Chapter 3

Conservation Strategy (Sections 3.1, 3.2 and 3.3)

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Acronyms and Abbreviations

BiOp	biological opinion
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CNDDB	California Natural Diversity Database
CVP	Central Valley Project
Delta Native Fish Recovery Plan	*Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes*
DO	dissolved oxygen
DPS	distinct population segment
Draft Tidal Marsh Recovery Plan	*Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DWSC	Deep Water Ship Channel
ESA	Endangered Species Act
ESU	evolutionarily significant unit
Final Tidal Marsh Recovery Plan	*Final Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*
FR	Federal Register
HCP	habitat conservation plan
IAV	invasive aquatic vegetation
NCCPA	Natural Community Conservation Planning Act
NCCP	natural community conservation plan
NMFS	National Marine Fisheries Service
psu	practical salinity unit
ROA	restoration opportunity area
San Joaquin County MSHCP	San Joaquin County Multi-Species Habitat Conservation and Open Space Plan
SAV	submerged aquatic vegetation
Solano County HCP	Solano County Multispecies Habitat Conservation Plan
SWP	State Water Project
Upland Species Recovery Plan	Recovery Plan for Upland Species of the San Joaquin Valley, California
USFWS	U.S. Fish and Wildlife Service
Vernal Pool Recovery Plan	Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon
YOY	young-of-the-year

Chapter 3
Conservation Strategy

3.1 Introduction

This chapter presents the conservation strategy, which has been designed to achieve the BDCP's overall goals of restoring and protecting ecosystem health, water supply, and water quality within a stable regulatory framework. The conservation strategy has been developed to meet the regulatory standards of Sections 7 and 10 of the federal Endangered Species Act (ESA), the Natural Community Conservation Planning Act (NCCPA), and the California Endangered Species Act (CESA).

The chapter describes the Plan's intended biological outcomes and details the means by which these outcomes will be achieved. The conservation strategy includes the biological goals and objectives and identifies a set of implementation actions to provide for the conservation and management of covered species and natural communities upon which they depend, and to appropriately avoid, minimize, and mitigate the potential negative effects of covered activities on these resources (Chapter 4, *Covered Activities and Associated Federal Actions*). The conservation strategy also includes comprehensive programs for monitoring, research, and adaptive management.

The conservation strategy addresses the challenge of restoring key ecosystem functions in the highly altered environment of Suisun Bay/Marsh and the Delta while providing reliable water supplies. The Delta was once a vast marsh and floodplain intersected by meandering channels and sloughs that provided habitat for a rich diversity of fish, wildlife, and plants. The Delta of today is a system of artificially channeled and dredged waterways constructed into static geometries designed, initially, to support farming and, later, shipping and urban development. These channels also serve to convey water supplies across the Delta for export to cities and farms in the San Francisco Bay Area, San Joaquin Valley, and southern California. Physical disturbances in the Delta, the introduction of nonnative species that have disrupted the foodweb, and multiple other environmental challenges have contributed to declines in native fish, wildlife, plant species, and other organisms. In recent years, these factors have contributed to significant impairments in the size and structure of key native species populations.

The approach embodied in the conservation strategy reflects a significant departure from past management of at-risk Delta species and natural communities, by addressing ecological functions and processes at a broad landscape scale while also focusing on discrete components. Past regulatory approaches have relied almost exclusively on iterative adjustments to the operations of the State Water Project (SWP) and the Central Valley Project (CVP), including those reflected in recent biological opinions (BiOps) issued by the U.S. Fish and Wildlife Service (USFWS) (2008) and the National Marine Fisheries Service (NMFS) (2004, 2009). The BDCP proposes fundamental, systemic, long-term physical changes to the Delta, including substantial alterations to water conveyance infrastructure and water management regimes; extensive restoration of natural communities, and measures specifically designed to offset ecological stressors on covered species. These ecosystem-wide changes are intended to enhance the productivity of native species (structure and function) and desired natural communities. While the scope of the BDCP is broader than previous regulatory consultations, it focuses on many of the same issues as prior regulatory approaches, and continues many ongoing actions intended to benefit natural communities and covered species.

The Plan Area includes the statutory Sacramento-San Joaquin Delta, as defined in California Water Code Section 12220, Suisun Marsh, Suisun Bay, and the Yolo Bypass (Section 1.4.1, *Geographic Scope of the BDCP*). Because the state and federal water infrastructure operates as an integrated system, indirect effects of the BDCP will extend both upstream and downstream of the Plan Area, and will influence both water operational parameters and covered fish species and their habitats. Therefore, the BDCP will take into account these upstream and downstream effects, both positive and negative, to ensure that the overall effects of the BDCP are fully analyzed and understood (Section 3.6, *Adaptive Management and Monitoring Program*).

While the initial focus of the BDCP was to address the conservation of Delta fish species that are currently at very low population levels, such as delta smelt, longfin smelt, winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon, the conservation strategy evolved to include measures to address a broad range of species and natural communities. The conservation strategy provides for the conservation and management of 56 species—11 fish species, 27 terrestrial wildlife species, and 18 plant species (Section 1.4.3, *Covered Species*)—and 13 natural communities (Section 1.4.2, *Natural Communities*). It proposes actions intended to reduce the effects of environmental stressors on these biological resources at three ecological scales: landscape, natural community, and species. Landscape actions address physical and chemical processes and foodwebs; natural community actions address ecological functions and processes that occur in specific natural communities and contribute to overall ecological health; and species-specific actions address population size and structure as well as the distribution of individual covered species, and specific habitat needs that are not addressed at the ecosystem and natural community levels.

The conservation strategy is built upon and reflects the extensive body of scientific investigation, study, and analysis of the Delta compiled over several decades (CALFED Bay-Delta Program 2008). For example, the BDCP draws on the results and findings of numerous studies that were initiated under the CALFED Bay-Delta Science Program (since replaced by the Delta Science Program) and Ecosystem Restoration Program, the long-term monitoring programs conducted by the Interagency Ecological Program, research and monitoring conducted by state and federal resource agencies, and research contributions of academic investigators.

The development of the BDCP has also been informed by a number of other recent reports on the Delta, including reports of the Governor's Delta Vision Blue Ribbon Task Force (2008a, 2008b), reports from the Public Policy Institute of California (Lund et al. 2007, 2008), and reviews by the National Research Council (2011, 2012). Many elements of the conservation strategy parallel the recommendations of these other reports and reflect broad agreement that the Delta is dysfunctional from both an ecological and water supply reliability perspective and that fundamental change is necessary.

To ensure that the BDCP would be based on the best information available, the Plan participants engaged in a rigorous process to develop new and updated information and to evaluate a wide variety of issues and approaches. This effort included a 2009 evaluation of conservation options using the modified version of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) evaluation process (Essex Partnership 2009). Reflecting the requirements of the NCCPA planning process, the Steering Committee also sought and used independent scientific input at several key stages of the planning process, enlisting well-recognized experts in ecological and biological sciences to produce recommendations on a range of relevant topics, including approaches to conservation planning for both aquatic and terrestrial species, establishing an adaptive management and monitoring program, and devising biological goals and objectives. These processes are summarized in Chapter 10, *Integration of Independent Science in BDCP Development*.

The following sections introduce the components of the conservation strategy in more detail.

3.1.1 Biological Goals and Objectives

The biological goals and objectives reflect the expected ecological outcomes of Plan implementation and set out the broad principles that were used to help guide the development of the conservation strategy. Biological goals and objectives are the foundation of the conservation strategy and are intended to provide the following functions.

- Describe the desired biological outcomes of the conservation strategy and how those outcomes will contribute to the long-term conservation of covered species and their habitats.
- Provide, where feasible, quantitative targets and timeframes for achieving the desired outcomes.
- Serve as benchmarks by which to measure progress in achieving those outcomes across multiple temporal and spatial scales.
- Provide metrics for the monitoring program that will evaluate the effectiveness of the conservation measures and, if necessary, provide a basis to adjust the conservation measures to achieve the desired outcomes.

The biological goals and objectives describe the desired future conditions of the Plan Area and set the benchmarks for evaluating BDCP performance relative to ecological health. They reflect the relationship between projected environmental changes and anticipated species responses and are intended to be attainable through the implementation of the conservation measures. Section 3.3, *Biological Goals and Objectives*, describes the process that was used to develop the biological goals and objectives, the role of biological goals and objectives in the Plan, presents the biological goals and objectives, and describes the underlying rationale for each.

3.1.2 Conservation Measures

The conservation measures comprise specific actions that will be implemented to meet the requirements of the ESA and the NCCPA. They have been developed in accordance with the principles of conservation biology; as such, they address, among other things, ecological processes, environmental gradients, biological diversity, and regional aquatic and terrestrial linkages. The conservation measures fit into the same ecological hierarchy as the biological goals and objectives, as described below.

- **Landscape.** Landscape-scale conservation measures are designed to improve the overall condition of hydrological, physical, chemical, and biological processes in the Plan Area. These measures include improving the method, timing, and amount of flow and quality of water into and through the Delta for the benefit of covered species and natural communities. They also focus on establishing a reserve system, an interconnected system of protected lands across the Plan Area.

- **Natural community.** Natural community conservation measures include actions to restore natural communities to expand the extent and quality of intertidal, floodplain, and other ecological functions and processes.
- **Species.** Species-specific conservation measures are designed to reduce the adverse effects of various stressors on one or more covered species. These include measures addressing toxic contaminants, nonnative predators, illegal harvest, and genetic threats.

The conservation measures comprise the specific actions to be taken to meet the biological the goals and objectives. Biological goals and objectives helped inform the development of conservation measures, and conservation measures also helped inform the development of goals and objectives. Although the conservation measures have been developed to meet all of the biological goals and objectives, the relationship between goals and objectives and conservation measures is not direct; most of the conservation measures address several goals and objectives, and most objectives will be met through a combination of conservation measures. This comprehensive suite of actions is expected to provide for the conservation of the covered species and natural communities, and help restore ecosystem health in the Delta.

The conservation measures were developed in the context of the 50-year timeframe for implementation of the BDCP. Section 3.2, *Methods and Approaches Used to Develop the Conservation Strategy*, describes how the conservation measures were developed. Section 3.4, *Conservation Measures*, describes each of the 22 conservation measures in detail.

3.1.3 Adaptive Management and Monitoring Program

The adaptive management and monitoring program has been designed to use new information and insight gained during the course of Plan implementation to assure that strategies employed by the BDCP can achieve the biological goals and objectives. It is possible that some of the conservation measures will not achieve their expected outcomes, while others will produce better results than expected. The adaptive management process will afford the flexibility to allow for changes to be made to the conservation measures to improve their effectiveness over time. The results of monitoring and research efforts will be used to assess progress toward achieving the biological goals and objectives and gauge the effectiveness of the conservation strategy. Extensive monitoring and research programs are currently in place in the Delta; these efforts will be enhanced through the additional monitoring and research actions performed under the BDCP.

3.1.3.1 Adaptive Management

Adaptive management is an organizational process that provides the means by which management actions (e.g., conservation measures) can be assessed for their effectiveness (e.g., monitoring and research), and by which adjustments to those actions may be made (e.g., resource management decisions). The concept of adaptive management has gained worldwide interest and support as an approach to sustainable ecosystem management. Lindenmayer and Burgman (2005) suggest that an adaptive management program should include these key elements.

- Explicit definition of management goals.
- Development of plausible strategies to achieve those goals.
- Implementation of strategies in a comparative experimental framework to spread risks of management failure and improve understanding of system responses to management.

- Monitoring to evaluate the relative merits and limitations of management strategies.
- Iterative modification of management strategies to improve outcomes.

Within the context of the BDCP, a number of additional key factors will influence resource management decisions. These factors are associated with both the expected certainty associated with the outcome and the scientific and/or policy drivers associated with taking a resource management action.

If monitoring data or other scientific information suggest that progress toward the biological goals and objectives is not being made, decisions will be made through adaptive management regarding whether and how to refine the appropriate conservation measures to contribute toward achieving the biological goals and objectives or whether insufficient information exists to fully measure progress toward the biological goals and objectives and thus further monitoring actions should be implemented and/or conceptual models (including hypotheses on which the models are based) revised to better represent conditions in the Plan Area. Additionally, should a cause for not achieving a biological goal or objective be identified, adaptive management will be used to change conservation measures, if necessary, to address the cause. However, if a cause is not identified, the monitoring program will be refined so that the cause can be determined and addressed.

3.1.3.2 Monitoring

The BDCP provides for monitoring to determine both the ongoing effects and effectiveness of implementing the conservation strategy, as well as to ensure compliance with the Plan and its associated authorizations. Monitoring is a mandatory element of all habitat conservation plans (HCPs) (50 CFR 17.22, 17.32, and 222.307). Monitoring programs for HCPs will provide the information necessary to assess compliance and project impacts and verify progress toward the biological goals and objectives. Monitoring also provides the scientific data necessary to evaluate the success of the HCP's conservation strategy (65 FR 35353). HCP monitoring is required to provide information to evaluate compliance, determine if biological goals and objectives are being met, and provide information for use in adaptive management strategy (65 FR 35253).

Monitoring will be performed to ensure that the conservation strategy is implemented appropriately, is having its intended effects, and is making progress towards achieving the biological goals and objectives. To that end, there are three types of monitoring.

- **Compliance monitoring** provides information to determine whether the provisions of the BDCP are being properly implemented.
- **Effectiveness monitoring** provides information on how well the conservation measures are advancing biological goals and objectives.
- **Status and trend monitoring** provides information on the condition of the resources (covered species and natural communities) protected through the Plan.

Specific monitoring actions are linked to each conservation measure, as described in Section 3.4, *Conservation Measures*. Appendix 3.D, *Monitoring and Research Actions*, provides a comprehensive list of monitoring actions.

3.1.3.3 Uncertainty and Directed Research

Over the course of many years, significant advances have occurred in the scientific understanding of Bay-Delta ecosystems and their component organisms, structures, and processes. Notwithstanding this progress, significant scientific uncertainties persist—and always will persist—including uncertainties related to the following factors.

- Ability to forecast natural variability in environmental conditions caused by local, regional, and global factors.
- Ability to forecast long-term changes in the global environment that affect conditions in the Plan Area (e.g., climate change).
- Limitations in scientific capacity to precisely describe the year-to-year importance of key factors and pathways that cause covered species to increase and decrease in abundance.
- Ability to forecast rare events (e.g., earthquakes).

The adaptive management and monitoring program is intended to reduce the level of uncertainty about what makes covered species abundance increase or decrease over time through a structured process that incorporates continually improved scientific understanding into decisions related to implementing the conservation strategy. Detailed discussions of the existing uncertainty surrounding certain scientific issues and of the research strategy to reduce such uncertainty are set out in Section 3.6*, Adaptive Management and Monitoring Program*. Key uncertainties associated with implementation of specific conservation measures and research actions to resolve these uncertainties are described in Section 3.4, *Conservation Measures*. Appendix 3.D, *Monitoring and Research Actions*, provides a comprehensive list of uncertainties and research actions pertaining to the conservation measures.

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3.2 Methods and Approaches Used to Develop the Conservation Strategy

This section describes the methods and the approaches used to develop the conservation strategy. Section 3.2.1, *Framework for the Conservation Strategy*, describes the regulatory and temporal contexts for the conservation strategy. It also describes the role of the adaptive management and monitoring program in reinforcing the effectiveness of the conservation strategy over time. Section 3.2.2, *Identifying Conservation Zones and Restoration Opportunity Areas*, describes the establishment of geographic areas to facilitate the identification of conservation targets and the implementation of protection and restoration actions.

The conservation strategy addresses both aquatic resources—the aquatic ecosystem and covered fish species—and terrestrial resources—natural communities providing terrestrial species habitat, and covered wildlife and plant species. The approach to developing the aquatic resources component is described in Section 3.2.3, *Developing the Aquatic Resources Component of the Conservation Strategy*. The terrestrial resources conservation strategy was guided by an established process used in other HCPs, natural community conservation plans (NCCPs), and USFWS recovery plans that address many of the same species and natural communities. The approach to the development of the terrestrial resources component is described in Section 3.2.4, *Developing the Terrestrial Resources Component of the Conservation Strategy*. Background on the planning process for the major elements of the conservation strategy is provided in Appendix 3.A, *Background on the Process of Developing the BDCP Conservation Measures.*

3.2.1 Framework for the Conservation Strategy

The conservation strategy is designed to meet the regulatory requirements of the ESA and the NCCPA, while achieving the overall BDCP goal to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework. Consistent with the requirements of the ESA and NCCPA, the conservation strategy includes appropriate avoidance, minimization, and mitigation measures to address the negative effects of covered activities as well as actions that provide for the conservation and management of covered species through the creation, protection, restoration, and enhancement of ecosystem processes, natural communities, and species habitat.

Biological goals and objectives were first developed at the landscape scale to account for ecological processes that could be addressed by the BDCP. Next, goals and objectives were developed at the natural community level to address functions distinctive to each of the various natural communities found in the Plan Area that were not sufficiently addressed at the landscape scale. While developing the conservation strategy, each covered species was evaluated to determine whether achieving the landscape-scale or natural community goals and objectives would be sufficient to provide for the conservation of that species. If not, biological goals and objectives specific to that species were developed. These species-specific goals and objectives provide metrics regarding the outcomes expected through the implementation of the Plan. For many species, the species-specific goals and objectives were informed by broader "global" or range-wide recovery goals developed by the fish and wildlife agencies (USFWS, NMFS, and California Department of Fish and Wildlife [CDFW]).

The conservation measures were developed to achieve these landscape-scale, natural community, and species biological goals and objectives. The 22 conservation measures fall into the following categories.

- Development and operation of new water conveyance infrastructure and the establishment of operational criteria associated with both existing and new facilities.
- Protection of existing functioning natural communities that are not currently protected.
- Restoration or creation of specific natural communities in areas that do not currently support those communities.
- Improvement of existing habitat functions within existing natural communities.
- Ongoing management of natural communities and habitat to maximize the desired ecological function in the reserve system over the long term.
- Reduction of the adverse effects on covered fish species that result from specific stressors such as predation, toxic constituents in water, or sediment, and illegal harvest.
- Avoidance and minimization of adverse effects of covered activities on covered species.

All conservation measures have been developed at a sufficient level of detail and specificity to ensure their implementation. Because the BDCP is broad in scope and has an extended timeframe for implementation, many of the measures have flexibility to accommodate changes in conditions and methods over time. For example, conservation measures that protect, restore, or enhance natural communities provide management guidelines and principles that allow land managers the freedom to implement techniques best suited to site-specific conditions. Preserving this flexibility is an important part of the conservation strategy and is articulated in Section 3.6, *Adaptive Management and Monitoring Program*.

Implementation of conservation measures that protect, enhance, and restore natural communities and covered species' habitats will require preparation of site-specific implementation documents. These implementation documents, as well as any additional environmental documentation, will be prepared in accordance with the schedule for the implementation of conservation measures (Chapter 6, *Plan Implementation*).

3.2.1.1 Timing and Interrelatedness of Conservation Measures

The conservation strategy is divided into near-term and long-term implementation timeframes. The near-term implementation period, anticipated to be 15 years, begins with the issuance of the BDCP's final permit and ends with the onset of operation of the new north Delta diversions and tunnel/pipeline facility to allow for dual conveyance. The long-term implementation covers the remaining approximately 35 years of the 50-year BDCP permit term. These periods were established to account for the ecological changes facilitated by the greater operational flexibility of dual conveyance. Some of the conservation measures are dependent upon the flexible operations and the positive ecological changes they are expected to foster.

Near-term implementation of conservation measures will allow for rapid response to currently degraded or absent ecological functions, while building the foundation to improve long-term ecological functions. Conservation measures that create or restore natural communities, address other stressors on covered fish species, and protect terrestrial and wetland habitat for covered wildlife and plant species will be implemented beginning in the near-term implementation period.

Completion and operation of the north Delta intakes and conveyance facility will facilitate the implementation of conservation measures focused on the restoration of tidal and floodplain natural communities in the Delta, including areas in the east and south Delta associated with the Mokelumne, Cosumnes, Middle, Old, and San Joaquin Rivers. Changes in water operations in any one part of the Delta affect flow in other parts of the Delta, and these relationships will be addressed. For example, diversions in the north Delta will reduce the need to export at the south Delta diversions, thereby reducing reverse flows in Old and Middle Rivers. The coordinated operations of new and existing water facilities in a flexible and adaptable manner is a necessary step towards meeting the overall BDCP goals of restoring and protecting ecosystem health, water supply, and water quality within a stable regulatory framework.

Restoring large portions of the Delta to tidal natural communities will affect flows and water quality in the Delta by enlarging the tidal prism (the volume of water in an estuary as calculated by the volume between mean high tide and mean low tide) and reducing the tidal range (how far the tide reaches upstream). For example, restoration of tidal natural communities in the Cache Slough area is projected to result in reduced tidal range and greater unidirectional flows in Sutter and Steamboat Sloughs, increasing habitat suitability for, and speeding the passage of, juvenile salmonids migrating through these sloughs and thereby reducing their exposure to predation. The reduction in pesticide and herbicide loads that will result from restoring natural communities on cultivated lands is expected to interact synergistically with improvements in organic and nutrient input from restored tidal marsh and floodplains to benefit the aquatic foodweb. These examples show how substantial benefits of the conservation strategy are derived from understanding interconnections between conservation measures across program elements, across the wide geography of the Delta, and across time. In short, the conservation strategy is intended to be greater than the sum of its parts.

The Implementation Office will time and sequence the acquisition of reserves to protect and restore natural communities, ensuring that restoration and protection actions occur in a manner that is roughly proportional to and commensurate with the effects of covered activities. See Chapter 6, *Plan Implementation*, for a discussion of the implementation schedule for each conservation measure.

3.2.1.2 Functional Relationship of Conservation Strategy Components

The process of developing the conservation strategy was complicated by the challenges associated with ecological requirements that vary among the covered species, the physical complexity of the Delta, and uncertainties related to processes and functions in these ecosystems. Linkages between key elements of the Plan were identified to help organize and address this complex system. Biological goals and objectives were also identified and refined during this process.

The biological goals and objectives were informed by global recovery goals provided by the fish and wildlife agencies, but have been framed to reflect what is achievable within the context of the BDCP. The BDCP is not intended to encompass the entire range of the covered species (except in the case of Delta smelt), nor is it intended to address all of the stressors that have contributed to the decline of these species. Rather, it is focused on stressors that can be addressed feasibly within the Plan Area. Accordingly, the conservation strategy reflects the relationships between the biological outcomes that the BDCP is intended to achieve and the actions that will be implemented to meet these objectives (Figure 3.2-1). Understanding these relationships facilitated the evaluation of the Plan components and their likely effectiveness over the period of implementation.

The narrative below describes the elements outlined in Figure 3.2-1; the numbers below correlate to those in the figure.

1. At the top of triangle are the global recovery goals and objectives that were developed by the fish and wildlife agencies for the species that are covered in the BDCP. These goals and objectives were developed independent of the BDCP and have helped guide the development of the conservation strategy. The global recovery goals and objectives reflect conditions throughout the range of the covered species and all stressors that have contributed to the species' declines. For some of the species, global recovery goals and objectives are set out in adopted recovery plans; in other cases, they are contained in draft plans or guidance provided by the responsible fish and wildlife agencies.

2. The level of conservation of each covered species, as articulated in the biological goals and objectives, is not uniform. Expert opinion and conceptual models were relied upon to identify limiting factors/stressors for each species. Only limiting factors/stressors that occur in the Plan Area and could be addressed by the Plan were selected. This subset of limiting factors was used to help guide the development of the biological goals and objectives.

   The level of conservation of covered species was informed, in part, by the proportion of a species' range and life cycle occurring within the Plan Area and the level of effect that the covered activities are expected to have on those species. For example, all else being equal, actions taken to conserve a species with a small portion of its range in the Plan Area may be less extensive than for a species with a large portion of its range in the Plan Area.

3. Conservation measures are designed and expected to produce ecosystem changes sufficient to achieve the biological goals and objectives. The biological goals and objectives, in turn, have been formulated in such a way that conservation measure effectiveness can be accurately determined via monitoring.

4. Once the conservation measures were identified, they were developed in greater detail and more specific expected outcomes identified. Available models were used to test whether conservation measures, collectively, would likely achieve the biological goals and objectives. Where results were weak or an outcome highly uncertain, testable hypotheses were developed to link the action to the outcome (Chapter 5, *Effects Analysis*), and directed research projects were identified to test the hypotheses, monitor trends, and to fill data gaps and uncertainties in our understanding of the covered species and their expected reaction to changes in their environment (Section 3.6, *Adaptive Management and Monitoring Program*). These hypotheses will be tested during Plan implementation.

5. Monitoring data and information will be used to assess the effectiveness of the conservation measures. System monitoring provides information regarding status and trends that support assessments of the progress being made toward achieving the goals and objectives. Compliance monitoring provides information to determine whether conservation measures are being implemented properly. Performance and mechanistic monitoring provide information on the effectiveness of the conservation measures in advancing the biological goals and objectives. This information will help advance scientific understanding concerning the complexity of the Delta ecosystem and species' responses to the conservation measures. These types of monitoring are described in detail in Section 3.6, *Adaptive Management and Monitoring Program*.

6. As conservation measures are being implemented and monitoring data become available, the adaptive management process will be used to inform whether adjustments to the conservation

measures are necessary to improve their effectiveness. The adaptive management and monitoring program will be used to assess performance, inform decisions regarding adjustments to conservation measures, and facilitate the compilation of data and information as part of the knowledge base. (Dahm et al. 2010).

3.2.2 Identifying Conservation Zones and Restoration Opportunity Areas

To facilitate development of protection and restoration elements of the conservation strategy, the Plan Area was subdivided into 11 conservation zones within which conservation targets for natural communities and covered species' habitats were established (Figure 3.2-2). Conservation zones were delineated primarily on the basis of landscape characteristics and logical geographic or landform divisions. Conservation zones were used as a planning tool to ensure that targets identified for natural communities and covered species' habitat are spatially distributed to help achieve biological goals and objectives.

The following factors were considered in establishing the conservation zones.

- Distribution of covered species in and adjacent to the Plan Area.
- Distribution of natural communities supporting covered species' habitats.
- Differences in the function of covered species' habitats supported by natural communities in different portions of the Plan Area (e.g., high-, medium-, and low-value habitats).
- Landscape features (e.g., watercourses).
- Locations of barriers to covered species movement among habitats.
- Connectivity with existing habitat areas adjacent to the Plan Area.

A different set of planning units, restoration opportunity areas (ROAs), was also established to assist in the development of the conservation strategy. ROAs are different from, but overlap with, the conservation zones, as illustrated in Figure 3.2-2. ROAs encompass those locations considered to be the most appropriate for the restoration of tidal natural communities in the Plan Area (*CM4 Tidal Natural Communities Restoration*).

The existing distribution of natural communities in each of the conservation zones is presented in Figure 3.2-3 through Figure 3.2-12.

3.2.3 Developing the Aquatic Resources Component of the Conservation Strategy

The aquatic resources component of the conservation strategy is focused on the restoration of native fish productivity of the Delta and adjacent areas. During the development of this component, the following key principles were identified.

- **Changes in the estuarine ecosystem may be irreversible.** Human land use has become a major driver of the Bay-Delta ecosystem. Human activities have fundamentally altered the physical, biological, and chemical structure of the Delta and introduced numerous new species that now compete with and prey on native species (Baxter et al. 2010). These changes have produced a Delta ecosystem that is different from the historical ecosystem and will remain so even as anthropogenic stressors are modified as a result of the BDCP. The BDCP will be implemented in the context of natural and cultural elements that differ markedly from predevelopment conditions.

- **Future states of the Delta ecosystem depend on both foreseeable changes (e.g., climate change and associated sea level rise) and unforeseen or rare events (e.g., the consequences of new species invasions).** The Delta ecosystem is and will continue to be highly variable and will change in both predictable and unpredictable ways. Efforts to provide for the conservation of covered species will include adaptive management that responds to new information, different circumstances, and environmental change.
- **The Delta is part of a larger river-estuarine system that is affected by both rivers and tides. The Delta is also influenced by long-distance connections, extending from the headwaters of the Sacramento and San Joaquin Rivers into the Pacific Ocean.** The effects of BDCP will reflect the environmental context in which it is implemented.
- **The Delta is characterized by substantial spatial and temporal variability, including disturbances and extreme events that are fundamental characteristics of ecosystem dynamics.** Conditions in the Delta are inherently variable and future conditions are uncertain. Scientific methods will always have a limited capacity to forecast how future social and economic factors will affect human land and water use. In short, uncertainty is an inherent feature of the Delta that must be accommodated in an effective and flexible management structure.
- **Species that use the Delta have evolved life-history strategies in response to variable environmental processes that have predictably occurred at certain times and in certain places. A number of covered species have limited ability to adapt to rapid changes caused by human activities.** While estuarine species are adapted to highly variable conditions, the fundamental changes to the Delta ecosystem as a result of human activities may be beyond the adaptive potential of native species.
- **Achieving desired ecosystem outcomes will require more than manipulation of a single ecological stressor.** The physical and biological complexities of the Delta ecosystem argue against simplistic single-factor solutions. Restoration of ecosystem health will require more holistic approaches (Baxter et al. 2010).
- **Habitat should be defined from the perspective of a given species.** Habitat is a species-based concept reflecting the physiological and life-history requirements of species. Habitat is not synonymous with vegetation type, land (water) cover type, or land (water) use type. To succeed, species require sufficient diversity, quantity, and quality of habitat to complete their life histories (Williams 2006).
- **Changes in water quality have important direct and indirect effects throughout the estuarine ecosystem.** Water quality in the Delta is affected by a variety of discharges from agricultural, industrial, and urban sources that have been linked to ecological changes (e.g., Thompson et al. 2000; Glibert 2010). The Delta environment is characterized by distinct salinity gradients that vary with managed and natural outflow and tides. Water in the Delta is typically turbid, although dams, submerged aquatic vegetation, and other factors have reduced turbidity. Some or all of these conditions may adversely affect the viability of native species.
- **Land use is a key determinant of the spatial distribution and temporal dynamics of flow and contaminants, which, in turn, affect habitat quality.** The Plan Area is a natural-cultural

system with a mix of natural and human-caused features and constraints. Human actions, including the covered activities, may control and alter conditions and could affect species viability.

