reinvigorate County WMAs (ALS Strategy A3).[52] Led by the County Agricultural Commissioner or local Resource Conservation District, WMAs are local stakeholder groups with strategic plans focusing on invasive species control and management. The WMAs that overlap the Delta are Alameda-Contra Costa, Sacramento, Northern San Joaquin Valley, Solano, and Yolo. Controlling invasive species area-wide through coordinated partnership efforts has the potential to reduce their spread throughout Delta waterways, farmlands, and Delta conservation lands, lowering management costs over the long term (see Strategy D6, Table 3.1).

The increased support to continue current control efforts by DBW and WMAs will help keep the focus of Delta conservation projects on the invasive species challenge; and it will help coordinate farmers and other Delta partners to implement additional invasive species management projects, including early detection, eradication, and control of terrestrial and aquatic invasive species in and around agricultural and grazing lands.[52] Once identified, invasive species populations, particularly those outlined in the Delta smelt and salmon resiliency strategies,[43,45] could be prioritized by the WMAs for coordinated area-wide control or eradication, offering multiple benefits of reduced environmental impacts, nuisance, and cost.[52] Supporting WMAs to prioritize efforts to control invasive species will also help increase the current level of early detection and management of invasive species of concern, to reduce negative impacts on ecosystem function, special status species, and Delta community interests.

Optimized Conservation Area Use for Humans and Wildlife

Public access to open space is critical to the Delta local community, which would benefit from recreation and tourism. However, public access is not always part of recommended conservation design because of the potential to disturb wildlife. There is a growing awareness that even hiking, wildlife viewing, and other quiet, non-consumptive recreational activities can influence the distribution and abundance of some animal species within protected areas.[53] Outdoor recreation is often assumed to be compatible with species protection, but an increasing body of research demonstrates that outdoor recreation can negatively impact plant and animal communities3.[54,55,56,57] For these reasons, Strategy D7 (Table 3.1) aims to balance competing tradeoffs between objectives for restoration outcomes and human use.

GOAL D: Conserve ecosystems and their ecological processes to promote function to benefit society and wildlife and improve conditions for species recovery.

Strategy D7: Balance the benefits of conservation areas for recreation with reduced adverse effects on Delta wildlife from human disturbance.

- OBJECTIVE D7-1: By 2020, develop a Public Access Plan for Delta conservation lands, recognizing existing management plans and management objectives to clearly outline a needed balance between conserving Delta ecosystems and supporting public access and recreation activities.

- OBJECTIVE D7-2: By 2030, double the current capacity for law enforcement and public safety in the context of public access and conservation land management.

In addition to many recognized human health and economic benefits of outdoor recreation,[58] access to pen space also encourages people's political and financial support for land and wildlife conservation.[59] California has the greatest number of listed species threatened by recreation in the U.S., and recreation is the second-leading cause of endangerment to species occurring on federal lands, among all U.S. states.[53] Therefore, land and wildlife managers in the Delta, as elsewhere, must seek solutions for balancing the benefits of outdoor recreation for human visitors with the potentially negative effects on species and ecosystems. The strategy should reduce adverse effects on Delta wildlife from human disturbance by carefully considering where to allow and how to best regulate and enforce public access in relation to protecting wildlife needs. Signage, informational kiosks, and clearly developed nature trails or boardwalks would also reduce visitor impacts on sensitive wildlife and their habitats.

468 # Endnotes

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