- **Changes in one part of the Delta may have far-reaching effects in space and time.** The Delta is a system of interconnected biological and physical processes operating across multiple scales. The covered activities and conservation measures are part of an integrated plan. Actions should not be considered in isolation but rather in the context of the Delta ecosystem.
- **Prevention of undesirable ecological responses is more effective than attempting to reverse undesirable responses after they have occurred.** Many undesirable ecological responses have already occurred in the Delta. The BDCP would significantly alter the Delta environment and SWP/CVP operations to try to reverse some undesirable changes. In some cases, conservation measures address conditions resulting from the past, for example breaching of dikes to expand wetland natural communities.
- **Adaptive management is a key component of the BDCP.** Many of these principles point to the highly variable and unpredictable nature of natural systems, in general, and the Delta, in particular. Fixed management programs may fail as the system shifts and new stressors emerge. Effective management must be adaptive, accepting uncertainty as an inherent condition. An adaptive approach requires explicit management and scientific designs to implement actions.
- **Conservation measures to benefit one native species may have negative effects on other native species.** Species are connected through the foodweb and through use of common resources. Efforts to conserve one species or a collection of species may have consequences for other species. The BDCP will strive to avoid and minimize such negative effects, and mitigate any such conflicts.

Modifying the water conveyance infrastructure to allow for both north and south Delta diversions is essential to creating new opportunities to restore the ecological health of the Delta and to achieve improvements in water supply reliability. Operation of the north and south Delta intakes provides the operational flexibility to achieve the following improvements.

- Improve passage of fish within and through the Delta by improving hydrodynamic and water quality conditions that can create barriers to movement and high susceptibility to predators.
- Reduce the risk of entrainment of covered fishes by conveying water from either the north or south Delta, depending on the seasonal distribution of their sensitive life stages.
- Create new opportunities to restore tidal natural communities in the east and south Delta by reducing the risk for entrainment of food produced in restored areas and all life stages of delta smelt and longfin smelt and juvenile salmonids and sturgeons using restored areas.

The aquatic resources component of the conservation strategy includes actions to effectively reverse or reduce some of the adverse effects of environmental stressors associated with the current water operation regimes on the aquatic ecosystem, covered fish species, and other native aquatic organisms. It also provides for restoration actions to improve rearing, spawning, and migration habitat conditions for the covered fishes and to increase the productivity of their supporting foodwebs. In addition, it addresses specific stressors on covered fishes, such as impediments to fish passage, sources of unnatural mortality, and water quality impairments.

3.2.3.1 Water Facilities and Operation

The conservation strategy includes conservation measures that provide for the development and operation of new water conveyance infrastructure and the establishment of operational parameters associated with both existing and new facilities. Central to the conservation strategy is the development and operation of three new north Delta intakes that will be located along the Sacramento River and will divert water to the south Delta through an isolated tunnel/pipeline. The combination of moving water through a new isolated tunnel/pipeline facility in conjunction with the existing south Delta facilities—referred to as dual conveyance—is expected to provide flexibility sufficient to substantially reduce the entrainment of covered fish species while providing the desired average water supply.

Although the operation of the new diversions is expected to yield beneficial outcomes for covered fishes, it could also have indirect or unforeseen adverse effects on some of the covered fishes. Such adverse effects would be assessed through the adaptive management process, which could result in changes to the conservation measures to minimize these effects. To minimize the potential for entrainment of fish at the new intakes on the Sacramento River, state-of-the-art positive-barrier fish screens will be constructed at each of the new intakes and flexible operational methods related to the timing and rate of diversion will be coordinated among the intakes. The positive-barrier fish screens will be designed and operated in accordance with design criteria (e.g., screen mesh size, approach velocity) currently used by the fish and wildlife agencies. These operational measures have been devised to ensure that entrainment of migrating juvenile salmonids and other species (e.g., green sturgeon, delta smelt) in the new north intakes will be avoided or greatly minimized.

CM1 Water Facilities and Operation establishes criteria for water diversion rates and bypass flows in the Sacramento River at the intakes that have been informed by seasonal movement patterns of covered fish species, including specific real-time responses during periods in which fish species are present in the vicinity of the intakes. These criteria have been developed to better reflect seasonal synchrony with hydrologic conditions within the river and upstream watersheds. Bypass criteria set out in *CM1 Water Facilities and Operation* reflect the variation in the seasonal periods of hydrology. The criteria include pulse flow operations, minimum river-flow requirements, and other flow requirements based on a percentage of the river flow that passes by the intakes (bypass flows). Extensive hydrologic simulation modeling has been used to evaluate and develop the range of water diversion criteria included in the conservation strategy.

The conservation measures also include actions to improve flows through the Yolo Bypass floodplain (*CM2 Yolo Bypass Fisheries Enhancement*), ensure sufficient water for fish transport in the Sacramento River downstream of the north Delta intakes (*CM1 Water Facilities and Operation*), deter fish from being drawn into the central Delta through the Delta Cross Channel via nonphysical fish barriers (*CM16 Nonphysical Fish Barriers*), provide quality habitat for delta smelt and longfin smelt in the Delta and Suisun Bay (*CM1 Water Facilities and Operation* and *CM4 Tidal Natural Communities Restoration*), and minimize entrainment of fish at the south Delta SWP/CVP intakes (*CM1 Water Facilities and Operation*). The flexibility associated with dual conveyance will allow for tidal natural communities restoration in the western, eastern, and southern Delta. Some of the enhanced production of carbon, phytoplankton, and zooplankton generated from these restored tidal natural communities is expected to pass through the interior Delta, while some should also be consumed by fish within and adjacent to the tidal marshes.

CM2 Yolo Bypass Fisheries Enhancement contains provisions to modify Fremont Weir (lowering a portion of the weir and installing an operable gate facility), so that it can be actively managed to increase the inundation of the Yolo Bypass. Increasing the extent, duration, and frequency of floodplain inundation within Yolo Bypass is expected to increase the extent of suitable spawning and rearing habitat available to Sacramento splittail and rearing habitat for juvenile Chinook salmon. Additionally, these changes are expected to increase the levels of phytoplankton, zooplankton, and other organic material transported from the Yolo Bypass floodplain to Cache Slough, the lower Sacramento River, the western Delta, and Suisun Bay, thereby increasing the food supply for Chinook salmon, delta smelt, and longfin smelt in those areas.

Operational criteria presented in *CM1 Water Facilities and Operation* set seasonal limits on Old and Middle River reverse flows. These limits are intended to reduce the risk that south Delta SWP/CVP exports will entrain covered fish species or increase the export of nutrients and food resources produced in restored southern and eastern Delta marshes.

The western Delta and Suisun Bay system functions as an estuarine mixing zone for freshwater passing downstream from the tributary rivers and saltwater from coastal waters entering the estuary through the Golden Gate. Suisun Bay and the western Delta serve as the low-salinity mixing area, which is an important rearing and foraging habitat for the covered fish species. This estuarine environment is also important to production of phytoplankton, zooplankton, and many other aquatic organisms that are prey for covered fish species. The physical mixing that occurs in this estuarine environment defines its habitat value and is determined largely by how tides and Delta outflow interact with the landscape. Habitat conditions and salinity gradients in the Suisun Bay and western Delta are important to the largest number of covered fish species during the winter and spring months, but are likely important to resident species all year. Consequently, *CM1 Water Facilities and Operation* includes the possibility of seasonally adjusted Delta flow regimes designed to better maintain the functions of this low-salinity estuarine environment.

3.2.3.2 Physical Habitat Restoration

A second major component of the aquatic resources component of the conservation strategy is the protection, enhancement, and restoration of natural communities and covered species' habitat elements. Enhancement and restoration actions will involve both the reestablishment of natural communities in locations where they were historically supported and the creation of natural communities on altered landscapes where no such habitat previously existed. Enhancement refers to the improvement of ecological support functions of existing natural communities; protection refers to the preservation of existing natural communities susceptible to changes in human land use activity.

The natural communities restoration conservation measures include commitments to restore natural community mosaics and gradients to levels that have not been present in the Delta for at least 70 years. Specifically, these conservation measures will restore more than 84,000 acres of natural communities. This will include 65,000 acres of tidal natural communities and associated transitional uplands distributed across the Plan Area, but primarily located within Suisun Marsh, South Delta, and Cache Slough ROAs (CM4 *Tidal Natural Communities Restoration*) (Figure 3.2-2). The ROAs encompass potential restoration areas that could support covered fish species that use main channels, distributaries, and sloughs of the Sacramento, San Joaquin, and Mokelumne Rivers in the Delta and the channels and sloughs of Suisun Marsh. Primarily within the restored floodplains and tidal restoration areas, 5,000 acres of riparian natural community will be restored. Grasslands, nontidal marsh, vernal pool complex, and alkali seasonal wetland complex natural communities will also be restored to support the conservation of covered species and native biodiversity. Restoration of large, connected tracts of these natural communities is intended to substantially increase the extent of physical habitat for covered species (including cover, rearing habitat, nesting habitat, and food resources) and improve overall foodweb productivity in the restoration areas and adjacent aquatic habitat.

3.2.3.3 Measures to Address Other Stressors

The aquatic resources component of the conservation strategy also includes measures to reduce the impairment of supporting foodweb productivity and mortality rates of fishes due to stressors other than river flows and entrainment. These other stressors include, among other factors, predation, localized low dissolved oxygen, and impairment of genetic fitness of wild fish stocks caused by hatchery fish.

Specific conservation measures to address these other stressors include actions to reduce predator numbers through the removal of predator habitat, such as submerged and floating aquatic vegetation (*CM13 Invasive Aquatic Vegetation Control*) and abandoned structures and vessels (*CM15 Localized Reduction of Predatory Fishes*), particularly in reaches important to juvenile salmonid migration. New nonphysical barriers (*CM16 Nonphysical Fish Barriers*) are proposed to direct certain covered species away from areas that pose a high risk of predation and entrainment. Other measures include actions to increase dissolved oxygen in specific problem areas important to salmonid migration (*CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*), to contribute to overall Delta water quality improvements (*CM12 Methylmercury Management*, *CM19 Urban Stormwater Treatment*) to reduce illegal harvest of covered fishes (*CM17 Illegal Harvest Reduction*), to reduce the number of small water diversions in the Plan Area (*CM21 Nonproject Diversions*), to develop new and expanded conservation hatcheries for delta smelt and longfin smelt for the purpose of establishing refugial populations that will not impair the genetic fitness of the wild stocks (*CM18 Conservation Hatcheries*), and to reduce the risk of new invasive species appearing in the Plan Area (*CM20 Recreational Users Invasive Species Program*).

3.2.3.4 Consistency with the Biological Opinions

The conservation strategy incorporates many actions identified in the USFWS (2008) and NMFS (2004, 2009) BiOps. The BDCP focuses on many of the same issues and continues many ongoing actions intended to benefit natural communities and covered species, but modifies some of these actions to reflect improved understanding and policy changes that have occurred since the BiOps were issued. BDCP implementation of actions mandated under the BiOps is described in Table 3.2-1.

1 **Table 3.2-1. Consistency of the BDCP with Requirements of Recent Biological Opinions[a]**

Requirement[b]	Summary of Requirement[c]	Is the Action Incorporated in the Conservation Strategy?	Comment or Explanation
Actions required in the National Marine Fisheries Service (2009) BiOp			
Action I.5	Funding for CVPIA Anadromous Fish Screen Program	Modified	Action is modified by *CM21 Nonproject Diversions*, which financially supports the program in the Plan Area and extends it to include consideration of potential benefits to other covered fishes.
Action Suite I.6	Sacramento River Basin salmonid rearing habitat improvements	Yes	Addressed by *CM2 Yolo Bypass Fisheries Enhancement* and *CM6 Channel Margin Enhancement*. BiOp states that the BDCP may meet the requirements of Action Suite I.6 and Action I.7.
Action I.6.1	Restoration of floodplain rearing habitat	Yes	Addressed by *CM2 Yolo Bypass Fisheries Enhancement* and *CM6 Channel Margin Enhancement*. BiOp states that the BDCP may meet the requirements of Action Suite I.6 and Action I.7. This action may overlap with the 8,000-acre habitat requirement stated in the USFWS (2008) BiOp, RPA Component 4.
Action I.6.2	Near-term actions at Liberty Island/lower Cache Slough and lower Yolo Bypass	Yes	These actions are underway but are also part of *CM2 Yolo Bypass Fisheries Enhancement* and *CM4 Tidal Natural Communities Restoration*. Their completion and maintenance would be covered under the BDCP.
Action I.6.3	Lower Putah Creek enhancements	Yes	Addressed by *CM2 Yolo Bypass Fisheries Enhancement*.
Action I.6.4	Lisbon Weir improvements	Yes	Addressed by *CM2 Yolo Bypass Fisheries Enhancement*.
Action I.7	Reduce migratory delays and loss of salmon, steelhead, and sturgeon at Fremont Weir and other structures in the Yolo Bypass	Yes	Action is addressed by *CM2 Yolo Bypass Fisheries Enhancement*. BiOp states that the BDCP may meet the requirements of Action I.7.
Action IV.1.1	Monitoring and alerts to trigger changes in Delta Cross Channel operations	Yes	Action would continue, under *CM1 Water Facilities and Operation*, as a part of real-time operations.
Action IV.1.2	Delta Cross Channel gate operation	Yes	Action would continue, under *CM1 Water Facilities and Operation*, as a part of real-time operations.
Action IV.1.3	Consider engineering solutions to further reduce diversion of emigrating juvenile salmonids to the interior and south Delta, and reduce exposure to SWP/CVP export facilities	Yes	Addressed by BDCP *CM1 Water Facilities and Operation*.

Requirement[b]	Summary of Requirement[c]	Is the Action Incorporated in the Conservation Strategy?	Comment or Explanation
Action Suite IV.2	Delta flow management	Modified	The BDCP is intended to achieve protection equaling or exceeding this requirement, per *CM1 Water Facilities and Operation*.
Action IV.2.3	Old and Middle River flow management	Modified	The BDCP will continue to protect and manage flows in the Old and Middle Rivers, but flow constraints are expressed differently (*CM1 Water Facilities and Operation*).
Action IV.3	Reduce likelihood of entrainment or salvage at the export facilities	Yes	Action would continue, under *CM1 Water Facilities and Operation*, as a part of real-time operations.
Action Suite IV.4	Modifications of the operations and infrastructure of the SWP/CVP fish salvage facilities	No	Some of these changes are expected to be completed prior to BDCP implementation. None is specifically mentioned in the conservation strategy.
Action IV.4.1	Tracy Fish Collection Facility improvements to reduce prescreen loss and improve screening efficiency	No	Action is expected to be completed prior to BDCP implementation. Traveling screen installation scheduled for 2013.
Action IV.4.2	Skinner Fish Collection Facility improvements to reduce prescreen loss and improve screening efficiency	No	Action is expected to be completed prior to BDCP implementation.
Action IV.4.3	Tracy Fish Collection Facility and the Skinner Fish Collection Facility actions to improve salvage monitoring, reporting and release survival rates	No	Action is expected to be completed prior to BDCP implementation.
Action IV.5	Formation of Delta Operations for Salmon and Sturgeon Technical Working Group	Yes	This working group would continue, under *CM1 Water Facilities and Operation*, as a part of real-time operations.
Action IV.6	South Delta Improvement Program—Phase I (Permanent Operable Gates)	Modified	BiOp directs to not install permanent operable gates, but to study predation at the gate. NMFS (2011) now approves of installation of an operable gate at the Head of Old River Barrier. This is part of the BDCP, as described under *CM1 Water Facilities and Operation*.
Actions required in the U.S. Fish and Wildlife Service (2008) Biological Opinion			
Reasonable and Prudent Alternative (RPA) general	Smelt Working Group and Water and Operations Management Team	Yes	These groups would continue, under *CM1 Water Facilities and Operation*, as a part of real-time operations.
RPA Component 1	Protection of the adult delta smelt life stage	Yes	These entrainment minimization measures would continue under *CM1 Water Facilities and Operation*.

Requirement[b]	Summary of Requirement[c]	Is the Action Incorporated in the Conservation Strategy?	Comment or Explanation
RPA Component 2	Protection of larval and juvenile delta smelt	Yes	These entrainment minimization measures would be continued under *CM1 Water Facilities and Operation*.
RPA Component 3	Improve habitat for delta smelt growth and rearing	Modified	This is the Fall X2 requirement for wet and above normal years. Its longer-term implementation is contingent on the outcome of the fall outflow decision tree, explained in *CM1 Water Facilities and Operation*.
RPA Component 4	Habitat restoration	Yes	In addition to efforts currently underway, *CM4 Tidal Natural Communities Restoration* addresses this 8,000-acre tidal habitat restoration requirement.
RPA Component 5	Monitoring and reporting	Modified	BDCP monitoring will include these data within a more extensive monitoring program.
Reasonable and Prudent Measure (RPM) 1	Minimize adverse effects of the operations of the permanent operable gates	Modified	A gate will be installed at the Head of Old River Barrier, but no agricultural barriers in the south Delta will be installed.
RPM 2	Minimize adverse effects of operations of the North Bay Aqueduct	Modified	*CM1 Water Facilities and Operation* provides an additional diversion to the North Bay Aqueduct, with provisions to manage the two diversions to minimize impacts on covered fish.
RPM 3	Obtain real-time data on the abundance and distribution of delta smelt in the Bay-Delta	Modified	BDCP monitoring will include these data within a more extensive monitoring program.
RPM 4	Minimize adverse effects of Banks and Jones Pumping Plants on delta smelt	Yes	Minimization at the south Delta pumps would continue to be a part of real-time operations, under *CM1 Water Facilities and Operation*.
Monitoring & Reporting	Various requirements	Yes	The required data would continue to be reported, in conjunction with other BDCP reporting.

[a] U.S. Fish and Wildlife Service (2008) and National Marine Fisheries Service (2009) Biological Opinions.

[b] Required actions not listed in this table would occur outside the Plan Area and thus are not covered activities under the BDCP.

[c] For details of each action, see the U.S. Fish and Wildlife Service (2008) and National Marine Fisheries Service (2004, 2009, 2011) Biological Opinions.

3.2.4 Developing the Terrestrial Resources Component of the Conservation Strategy

The terrestrial resources component of the conservation strategy comprises a comprehensive set of actions that protects existing functioning natural communities, restores new areas of specific natural communities, enhances the function of degraded natural communities for covered species habitat, establishes long-term management of geographically distributed reserves, and establishes monitoring and adaptive management to measure and ensure success of the conservation strategy.

The conservation strategy is designed to maximize opportunities to protect and restore natural communities sufficient to achieve the biological goals and objectives for the covered terrestrial species. The conservation measures identify specific targets for protection and restoration of covered species' habitat, including requirements relating to reserve size, habitat corridors and linkages, and reserve management. Where the biological goals and objectives for a covered terrestrial species may not be fully achieved through implementation of natural community protection and restoration, species-specific requirements have been included to ensure the species needs are being met.

Because of the diverse species habitat requirements and highly altered nature of the Delta, the covered wildlife and plant species are distributed unevenly in the Plan Area, often in discrete, disconnected patches of habitat. A few of the covered wildlife and plant species are distributed broadly across the Plan Area, but many are found only at the margins or in discrete portions of the Plan Area. For some of these species, the Plan Area only provides low-quality or marginal habitat, whereas for others the Plan Area provides the key resources required for conservation. Hence, the conservation approaches vary among species.

Each natural community supports habitat for multiple covered wildlife and plant species, and the suite of species' habitats supported by some communities are similar. Actions to provide for the conservation of each natural community are addressed based on the specific spatial, temporal and structural attributes of those communities in relation to the needs of the covered wildlife and plant species.

The conservation strategy includes actions to provide connectivity between areas that are important for sustaining and improving ecosystem functions and providing for the conservation of covered species. For some species and natural communities, this increased connectivity will be achieved through large-scale restoration of aquatic natural communities, such as tidal natural communities concentrated in the Delta and Suisun Marsh and associated riparian forest and scrub. For covered species that occur in terrestrial natural communities along the periphery of the Plan Area (e.g., San Joaquin kit fox, California red-legged frog), opportunities for increased habitat connectivity will be mostly between existing and newly protected terrestrial species' habitat in the Plan Area and protected terrestrial species' habitat adjacent to the Plan Area (mostly associated with adjacent or surrounding HCPs and NCCPs).

The geographic pattern of terrestrial species' habitat protection and restoration in the Plan Area will result in a system of core habitat patches linked by ribbons of habitat along channels, sloughs, and floodplains. This approach can be thought of as a "node and network" approach. In habitat areas that covered species currently occupy, patches, or "nodes," of protected and restored habitat will be established to address site-specific species needs. Steps to establish a connectivity network for covered species within the Plan Area will be informed and guided by the California Essential Habitat Connectivity project (Spencer et al. 2010).

Many of the natural communities addressed by the BDCP share common characteristics that are related to spatial proximity on the landscape, shared ecosystem process (e.g., exchanges of nutrients through daily tidal cycles or seasonal flooding regimes), and similarity of habitat structural characteristics (e.g., herbaceous versus woody vegetation), and some are dominated by human land use practices (e.g., managed wetlands or cultivated lands). For example, tidal freshwater emergent wetland, tidal mudflat, and tidal perennial aquatic natural communities are typically spatially contiguous along a tidal elevation gradient and are linked through ecosystem processes such as energy and nutrient flows. Another example is the spatial distribution of grassland, alkali seasonal wetland complex, and vernal pool complex communities that, within the Plan Area, are typically intermingled with each other to the extent that they form a complex mosaic on the landscape. While grassland in the Plan Area can occur in discrete patches that can be mapped, it is often intermixed with the alkali seasonal wetland and vernal pool complexes. On fine spatial scales, the seasonal wetland communities are embedded as "islands" within a larger matrix of the grassland natural community; for BDCP development, those areas were mapped as complexes of communities.

3.2.4.1 Conservation Targets

Conservation targets have been established for the natural communities and the covered wildlife and plant species' habitats they support. Conservation targets represent the extent and distribution of natural community or habitat to be protected, enhanced, and restored/created to achieve the biological goals and objectives. Under the monitoring program, the effectiveness of protection, enhancement, restoration, and management actions will be assessed and potential adjustments identified to maintain or improve ecological functions over time (Section 3.6, *Adaptive Management and Monitoring Program*). The conservation targets are intended to satisfy mitigation requirements associated with the effects of covered activities on natural communities and covered species and provide for the conservation of those species and their habitats.

The process used to develop conservation targets is presented in Figure 3.2-13. The following information was used to develop the conservation targets.

- Current distribution and extent of each natural community in the Plan Area (Figure 3.2-3 through Figure 3.2-12).
- Modeled distribution and extent of each covered species' habitat in the Plan Area (Appendix 2.A, *Covered Species Accounts*).
- Primary threats and stressors for each of the covered species (Appendix 2.A).
- Location of habitat areas known to be occupied by each of the covered species (Appendix 2.A).
- The distribution and extent of existing protected patches of each natural community and covered species' habitat (Section 3.3.6, *Natural Community Biological Goals and Objectives*, and Appendix 2.A, respectively).
- Potential for increasing connectivity with existing conservation lands adjacent to the Plan Area (from documents of HCP/NCCPs approved or under development).

To establish the conservation targets, the above information was evaluated for each of the following variables.

- **Patch size and connectivity of each natural community with other protected and unprotected natural community patches, and connectivity with existing protected natural communities.** The conservation targets were formulated to include large patches of connected natural communities rather than small fragmented/disconnected patches.
- **The extent of modeled habitat for covered species that is supported by each natural community within each of the conservation zones.** The conservation targets were

formulated to include natural communities in locations that support modeled habitat for multiple covered species and exclude areas that do not support modeled habitat for covered species or only a relatively small number of covered species, except where such patches are important for conserving a particular species or providing connectivity between larger natural community patches.

- **The habitat value of patches of natural communities to covered species and the ability to maintain such habitats into the future.** The conservation targets avoid or minimize the inclusion of low value habitats (e.g., disconnected or fragmented patches of grassland on levee slopes) and habitat areas at risk for future loss to natural events (e.g., habitats on subsided lands that may be lost to future levee failures associated with flood and seismic events).
- **The patch size and connectivity of each covered species' modeled habitat to other patches of modeled protected and unprotected species habitat within the Plan Area and habitat adjacent to the Plan Area.** The conservation targets were formulated to give higher priority to large patches of connected modeled habitat for each of the covered species rather than small fragmented patches, except where small patches may provide connectivity between larger patches.
- **Location of important known covered wildlife species population centers and covered plant species occurrences.** The conservation targets were formulated to give priority to protection at prime locations to maximize conservation benefits.
- **Proximity of modeled covered species' habitats to known occupied habitats.** The conservation targets were formulated to give priority to the protection of occupied habitats as well as currently unoccupied habitat areas connected to known occupied habitat areas.

Based on the evaluation of these variables for each natural community and covered wildlife and plant species, the conservation targets were developed to help direct protection efforts toward the largest and most significant patches of natural communities and associated covered species' habitats remaining in the Plan Area. The rationale for how the natural community conservation targets address the conservation needs for each of the covered species is presented in Section 3.3.7, *Species Biological Goals and Objectives*.

Natural community protection, enhancement, restoration, and management contribute to the conservation of the covered species and their habitats. Conservation measures also include species-specific actions, some of which reflect approaches identified in approved recovery plans and approved conservation plans that overlap with the Plan Area.

3.2.4.2 Assembly of Reserve System

The reserve system includes all areas of land and water in the Plan Area managed under the BDCP for conservation of natural communities or covered species. The full assembly and management of the reserve system over the term of the BDCP, in combination with the benefits afforded by the operation of new water conveyance facilities and the actions designed to address other stressors are expected to result in the achievement of all natural community and species-specific goals and objectives. This section describes the factors considered in the assembly of the reserve system and provides guidance for selecting reserves during implementation of the BDCP. Included are discussions of reserve system assembly principles, existing conservation lands and their relationship to reserve system assembly, implementation actions that may occur outside the Plan

Area, and the relationship between other regional conservation planning programs and the conservation strategy.

3.2.4.2.1 Reserve System Assembly Principles

The following reserve system assembly principles were used to guide decisions regarding the distribution of targeted natural communities and covered species habitats among the conservation zones to ensure the greatest biological benefits. These assembly principles will also support the decisions of the BDCP Implementation Office regarding the acquisition of reserve lands.

- Protect, enhance, and restore the ecological diversity of natural communities and covered species habitats at the periphery of the Plan Area on lands most likely to accommodate future sea level rise and less likely to be flooded as a result of levee failures (i.e., terrestrial habitat areas should be located where there is a low risk of future flooding).
- Maintain a range of contiguous ecological gradients and provide connectivity between estuarine/wetland and upland communities inside and outside the Plan Area.
- Design reserves to appropriately scale the ecological gradient and emphasize compatibility between restored natural communities and working landscapes (e.g., cultivated lands).
- Design reserves of sufficient size to ensure the intended conservation benefits for the target covered species.
- Design reserves of sufficient size and configuration to ensure that they can be effectively managed given site constraints.
- Maximize connections between reserves and with existing conservation lands in and adjacent to the Plan Area.
- Where feasible, build off of existing conservation lands and management systems to increase management efficiency, connectivity, and patch size.
- Protect the highest-value natural communities and covered species habitats available consistent with the BDCP implementation schedule.

The following concepts will be used by the Implementation Office to guide the design and timing of restoration actions and selection of sites for protection and restoration.

- During the BDCP near-term implementation period, focus restoration and enhancement of covered fish species habitats in north Delta locations to generate improvements in productivity consistent with continued operations of the south Delta SWP/CVP facilities.
- Identify restoration areas and design actions to accommodate and integrate with *CM1 Water Facilities and Operation* to optimize primary and secondary productivity, spawning and rearing, and other aquatic functions that support covered species (e.g., allochthonous inputs, complex habitat, floodplain connectivity, more natural flow regimes).
- During the long-term implementation period, expand the restoration and enhancement of covered fish species habitats to include portions of the Mokelumne and San Joaquin Rivers that lie in the Plan Area to provide benefits to covered fish species found in each of those areas.
- Implement conservation measures for terrestrial and nontidal wetland communities and covered wildlife and plants in a manner that complements or supports the conservation

strategies of approved and developing conservation plans for areas adjacent to and overlapping the Plan Area.

- Restore natural communities and covered species' habitat in large patches to increase the likelihood of providing the desired levels of ecological function and to support large numbers of covered species.
- Strategically distribute restored and enhanced natural communities and covered species' habitat throughout the Delta to minimize the risk of loss of benefits to catastrophic events in one part of the Delta, while maintaining the goals of large, connected reserves.
- Distribute and design restored natural communities and covered species' habitat to withstand potential changes in Delta conditions associated with future sea level rise and changes in stream hydrographs.
- Design tidal natural communities restoration to withstand effects associated with Delta levee failures.
- Restore suitable habitat in patch sizes that are equal to or greater than the patch sizes required to meet the ecological needs of the covered species, considering adjacent and connected habitats as appropriate.
- Juxtapose restored habitats with existing habitats to improve and maintain habitat corridors and connectivity among covered species habitats.
- Locate and design restored natural communities to provide beneficial hydrodynamic effects on adjacent channel systems (e.g., dispersal of tidal flows to reduce tidal intrusion and promote increased unidirectional freshwater flow through the Plan Area to maintain desired habitat attributes).
- Locate and design restored natural communities to create natural gradients in the Delta that historically transitioned from shallow subtidal aquatic areas, to riverine floodplains, and to transitional uplands (e.g., seasonal wetland, riparian, grassland).
- Design tidal marsh and seasonally inundated floodplain restoration to provide ingress and egress for covered fish species in a manner that avoids stranding or trapping of fish beyond a single tidal cycle.
- Locate and design restored natural communities to minimize potential effects of other stressors that could degrade intended covered species benefits (e.g., effects of nearby diversions, discharges of low-quality water).

3.2.4.2.2 Existing Conservation Lands

An important consideration in the assembly of the reserve system is the extent and distribution of existing conservation lands, which are undeveloped lands subject to irrevocable protection against a change in primary land use through local, state, or federal authority. The BDCP Existing Conservation Lands GIS data layer was generated using the following public data sources.[1]

[1] Protected Lands GIS layer for areas outside the Plan Area was generated from two datasets: California Protected Areas Database 1.9 (GreenInfo Network 2013) and California Wildlife Conservation Board (2009) Approved Projects GIS dataset.

- Delta Land Ownership Dataset (Delta Habitat Conservation and Conveyance Program May 2013)
- California Protected Areas Database 1.9 (GreenInfo Network 2013)
- National Conservation Easement Database (Natural Resources Conservation Service 2012)
- Region 3 Lands (California Department of Fish and Wildlife 2013a)
- Region 3 Public Trust Lands (California Department of Fish and Wildlife, 2013b)
- Protected Lands (Central Valley Joint Venture & Ducks Unlimited 2009)
- Wildlife Conservation Board Approved Projects (California Wildlife Conservation Board 2009)
- Solano County Protected Lands Dataset (LSA Associates 2013)
- Public and Private Open Space Lands (many for protection of habitat) (LSA Associates 2006)
- San Joaquin County Multi-Species Habitat Conservation and Open Space Plan Preserves (San Joaquin Council of Governments 2011)
- Primary Management Area of the Suisun Marsh (San Francisco Bay Conservation and Development Commission 2011a)
- Secondary Management Area of the Suisun Marsh (San Francisco Bay Conservation and Development Commission 2011b)
- Suisun Marsh Conservation Lands (Chappell pers. comm.)
- Conservation Bank Lands (Jensen pers. comm.)
- Conservation lands within and adjacent to Stone Lakes Planning Boundary (McDermott pers. comm.)

Ownership information was collected and organized by County, County Assessor's Parcel Number, Management Level, Management Agency, Alias (if known), Type (type of ownership), and Data Source attributes. Although the boundaries depicted within the data do not represent legal boundaries, they represent the best available information and were considered to be sufficiently accurate to guide development of the conservation measures at a landscape level.

The data layer was created by overlaying source data on top of county parcel boundary data. Parcels identified as protected lands via source datasets were then attributed with the appropriate information. The layer was then reviewed by land managers with expertise in specific geographic locations (e.g., Stone Lakes, Yolo Bypass, Suisun Marsh).

The protection and resource management status of conservation lands was evaluated and classified based on the level of land use protection and the general level of ecological management. Each conservation land unit within the Plan Area was assigned one of four types as shown in Table 3.2-2. The decision-making process used to assign conservation lands according to these types is shown in Figure 3.2-14.

The first three types of conservation lands are protected from land use change by irrevocable means, such as a conservation easement *in perpetuity*, or a local, state, or federal law. Type 1 lands have natural resource management and ecological protection as their primary purpose. Local examples of Type 1 conservation lands include lands owned by the Solano Land Trust and ecological preserves owned and by CDFW, lands that are under a permanent conservation easement, and habitat or species mitigation lands subject to permanent easement. It is understood that the extent of ecological protection and management that actually occurs on these lands is subject to the availability of funding. The designation of Type 1 lands notes that the land use protections and management objectives are in place on those lands, provided the funding becomes available.

If ecological protection is not the primary goal, but the land is managed as conservation land with a consistent and measurable ecological value[2], then it is designated Type 2. If ecological protection is not the primary or secondary management goal but the land is managed as open space and has some potential ecological value,[3] then it is designated Type 3. Lands managed as open space and having some ecological value[3], but not irrevocable protection, are designated Type 4.

The Plan Area includes 68,741 acres of Type 1; 126,280 acres of Type 2; 2,334 acres of Type 3; and 25,547 acres of Type 4 conservation lands. Figure 3.2-15 depicts existing conservation lands in and around the Plan Area.

Table 3.2-2. Examples of Existing Conservation Lands in the Plan Area by Type[a]

Type 1	Type 2	Type 3	Type 4
• Properties under easement managed by The Nature Conservancy[b] • Solano Land Trust properties owned in fee-title or held under easement from change in land use[b] • California Department of Fish and Wildlife Peytonia Slough Ecological Reserve and Hill Slough Wildlife Area • Designated biological mitigation sites under easement (e.g., lands owned by the California Department of Water Resources or by a private mitigation bank) • Private property under conservation easement with the primary purpose of ecological protection • Conservation lands associated with the implementation of neighboring HCPs and NCCPs (e.g., San Joaquin HCP) • East Bay Regional Park District	• Managed wetlands owned by a public agency or held in a permanent easement • Managed wetlands held in private ownership within the Suisun Marsh Primary Management Area • Bureau of Land Management properties • Mandeville Island (Tuscany Research Center)	• Historic or recreation parks • Farm lands held under permanent easement with the Central Valley Farmland Trust	• California Department of Water Resources Land (except those held under conservation easement) • Lands held by reclamation or irrigation districts

[a] See Figure 3.2-14 and Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of types of conservation lands.
[b] Some lands allow hiking, mountain biking, equestrian recreation, and hunting.

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[2] Allows multiple species to complete some portion of their life cycles (e.g., reproduction, growth, foraging).
[3] Provides movement opportunities or acts as a buffer between habitat and development.

3.2.4.2.3 Relationship of the Conservation Strategy with other Regional Conservation Planning Programs

Several regional conservation plans have been approved in the vicinity of the Delta and others are being developed. These plans are generally sponsored by local governments and special districts to address the mitigation and conservation needs of terrestrial and wetland wildlife and plant species. The regional conservation plans that overlap with the Plan Area, listed in rank order of amount of physical overlap, are listed below and illustrated in Figure 1-2, *Plan Area in Relation to Neighboring Conservation Plan Boundaries*, in Chapter 1, *Introduction*.

- San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (approved)
- East Contra Costa County HCP/NCCP (approved)
- Solano County Multispecies HCP (in development)
- Yolo Natural Heritage Program Plan (in development)
- Suisun Marsh Habitat Management, Preservation, and Restoration Plan (in development)
- South Sacramento HCP (in development)
- East Alameda County Conservation Strategy (approved)

The San Joaquin County HCP has the largest amount of overlap with the BDCP Plan Area (more than 300,000 acres). The East Alameda County Conservation Strategy has the least amount of overlap (less than 5,000 acres). An additional plan, the approved Natomas Basin HCP in Sacramento and Sutter Counties, is adjacent to the Upper Yolo Bypass, east of the northern tip of the Plan Area. Most of the BDCP wildlife and plant covered species are also covered or proposed for coverage by at least one of these other plans (Table 1-4, *Overlapping Regional Conservation Plans that Address Some BDCP Covered Species*, in Chapter 1, *Introduction*). The geographic and species overlap with surrounding plans provides an opportunity for collaboration and partnership in the implementation of actions contributing to species conservation. For further description of these plans, see Section 1.5, *Relationship to Other Plans in the Delta*.

Opportunities exist for joint implementation of actions contributing to conservation of covered species and natural communities both inside and outside of the Plan Area. The Implementation Office may partner with willing regional conservation planning sponsors to jointly implement such actions in a manner that complement each plan and provide economies of scale and efficiencies. These partnerships would be guided by the following criteria.

- The BDCP is responsible for the mitigation of its effects.
- The mitigation actions and the mitigation requirements of the BDCP must be additive to the mitigation obligations of other plans (i.e., BDCP mitigation cannot supplant the mitigation obligations of other plans and vice-versa).
- In cases where the BDCP shares the goal of providing for the conservation of covered species with another conservation program, where actions contributing to species or natural community conservation are not related to either program's mitigation requirements and limited opportunities exist for either plan to achieve its goal separately, the BDCP and the other conservation program may share conservation credit for the same action with approval of the fish and wildlife agencies. (This situation is most likely to arise for requirements to protect rare and fragmented natural communities.)

- Actions contributing to species or natural community conservation, when implemented by another conservation program in the Plan Area on behalf of the BDCP, could be funded by the BDCP to cover the costs of initial implementation, long-term management, long-term monitoring, and remedial actions.

3.2.5 Landscape Linkages

The NCCPA explicitly requires NCCPs to address landscape or habitat linkages, as shown below.

- Establishing one or more reserves or other measures that provide equivalent conservation of covered species within the plan area and linkages between them and adjacent habitat areas outside of the plan area. (Section 2820[a][4][B].)
- Sustaining the effective movement and interchange of organisms between habitat areas in a manner that maintains the ecological integrity of the habitat areas within the plan area. (Section 2820[a][4][E].)

For the purposes of the BDCP, landscape linkages are defined as areas that allow for the movement of species from one area of suitable habitat to another. A linkage can vary in spatial scale and shape, ranging from a narrow strip of habitat that only functions as a conduit for movement (i.e., a corridor) to a large area of intact habitat that is used for movement, dispersal, and other life functions such as foraging and breeding.

Landscape linkages are essential to provide natural community and habitat connectivity. In landscape ecology, connectivity refers to both the physical relationship between landscape elements (physical connectivity) and the degree to which landscapes facilitate or impede the movement of organisms and processes (functional connectivity, or permeability). An example of increasing physical connectivity is protection of species habitat between two existing large protected areas of species habitat to link the two areas. Increasing physical connectivity also includes protection of habitat areas large enough to include all the life-history requisites for a species (e.g., protecting both upland and aquatic habitat for amphibians, or upland flood refugia adjacent to wetland habitat for salt marsh harvest mouse) and to include sufficient land to accommodate ecosystem-level processes and changes (e.g., protecting transitional uplands adjacent to tidally restored areas to accommodate sea level rise). Physical connectivity is established through natural community protection and restoration, as described in *CM3 Natural Communities Protection and Restoration*. Physical connectivity of aquatic habitats for various life stages of covered fish species is provided through *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement*. Functional connectivity, or permeability, is addressed by increasing the relative potential for species to move through the reserve system by minimizing barriers or obstacles to movement, and is addressed in *CM11 Natural Communities Enhancement and Management* for terrestrial species and in *CM2 Yolo Bypass Fisheries Enhancement* and *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* for fish species.

Some species require linkages for periodic movement between different habitat types used for breeding, feeding, or roosting. Wildlife movement from one habitat area to another may vary from daily to seasonal movement depending on the species. Linkages may also be needed for the immigration or emigration of individuals among habitat patches, allowing for gene flow and recolonization after local extirpation (Beier and Noss 1998; Hilty et al. 2006; Groom et al. 2006). Linkage requirements differ greatly from species to species. Specific characteristics of linkages, such as dimensions, location, and quality of habitat, can influence species use. Wider linkages tend to be more effective than narrower linkages (Merenlender and Crawford 1998; Hilty et al. 2006).

To incorporate landscape linkages in the reserve design process, known or potential linkages important for covered species were identified by CDFW, and inferred from the land cover data, occurrence data, and covered species habitat models. The identified linkages are described in Table 3.2-3 and shown on Figure 3.2-16. These linkages are drawn at a regional level as broad swaths of natural land cover types rather than specific alignments or corridors. The linkages shown on Figure 3.2-16 are relatively large-scale linkages that can be identified at a regional planning level; there are also connectivity needs at smaller scales that will be identified during Plan implementation as the reserve system is assembled, such as connecting sites that are protected during implementation, connecting aquatic and upland habitat for covered amphibians, and connecting riparian and emergent wetland natural communities with adjacent uplands for covered mammals (i.e., riparian brush rabbit, salt marsh harvest mouse, Suisun shrew).

3.2.5.1.1 Regional Connections

Maintaining linkages with areas outside the Plan Area (i.e., regional habitat connectivity) facilitates conservation of native species within the Plan Area. For example, linkage of Conservation Zones 1 and 11 with adjacent lands in the Jepson Prairie area of Solano County (Figure 3.2-16 and Table 3.2-3, Linkage 1) is important to provide habitat connectivity for vernal pool species such as California tiger salamander and grassland foragers such as western burrowing owl and Swainson's hawk. Similarly, linkage between Conservation Zone 8 and adjacent lands in East Contra Costa County (Figure 3.2-16 and Table 3.2-3, Linkage 2) is important to provide connectivity for grassland species such as San Joaquin kit fox, vernal pool species such as California tiger salamander, and aquatic species such as California red-legged frog. Riparian connectivity along the San Joaquin River (Figure 3.2-16 and Table 3.2-3, Linkages 3) to lands south of the Plan Area is important for species such as least Bell's vireo, riparian brush rabbit, and riparian woodrat.

3.2.5.1.2 Connections within the Plan Area

Within the Plan Area, landscape linkages maintain connectivity among populations. For example, within Conservation Zone 7, floodplain and riparian linkages (Figure 3.2-16 and Table 3.2-3, Linkages 5, 6, and 7) are important to provide habitat connectivity for slough thistle, riparian brush rabbit, riparian woodrat, and other native riparian species. Connectivity along the Yolo Bypass, Sacramento River, and San Joaquin River within the Plan Area (Figure 3.2-16 and Table 3.2-3, Linkages 3, 8, and 9) are important to provide for passage of covered fish species; these linkages will be addressed by providing sufficient flows and appropriate water quality conditions to retain permeability for fish movement.

1 **Table 3.2-3. Landscape Linkages Considered for the Reserve Design**

Reference # (Figure 3.2-16)	Linkage	General Linkage Purpose	Covered Species Likely to Benefit	Applicable Conservation Measure(s)
Regional Connections (to lands outside the Plan Area)				
1	Jepson Prairie	Provide natural community and species habitat connectivity within Jepson Prairie, and within and between Conservation Zones 1 and 11 for vernal pool and grassland species.	Covered vernal pool crustaceans and plants, California tiger salamander	• CM3 Natural Communities Protection and Restoration • CM8 Grassland Natural Community Restoration • CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration
2	West to Contra Costa County	Provide natural community and species habitat connectivity for grassland, aquatic (streams and ponds), alkali seasonal wetland, and vernal pool species between the Plan Area and lands protected to the west in East Contra Costa County.	Vernal pool crustaceans and plants, alkali seasonal wetland plants, California red-legged frog, California tiger salamander, San Joaquin kit fox	• CM3 Natural Communities Protection and Restoration • CM8 Grassland Natural Community Restoration • CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration
3	Yolo Bypass	Provide connectivity for adult migration through the Yolo Bypass and over the Fremont Weir to the Sacramento River and from the Sacramento River onto the Yolo Bypass. (This provides connection within the Plan Area as well as connection to lands outside the Plan Area.)	Covered fish species, especially adult salmonids and sturgeon and juvenile salmonids and splittail	• CM2 Yolo Bypass Fisheries Enhancement
4	San Joaquin River to the south	Provide riparian connectivity for natural community and species habitat functions.	Riparian brush rabbit, riparian woodrat, least Bell's vireo, yellow-breasted chat, yellow-billed cuckoo, Swainson's hawk, white-tailed kite	• CM3 Natural Communities Protection and Restoration • CM5 Seasonally Inundated Floodplain Restoration • CM7 Riparian Natural Community Restoration
Connections within the Plan Area				
5	San Joaquin River	Provide aquatic and riparian connectivity along the San Joaquin River from the southern boundary of the Plan Area to large blocks of connected land around Medford and Mandeville Islands.	Riparian brush rabbit, riparian woodrat, least Bell's vireo, yellow-breasted chat, yellow-billed cuckoo, Swainson's hawk, white-tailed kite	• CM3 Natural Communities Protection and Restoration • CM5 Seasonally Inundated Floodplain Restoration • CM7 Riparian Natural Community Restoration

Reference # (Figure 3.2-16)	Linkage	General Linkage Purpose	Covered Species Likely to Benefit	Applicable Conservation Measure(s)
6	Middle River	Provide riparian connectivity along the Middle River.	Riparian brush rabbit, riparian woodrat, least Bell's vireo, yellow-breasted chat, yellow-billed cuckoo, Swainson's hawk, white-tailed kite	• CM3 Natural Communities Protection and Restoration • CM5 Seasonally Inundated Floodplain Restoration • CM7 Riparian Natural Community Restoration
7	Old River	Provide riparian connectivity along the Old River from San Joaquin River to Clifton Court Forebay.	Riparian brush rabbit, riparian woodrat, least Bell's vireo, yellow-breasted chat, yellow-billed cuckoo, Swainson's hawk, white-tailed kite	• CM3 Natural Communities Protection and Restoration • CM5 Seasonally Inundated Floodplain Restoration • CM7 Riparian Natural Community Restoration
8	Deep Water Ship Channel	Provide the most direct route for covered fish to migrate along the San Joaquin River to spawning habitat upstream of Stockton and rearing habitat downstream within the Delta.	Chinook salmon, steelhead, green sturgeon, white sturgeon	• CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels
9	Sacramento River	Provide sufficient flows through Sacramento River downstream of the north Delta intakes, and limit entrainment mortality to retain movement capacity for covered fish. Encourage linkage along the mainstem Sacramento River and Steamboat Slough.	Delta smelt, longfin smelt, Chinook salmon, steelhead, green sturgeon, white sturgeon	• CM1 Water Facilities and Operation
10	Cosumnes to Stone Lakes	Provide two greater sandhill crane roosting and foraging sites connecting the population in the vicinity of Cosumnes River Preserve with the population in the vicinity of Stone Lakes National Wildlife Refuge.	Greater sandhill crane	• CM3 Natural Communities Protection and Restoration • CM10 Nontidal Marsh Restoration • CM11 Natural Communities Enhancement and Management
11	White Slough to Stone Lakes	Provide giant garter snake habitat connecting the White Slough population to habitat in the Stone Lakes area.	Giant garter snake	• CM3 Natural Communities Protection and Restoration • CM4 Tidal Natural Communities Restoration • CM10 Nontidal Marsh Restoration • CM11 Natural Communities Enhancement and Management

3.2.5.1.3 Other Connectivity

In addition to the regional and local linkages described above and shown on Figure 3.2-16, the reserve system will be assembled to provide landscape, natural community, and species habitat connectivity taking into consideration geomorphic and vegetation factors and the functional connectivity needs of different taxonomic groups. Connectivity will be provided within and between upland, wetland, and aquatic natural communities, to accommodate sea level rise and provide for species that move between these three natural community types. For example, upland areas will be protected adjacent to tidal brackish emergent wetland for salt marsh harvest mouse, and upland areas will be protected adjacent to riparian natural community to provide flood refugia for riparian brush rabbit. Uplands will be protected in association with aquatic habitat for amphibians such as California tiger salamander and California red-legged frog, as well as for giant garter snake. Similarly, vernal pools and alkali seasonal wetlands will be protected in association with a grassland matrix to sustain the hydrologic and ecological requirements of these natural communities and the species that depend on them.

In addition to wildlife, it is also important that plant populations be able to disperse with minimal limitations to facilitate population expansion and ensure long-time viability within the context of global climate change. Reserve system assembly, management, and enhancement will improve landscape, natural community, and species habitat connectivity and permeability.

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3.2.6.1 Literature Cited

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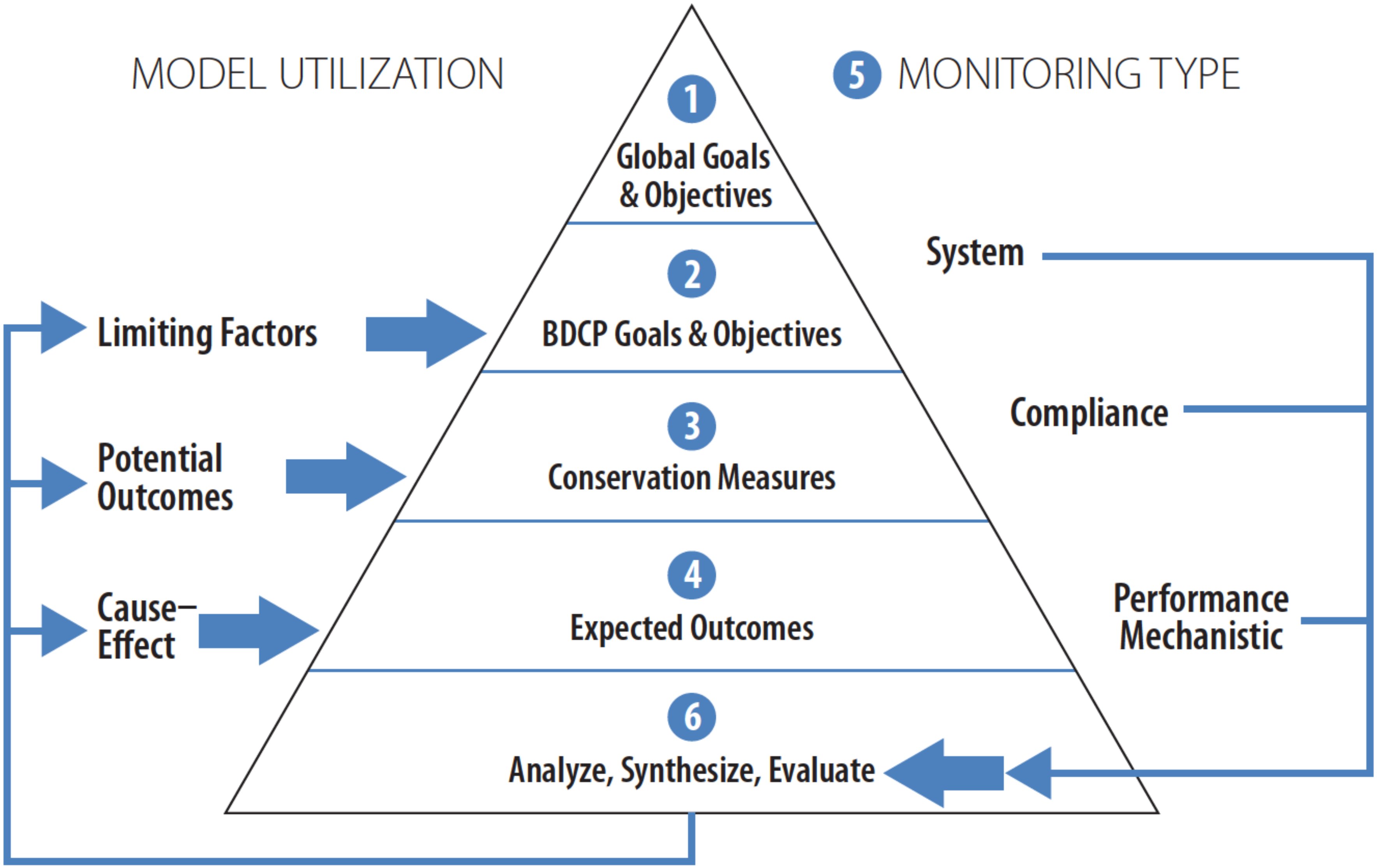
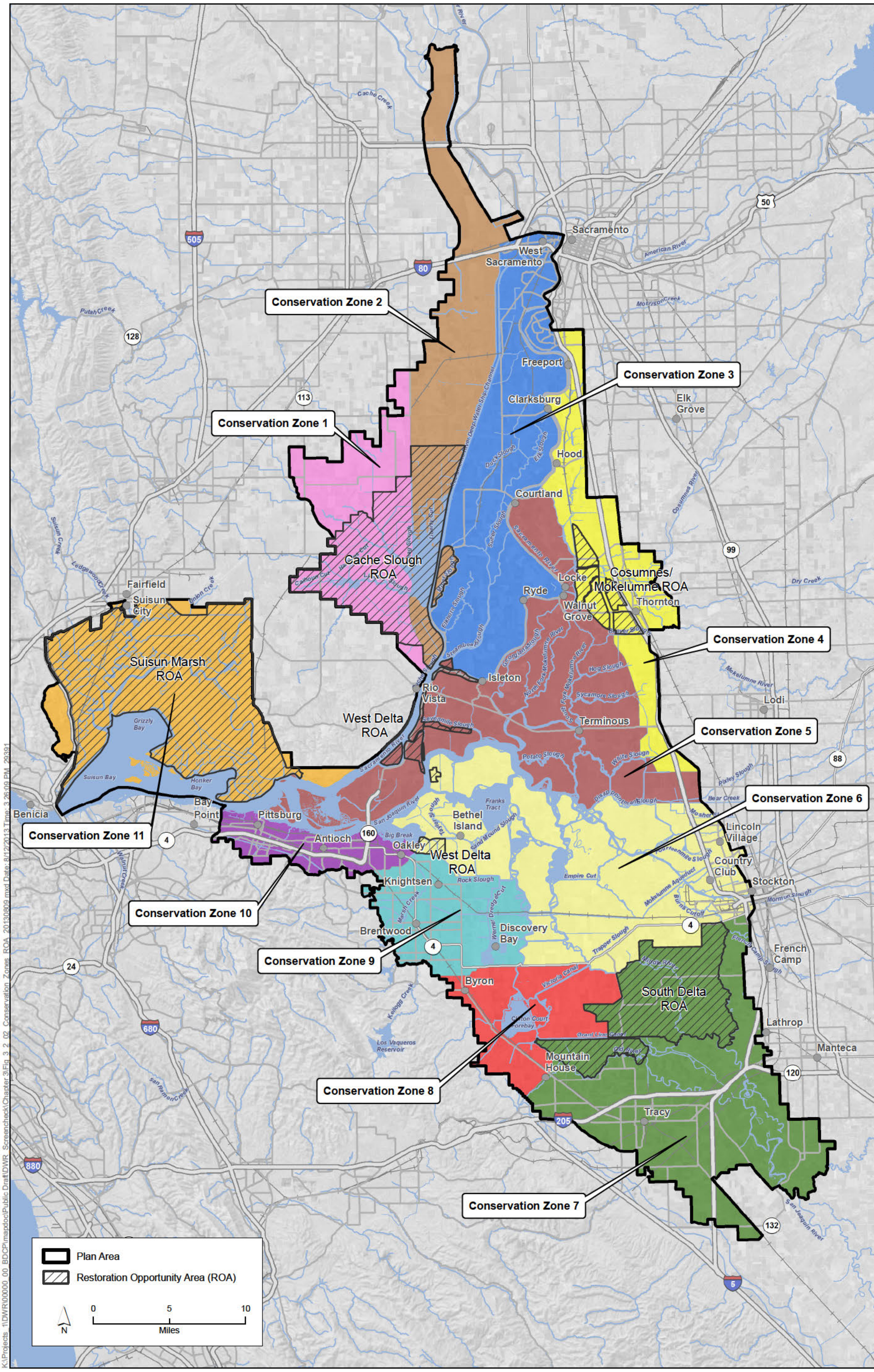


Source: Reed, Denise, Jim Anderson, Erica Fleishman, David Freyberg, Wim Kimmerer, Kenneth Rose, Mark Stacey, Susan Ustin, Inge Werner, Bruce DiGennaro, and Wayne Spencer. 2007. *Bay Delta Conservation Plan Independent Science Advisors Report.* November 16.

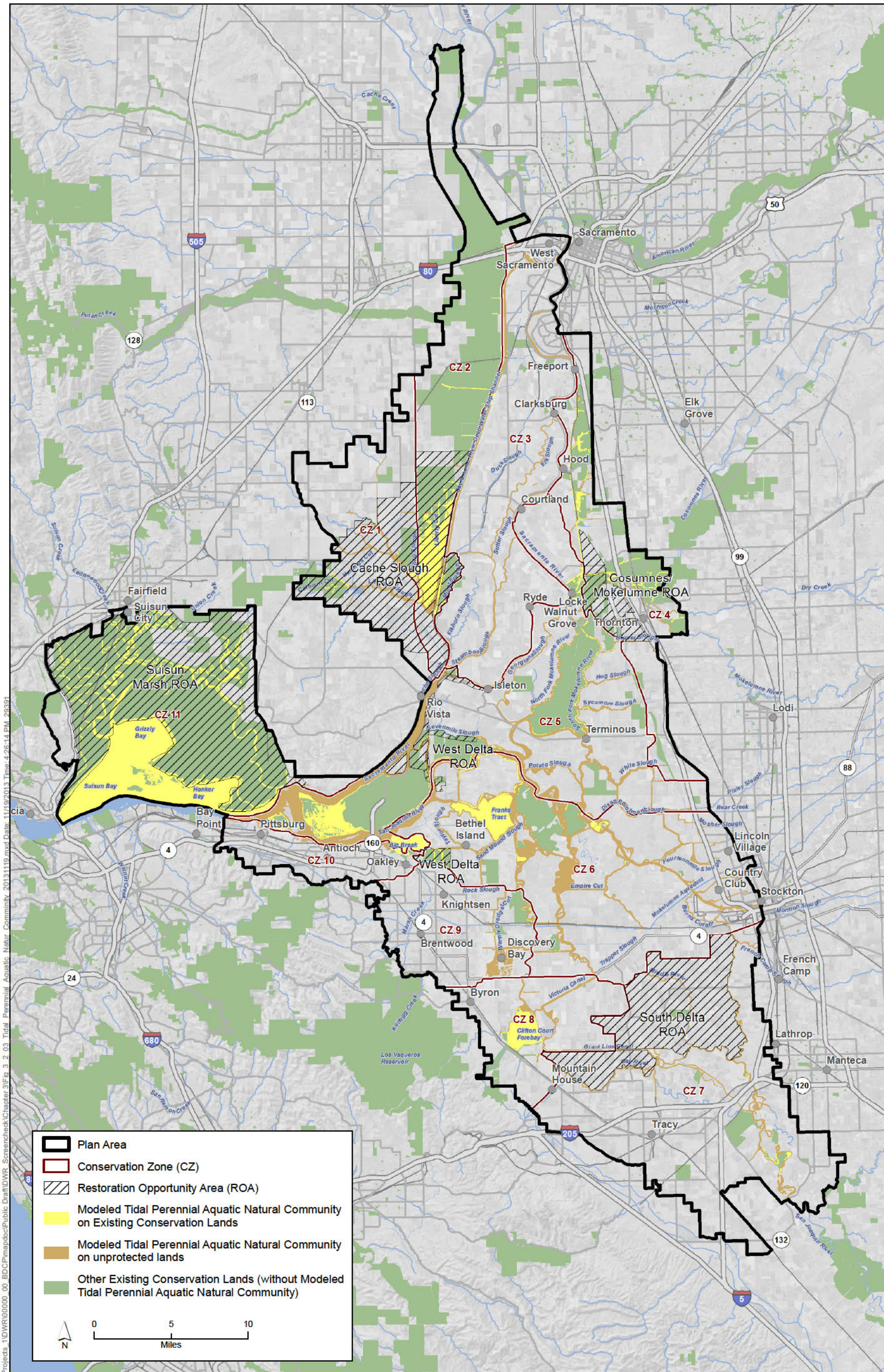
Graphics… BDCP Other Chapters (Rev. 11-9-12 TM)

Figure 3.2-1
Relationship of Goals and Objectives to Elements of the BDCP



GIS Data Source: Conservation Zones, SAIC 2012; ROA, SAIC 2010.

Figure 3.2-2
Conservation Zones and Restoration Opportunity Areas



GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-3
Tidal Perennial Aquatic Natural Community

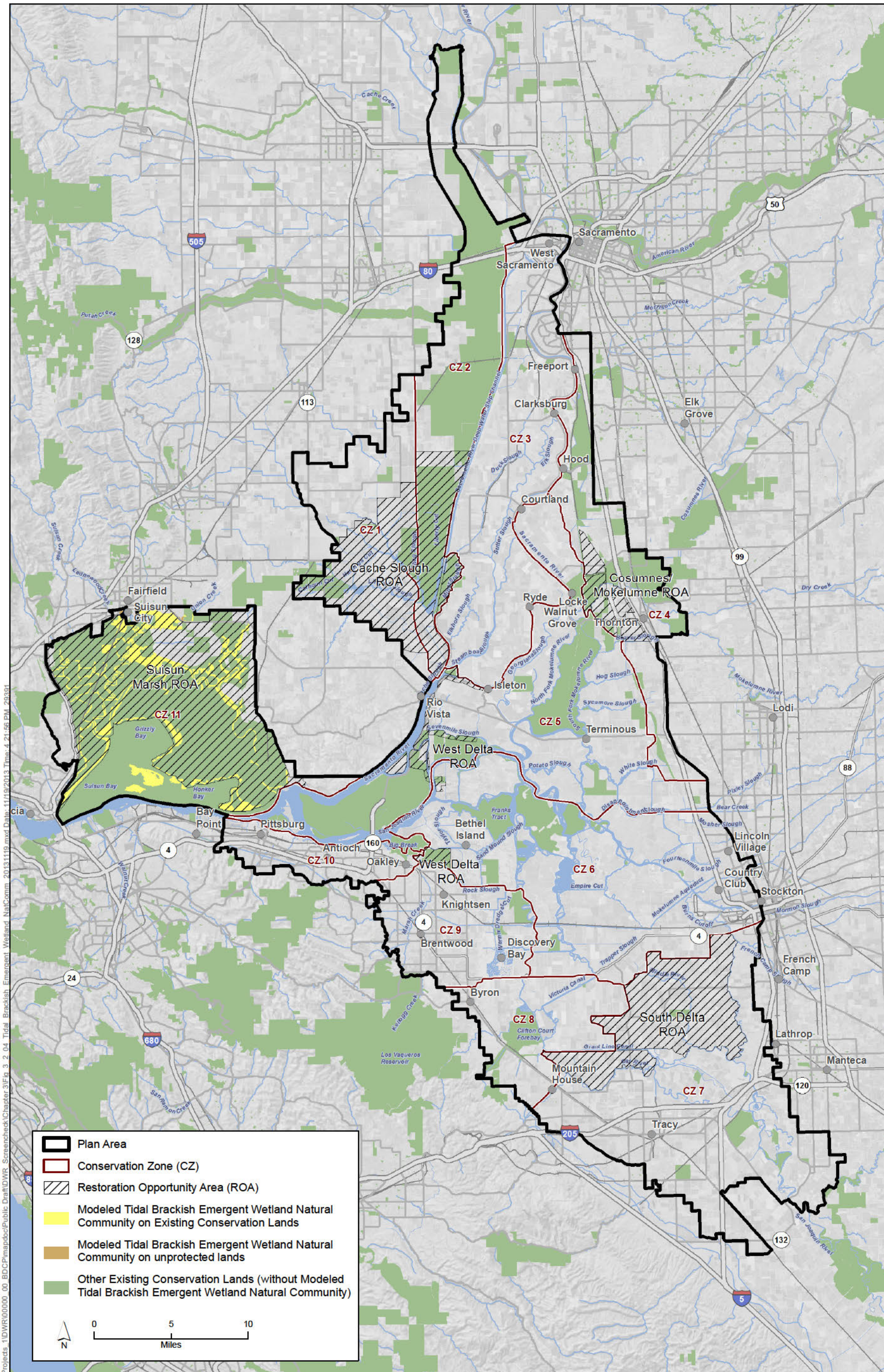


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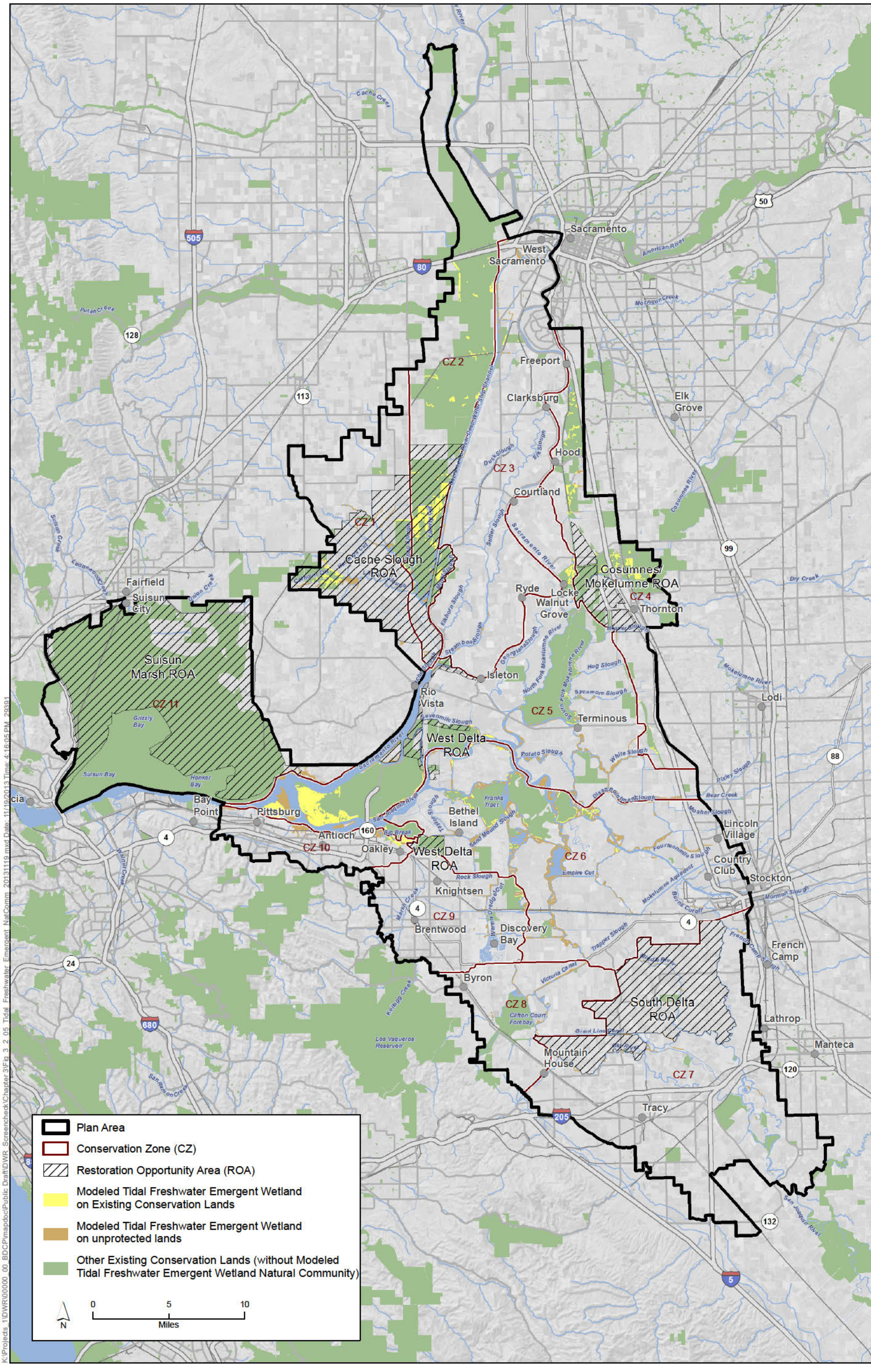
Figure 3.2-4
Tidal Brackish Emergent Wetland Natural Community



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GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-5
Tidal Freshwater Emergent Wetland Natural Community

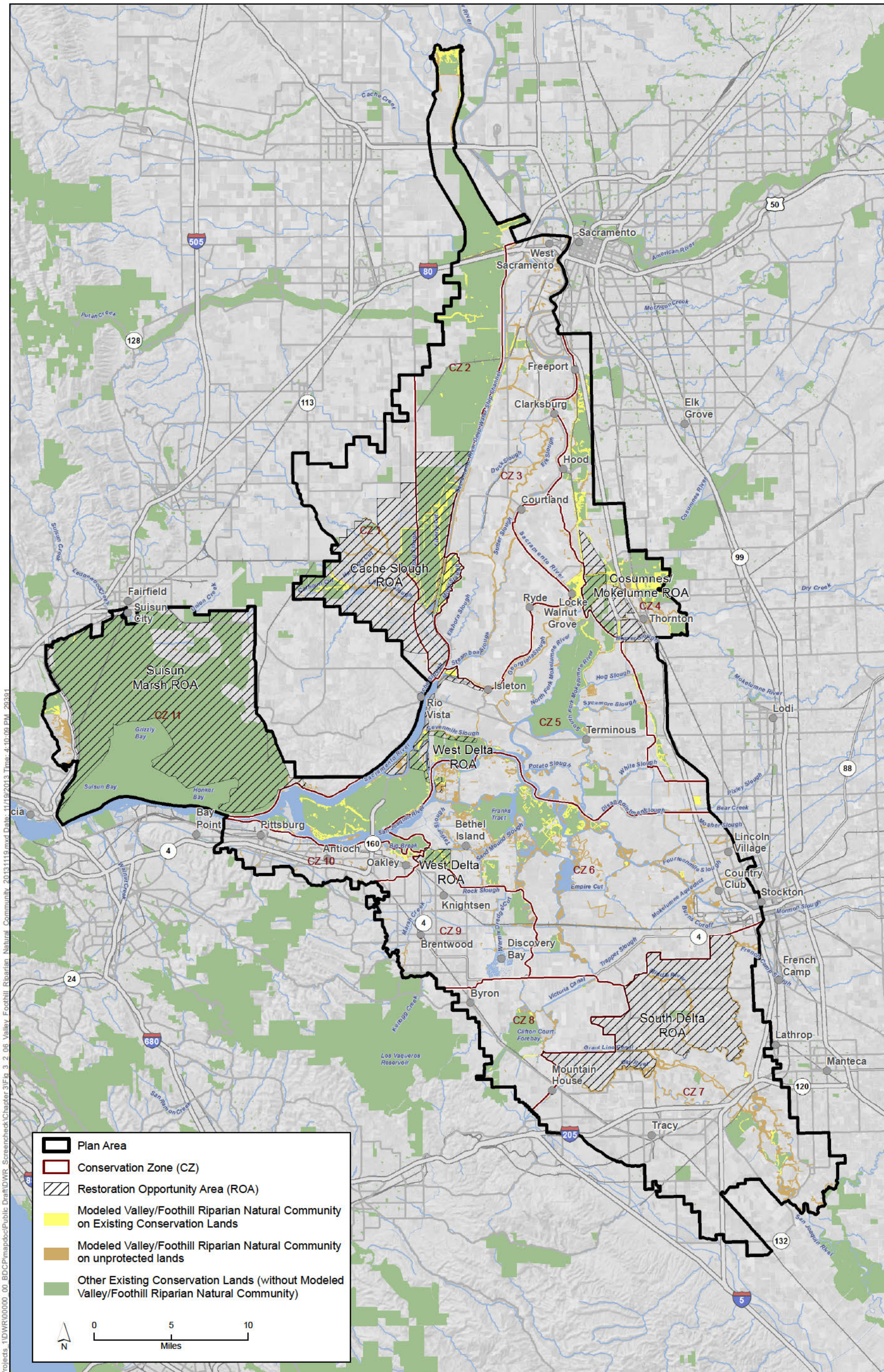

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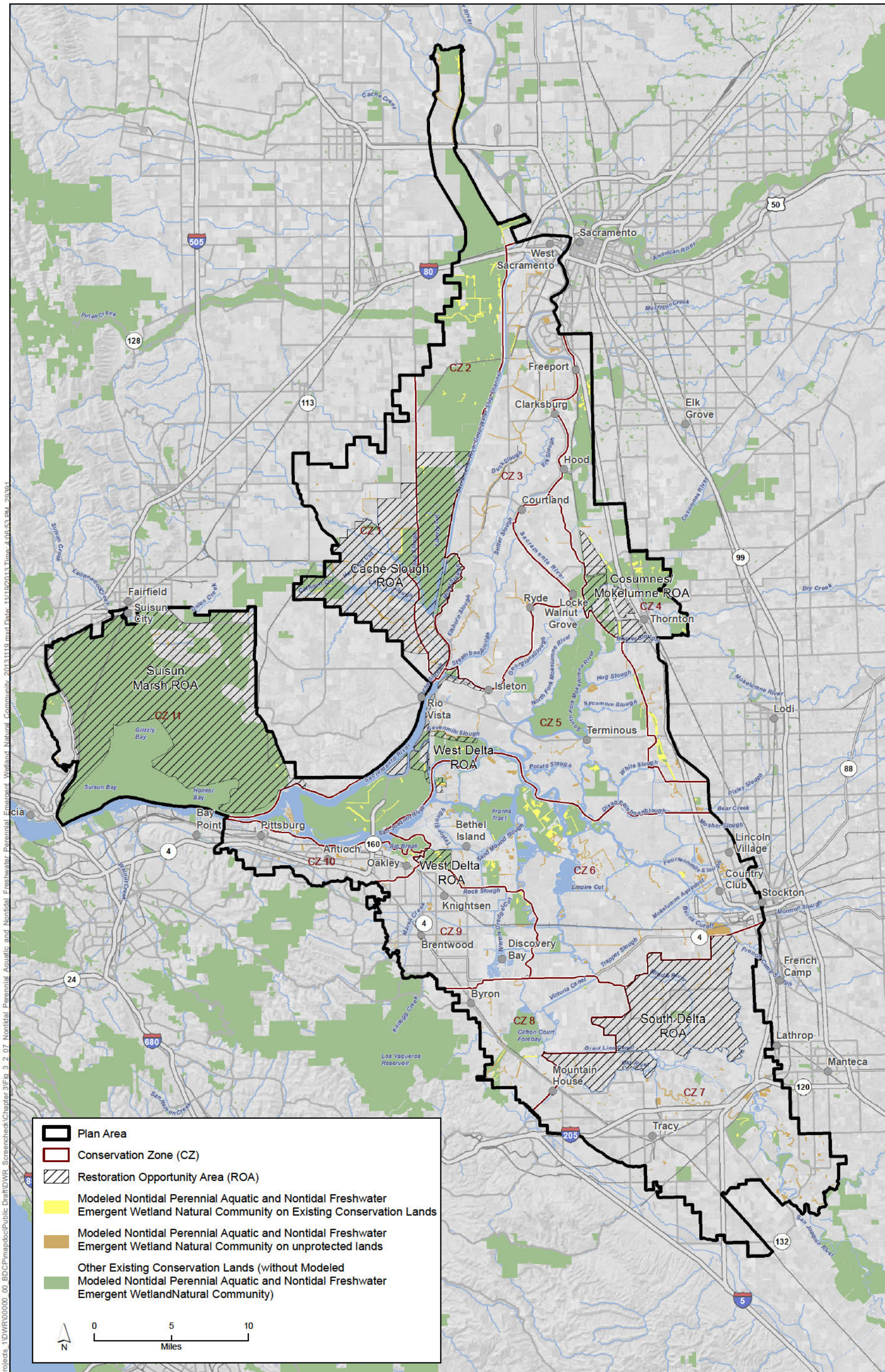
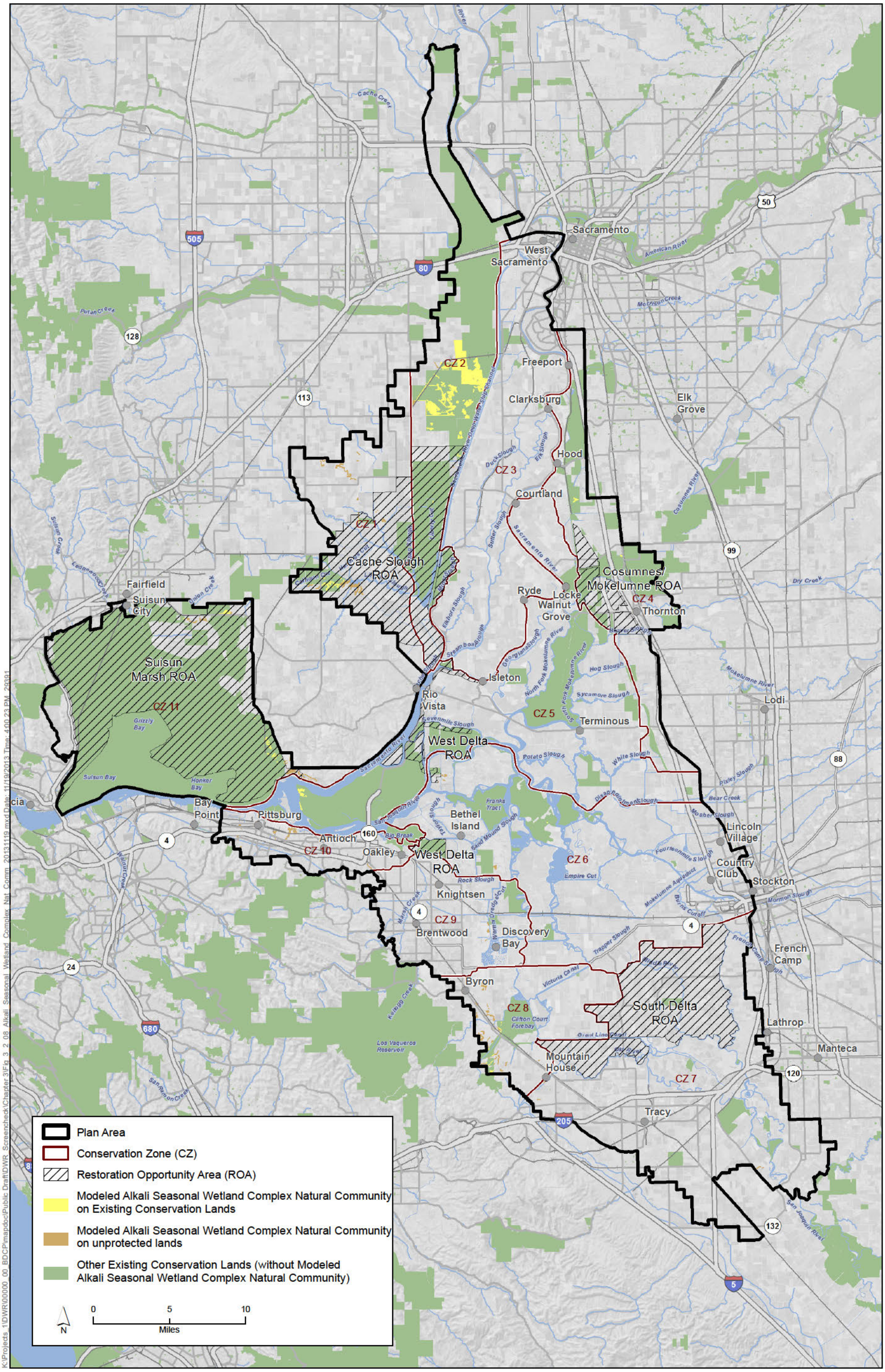
Figure 3.2-6
Valley/Foothill Riparian Natural Community



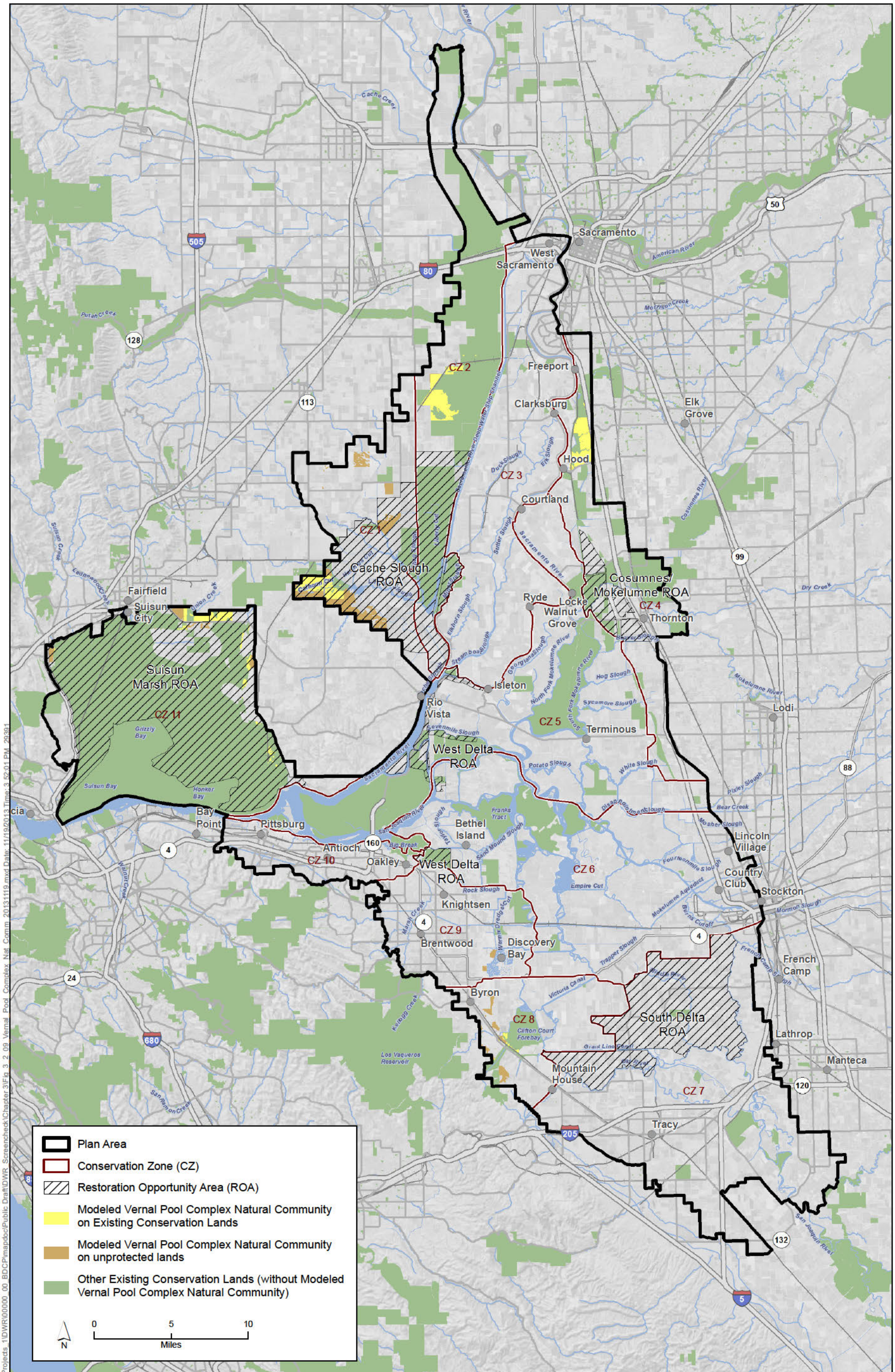
GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-7
Nontidal Perennial Aquatic and Nontidal Freshwater Perennial Emergent Wetland Natural Community



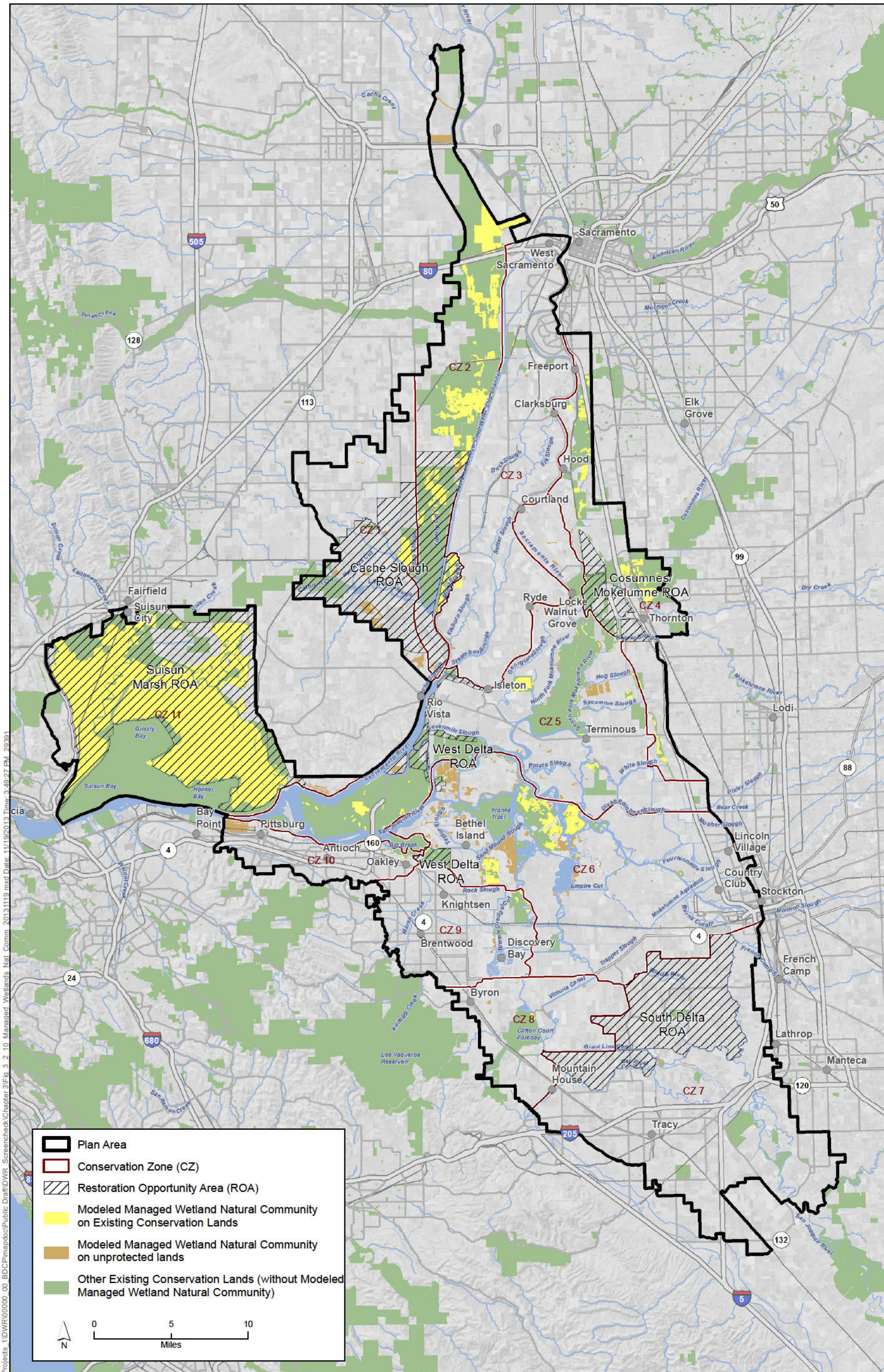
GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-8
Alkali Seasonal Wetland Complex Natural Community



GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-9
Vernal Pool Complex Natural Community



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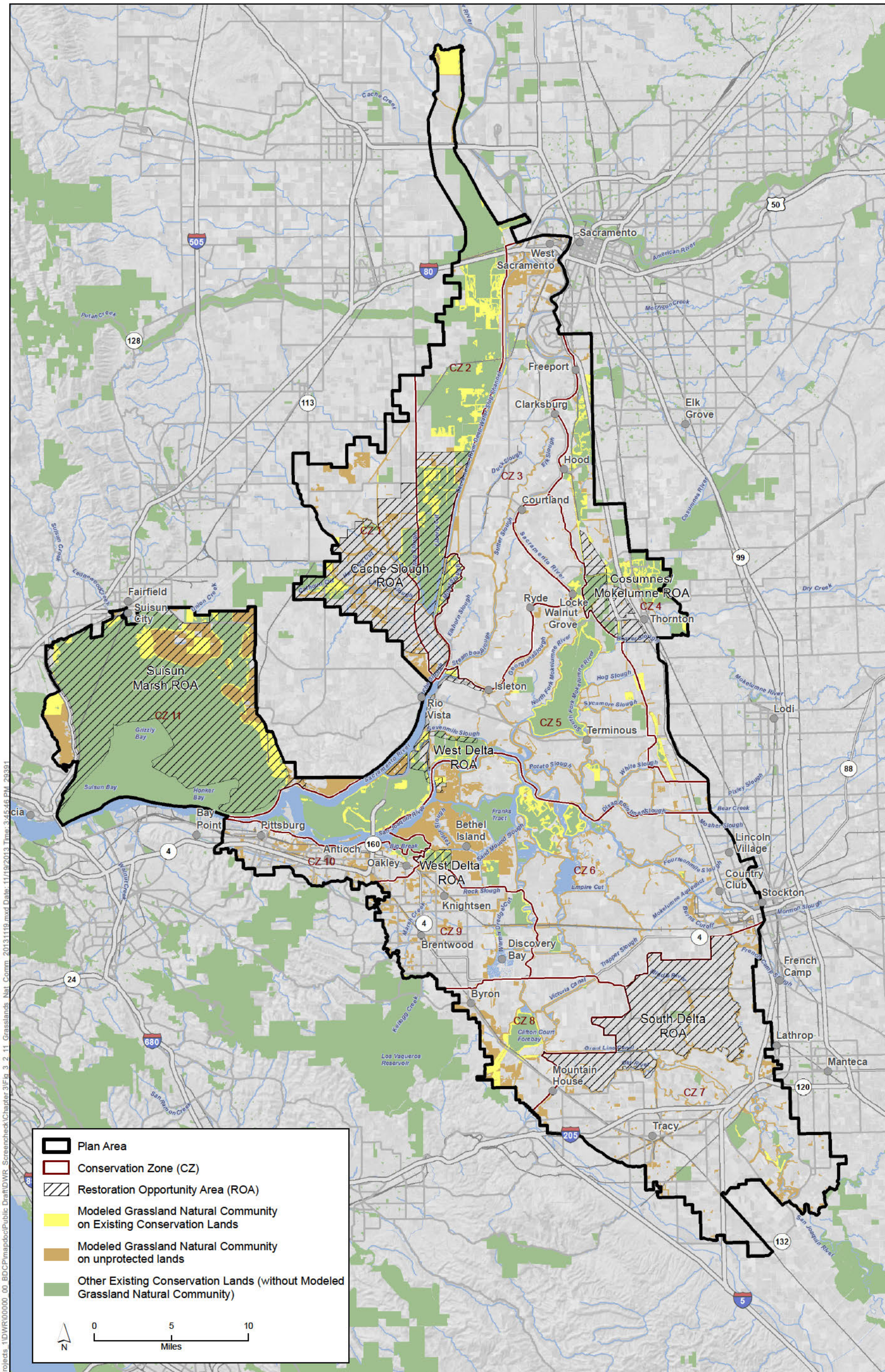
GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-10
Managed Wetland Natural Community



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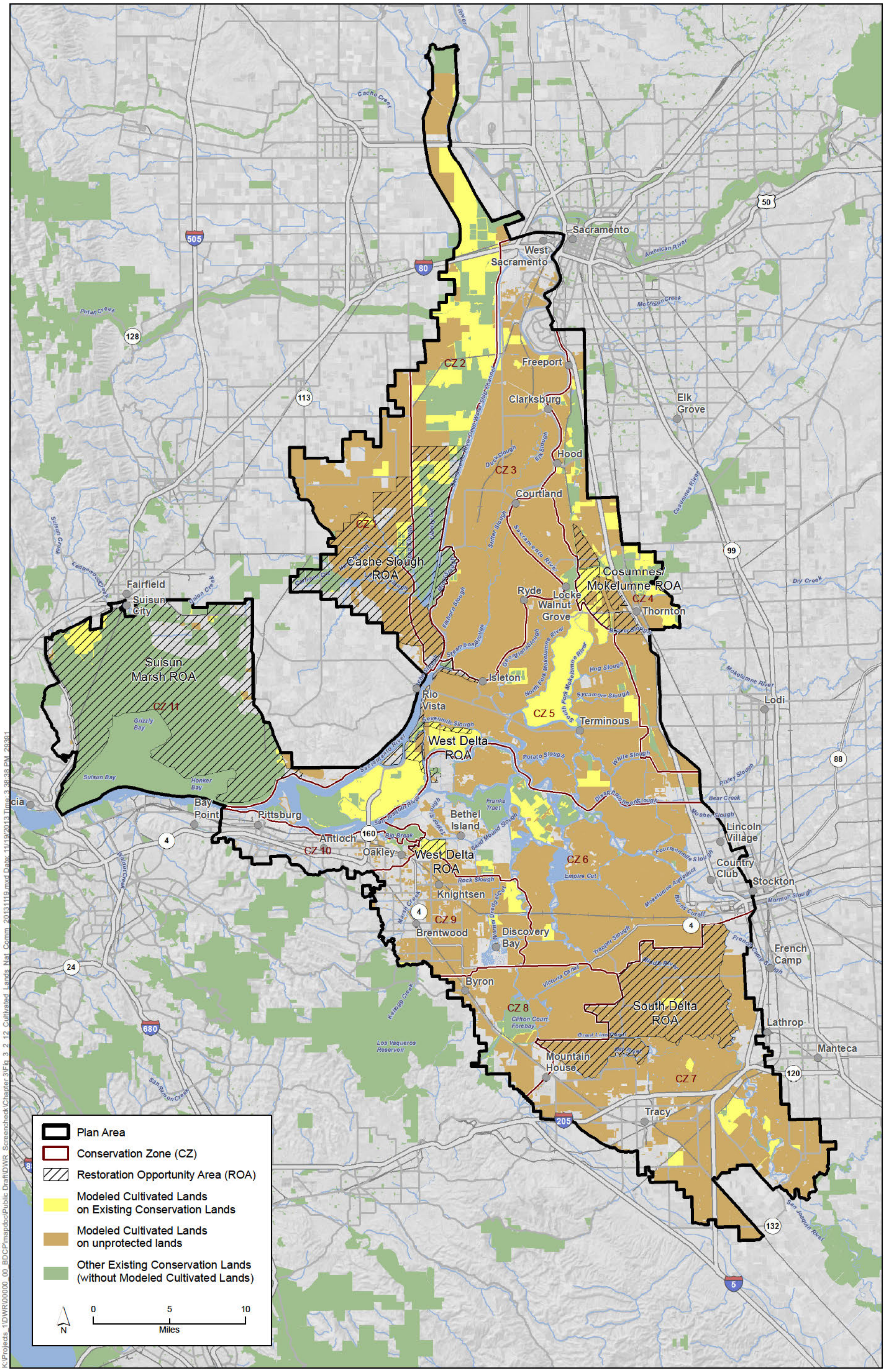
GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-11
Grassland Natural Community



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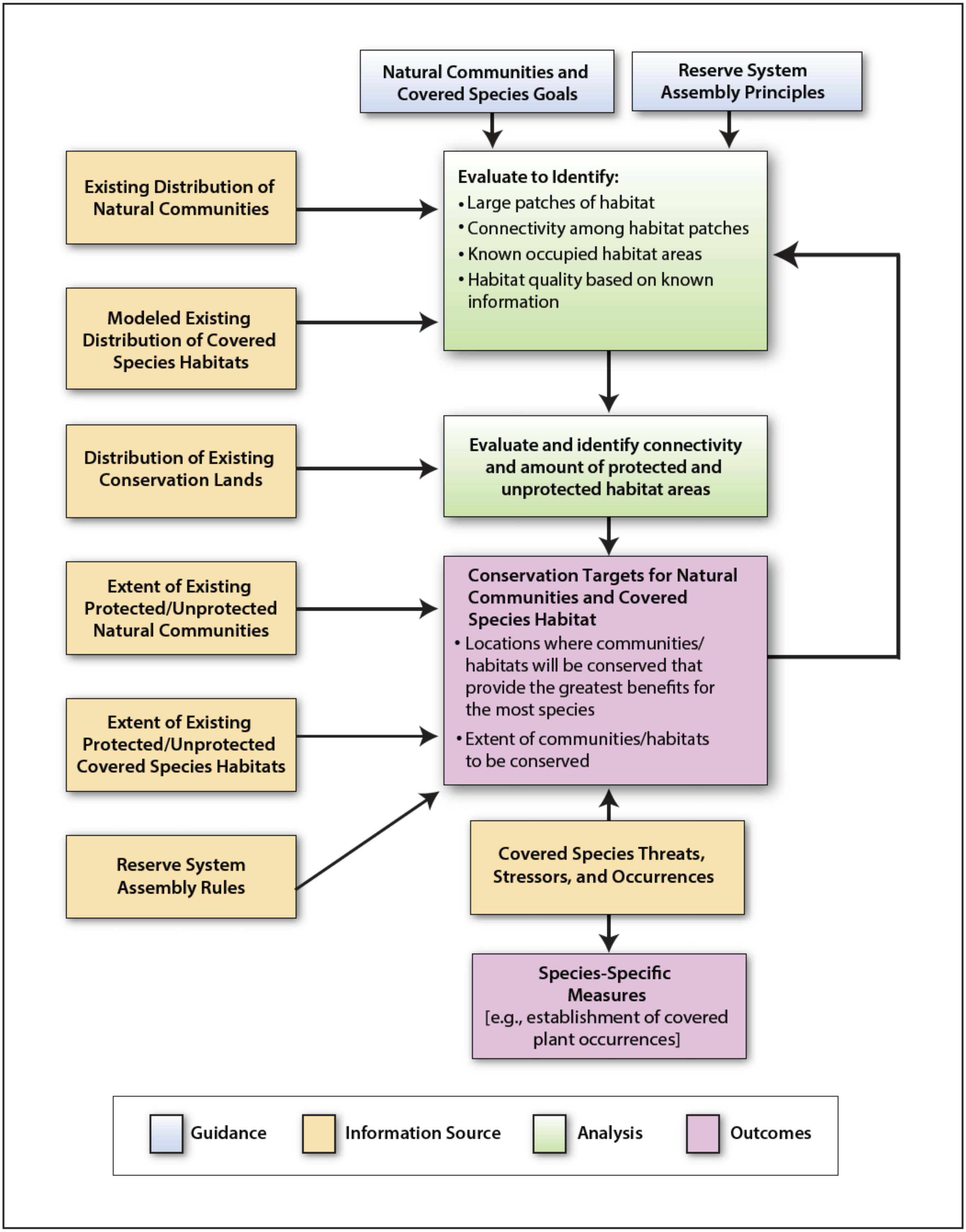
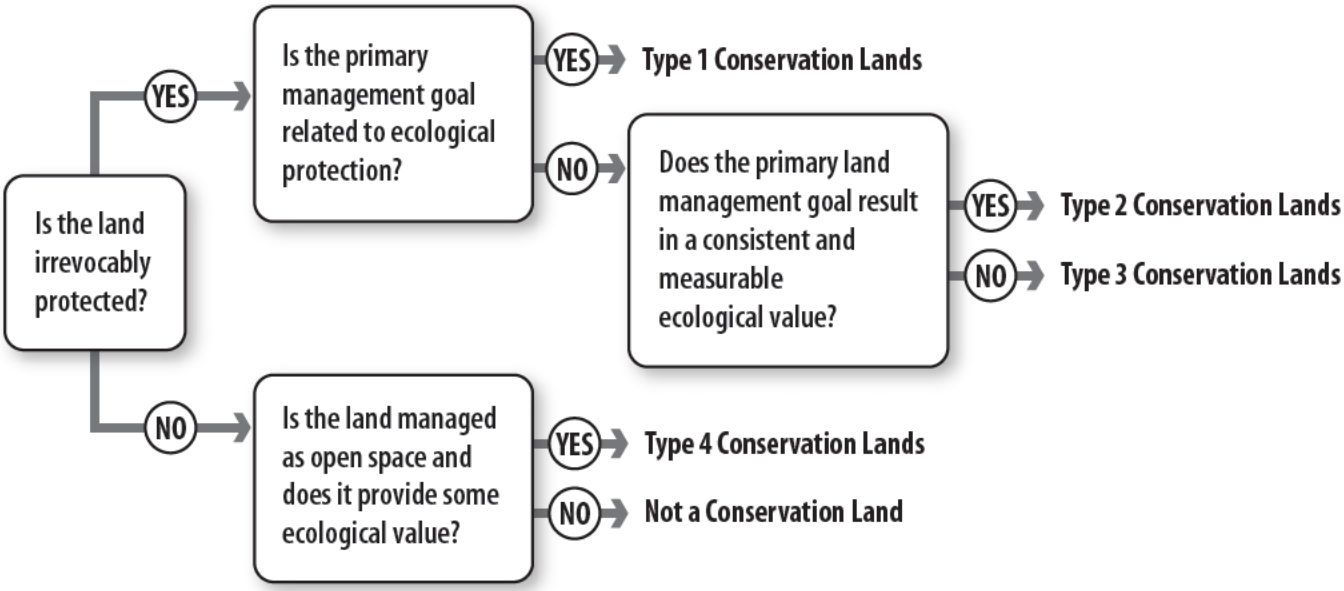
GIS Data Source: Conservation Zones, SAIC 2012; Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-12
Cultivated Lands



Graphics/...BDCP Other Chapters/SAIC Nov 2010 (created: 11/19/10) (Rev. 12-17-2012 TM)

Figure 3.2-13
Process for Establishing Conservation Targets for Natural Communities and Covered Species and Species-Specific Measures



Criteria

Type 1 Conservation Land

1) The primary management goal is related to ecological protection.
2) That protection is irrevocable through local, state or federal authority and there are legal assurances such as wilderness status or a conservation easement that the primary land use will never change.

Type 2 Conservation Land

1) The primary management goal is not ecological protection but the land is managed as open space and has a consistent and measurable ecological value [allows multiple species to complete some portion of their life cycle (e.g., reproduction, growth, foraging) or provides movement or migration opportunities].
2) Protection is irrevocable through local, state, or federal authority.

Type 3 Conservation Land

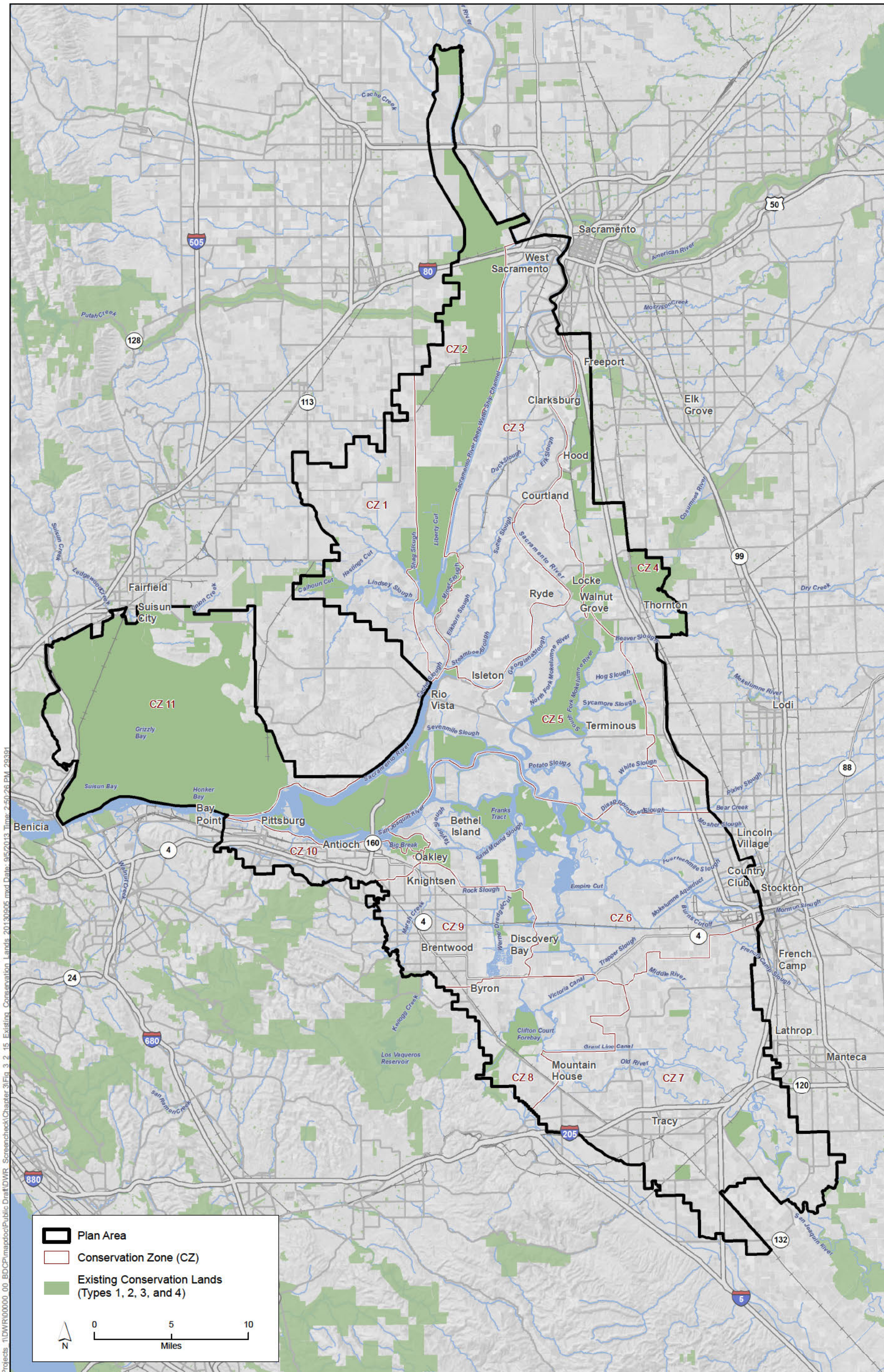
1) The land is undeveloped but current management goals do not promote any consistent or measurable ecological value.
2) Protection is irrevocable through local, state, or federal authority.

Type 4 Conservation Land

1) The land is managed as open space and has a consistent and measurable ecological value.
2) The land is not subject to irrevocable protection from a change in primary land use or protections are uncertain or political in nature.

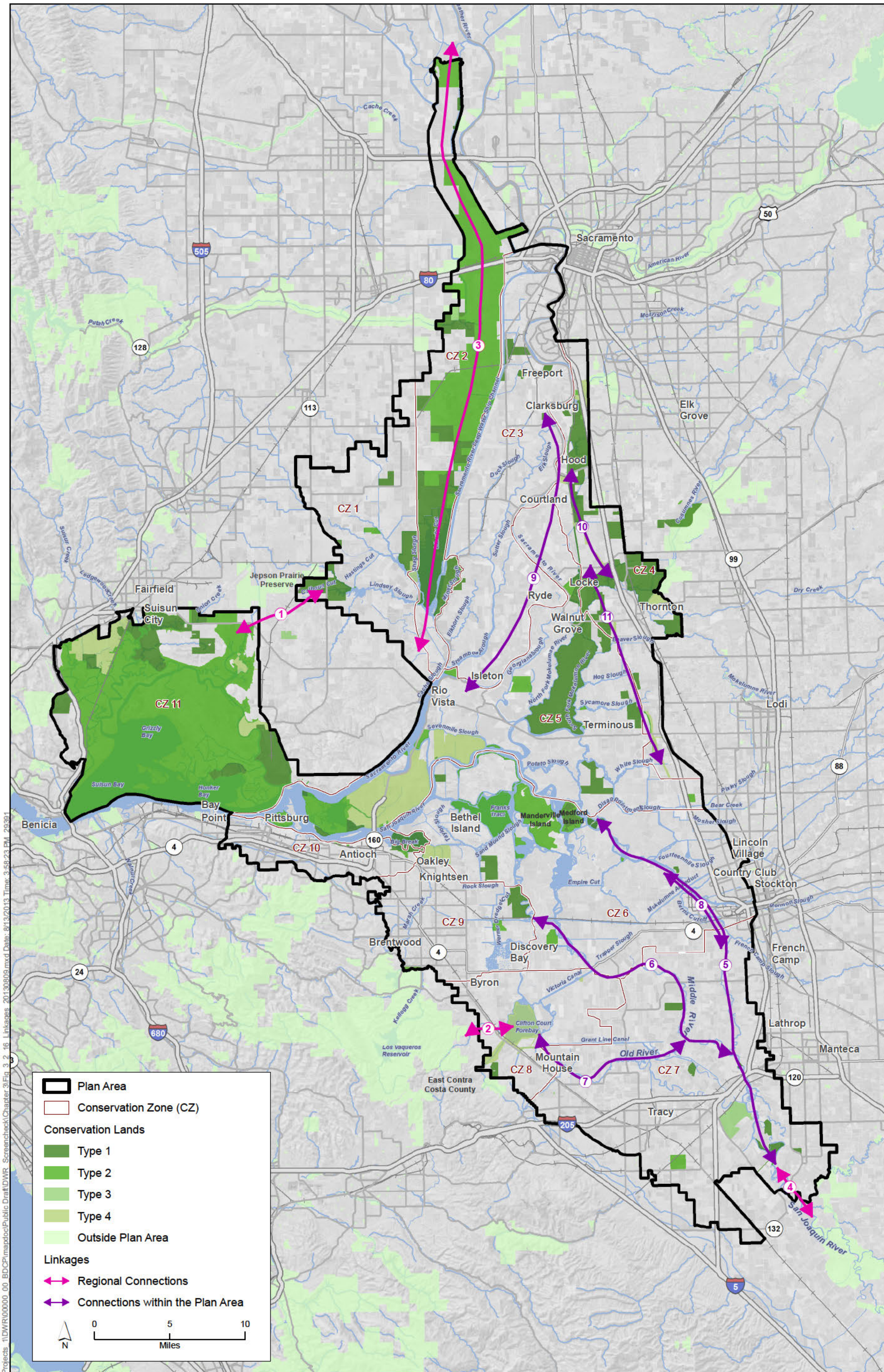
Graphics...00343.12 (7/25/13) AB

Figure 3.2-14
Decision Matrix



GIS Data Source: Conservation Zones, SAIC 2012;
Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-15
Existing Conservation Lands



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GIS Data Source: Conservation Zones, SAIC 2012
Existing Conservation Lands Outside Plan Area, CPAD 2013 and CDFG-WCB 2011.

Figure 3.2-16
Landscape Linkages

3.3 Biological Goals and Objectives

The purposes of the biological goals and objectives in the BDCP are described above in Section 3.1.1, *Biological Goals and Objectives*. As described there, the biological goals and objectives articulate the intended outcomes that will be achieved through the implementation of the Plan. Biological goals are broad statements of intention. Biological objectives are specific, measurable outcomes that are expected to be achieved by the Plan.

3.3.1 Role of the Biological Goals and Objectives in Plan Implementation

An important purpose of the biological goals and objectives during implementation is to serve as benchmarks by which to measure the Plan's progress across multiple temporal and spatial scales. The adaptive management and monitoring program, described in Section 3.6, *Adaptive Management and Monitoring Program*, is designed and will be implemented to measure this progress throughout Plan implementation. For example, Section 3.6.3, *Adaptive Management Process*, states that one purpose of BDCP monitoring and research actions is to document and evaluate the effectiveness of conservation measures in achieving biological goals and objectives.

In some cases, it will take many years to achieve biological goals and objectives. Because of the long time scale in which these goals and objectives will be achieved, the Implementation Office will be required to track the progress being made. Progress toward meeting the biological goals and objectives will be assessed throughout implementation and reported annually to the fish and wildlife agencies (USFWS, NMFS, and CDFW) and to the public (Section 6.3.3, *Annual Progress Report*). A comprehensive assessment will be conducted every 5 years (Section 6.3.5, *Five-Year Comprehensive Review*). An important purpose of the annual reporting and 5-year comprehensive reviews is to identify trends early in the Plan's ability to meet biological goals and objectives and to allow sufficient time for course corrections if needed.

As described in this chapter, the conservation measures were designed collectively to achieve the biological goals and objectives. However, during implementation it may become evident that insufficient progress is being made toward meeting certain biological objectives.

The conservation strategy has been designed to be sufficiently flexible to respond to signals of insufficient progress toward meeting biological objectives. The primary tool to ensure this flexibility is the adaptive management and monitoring program, described in Section 3.6. During implementation, conservation measures may be adjusted, as necessary, appropriate, and consistent with the best available science, and subject to certain guidelines and established limits through the adaptive management process, to advance progress toward achieving the biological goals and objectives. Biological goals and objectives may too be adjusted, consistent with the best available science, and subject to the guidelines, limits, and processes within the Plan described in Section 3.6 and Chapter 7, *Implementation Structure*.

A lack of sufficient progress by the Plan in achieving a biological objective will compel an adaptive change. Subject to certain guidelines and limits—described in *CM1 Water Facilities and Operation*, Section 3.4.23, *Resources to Support Adaptive Management*, Section 3.6, *Adaptive Management and Monitoring Program,* and Section 6.4, *Regulatory Assurances, Changed Circumstances, and Unforeseen*

Circumstances—such adaptive changes may result in a greater commitment of water, land, or money by the Permittees[4]. Failure to achieve a biological goal or objective will not be a basis for a determination by the fish and wildlife agencies of noncompliance or for the suspension or revocation of the permits as long as the Permittees are properly implementing the BDCP and in compliance with the Implementing Agreement and the permit terms and conditions.

The decision-making process for the adaptive management program is designed to foster collaboration between the Authorized Entities and the fish and wildlife agencies, and to provide a clear decision-making structure in the event of disagreement. This decision-making process is described in Section 3.6.2, *Structure of the Adaptive Management Program*. In instances where there is insufficient progress toward meeting a biological objective, two potential responses will be considered.

- A change in a conservation measure(s).
- A change in an objective(s).

Additional implementation actions may be employed consistent with the regulatory assurances provided under the federal No Surprises Rule and the NCCPA (Section 6.4.1, *Regulatory Assurances*).

The adaptive management process may also result in changes to biological objectives. New information may indicate that such a change is warranted based on monitoring data from relevant conservation measures or appropriate external data. Such information may indicate a different objective is more appropriate for the circumstances being addressed by the BDCP. Biological goals are unlikely to be modified. The process for modifying conservation measures and objectives is also described in Section 3.6, *Adaptive Management and Monitoring Program*, and Section 6.5.2, *Minor Modifications or Revisions*.

Upon issuance of the take permits, the legal obligation of the Permittees is to fully implement the Plan, which describes the biological goals and objectives, conservation measures, adaptive management and monitoring program, and remedial actions for changed circumstances should they occur. Therefore, the Permittees will satisfy their obligation to achieve the biological goals and objectives[5] through proper implementation of the Plan (including adaptive management changes developed through the adaptive management and decision-making processes described in Section 3.6, *Adaptive Management and Monitoring Program*, and Chapter 7, *Implementation Structure*), and compliance with the Implementing Agreement and the permit terms and conditions.

3.3.2 Development of the Biological Goals and Objectives

The biological goals were developed as broad statements of intention that the BDCP improves the ecosystem health of the Delta and provides for the conservation and management of the covered

[4] DWR and the participating state and federal water contractors.

[5] This approach is consistent with the USFWS/NMFS Five Point Policy, which states: "Whether the HCP is based on prescriptions, results, or both, the permittee's obligation for meeting the biological goals and objectives is proper implementation of the operating conservation program of the HCP. In other words, under the No Surprises assurances, a permittee is required only to implement the HCP, IA [Implementing Agreement], if used, and terms and conditions of the permit. Implementation may include provisions for ongoing changes in actions in order to achieve results or due to results from an adaptive management strategy."

species. Biological goals were often based on recovery goals for the covered species in cases where recovery plans have been developed.

Biological objectives are expressed as specific outcomes that are expected to be achieved by the Plan for ecosystems, natural communities, covered species or species' habitat, or stressor attributes. Biological objectives are "SMART"—specific, measurable, achievable, relevant, and time-bound—to the maximum extent possible. Where a high level of uncertainty is associated with the measurability or achievability of an objective, that uncertainty is explicitly acknowledged in the objective, its associated rationale, or in both locations.

The biological objectives are a mix of *prescription-based* and *result-based* objectives, consistent with the federal Five-Point Policy (65 *Federal Register* [FR] 106). Prescription-based objectives describe measurable actions that will be implemented with an assumed beneficial result for the target species. Examples include the permanent protection and management of specific amounts, types, and locations of terrestrial natural communities to conserve the covered terrestrial species. In contrast, results-based objectives describe a specific measurable result that will be achieved through one or more implementation actions. Examples include through-Delta survival targets for covered salmonids.

3.3.2.1 Process for Developing Terrestrial Species Biological Goals and Objectives

The biological goals and objectives for terrestrial species are mostly prescription-based. These objectives were developed through an iterative and collaborative process with the fish and wildlife agencies over several years. The goal of this process was to ensure that the biological objectives and their associated conservation measures, as a whole, meet the regulatory requirements of the ESA and NCCPA for each of the covered terrestrial species.

3.3.2.2 Process for Developing Fish Species Biological Goals and Objectives

Preliminary biological goals and objectives for covered fish species were developed in 2007. These goals and objectives were refined in 2010 in accordance with the Logic Chain approach through extensive Logic Chain workgroup meetings, two independent science review panel reviews and a two-day workshop in October 2010 (Dahm et al. 2010). An incomplete set of revised draft biological goals and objectives reflecting this work was presented in the November 18, 2010, BDCP Working Draft. In April 2011, a group of independent science advisors was convened to help in completing goals and objectives for covered fish species. The independent science advisors presented their findings and recommendations for the development of goals and objectives for covered fish species. The advisors produced draft recommendations for three species (Sacramento splittail, winter-run Chinook salmon, and delta smelt) in June 2011 (Anderson et al. 2011). Based on the science advisor's recommendations, refined goals and objectives were then developed for all 11 covered fish species, in a process further informed by discussions with the science advisors and a working group meeting in October 2011. Thereafter, the goals and objectives were continually reviewed and revised through a collaborative process that included DWR, its consultants, representatives of each of the fish and wildlife agencies, and representatives of various interested nongovernmental organizations. This process concluded in late 2012 with adoption of the biological goals and objectives for covered fishes as presented in this chapter.

Some of the targets in the biological objectives for covered fish are expressed as a population metric such as species growth or survival. This approach was used because it was recommended by the science advisors, is consistent with the criteria listed above, and addresses important uncertainties related to the efficacy of the conservation measures for the covered fish. Biological objectives with specific population metrics risk being infeasible if the metric cannot be measured accurately, the target cannot be achieved by the Plan, or the target cannot be reached due to factors beyond the control of the Plan. These objectives were developed to minimize these risks and to meet the regulatory requirements of the ESA and NCCPA for each covered fish. See Section 5.2, *Methods*, for a description of the process used to quantitatively evaluate whether the Plan will be able to meet each biological objective for covered fish.

The biological goals and objectives developed for the BDCP are intended to provide for the conservation and management of the covered fishes in the Plan Area. Recovery of the species throughout their ranges will generally be measured by the fish and wildlife agencies via their broader "global recovery goals and objectives," which are independent of BDCP. The global recovery goals and objectives presented for each of the covered fishes have not been formally adopted, and do not represent official agency recovery goals and objectives. They were developed as part of work group discussions involving the fish and wildlife agencies and BDCP consultant staff to provide a broader recovery context for regional conservation planning efforts. Agency recovery plans provide this context but, in some cases, do not reflect the current state of knowledge regarding the needs of the covered fishes and the threshold for recovery of each of the covered fish species. As such, the global goals and objectives provide interim recovery guidance. The biological goals and objectives are intended to contribute toward the achievement of the global goals and objectives.

3.3.3 Structure of the Biological Goals and Objectives

Section 3.3.4, *Goal and Objective Statements,* below, lists all of the biological goals and objectives. The biological goals and objectives are organized hierarchically on the basis of the following ecological scale.

- **Landscape.** The landscape-scale biological goals and objectives focus on the extent, distribution, and connectivity among natural communities and improvements to the overall condition of hydrological, physical, chemical, and biological processes in the Plan Area in support of achieving natural community and species-specific biological goals and objectives.
- **Natural community.** Natural Community biological goals and objectives focus on maintaining or enhancing ecological functions and values of specific natural communities. Achieving natural community goals and objectives will also conserve the habitat of associated covered species and other native species.
- **Species.** Species biological goals and objectives address stressors and habitat needs specific to individual species (or, in some cases, groups of species with similar needs) that are not addressed under the landscape and natural community goals and objectives.

Section 3.3.5, *Landscape-Scale Biological Goals and Objectives*, lists the landscape-scale goals and objectives and describes the rationale for each. Section 3.3.6, *Natural Community Biological Goals and Objectives*, addresses the conservation strategy for natural communities using a nested approach. For each natural community, the landscape-scale goals and objectives that would benefit that community's conservation strategy are listed with a description of the benefit each provides. Next the goals and objectives developed specifically for that natural community are listed with their associated rationale. Section 3.3.7, *Species Biological Goals and Objectives*, uses the same nested approach for covered species: for each species, the landscape-scale and natural community goals and objectives that would benefit that species are described along with their benefits, followed by goals and objectives developed for that species and their associated rationale. For the most part, the conservation strategies for covered species are addressed through goals and objectives at the landscape and natural community levels. Species-specific goals and objectives were only developed when additional factors, such as specific habitat requirements or population factors, needed to be addressed to provide for the conservation and management of the species in the Plan Area.

3.3.4 Goal and Objective Statements

The biological goals and objectives are listed in Table 3.3-1 at the landscape, natural community, and species levels. Each biological objective will be met through implementation of one or more conservation measures, which are also listed in Table 3.3-1.

In all, the conservation strategy includes the following biological goals and objectives.

- Four landscape-scale goals with 27 landscape-scale objectives.
- Eighteen natural community goals with 47 natural community objectives.
- Forty-five species goals with 91 species objectives.

1 **Table 3.3-1. Conservation Strategy Goals and Objectives with Associated Conservation Measures**

Goals and Objectives	Applicable Conservation Measures
Landscape-Scale Goals and Objectives	
Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.	
Objective L1.1: Protect or restore 142,200 acres of high-value natural communities and covered species habitats.[6]	CM3 Natural Communities Protection and Restoration
Objective L1.2: Protect sufficient lands for the restoration of natural communities as described in Objective L1.1.	CM3 Natural Communities Protection and Restoration
Objective L1.3: Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.	CM2 Yolo Bypass Fisheries Enhancement CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration
Objective L1.4: Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.	CM2 Yolo Bypass Fisheries Enhancement CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration CM13 Invasive Aquatic Vegetation Control
Objective L1.5: In restored floodplains, provide a range of elevations that transition from frequently flooded (e.g., every 1 to 2 years) to infrequently flooded (e.g., every 10 years or more) areas to provide a range of habitat conditions, upland habitat values, and refugia from flooding during most flood events.	CM3 Natural Communities Protection and Restoration CM5 Seasonally Inundated Floodplain Restoration CM8 Grassland Natural Community Restoration
Objective L1.6: Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.	CM3 Natural Communities Protection and Restoration
Objective L1.7: Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration CM8 Grassland Natural Community Restoration
Objective L1.8: To accommodate sea level rise, provide potential tidal marsh plain within the anticipated future eastward position of the low-salinity zone of the estuary.	CM4 Tidal Natural Communities Restoration

[6] See Table 3.3-2 for a breakdown of the natural community and species habitat acreages to be protected and restored.

Goals and Objectives	Applicable Conservation Measures
Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.	
Objective L2.1: Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances.	CM3 Natural Communities Protection and Restoration CM5 Seasonally Inundated Floodplain Restoration CM11 Natural Communities Enhancement and Management
Objective L2.2: Allow lateral river channel migration.	CM3 Natural Communities Protection and Restoration CM5 Seasonally Inundated Floodplain Restoration
Objective L2.3: Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers.	CM3 Natural Communities Protection and Restoration CM5 Seasonally Inundated Floodplain Restoration CM7 Riparian Natural Community Restoration
Objective L2.4: Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system.	CM4 Tidal Natural Communities Restoration CM12 Methylmercury Management CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM19 Urban Stormwater Treatment
Objective L2.5: Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement
Objective L2.6: Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.	CM11 Natural Communities Enhancement and Management CM13 Invasive Aquatic Vegetation Control CM20 Recreational Users Invasive Species Program
Objective L2.7: Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.	CM4 Tidal Natural Communities Restoration
Objective L2.8: Provide refuge habitat for migrating and resident covered fish species.	CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM15 Localized Reduction of Predatory Fishes

Goals and Objectives	Applicable Conservation Measures
Objective L2.9: Increase the abundance and productivity of plankton and invertebrate species that provide food for covered fish species in the Delta waterways.	CM2 Yolo Bypass Fisheries Enhancements CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM7 Riparian Natural Community Restoration CM13 Invasive Aquatic Vegetation Control CM21 Nonproject Diversions
Objective L2.10: Restore or create 20 linear miles of transitional intertidal areas including tidal mudflat natural community and patches of subtidal and lower marsh.	CM4 Tidal Natural Communities Restoration
Objective L2.11: Restore 10,000 acres of seasonally inundated floodplain.	CM5 Seasonally Inundated Floodplain Restoration
Objective L2.12: Enhance 20 miles of channel margin in the Sacramento River and San Joaquin River systems to provide habitat along important migratory routes for anadromous fish and improve wildlife movement.	CM6 Channel Margin Enhancement
Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.	
Objective L3.1: Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM7 Riparian Natural Community Restoration CM8 Grassland Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective L3.2: Promote connectivity between low-salinity zone habitats and upstream freshwater habitats and availability of spawning habitats for native pelagic fish species.	CM1 Water Facilities and Operation CM4 Tidal Natural Communities Restoration
Objective L3.3: Provide flows that support the movement of juvenile life stages of native fish species to downstream rearing habitats.	CM1 Water Facilities and Operation
Objective L3.4: Provide flows that support the movement of adult life stages of native fish species to natal spawning habitats.	CM1 Water Facilities and Operation
Goal L4: Increased habitat suitability for covered fish species in the Plan Area.	
Objective L4.1: Manage the distribution and abundance of nonnative predators in the Delta to reduce predation on covered fishes.	CM6 Channel Margin Enhancement CM13 Invasive Aquatic Vegetation Control CM15 Localized Reduction of Predatory Fishes

Goals and Objectives	Applicable Conservation Measures
Objective L4.2: Manage the distribution of covered fish species to minimize movements into areas of high predation risk in the Delta.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM16 Nonphysical Fish Barriers CM15 Localized Reduction of Predatory Fishes
Objective L4.3: Reduce entrainment losses of covered fish species.	CM1 Water Facilities and Operation CM21 Nonproject Diversions
Natural Community Goals and Objectives	
Tidal Perennial Aquatic	
Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.	
Objective TPANC1.1: Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration
Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.	
Objective TPANC2.1: Control invasive aquatic vegetation that adversely affects native fish habitat.	CM13 Invasive Aquatic Vegetation Control CM20 Recreational Users Invasive Species Program
Tidal Mudflat	
No natural community goals and objectives specific to this natural community.	
Tidal Brackish Emergent Wetland	
Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.	
Objective TBEWNC1.1: Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*[7].	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration

[7] While the conservation strategy is based on the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U.S. Fish and Wildlife Service 2010), Objective TBEWNC1.1 will restore wetlands consistent with the final version of the plan.

Goals and Objectives	Applicable Conservation Measures
Objective TBEWNC1.2: Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*[8]. Restore the at least 1,500 acres of middle and high marsh by year 25.	CM4 Tidal Natural Communities Restoration
Objective TBEWNC1.3: Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them.	CM4 Tidal Natural Communities Restoration
Objective TBEWNC1.4: Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.	CM4 Tidal Natural Communities Restoration
Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.	
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.	CM11 Natural Communities Enhancement and Management
Tidal Freshwater Emergent Wetland	
Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.	
Objective TFEWNC1.1: Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration
Objective TFEWNC1.2: Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration
Goal TFEWNC2: Biologically diverse tidal freshwater emergent wetland that is enhanced for native species and sustained by natural ecological processes and functions.	
Objective TFEWNC2.1: Restore and sustain a diversity of marsh vegetation that reflects historical species compositions and high structural complexity.	CM4 Tidal Natural Communities Restoration CM11 Natural Communities Enhancement and Management

[8] While the conservation strategy is based on the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U.S. Fish and Wildlife Service 2010), Objective TBEWNC1.2 will distribute middle and high marsh as specified in the final version of the plan.

Goals and Objectives	Applicable Conservation Measures
Objective TFEWNC2.2: Create topographic heterogeneity in restored tidal freshwater emergent wetland to provide variation in inundation characteristics and vegetative composition.	CM4 Tidal Natural Communities Restoration CM11 Natural Communities Enhancement and Management
Valley/Foothill Riparian	
Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian natural community, with locations informed by both existing and historical distribution.	
Objective VFRNC1.1: Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration
Objective VFRNC1.2: Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.	CM3 Natural Communities Protection and Restoration
Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.	
Objective VFRNC2.1: Restore, maintain, and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands.	CM5 Seasonally Inundated Floodplain Restoration CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective VFRNC2.2: Maintain 1,000 acres of early- to midsuccessional vegetation with a well-developed understory of dense shrubs on restored seasonally inundated floodplain.	CM5 Seasonally Inundated Floodplain Restoration CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective VFRNC2.3: Maintain at least 500 acres of mature riparian forest in Conservation Zones 4 or 7.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective VFRNC2.4: Maintain the at least 500 acres of mature riparian forest (VFRNC2.3) intermixed with a portion of the early- to midsuccessional riparian vegetation (VFRNC2.2) in large blocks with a minimum patch size of 50 acres and minimum width of 330 feet.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Goal VFRNC3: Maintenance or increase of native biodiversity that is characteristic of the valley/foothill riparian natural community.	
Objective VFRNC3.1: Maintain or increase abundance and distribution of valley/foothill riparian natural community vegetation alliances that are rare or uncommon as recognized by California Department of Fish and Game (2010), such as *Cephalanthus occidentalis* (button willow thickets) alliance and *Sambucus nigra* (blue elderberry stands) alliance.	CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management

Goals and Objectives	Applicable Conservation Measures
Nontidal Freshwater Perennial Emergent Wetland and Nontidal Perennial Aquatic	
Goal NFEW/NPANC1: Nontidal marsh consisting of a mosaic of nontidal freshwater emergent perennial wetland and nontidal perennial aquatic natural communities, and providing habitat for covered and other native species.	
Objective NFEW/NPANC1.1: Create 1,200 acres of nontidal marsh consisting of a mosaic of nontidal perennial aquatic and nontidal freshwater emergent wetland natural communities, with suitable habitat characteristics for giant garter snake and western pond turtle.	CM3 Natural Communities Protection and Restoration CM10 Nontidal Marsh Restoration
Alkali Seasonal Wetland Complex	
Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.	
Objective ASWNC1.1: Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.	CM3 Natural Communities Protection and Restoration
Objective ASWNC1.2: Restore or create alkali seasonal wetlands in Conservation Zones 1, 8, and/or 11 to achieve no net loss of wetted acres (up to 72 acres of alkali seasonal wetland complex restoration, assuming all anticipated impacts occur).	CM3 Natural Communities Protection and Restoration CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration
Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.	
Objective ASWNC2.1: Provide appropriate seasonal flooding characteristics for supporting and sustaining alkali seasonal wetland species.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Objective ASWNC2.2: In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs.	CM11 Natural Communities Enhancement and Management
Objective ASWNC2.3: In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase burrow availability for burrow-dependent species.	CM11 Natural Communities Enhancement and Management
Objective ASWNC2.4: In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase prey abundance and accessibility, especially small mammals and insects, for grassland-foraging species.	CM11 Natural Communities Enhancement and Management
Vernal Pool Complex	
Goal VPNC1: Vernal pool complexes composed of large, interconnected, or contiguous expanses that represent a range of environmental conditions.	
Objective VPNC1.1: Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005).	CM3 Natural Communities Protection and Restoration

Goals and Objectives	Applicable Conservation Measures
Objective VPNC1.2: Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools).	CM3 Natural Communities Protection and Restoration CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration
Objective VPNC1.3: Increase the size and connectivity of protected vernal pool complex in the Plan Area and increase connectivity with protected vernal pool complex adjacent to the Plan Area.	CM3 Natural Communities Protection and Restoration CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration
Objective VPNC1.4: Protect the range of inundation characteristics that are currently represented by vernal pools throughout the Plan Area.	CM3 Natural Communities Protection and Restoration
Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.	
Objective VPNC2.1: Maintain or enhance vernal pool complexes to provide the appropriate inundation (ponding) characteristics for supporting and sustaining vernal pool species.	CM11 Natural Communities Enhancement and Management
Objective VPNC2.2: Maintain and enhance pollination service in the vernal pool complex, especially by native invertebrates including native solitary bees.	CM11 Natural Communities Enhancement and Management
Objective VPNC2.3: In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs.	CM11 Natural Communities Enhancement and Management
Objective VPNC2.4: In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase burrow availability for burrow-dependent species.	CM11 Natural Communities Enhancement and Management
Objective VPNC2.5: In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase prey abundance and accessibility, especially small mammals and insects, for grassland-foraging species.	CM11 Natural Communities Enhancement and Restoration
Managed Wetland	
Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species and native biodiversity.	
Objective MWNC1.1: Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Other Natural Seasonal Wetland	
No natural community biological goals or objectives.	

Goals and Objectives	Applicable Conservation Measures
Grassland	
Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.	
Objective GNC1.1: Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11.	CM3 Natural Communities Protection and Restoration
Objective GNC1.2: Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian, tidal, and nontidal natural communities for wildlife foraging and upland refugia.	CM3 Natural Communities Protection and Restoration CM8 Grassland Natural Community Restoration
Objective GNC1.3: Protect stock ponds and other aquatic features within protected grasslands to provide aquatic breeding habitat for native amphibians and aquatic reptiles.	CM3 Natural Communities Protection and Restoration
Objective GNC1.4: Of the 8,000 acres of grassland protected under Objective GNC1.1 and 2,000 acres of grassland restored under Objective GNC1.2, protect or restore grasslands adjacent to restored tidal brackish emergent wetlands to provide at least 200 feet of adjacent grasslands beyond the sea level rise accommodation.	CM3 Natural Communities Protection and Restoration CM8 Grassland Natural Community Restoration
Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.	
Objective GNC2.1: Restore and sustain a mosaic of grassland vegetation alliances, reflecting localized water availability, soil chemistry, soil texture, topography, and disturbance regimes, with consideration of historical states.	CM8 Grassland Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective GNC2.2: Increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs.	CM8 Grassland Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective GNC2.3: Increase burrow availability for burrow-dependent species.	CM11 Natural Communities Enhancement and Management
Objective GNC2.4: Increase prey abundance and accessibility, especially of small mammals and insects, for grassland-foraging species.	CM11 Natural Communities Enhancement and Restoration
Objective GNC2.5: Maintain and enhance aquatic features in grasslands to provide suitable inundation depth and duration and suitable composition of vegetative cover to support breeding for covered amphibian and aquatic reptile species.	CM11 Natural Communities Enhancement and Restoration
Inland Dune Scrub	
No natural community biological goals or objectives.	

Goals and Objectives	Applicable Conservation Measures
Cultivated Lands	
Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.	
Objective CLNC1.1: Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Objective CLNC1.2: Target cultivated land conservation to provide connectivity between other conservation lands.	CM3 Natural Communities Protection and Restoration
Objective CLNC1.3: Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Species-Specific Goals and Objectives	
Delta Smelt	
Goal DTSM1: Increased end of year fecundity and improved survival of adult and juvenile delta smelt to support increased abundance and long-term population viability.	
Objective DTSM1.1: Increase fecundity of delta smelt over baseline conditions as measured through field investigations and laboratory studies conducted through year 10 and refined through adaptive management.	CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM12 Methylmercury Management CM13 Invasive Aquatic Vegetation Control CM15 Localized Reduction of Predatory Fishes CM19 Urban Stormwater Treatment
Objective DTSM1.2: Limit entrainment mortality associated with operations of water facilities in the south Delta to ≤5% of the delta smelt population, calculated as a 5-year running average of entrainment for subadults and adults in the fall and winter and their progeny in the spring and summer. Assure that the proportional entrainment risk is evenly distributed over the adult migration and larval-juvenile rearing time-periods.	CM1 Water Facilities and Operation

Goals and Objectives	Applicable Conservation Measures
Objective DTSM1.3: Achieve a Recovery Index ≥239 for delta smelt for at least 2 years of any consecutive 5-year period; measured from initial operations through the end of the permit term, the midpoint of any two consecutive Recovery Index values cannot be lower than 84.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM12 Methylmercury Management CM13 Invasive Aquatic Vegetation Control CM15 Localized Reduction of Predatory Fishes CM18 Conservation Hatcheries CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Goal DTSM2: Increased quality and availability of habitat for all life stages of delta smelt and increased availability of high-quality food for delta smelt. The habitat objective can be met through a combination of Delta outflow and/or physical habitat restoration suitable for delta smelt.	
Objective DTSM2.1: Increase the extent of suitable habitat, as defined by flow, salinity, temperature, turbidity, food availability and presence of delta smelt, to provide for the conservation and management of delta smelt in the Plan Area by the achieving the following subobjectives.[9] a) Provide a monthly average of at least 37,000 acres of open-water habitat in hydrologically wet years*, and at least 20,000 acres of connected open-water habitat in hydrologically above-normal years*, of 1 to 6 psu habitat surface area during July–November. This habitat will meet all of the following criteria: extensive vertical circulation including gravitational circulation, contiguous with other open-water habitat, lateral mixing, and other hydrodynamic processes keeping Secchi disk depths less than 0.5 meter, high calanoid copepod densities (over 7,000 per cubic meter), hydrologically connected to substantial tidal marsh areas, and maximum water temperatures less than 25°C. * Because July–November crosses a water-year boundary, the water-year type criteria apply to the first 3 months of that period.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM12 Methylmercury Management CM13 Invasive Aquatic Vegetation Control CM15 Localized Reduction of Predatory Fishes CM19 Urban Stormwater Treatment CM20 Recreational Users Invasive Species Program

[9] The same restored tidal area can meet more than one of the subobjectives, but not necessarily all of the subobjectives. For example, the same area could satisfy subobjectives (a) and (b) or (b) and (c), but potentially not (a) and (c). The exact combination will be informed by the decision-tree process.

Goals and Objectives	Applicable Conservation Measures
b) Increase the extent of tidal wetlands of all types in the Plan Area by 10,000 acres by year 10, 17,000 acres by year 15, and 48,000 acres by year 40. In Suisun Marsh, West Delta and Cache Slough ROAs, individual restoration projects must show a net-positive flux of calanoid copepods and mysids off of the restored wetlands into open water occupied by delta smelt. Food production targets and export distances will be determined through field investigations and modeling, and refined through adaptive management. c) Increase by 100% the surface area of open-water, very low-salinity (<1 psu) habitat in the Cache Slough ROA during July–November by 2060. This habitat will meet all of the following criteria: extensive lateral mixing, contiguous with other open-water habitat, hydrodynamic processes keeping **Secchi** depth less than 0.5 meter, high calanoid copepod density (over 7,000 per cubic meter), and temperature criteria described in item b, above.	
Longfin Smelt	
Goal LFSM1: Increased fecundity and improved survival of adult and juvenile longfin smelt to support increased abundance and long-term population viability.	
Objective LFSM1.1: Achieve longfin smelt population growth, to be measured as follows. • Future indices of annual recruitment that are equal or exceed expected levels based on the 1980–2011 trend in recruitment relative to winter-spring flow conditions.	CM1 Water Facilities and Operation CM4 Tidal Natural Communities Restoration CM18 Conservation Hatcheries CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Objective LFSM1.2: Limit entrainment mortality associated with operation of water facilities to ≤5% of the longfin smelt population, calculated as a 5-year running average of entrainment for subadults and adults in the fall and winter and their progeny in the winter and spring. Assure that the proportional entrainment risk is evenly distributed over the adult migration and larval-juvenile rearing periods.	CM1 Water Facilities and Operation

Goals and Objectives	Applicable Conservation Measures
Chinook Salmon, Sacramento River Winter-Run Evolutionarily Significant Unit	
Goal WRCS1: Improved survival (to contribute to increased abundance) of immigrating and emigrating winter-run Chinook salmon through the Plan Area.	
Objective WRCS1.1: For winter-run Chinook salmon originating in the Sacramento River, achieve a 5-year geometric mean interim through-Delta survival objective of 52% by year 19 (from an estimated 40%), 54% by year 28, and 57% by year 40, measured between Knights Landing and Chipps Island. This survival metric is an interim value based on limited data from fall-run Chinook salmon in the Sacramento River. This survival metric will be revised to account for new monitoring data and improved modeling expected by year 10.[10]	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM15 Localized Reduction of Predatory Fishes CM16 Nonphysical Fish Barriers CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Objective WRCS1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating winter-run Chinook salmon juveniles by year 15.	CM2 Yolo Bypass Fisheries Enhancement
Objective WRCS1.3: Reduce illegal harvest of adult winter-run Chinook salmon in the Plan Area by year 5.	CM17 Illegal Harvest Reduction
Goal WRCS2: Substantial reduction of passage delays (to contribute to increased migration and spawning success, and thus abundance) at human-made impediments for adult winter-run Chinook salmon migrating through the Delta.	
Objective WRCS2.1: Limit adult winter-run Chinook salmon passage delays in the Yolo Bypass to fewer than 36 hours by year 15.	CM2 Yolo Bypass Fisheries Enhancement
Goal WRCS3: No degradation of aquatic habitat conditions for winter-run Chinook salmon upstream of the water facilities.	
Objective WRCS3.1: Implement covered activities so as to not result in a reduction of the primary constituent elements of designated critical habitat for winter-run Chinook salmon upstream of the Plan Area.	CM1 Water Facilities and Operation
Objective WRCS3.2: Operate water facilities to support a wide range of life-history strategies for winter-run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area.).	CM1 Water Facilities and Operation

[10] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Goals and Objectives	Applicable Conservation Measures
Chinook Salmon, Central Valley Spring-Run Evolutionarily Significant Unit	
Goal SRCS1: Increased spring-run Chinook salmon abundance.	
Objective SRCS1.1: For spring-run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 49% by year 19 (from an estimated 40%), 52% by year 28, and 54% by year 40, measured between Knights Landing and Chipps Island. The Sacramento River survival metric is an interim value based on limited data from fall-run Chinook salmon in the Sacramento River. This survival metric will be revised to account for new monitoring data and improved modeling expected by year 10.[11] For spring-run Chinook salmon originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 33% by year 19, 35% by year 28, and 38% by year 40, measured between Mossdale and Chipps Island. Spring-run Chinook salmon do not currently exist in the San Joaquin subbasin, thus these survival metrics are considered very interim.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM15 Localized Reduction of Predatory Fishes CM16 Nonphysical Fish Barriers CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Objective SRCS1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating spring-run Chinook salmon juveniles by year 15.	CM2 Yolo Bypass Fisheries Enhancement
Objective SRCS1.3: Reduce illegal harvest of adult spring-run Chinook salmon in the Plan Area by year 5.	CM17 Illegal Harvest Reduction
Goal SRCS2: Substantial reduction of passage delays (to contribute to increased migration and spawning success and thus abundance) at human-made impediments for adult spring-run Chinook salmon migrating through the Delta.	
Objective SRCS2.1: Limit adult spring-run Chinook salmon passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton DWSC) to fewer than 36 hours by year 15.	CM2 Yolo Bypass Fisheries Enhancement CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels
Goal SRCS3: No degradation of aquatic habitat conditions for spring-run Chinook salmon upstream of water facilities.	
Objective SRCS3.1: Implement covered activities so as to not result in a reduction in the primary constituent elements of designated critical habitat for spring-run Chinook salmon upstream of the Plan Area.	CM1 Water Facilities and Operation

[11] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Goals and Objectives	Applicable Conservation Measures
Objective SRCS3.2: Operate water facilities to support a wide range of life-history strategies for spring-run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., Real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area.).	CM1 Water Facilities and Operation
Chinook Salmon, Central Valley Fall- and Late Fall–Run Evolutionarily Significant Unit	
Goal FRCS1: Increased fall-run/late fall–run Chinook salmon abundance.	
Objective FRCS1.1: For fall-run Chinook salmon originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 27% by year 19 (from an estimated 5%), 29% by year 28, and 31% by year 40, measured between Mossdale and Chipps Island. For fall-run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 42% by year 19 (from an estimated 40%), 44% by year 28, and 46% by year 40, measured between Knights Landing and Chipps Island. For late fall–run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 49% by year 19 (from an estimated 40%), 51% by year 28, and 53% by year 40, measured between Knights Landing and Chipps Island. These survival metrics are interim values, based on limited data from fall-run Chinook salmon in the San Joaquin and Sacramento Rivers, and will be revised to account for new monitoring data and improved modeling expected by year 10.[12]	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM15 Localized Reduction of Predatory Fishes CM16 Nonphysical Fish Barriers CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Objective FRCS1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating fall-run/late fall–run Chinook salmon juveniles by year 15.	CM2 Yolo Bypass Fisheries Enhancement
Objective FRCS1.3: Reduce illegal harvest of adult fall-run/late fall–run Chinook salmon in the Plan Area by year 5.	CM17 Illegal Harvest Reduction
Goal FRCS2: Substantial reduction in passage delays (to contribute to increased migration and spawning success and thus abundance) at human-made impediments for adult fall-run/late fall–run Chinook salmon migrating through the Delta.	
Objective FRCS2.1: Limit adult fall-run/late fall–run Chinook salmon passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton DWSC) to fewer than 36 hours by year 15.	CM2 Yolo Bypass Fisheries Enhancement CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels

[12] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Goals and Objectives	Applicable Conservation Measures
Goal FRCS3: No degradation of aquatic habitat conditions for fall-run/late fall–run Chinook salmon upstream of water facilities.	
Objective FRCS3.1: Implement covered activities so as to not result in a degradation of current habitat conditions for fall-run/late fall–run Chinook salmon (e.g., spawning sites, rearing sites, migration corridors) upstream of the Plan Area.	CM1 Water Facilities and Operation
Objective FRCS3.2: Operate water facilities to support a wide range of life-history strategies for fall-run/late fall–run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., Real-time operation of water facilities will have an implementation window covering at least 95% of life stages present in the Plan Area.).	CM1 Water Facilities and Operation
Steelhead, Central Valley Distinct Population Segment	
Goal STHD1: Increased steelhead abundance.	
Objective STHD1.1: For steelhead originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 44% by year 19 (from an estimated 10%), 47% by year 28, and 51% by year 40, measured between Mossdale and Chipps Island. For steelhead originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 54% by year 19 (from an estimated 45%), 56% by year 28, and 59% by year 40, measured between Knights Landing and Chipps Island. These survival metrics are interim values based on limited data from fall-run Chinook salmon in the San Joaquin and Sacramento Rivers. These survival metrics will be revised to account for new monitoring data and improved modeling expected by year 10.[13]	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM15 Localized Reduction of Predatory Fishes CM16 Nonphysical Fish Barriers CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Objective STHD1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating steelhead juveniles by year 15.	CM2 Yolo Bypass Fisheries Enhancement
Objective STHD1.3: Reduce illegal harvest of adult steelhead in the Plan Area by year 5.	CM17 Illegal Harvest Reduction
Goal STHD2: Substantial reduction in passage delays (to contribute to increased migration and spawning success and thus abundance) at human-made impediments for adult steelhead migrating through the Delta.	
Objective STHD2.1: Limit adult steelhead passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton DWSC) to fewer than 36 hours by year 15.	CM2 Yolo Bypass Fisheries Enhancement CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels

[13] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Goals and Objectives	Applicable Conservation Measures
Goal STHD3: No degradation of aquatic habitat conditions for steelhead upstream of the water facilities.	
Objective STHD3.1: Implement covered activities so as to not result in a reduction to the primary constituent elements of designated critical habitat for steelhead upstream of the Plan Area.	CM1 Water Facilities and Operation
Objective STHD3.2: Operate water facilities to support a wide range of life-history strategies for steelhead without favoring any one life-history strategy or trait over another (e.g., real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area).	CM1 Water Facilities and Operation
Sacramento Splittail	
Goal SAST1: Increased abundance of Sacramento splittail in the Plan Area.	
Objective SAST1.1: Maintain 5-year running average of age-0 splittail index of abundance in the Plan Area of 150% of baseline conditions by providing increased access to suitable spawning and rearing habitat in the Plan Area by year 15.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Restoration CM12 Methylmercury Management
Green Sturgeon, Southern Distinct Population Segment	
Goal GRST1: Increased abundance of green sturgeon in the Plan Area.	
Objective GRST1.1: Increase juvenile green sturgeon survival (as a proxy for juvenile abundance and population productivity) throughout the BDCP permit term and increase adult green sturgeon survival (as a proxy for adult abundance and productivity) by year 15.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM13 Invasive Aquatic Vegetation Control CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM17 Illegal Harvest Reduction CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Goal GRST2: Improved connectivity that facilitates timely passage and reduces stranding of adult green sturgeon.	
Objective GRST2.1: Eliminate stranding of adult green sturgeon at Fremont Weir, the scour pools directly below Fremont Weir, and the Tule Pool by providing passage at these locations, by year 15, and minimize stranding until this time.	CM2 Yolo Bypass Fisheries Enhancement

Goals and Objectives	Applicable Conservation Measures
Goal GRST3: Increased spatial distribution of young-of-the-year (YOY) and juvenile green sturgeon in the Delta compared to existing conditions.	
Objective GRST3.1: Improve water quality parameters and physical habitat characteristics in the Bay-Delta to increase the spatial distribution of green sturgeon in the Plan Area by year 15.	CM12 Methylmercury Management CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM19 Urban Stormwater Treatment
White Sturgeon	
Goal WTST1: Increased abundance of white sturgeon in the Plan Area.	
Objective WTST1.1: Increase juvenile white sturgeon survival (as a proxy for juvenile abundance and population productivity) throughout the BDCP permit term and increase adult white sturgeon survival (as a proxy for adult abundance and productivity) by year 15.	CM1 Water Facilities and Operation CM2 Yolo Bypass Fisheries Enhancement CM4 Tidal Natural Communities Restoration CM5 Seasonally Inundated Floodplain Restoration CM6 Channel Margin Enhancement CM13 Invasive Aquatic Vegetation Control CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM17 Illegal Harvest Reduction CM19 Urban Stormwater Treatment CM21 Nonproject Diversions
Goal WTST2: Improved habitat connectivity that facilitates timely passage and reduces stranding of adult white sturgeon.	
Objective WTST2.1: Eliminate stranding of adult white sturgeon at Fremont Weir, the scour pool directly below Fremont Weir, and the Tule Pond by providing passage at these locations, by year 15, and minimize stranding until this time.	CM2 Yolo Bypass Fisheries Enhancement
Goal WTST3: Increased spatial distribution of young-of-the-year (YOY) and juvenile white sturgeon in the Bay-Delta compared to existing condition SWP/CVP regulatory requirements.	
Objective WTST3.1: Improve water quality parameters and physical habitat characteristics in the Bay-Delta to increase the spatial distribution of white sturgeon in the Plan Area by year 15.	CM12 Methylmercury Management CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels CM19 Urban Stormwater Treatment
Pacific and River Lamprey	
Goal PRL1: Improved habitat connectivity that facilitates timely passage for Pacific and river lamprey within the Plan Area.	
Objective PRL1.1: Reduce passage delays for lamprey adults migrating upstream within the Yolo Bypass by year 15.	CM2 Yolo Bypass Fisheries Enhancement
Objective PRL1.2: Improve downstream passage conditions for lamprey ammocoetes and macropthalmia at the Fremont Weir by year 15.	CM2 Yolo Bypass Fisheries Enhancement

Goals and Objectives	Applicable Conservation Measures
Riparian Brush Rabbit	
Goal RBR1: Suitable habitat available for the future growth and expansion of riparian brush rabbit populations.	
Objective RBR1.1: Of the 750 acres of protected valley/foothill riparian natural community protected under Objective VFRNC1.2, protect 200 acres of suitable riparian brush rabbit habitat (defined in *CM7 Riparian Natural Community Restoration*) that is occupied by the species or contiguous with occupied habitat.	CM3 Natural Communities Protection and Restoration
Objective RBR1.2: Of the 1,000 acres of early- to midsuccessional riparian habitat maintained under VFRNC2.2, maintain at least 800 acres within the range of the riparian brush rabbit (Conservation Zone 7), in areas that are adjacent to or that facilitate connectivity with occupied or potentially occupied habitat.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective RBR1.3: Of the 5,000 acres of valley/foothill riparian natural community restored under Objective VFRNC1.1, restore/create and maintain 300 acres of early- to midsuccessional riparian habitat that meets the ecological requirements of the riparian brush rabbit and that is within or adjacent to or that facilitates connectivity with existing occupied or potentially occupied habitat.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective RBR1.4: Create and maintain high-water refugia in the 300 acres of restored riparian brush rabbit habitat and the 200 acres of protected riparian brush rabbit habitat, through the retention, construction and/or restoration of high-ground habitat on mounds, berms, or levees, so that refugia are no further apart than 20 meters.	CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Objective RBR1.5: In protected riparian areas that are occupied by riparian brush rabbit, monitor for and control nonnative predators that are known to prey on riparian brush rabbit.	CM11 Natural Communities Enhancement and Management
Objective RBR1.6: Of the 8,000 acres of grasslands protected under Objective GNC1.1 and the 2,000 acres of grasslands restored under Objective GNC1.2, protect or restore grasslands on the landward side of levees adjacent to restored floodplain to provide flood refugia and foraging habitat for riparian brush rabbit.	CM3 Natural Communities Protection and Restoration CM8 Grassland Natural Community Restoration
Riparian Woodrat (San Joaquin Valley)	
Goal RW1: A reserve system that includes suitable habitat available for the future growth and expansion of riparian woodrat populations.	
Objective RW1.1: Of the 5,000 acres of valley/foothill riparian natural community restored under Objective VFRNC1.1, restore/create and maintain 300 acres riparian habitat in Conservation Zone 7 that meets the ecological requirements of the riparian woodrat (e.g., dense willow understory and oak overstory) and that is adjacent to or facilitates connectivity with existing occupied or potentially occupied habitat.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management

Goals and Objectives	Applicable Conservation Measures
Objective RW1.2: Provide and maintain high-water refugia in the 300 acres of riparian woodrat habitat restored under Objective RW1.1 through the retention, construction, and/or restoration of high-ground habitat on mounds, berms, or levees, so that refugia are no further apart than 20 meters.	CM7 Riparian Natural Community Restoration CM11 Natural Communities Enhancement and Management
Salt Marsh Harvest Mouse	
Goal SMHM1: Suitable habitat and conditions to sustain a population of salt marsh harvest mouse in the reserve system.	
Objective SMHM1.1: Within the at least 1,500 acres of middle and high marsh restored under Objective TBEWNC1.2, provide viable habitat areas for salt marsh harvest mouse, as defined in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*[14]. Meet population capture efficiency targets described in that plan.	CM4 Tidal Natural Communities Restoration CM11 Natural Communities Enhancement and Management
Objective SMHM1.2: Within the 1,500 acres of managed wetland protected and enhanced in the Grizzly Island Marsh Complex under Objective MWNC1.1, provide viable habitat areas for salt marsh harvest mouse, as defined in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*[15], and increase population levels above the current baseline.	CM11 Natural Communities Enhancement and Management
San Joaquin Kit Fox	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
Suisun Shrew	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	

[14] While the conservation strategy is based on the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U.S. Fish and Wildlife Service 2010), Objective SMHM1.1 will provide viable habitat areas for salt marsh harvest mouse as defined in the final version of the plan.

[15] While the conservation strategy is based on the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U.S. Fish and Wildlife Service 2010), Objective SMHM1.1 will provide viable habitat areas for salt marsh harvest mouse as defined in the final version of the plan.

Goals and Objectives	Applicable Conservation Measures
California Black Rail	
Goal CBR1: A reserve system that includes suitable habitat for the future growth and expansion of California black rail populations.	
Objective CBR1.1: At the ecotone that will be created between restored tidal freshwater emergent wetlands and transitional uplands (Objectives L1.3 and TFEW1.1), provide for at least 1,700 acres of California black rail habitat consisting of shallowly inundated emergent vegetation at the upper edge of the marsh (within 50 meters of upland refugia habitat) with adjacent riparian or other shrubs that will provide upland refugia, and other moist soil perennial vegetation.	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration CM11 Natural Communities Enhancement and Management
California Clapper Rail	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
Greater Sandhill Crane	
Goal GSHC1: Protection and expansion of greater sandhill crane winter range.	
Objective GSHC1.1: Within the 48,625 acres of cultivated lands protected under Objective CLNC1.1, protect 7,300 acres of high- to very high-value habitat for greater sandhill crane, with at least 80% maintained in very high-value types in any given year, as defined in *CM3 Natural Communities Protection and Restoration*. This protected habitat will be within 2 miles of known roosting sites in Conservation Zones 3, 4, 5, and/or 6 and will consider sea level rise and local seasonal flood events, greater sandhill crane population levels, and the location of foraging habitat loss. Patch size of protected cultivated lands will be at least 160 acres.	CM3 Natural Communities Protection and Restoration
Objective GSHC1.2: To create additional high-value greater sandhill crane winter foraging habitat, at least 10% of the habitat protected under Objective GSHC1.1 will involve acquiring low-value habitat or nonhabitat areas and converting it to high- or very high-value habitat. Created habitat will be within 2 miles of known roosting sites in Conservation Zones 3, 4, 5, and/or 6 and will consider sea level rise and local seasonal flood events, greater sandhill crane population level, and the location of habitat loss.	CM3 Natural Communities Protection and Restoration

Goals and Objectives	Applicable Conservation Measures
Objective GSHC1.3: Create 320 acres of managed wetlands consisting of greater sandhill crane roosting habitat in minimum patch sizes of 40 acres within the Greater Sandhill Crane Winter Use Area[16] in Conservation Zones 3, 4, 5, or 6, with consideration of sea level rise and local seasonal flood events. The wetlands will be located within 2 miles of existing permanent roost sites and protected in association with other protected natural community types (excluding nonhabitat cultivated lands) at a ratio of 2:1 upland to wetland to provide buffers around the wetlands.	CM3 Natural Communities Protection and Restoration CM10 Nontidal Marsh Restoration
Objective GSHC1.4: In addition to the at least 320 acres of created managed wetland greater sandhill crane roosting habitat (Objective GSHC1.3), create two wetland complexes within the Stone Lakes National Wildlife Refuge project boundary[17]. The complexes will be no more than 2 miles apart and will help provide connectivity between the Stone Lakes and Cosumnes greater sandhill crane populations. Each complex will consist of at least three wetlands totaling 90 acres of greater sandhill crane roosting habitat, and will be protected in association with other protected natural community types (excluding nonhabitat cultivated lands) at a ratio of at least 2:1 uplands to wetlands (i.e., two sites with 90 acres of wetlands each). One of the 90-acre wetland complexes may be replaced by 180 acres of cultivated lands (e.g., cornfields) that are flooded following harvest to support roosting cranes and provide highest-value foraging habitat, provided such substitution is consistent with the long-term conservation goals of Stone Lakes National Wildlife Refuge for greater sandhill crane.	CM10 Nontidal Marsh Restoration
Objective GSHC1.5: Create an additional 95 acres of roosting habitat within 2 miles of existing permanent roost sites. The habitat will consist of active cornfields that are flooded following harvest to support roosting cranes and that provide highest-value foraging habitat. Individual fields will be at least 40 acres and can shift locations throughout the Greater Sandhill Crane Winter Use Area, but will be sited with consideration of the location of roosting habitat loss and will be in place prior to roosting habitat loss.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Least Bell's Vireo	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	

[16] Important geographically defined greater sandhill crane wintering areas in the Central Valley (Pogson and Lindstedt 1988; Littlefield and Ivey 2000; Ivey pers. comm.) (Figure 2A.19-2).

[17] The project boundary delineates the area surrounding the existing refuge for which the refuge has authority to acquire land or easements.

Goals and Objectives	Applicable Conservation Measures
Suisun Song Sparrow	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
Swainson's Hawk	
Goal SH1: Large, interconnected patches or contiguous expanses of protected Swainson's hawk foraging habitat.	
Objective SH1.1: Conserve 1 acre of Swainson's hawk foraging habitat for each acre of lost[18] foraging habitat.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Objective SH1.2: Within the 48,625 acres of protected cultivated lands, protect at least 43,325 acres of Swainson's hawk foraging habitat with at least 50% in very high-value habitat production in Conservation Zones 1, 2, 3, 4, 7, 8, 9, and 11.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Objective SH1.3: Of the at least 43,325 acres of cultivated lands protected as Swainson's hawk foraging habitat under Objective SH1.2, up to 1,500 acres can occur in Conservation Zones 5 and 6, all of which must have land surface elevations greater than -1 foot NAVD88.	CM3 Natural Communities Protection and Restoration
Objective SH1.4: Within the 138,789 acres of lands protected or restored under Objective L1.1, protect at least 10,750 acres of grassland, vernal pool, and alkali seasonal wetland as Swainson's hawk foraging habitat.	CM3 Natural Communities Protection and Restoration
Goal SH2: Cultivated lands that provide conditions suitable for supporting Swainson's hawk.	
Objective SH2.1: Increase distribution and abundance of potential Swainson's hawk nest trees in the Plan Area by planting and maintaining native trees along roadsides and field borders within protected cultivated lands at a rate of one tree per 10 acres.	CM11 Natural Communities Enhancement and Management
Objective SH2.2: Support the establishment and sustainability of Swainson's hawk prey populations by establishing 20- to 30-foot-wide hedgerows along field borders and roadsides within protected cultivated lands at a minimum rate of 400 linear feet per 100 acres.	CM11 Natural Communities Enhancement and Management

[18] "Lost" is the combination of permanent habitat loss and loss due to borrow and spoil sites that will eventually be restored.

Goals and Objectives	Applicable Conservation Measures
Tricolored Blackbird	
Goal TRBL1: Improved nesting, nesting-adjacent foraging, and wintering habitat for tricolored blackbirds in the Plan Area.	
Objective TRBL1.1: Protect and manage 50 acres of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat located within 5 miles of high-value foraging habitat in Conservation Zones 1, 2, 8, or 11. Nesting habitat will be managed to provide young, lush stands of bulrush/cattail emergent vegetation and prevent vegetation senescence.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Objective TRBL1.2: Within the 48,625 acres of cultivated lands protected under Objective CLNC1.1, protect at least 26,300 acres of moderate-, high-, or very high-value cultivated lands as nonbreeding foraging habitat, at least 50% of which is of high or very high value.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Objective TRBL1.3: Within the 48,625 acres of protected cultivated lands, protect at least 11,050 acres of high- to very high-value breeding-foraging habitat within 5 miles of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat in Conservation Zones 1, 2, 3, 4, 7, 8, or 11. At least 1,000 acres will be within 5 miles of the 50 acres of nesting habitat protected under Objective TRBL1.1.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Western Burrowing Owl	
Goal WBO1: Contribute to the sustainability of burrowing owl population by protecting cultivated lands suitable for burrowing owl foraging.	
Objective WBO1.1: Of the 48,625 acres of cultivated land protected under Objective CLNC1.1, protect at least 1,000 acres in Conservation Zones 1 and 11 that support high-value burrowing owl habitat and are within 0.5 mile of high-value grassland habitat or occupied low-value habitat.	CM3 Natural Communities Protection and Restoration
Western Yellow-Billed Cuckoo	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
White-Tailed Kite	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
Yellow-Breasted Chat	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	

Goals and Objectives	Applicable Conservation Measures
Giant Garter Snake	
Goal GGS1: Well-connected high-value upland and aquatic giant garter snake habitat in Conservation Zones 4 and/or 5.	
Objective GGS1.1: Of the 1,200 acres of nontidal marsh created under Objective NFEW/NPANC1.1, create at least 600 acres of aquatic habitat for the giant garter snake that is connected to the 1,500 acres of rice land or equivalent-value habitat (Objective GGS1.4).	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration CM10 Nontidal Marsh Restoration
Objective GGS1.2: Of the 8,000 acres of grassland protected under Objective GNC1.1 and 2,000 acres restored under Objective GNC1.2, create or protect at least 200 acres of high-value upland giant garter snake habitat adjacent to the at least 600 acres of nontidal perennial aquatic habitat being restored and/or created in Conservation Zones 4 and/or 5 (Objective GGS1.1).	CM3 Natural Communities Protection and Restoration CM8 Grassland Natural Community Restoration
Objective GGS1.3: Protect giant garter snakes on restored and protected nontidal marsh and adjacent uplands (Objectives GGS1.1 and GGS1.2) from incidental injury or mortality by establishing 200-foot buffers between protected giant garter snake habitat and roads (other than those roads primarily used to support adjacent cultivated lands and levees). Establish giant garter snake reserves at least 2,500 feet from urban areas or areas zoned for urban development.	CM3 Natural Communities Protection and Restoration
Objective GGS1.4: Create connections from the White Slough population to other areas in the giant garter snake's historical range in the Stone Lakes vicinity by protecting, restoring, and/or creating 1,500 acres of rice land or equivalent-value habitat (e.g., perennial wetland) for the giant garter snake in Conservation Zones 4 and/or 5. Any portion of the 1,500 acres may consist of tidal freshwater emergent wetland and may overlap with the at least 24,000 acres of tidally restored freshwater emergent wetland if it meets specific giant garter snake habitat criteria described in *CM4 Tidal Natural Communities Restoration*. Up to 500 (33%) of the 1,500 acres may consist of suitable uplands adjacent to protected or restored aquatic habitat.	CM3 Natural Communities Protection and Restoration CM4 Tidal Natural Communities Restoration
Goal GGS2: Expansive high-value upland and aquatic giant garter snake habitat in Conservation Zone 2 located outside the Yolo Bypass**.**	
Objective GGS2.1: Of the 1,200 acres of nontidal marsh created under Objective NFEW/NPANC1.1, create at least 600 acres of connected aquatic giant garter snake habitat outside the Yolo Bypass in Conservation Zone 2.	CM3 Natural Communities Protection and Restoration CM10 Nontidal Marsh Restoration
Objective GGS2.2: Of the 8,000 acres of grasslands protected under Objective GNC1.1 and the 2,000 acres restored under Objective GNC1.2, create or protect at least 200 acres of high-value upland habitat adjacent to the at least 600 acres of nontidal marsh habitat created in Conservation Zone 2 outside of Yolo Bypass (Objective GGS2.1).	CM3 Natural Communities Protection and Restoration CM8 Grassland Natural Community Restoration

Goals and Objectives	Applicable Conservation Measures
Objective GGS2.3: To expand upon and buffer the newly restored/created nontidal perennial habitat in Conservation Zone 2, protect 700 acres of cultivated lands, with at least 500 acres consisting of rice land and the remainder consisting of compatible cultivated land that can support giant garter snakes. The cultivated lands may be a subset of lands protected for the cultivated lands natural community and other covered species.	CM3 Natural Communities Protection and Restoration
Objective GGS2.4: Protect giant garter snakes on created nontidal marsh (Objectives GGS2.1) and created or protected adjacent uplands (Objective GGS2.2) from incidental injury or mortality by establishing 200-foot buffers between protected giant garter snake habitat and roads (other than those roads primarily used to support adjacent cultivated lands and levees). Establish giant garter snake reserves at least 2,500 feet from urban areas or areas zoned for urban development.	CM3 Natural Communities Projection and Restoration
Goal GGS3: At least 1 acre of giant garter snake habitat conserved for each acre of loss.	
Objective GGS3.1: Protect, restore, and/or create 2,740 acres of rice land or equivalent-value habitat (e.g., perennial wetland) for the giant garter snake in Conservation Zones 1, 2, 4, or 5. Up to 500 acres may consist of tidal freshwater emergent wetland and may overlap with the at least 5,000 acres of tidally restored freshwater emergent wetland in the Cache Slough ROA if this portion meets giant garter snake habitat criteria specified in *CM4 Tidal Natural Communities Restoration*. Up to 1,700 acres may consist of rice fields in the Yolo Bypass, if this portion meets the criteria specified in *CM3 Natural Communities Projection and Restoration*, (Section 3.4.3.3.2, *Siting and Reserve Design*, *Reserve Design Requirements by Species*). Any remaining acreage will consist of rice land or equivalent-value habitat outside the Yolo Bypass. Up to 915 (33%) of the 2,740 acres may consist of suitable uplands adjacent to protected or restored aquatic habitat.	CM3 Natural Communities Projection and Restoration CM4 Tidal Natural Communities Restoration CM10 Nontidal Marsh Restoration
Western Pond Turtle	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
California Red-Legged Frog	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
California Tiger Salamander (Central Valley Distinct Population Segment)	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	

Goals and Objectives	Applicable Conservation Measures
Valley Elderberry Longhorn Beetle	
Goal VELB1: Promote dispersal and expansion of the valley elderberry longhorn beetle where there are known source populations within the American River and Sacramento River systems.	
Objective VELB1.1: Mitigate impacts on elderberry shrubs by creating valley elderberry longhorn beetle habitat consistent with the U.S. Fish and Wildlife Service valley elderberry longhorn beetle conservation guidelines (Appendix 3.F) and planting elderberry shrubs in high-density clusters.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration
Objective VELB1.2: Site valley elderberry longhorn beetle habitat restoration within drainages immediately adjacent to or in the vicinity of sites confirmed to be occupied by valley elderberry longhorn beetle.	CM3 Natural Communities Protection and Restoration CM7 Riparian Natural Community Restoration
Vernal Pool Crustaceans	
Goal VPC1: Protected occurrences of the rarest covered vernal pool crustacean species.	
Objective VPC1.1: Protect one currently unprotected occurrence of conservancy fairy shrimp.	CM3 Natural Communities Protection and Restoration
Brittlescale, Heartscale, and San Joaquin Spearscale	
Goal BRIT/HART/SJSC1: A reserve system that includes habitat for and occurrences of brittlescale, heartscale, and San Joaquin spearscale.	
Objective BRIT/HART/SJSC1.1: Of the 150 acres of alkali seasonal wetland complex protected under Objective ASWNC1.1, 600 acres of vernal pool complex protected under Objective VPNC1.1, and 8,000 acres of grassland natural community protected under Objective GNC1.1, protect at least 75 acres of suitable brittlescale habitat and 75 acres of suitable heartscale habitat in Conservation Zones 1, 8, or 11.	CM3 Natural Communities Protection and Restoration
Objective BRIT/HART/SJSC 1.2: Protect two currently unprotected occurrences of San Joaquin spearscale in Conservation Zones 1, 8, or 11.	CM3 Natural Communities Protection and Restoration
Carquinez Goldenbush	
Goal CGB1: A reserve system that includes Carquinez goldenbush occurrences and sustains suitable habitat for this species.	
Objective CGB1.1: Protect three unprotected occurrences of the Carquinez goldenbush in Conservation Zones 1 and/or 11.	CM3 Natural Communities Protection and Restoration
Objective CGB1.2: Maintain and enhance occupied Carquinez goldenbush habitat to slow erosion and reverse degradation from livestock grazing.	CM11 Natural Communities Enhancement and Management

Goals and Objectives	Applicable Conservation Measures
Delta Button Celery	
Goal DBC1: Expand the distribution and increase the abundance of delta button celery populations.	
Objective DBC1.1: Protect and enhance two occurrences of delta button celery. If occurrences are not found in the Plan Area, establish self-sustaining occurrences of delta button celery for a total of two occurrences[19] within the restored floodplain habitat on the mainstem of the San Joaquin River in Conservation Zone 7 between Mossdale and Vernalis.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management
Delta Mudwort and Mason's Lilaeopsis	
Goal DMW/ML1: A reserve system that supports Mason's lilaeopsis and delta mudwort.	
Objective DMW/ML1.1: No net loss of Mason's lilaeopsis and delta mudwort occurrences within restoration sites, or within the area of affected tidal range of restoration projects.	CM4 Tidal Natural Communities Restoration CM11 Natural Communities Enhancement and Management
Delta Tule Pea and Suisun Marsh Aster	
Goal DTP/SMA1: A reserve system that supports the Delta tule pea and Suisun Marsh aster.	
Objective DTP/SMA1.1: No net loss of Delta tule pea and Suisun Marsh aster occurrences within restoration sites.	CM4 Tidal Natural Communities Restoration CM11 Natural Communities Enhancement and Management
Side-Flowering Skullcap	
Landscape and natural community biological goals and objectives adequately address the species. No species-specific biological goals or objectives are needed.	
Slough Thistle	
Goal ST1: Expanded distribution and increased abundance of slough thistle populations.	
Objective ST1.1: Protect and enhance two occurrences of slough thistle. If occurrences are not found in the Plan Area, establish self-sustaining occurrences of slough thistle for a total of two occurrences[20] within the 10,000 acres of restored floodplain on the mainstem of the San Joaquin River in Conservation Zone 7 between Mossdale and Vernalis.	CM3 Natural Communities Protection and Restoration CM11 Natural Communities Enhancement and Management

[19] This objective allows protection of one occurrence and establishment of one occurrence in the reserve system, or establishment of two occurrences in the reserve system.

[20] This objective allows protection of one occurrence and establishment of one occurrence in the reserve system, or establishment of two occurrences in the reserve system.

Goals and Objectives	Applicable Conservation Measures
Soft Bird's-Beak and Suisun Thistle	
Goal SBB/SuT1: Protected and expanded Suisun thistle and soft bird's-beak populations.	
Objective SBB/SuT1.1: Restore tidal inundation to wetlands in the Hill Slough Ecological Reserve and to the ponded area at Rush Ranch.	CM4 Tidal Natural Communities Restoration
Objective SBB/SuT1.2: Complete seed banking of all existing Suisun Marsh populations and the representative genetic diversity using accepted seed banking protocols.	CM11 Natural Communities Enhancement and Management
Objective SBB/SuT1.3: Establish a cultivated population of Suisun thistle from wild seed using accepted seed collection protocols.	CM11 Natural Communities Enhancement and Management
Objective SBB/SuT1.4: Establish two occurrences of Suisun thistle in Conservation Zone 11.	CM11 Natural Communities Enhancement and Management
Vernal Pool Plant Species	
Goal VPP1: A reserve system that protects vernal pool plant populations.	
Objective VPP1.1: Protect two currently unprotected occurrences of alkali milk-vetch in the Altamont Hills or Jepson Prairie core recovery areas (Conservation Zones 1, 8, or 11).	CM3 Natural Communities Protection and Restoration
Objective VPP1.2: Maintain no net loss of Heckard's peppergrass in Conservation Zones 1, 8, or 11 within restoration sites or within the area of affected tidal range of restoration projects.	CM3 Natural Communities Protection and Restoration CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration
ROA = restoration opportunity area; psu = practical salinity unit [a] The area where physical changes attributable to the BDCP have the potential to affect covered fish species. Included is the Sacramento River upstream to Keswick Dam, the San Joaquin River upstream to the Stanislaus River, tributaries downstream of SWP and CVP dams (Clear Creek, Feather River, American River, and Stanislaus River), and the Plan Area.	

3.3.5 Landscape-Scale Biological Goals and Objectives

The following landscape-scale goals and objectives address conditions in the reserve system, ecological processes and conditions, and landscape-scale factors that affect natural communities and covered species. These goals and objectives were developed to follow the principles of conservation biology and the requirements of the NCCPA. For the covered fish species, the landscape-scale goals and objectives are intended to address key stressors of ecosystem processes and functions that support the covered fish species. These goals and objectives address the hydrodynamic and water quality functions of habitat, movement, and food production important to the life stages of the covered fish species that occur within the Plan Area, as well as the effects of nonnative predator and competitor species. For the natural communities and nonfish covered species, these goals and objectives address biodiversity, ecosystem function, and the desired extent, distribution, connectivity, and ecological function of the landscape for supporting the habitats and life requirements of covered species in the Plan Area.

Landscape-scale goals and objectives are listed below, followed by descriptions of the approach and rationale used to establish them. The conservation measures that will be implemented to achieve these goals and objectives are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each biological objective.

3.3.5.1 Reserve System

Goal L1 and its associated objectives address the quantity and characteristics of land that will be protected in the reserve system.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.1:** Protect or restore 142,200 acres of high-quality natural communities and covered species habitats.
- **Objective L1.2:** Protect sufficient lands for the restoration of natural communities as described in Objective L1.1.
- **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.
- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.
- **Objective L1.5:** In restored floodplains, provide a range of elevations that transition from frequently flooded (e.g., every 1 to 2 years) to infrequently flooded (e.g., every 10 years or more) areas to provide a range of habitat conditions, upland habitat values, and refugia from flooding during most flood events.
- **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.
- **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.
- **Objective L1.8:** To accommodate sea level rise, provide potential tidal marsh plain within the anticipated future eastward position of the low-salinity zone of the estuary.

Objective L1.1 Rationale*:* Achieving this objective is intended to protect the highest quality natural communities and covered species habitat in the Plan Area to optimize the ecological value of the reserve system for conserving covered species and native biodiversity. The target for total protected and restored acreage is based on the sum of all natural community acreage targets. Achieving this objective is intended to protect and restore natural communities, species-specific habitat elements, and species diversity on a landscape-scale consistent with Section 2830(a)(3) of the NCCPA. Achieving this objective is also intended to conserve representative natural and seminatural landscapes in order to maintain the ecological integrity of large habitat blocks, including desired ecosystem function, and biological diversity, consistent with Section 2820(a)(4)(A) of the NCCPA. The acreage to be conserved for each natural community is provided in Table 3.3-2, and rationale for that acreage is provided in Section 3.3.6, *Natural Community Goals and Objectives. CM3 Natural Communities Protection and Restoration*, describes the site selection criteria that will be used to identify lands for protection to achieve this objective.

Objective L1.2 Rationale: Achieving this objective is intended to protect sufficient lands to restore natural communities. *CM3 Natural Communities Protection and Restoration*, describes how the Implementation Office will identify, prioritize, and secure lands for restoration to achieve this objective.

Objective L1.3 Rationale: Achieving this objective will restore 65,000 acres of tidal natural communities (tidal perennial aquatic, tidal brackish emergent wetland, tidal freshwater emergent wetland, and tidal mudflats) and transitional uplands to accommodate sea level rise. Achieving this objective is also intended to contribute to the conservation and restoration of representative natural and seminatural landscapes to maintain the ecological integrity of large habitat blocks, ecosystem function, and biological diversity, consistent with Section 2820(a)(4)(A) of the NCCPA. The rationale for restoring tidally influenced natural communities follows, and additional rationale specific to each of these natural communities is provided in Section 3.3.6, *Natural Community Goals and Objectives.*

The majority of tidal marsh and associated tidal mudflat in Suisun Marsh and the Delta has been lost and cannot be regenerated due to land subsidence (Lund et al. 2007, 2008). This loss may have greatly reduced the availability and quality of spawning and rearing habitat for many native fish species including covered fish species, as well as reduced the input of organic and inorganic material and food resources that supported covered fish species into adjoining deepwater habitats (sloughs and channels) and the downstream bays including the low-salinity zone. This loss of tidal marsh and mudflat has also greatly reduced the extent and quality of habitat for native wildlife and plants adapted to this once expansive marsh-river floodplain environment. Restored shallow subtidal aquatic habitat is expected to support, depending on location, tidal velocity, and freshwater flow regime; delta smelt, longfin smelt, juvenile salmonid rearing, sturgeon, and lamprey habitat elements. Terrestrial covered species specific to each community are described in Section 3.3.6, *Natural Community Goals and Objectives.*

Restoring tidal natural communities within the Suisun Marsh, Cache Slough, Cosumnes/Mokelumne, West Delta, and South Delta ROAs is intended to provide improved habitat conditions for covered fish species and increase primary productivity. A number of studies in the Bay-Delta indicate that Chinook salmon and steelhead fry and juveniles forage in tidal marshes, channels, and sloughs (Williams 2006; Shreffler et al. 1990, 1992; Sommer et al. 2001a, 2001b; Moyle 2002; Moyle et al. 2004). Greatly improving upon the existing gradients of floodplain and tidally influenced natural communities is intended to provide a greater range of conditions suitable for food production (Sommer et al. 2004; Benigno and Sommer 2008; Lehman et al. 2008, 2010). It is also intended to provide a broad gradient of environmental conditions and a range of potentially suitable habitats that covers the extensive rearing stages of the covered fish species, spatially and temporally (Sommer et al. 2001a; Feyrer et al. 2006a; Jeffres et al. 2008).

Restoration of tidal wetlands is expected to improve habitat conditions for some native species, improve connectivity among habitat areas within Suisun Marsh and Suisun Bay, provide nutrients and food to adjacent subtidal aquatic habitat, and contribute to the long-term conservation of marsh-associated covered species. Tidal natural communities restoration will be designed to provide an ecological gradient among subtidal, tidal mudflat, tidal marsh plain, riparian, and upland habitats to accommodate the movement of fish and wildlife species and provide flood refuge habitat for marsh-associated wildlife species during high-water events. Upland transition zones will be protected adjacent to restored tidal marshes to ensure that tidal emergent wetlands are sustainable in the event of predicted future rises in sea level.

Tidal restoration is expected to help restore the natural tidal fluctuation that is essential to improve the function of the tidal emergent wetlands. Restoration of tidal influence affects water accessibility, soil oxygen status, and soil salinity, all of which are critical factors for the emergent wetland vegetation. Effective tidal exchange is expected to enhance the following functions.

- Export of productivity from the marsh plain into adjacent Delta waterways in support of aquatic foodweb processes (Müller-Solger et al. 2002; Lehman et al. 2010a but also see Grimaldo et al. 2009).
- Production and export of phytoplankton and zooplankton from tidal channels into adjacent Delta waterways in support of the aquatic foodweb (Lehman et al. 2008, 2010).
- Maintenance of cooler localized water temperatures preferred by covered fish species through nocturnal thermal exchange on marsh plains (Enright et al. 2012).
- An additional 8,529 acres of nontidal natural communities, consisting of vernal pool complex[21], grasslands, valley/foothill riparian, nontidal perennial aquatic/nontidal freshwater emergent wetland, and managed wetland natural communities will be restored. The rationale for restoration related objectives specific to each of these natural communities is provided in Section 3.3.6, *Natural Community Goals and Objectives.*

Objective L1.4 Rationale: Achieving this objective will provide a variety of environmental gradients (e.g., hydrology, elevation, water depths, soils, slope, and aspect) in the reserve system to provide a range of habitat characteristics, food resources, and complexity for native species, including covered species. A variety of environmental gradients may allow shifting species distributions in response to potential future environmental changes, such as climate change, and is intended to facilitate species' responses to catastrophic events such as fire or extreme environmental fluctuations such as flood or drought. Achieving this objective will meet the requirements under Section 2820(a)(4)(D) of the NCCPA to protect a range of environmental gradients and provide for shifting distributions of species due to changed circumstances.

Protection of a variety of environmental gradients in the reserve system is necessary to accommodate climate change. Changes in temperature range and precipitation patterns resulting from climate change may cause some areas of currently suitable habitat to become unsuitable for

[21] Assuming 89 acres of vernal pool complex restoration.

some species, while other areas of currently unsuitable habitat may become suitable. Many habitats and species are expected to be affected by climate change and their temporal dynamics and spatial distributions are likely to change in ways that cannot be predicted. Faced with large, uncertain, and dynamic responses, it is important that a broad range of habitat characteristics be provided (i.e., elevation, water depth, slope, aspect) within an interconnected reserve system. This is intended to ensure that, while some current habitat may be lost or altered as a result of climate change, sufficient suitable habitat will be available as sea level rise occurs in response to climate change to sustain both covered and noncovered species.

Objective L1.5 Rationale: Achieving this objective will provide a gradient within the restored floodplains, from elevations that flood frequently (e.g., every 1 to 3 years) to elevations that flood infrequently (e.g., every 10 years or more). Although periodic flooding may enhance riparian habitat conditions, species such as riparian brush rabbit and riparian woodrat need adjacent areas that flood less frequently to provide upland refugia during most flood events (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*). Additional refugia will be provided for these species, as described in the species-specific objectives. Providing an elevational gradient also increases opportunities for a diversity of vegetation types and structural characteristics in the floodplain; areas with a range of elevations that flood frequently are likely to provide a range of water depths that provide suitable habitat for covered fish and support emergent vegetation and early-successional riparian vegetation, while areas that flood less frequently are expected to sustain more mature riparian vegetation and grasslands (Warner and Hendrix 1984).

Objective L1.6 Rationale: Achieving this objective will protect and restore large swaths of connected natural communities to enhance ecosystem processes and connectivity and help increase the abundance, distribution, and diversity of covered and other native species. Achieving this objective is also intended to contribute toward the maintenance of habitat areas large enough to support sustainable populations of covered species, consistent with Section 2820(a)(4)(C) of the NCCPA. Habitat loss, fragmentation, and degradation within as well as outside the Plan Area have disrupted the ecosystem function and large-scale habitat connectivity necessary to sustain covered and other native species and maintain biodiversity.

Objective L1.7 Rationale*:* Achieving this objective will protect the upland transitional areas adjacent to restored tidal natural communities to accommodate potential future upslope establishment of tidal emergent wetlands from sea level rise anticipated during and after the permit term. Sea level rise during the permit term (i.e., until 2060) is expected to be 18 inches. This objective calls for upland transitional areas to accommodate up to 3 feet of sea level, where possible, thus protecting this natural community beyond the permit term.

The effects of future climate change on the Plan Area are expected to have far-reaching and potentially dramatic effects on native species and natural communities. Sea level rise is expected to inundate some subsided and low-lying terrestrial areas, while other effects of climate change are expected to be more complex. For example, changes in temperature range and precipitation patterns may cause some areas of currently suitable habitat to become unsuitable for some species; while other areas of currently unsuitable habitats may become suitable. Many habitats and species are expected to be affected and their temporal dynamics and spatial distributions are expected to change in unpredictable ways. Faced with such large, uncertain, and dynamic responses, it is important that a broad range of habitat characteristics (i.e., elevation, water depth, slope, aspect) be protected to ensure that while some current habitat may be altered or lost to species as a result of anticipated climate change, sufficient suitable habitat will remain available to sustain both covered and noncovered native species. Achievement of this objective will benefit covered and other native species in the Plan Area.

The Implementation Office will provide upland refugia habitat for native species adjacent to restored tidal marsh, in addition to the transitional uplands protected under Objective L1.7 to accommodate anticipated sea level rise. A variety of native species, including covered species such as the salt marsh harvest mouse, Suisun shrew, Suisun song sparrow, California black rail, and California clapper rail, rely on uplands adjacent to tidal emergent wetlands to provide refugia and foraging habitat during high-tide events. Transitional uplands will be conserved as described in *CM3 Natural Communities Protection and Restoration*. Cultivated lands and managed wetlands within this upland transitional area will be converted to grasslands as described in *CM8 Grassland Natural Community Restoration*.

Objective L1.8 Rationale: Achieving this objective will restore tidal marsh within the anticipated future eastward position of the low-salinity zone (as represented by X2), which is positively correlated with the abundance of life stages of a number of fish species, including some covered fish species (e.g., longfin smelt) in the estuary (Baxter et al. 1999; Kimmerer 2004). Suisun Bay and the western Delta represent important low-salinity habitat areas. Open-water habitat in this region serves as larval and juvenile rearing, adult holding, and foraging habitat for resident and anadramous species such as salmon, steelhead, and lamprey. Lower outflow from the Plan Area during the dry season combined with sea level rise resulting from climate change are expected to increase the extent of saltwater intrusion into the Plan Area (Knowles and Cayan 2002, 2004; Cloern et al. 2012; Brown et al. 2013) and could shift the low-salinity zone farther upstream, which would decrease the amount of rearing habitat available to native estuarine species (U.S. Fish and Wildlife Service 2004; Feyrer et al. 2007, 2011) unless major landscape changes and increases in zooplankton production occur to offset this predicted trend.

3.3.5.2 Ecological Processes and Conditions

Goal L2 and its associated objectives address the ecological processes and conditions that will be protected within the reserve system. Consistent with Section 2810(b)(5)(B) of the NCCPA, the BDCP Planning Agreement (Anonymous 2006) states that the BDCP will employ a conservation strategy that focuses on ecological processes in the Plan Area. The ecological processes addressed through objectives under this goal include fluvial processes (Objective L2.1), lateral channel migration (Objective L2.2), deposition of organic material into rivers and floodplains (Objective L2.3), tidal exchange (Objective L2.7), and productivity of food for covered fish species (Objective L2.9). Specific ecological conditions will also be met through this goal, including water quality (Objective L2.4), habitat and native species diversity (Objectives L2.5, L2.6, and L2.12), refugial habitat for covered fish species (Objective L2.8), abundance of food for covered fish species (Objective L2.9), presence of transitional intertidal areas (Objective L2.10), and presence of seasonally inundated floodplain (Objective L2.11).

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances. • **Objective L2.2:** Allow lateral river channel migration. • **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers. • **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system. • **Objective L2.5:** Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity. • **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species. • **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species. • **Objective L2.8:** Provide refuge habitat for migrating and resident covered fish species. • **Objective L2.9:** Increase the abundance and productivity of plankton and invertebrate species that provide food for covered fish species in the Delta waterways. • **Objective L2.10:** Restore or create 20 linear miles of transitional intertidal areas including tidal mudflat natural community and patches of subtidal and lower marsh. • **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain. • **Objective L2.12:** Enhance 20 miles of channel margin in the Sacramento River and San Joaquin River systems to provide habitat along important migratory routes for anadromous fish and improve wildlife movement.

Objective L2.1 Rationale: Restoring floodplains helps to achieve this objective by promoting natural seasonal inundation (*CM5 Seasonally Inundated Floodplain Restoration*). Prior to channel straightening, dredging, and levee construction in the Delta, rivers and tributaries flowed and meandered through wide floodplains. Many native species are adapted to periodically flooded riparian habitat (Katibah 1984). The process and pattern of seasonal inundation drives plant succession and vegetation structure in the floodplain, and are especially important in maintaining early seral stage vegetation. Further description of the benefits of this objective is provided in Section 3.3.6.5, *Valley Foothill/Riparian*.

Objective L2.2 Rationale: This objective is intended to allow lateral channel migration in some locations. Lateral channel migration, which occurs when a river channel moves across or within its valley bottom or floodplain, is actively managed against in the Plan Area by riprapping levees and dredging channels. Lateral channel migration is a characteristic process of natural (unmanaged) stream systems, including their seasonally inundated floodplains, and it promotes fluvial processes such as erosion, transport, and deposition of sediments. Lateral channel migration results from erosion of floodplain material along one bank concurrent with deposition of sediment along the other bank. Bank erosion is the primary channel process necessary for channel migration to occur (Leopold et al. 1964). It is also an important aspect of maintaining fish and wildlife habitat mosaics in river-floodplain systems.

Channels that actively migrate have a high diversity of aquatic habitats. A migrating channel may include side channels and/or multiple channels, both of which increase channel complexity, thus contributing to biological diversity, richness, and sustainability of the aquatic ecosystem, and benefiting salmonid rearing habitat. Side channels provide refugia for fish, and while the mainstem river channel is not likely to experience significant cooling as a result of shading from overhanging vegetation, as provided through *CM6 Channel Margin Enhancement*, small pools that form in side channels can benefit from this shading and resultant cooling effect. Additionally, channels that are allowed to freely migrate are better able to accommodate flood flows without excessive erosional events or other flood related damage. *CM5 Seasonally Inundated Floodplain Restoration* describes how floodplains will be restored to provide lateral channel migration.

Objective L2.3 Rationale: This objective is intended to re-establish more connections between Plan Area river reaches and their floodplains, providing a host of ecological benefits. Floodplains provide habitat for rearing, migrating, and adult covered fish species; migratory waterfowl; and terrestrial amphibians, reptiles, and mammals native to the Delta. Seasonally inundated floodplains export phytoplankton and other organic matter to other regions of the Delta (Müller-Solger et al. 2002; Lehman et al. 2008). Also, because inundated portions of floodplains are shallower, have longer residence times, and are generally warmer than the mainstem river, they can have greater rates of phytoplankton production than do the channels of the rivers (Sommer et al. 2004; Lehman et al. 2008). Levee construction, dredging, channel straightening, bank hardening, and water removals for agriculture and export have disconnected river channels from their historical floodplains and resulted in a substantial reduction in the historical extent of active floodplains in the Delta. This has resulted in substantial loss of high-value spawning and rearing habitat for splittail, a decrease in rearing and foraging habitat for juvenile salmonids, a decrease in primary productivity and therefore food availability to planktivorous fishes, and likely a decline in the abundance and distribution of floodplain-associated species, including Sacramento splittail (*Pogonichthys macrolepidotus*) and Chinook salmon (*Oncorhynchus tshawytscha*). Connecting channels to their floodplains is intended to restore some natural fluvial processes and contribute to improved habitat conditions for covered fish species by increasing the extent of suitable habitat conditions such as spawning and rearing habitat, inundated floodplain, transport and deposition of sediments, refugia from high flows, and refugia from potential predators.

Two covered species of plants have also experienced a reduction in abundance and distribution related to the loss of the historical floodplain. Slough thistle is generally found in the portions of channels that flood at high water and on the banks of floodwater conveyance canals and drains (Griggs pers. comm.; Hansen pers. comm.). The reduction in slough thistle occurrence in the Plan Area is likely related to the loss of scour habitat found in and along floodplains. The loss of woody debris and stumps that are typically associated with well-connected floodplain habitat have contributed to reductions in the distribution and abundance of side-flowering skullcap, which grows on decaying wood along channel banks.

Objective L2.4 Rationale: Achieving this objective will minimize water quality impairments related to dissolved oxygen (DO), methylmercury, and stormwater pollution. These three parameters affect covered fish species and other aquatic organisms in the Delta.

As much as 60% of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses, and the depleted flows have contributed to higher water temperatures and lower DO levels. Levels of DO below 5 milligrams per liter have been reported to delay or block migratory movements by fall-run Chinook salmon (Hallock et al. 1970). Low DO levels can also cause physiological stress and mortality of fish, including Chinook salmon and steelhead (Jassby and Van Nieuwenhuyse 2005) and other aquatic organisms (Central Valley Regional Water Quality Control Board 2007).

Adult fish, including covered fish species migrating upstream in the fall and early winter, encounter low DO in the Stockton Deep Water Ship Channel (DWSC) resulting from low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed (Lehman et al. 2004; Jassby and Van Nieuwenhuyse 2005). The DWSC is important for covered fish species such as fall-run Chinook salmon and white sturgeon because it provides the lowest entrainment hazard and most direct route to spawning habitat upstream of Stockton and rearing habitat downstream in the Delta. As described in *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, the Stockton DWSC DWR Aeration Facility (Aeration Facility) has been shown to improve DO conditions and can be used in many circumstances to meet the Basin Plan DO objective and low DO TMDL in the San Joaquin River of 6 milligrams per liter from September 1 through November 30, and 5 milligrams per liter the rest of the year (ICF International 2010). Five milligrams per liter is high enough for salmonids to pass through if total ammonia concentration is low enough (Thurston et al. 1981), but not high enough for them to use as rearing habitat (Pedersen 1987). As mentioned previously, DO levels below 5 milligrams per liter have been reported to delay or block migratory movements by fall-run Chinook salmon (Hallock et al. 1970); thus BDCP, through implementation of *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, is expected to contribute toward meeting the low DO TMDL in the San Joaquin River of 6 milligrams per liter from September 1 through November 30, and 5 milligrams per liter the rest of the year and thus maintain DO levels at levels expected to provide migratory movements of Chinook salmon and potentially white sturgeon. Refer to Section 3.4.12.3, *Adaptive Management and Monitoring*, for specific effectiveness monitoring actions that will be implemented to ensure compliance with DO criteria of the low DO TMDL.

The available data indicate that the Aeration Facility can be used in many circumstances to meet the Basin Plan and TMDL DO objectives and that operating strategies can be developed that will increase the ability of the Aeration Facility to help meet the Basin Plan and TMDL DO objectives in the DWSC more frequently. However, it is not reasonable to expect the Aeration Facility to meet the Basin Plan and TMDL DO objectives in all situations, as the effectiveness of the Aeration Facility is strongly dependent on various factors, including natural DO concentrations in the DWSC, surface reaeration, biochemical oxygen demand concentrations, algal photosynthesis, river flow, and tidal cycle (ICF International 2010). The primary factor is inflow from the San Joaquin River (Lehman et al. 2004; Jassby and Van Nieuwenhuyse 2005), which is not a component of the BDCP.

Implementation of CM14 is expected to achieve the Basin Plan and TMDL DO objectives of 6 milligrams per liter September 1 through November 30 and 5 milligrams per liter the rest of the year. However, should the current aeration facility be unable to achieve full compliance, the potential causes of noncompliance will be evaluated and potential means of achieving full compliance identified. Options that may be considered to achieve the Basin Plan and TMDL DO objectives include, but may not be limited to, adding additional capacity to the existing aeration facility and constructing additional aeration facilities.

Mercury is present in water, sediments, and soils throughout the Delta, having been deposited by tributaries and rivers that drain former mining areas in the mountains. While mercury in its elemental form does not pose a risk to aquatic organisms, exposing soils to periodic wetting and drying results in a process called methylation, which converts mercury to a more toxic form, methylmercury. Restoration actions proposed in *CM4 Tidal Natural Communities Restoration* will increase the acreage of intermittently wetted areas in the Plan Area by converting cultivated lands and other upland areas to tidal, open water, and floodplain habitats, potentially increasing methylmercury production in the Plan Area. Some of this increased production is likely to be taken up by organisms, and bioaccumulated through the foodweb. However, some of it will also be sequestered within the restored natural communities. The risk that mercury and methylmercury pose to covered species is discussed in Appendix 5.D, *Contaminants*. The Implementation Office will monitor restoration-related mobilization of methylmercury and ensure compliance with the load allocations of methylmercury by subarea, within the Plan Area, per Resolution No. R5-2010-0043, as described in *CM12 Methylmercury Management.*

As stormwater runoff flows to the Delta, it accumulates sediment, oil and grease, metals (e.g., copper and lead), pesticides, and other toxic chemicals. Unlike sewage, stormwater is often not treated before discharging to surface water. Despite stormwater regulations limiting discharge volumes and pollutant loads, many pollutants still enter Delta waterways in stormwater. Of particular concern for fish species is the overuse of pesticides, some of which can have deleterious effects on the aquatic food chain (Weston et al. 2005; Teh et al. 2005). Pyrethroid chemicals used as pesticides on suburban lawns are of particular concern and are delivered to the Delta system by runoff. These chemicals at very low concentrations can have lethal effects on low trophic levels of the food chain (plankton), and mainly sublethal effects on covered fish species (Weston and Lydy 2010). Other urban pollutant sources, which can be transported directly or indirectly by stormwater runoff to the Delta, include nutrients from failing septic systems, and viruses and bacteria from agricultural runoff. As described in *CM19 Urban Stormwater Treatment*, the Implementation Office will provide a mechanism for implementing stormwater treatment measures that are intended to result in decreased discharge to the Delta of contaminants derived from urban stormwater, which is intended to improve water quality conditions in the Plan Area to the benefit of covered species. The stormwater treatment measures to be implemented as part of *CM19 Urban Stormwater Treatment* will help the local jurisdictions within the Plan Area achieve compliance with NPDES MS4 Phase I and Phase II permit conditions, which is expected to reduce pollutant loads of point and non-point source effluent discharged within the Plan Area.

Objective L2.5 Rationale: Achieving this objective is intended to provide a diversity of habitats to support the greater expression of life-history diversity. Life-history diversity is an important component of population resiliency (i.e., the ability to recover from disturbance or adapt to changing conditions). In the context of the BDCP, life-history diversity refers to diversity in behaviors between individuals in a population with respect to different life stages (e.g., timing of migration, spawning, and duration of rearing). For example, Chinook salmon often express a diversity of life-history strategies including variations in freshwater and estuarine residency, timing of seaward migration, and timing of and age at spawning (Bottom et al. 2009). Each life-history variant is an alternate pathway by which individuals can complete their life cycles. This life-history diversity, in which all individuals do not behave similarly or occupy the same habitats over time, has been described as an evolutionary strategy for Chinook salmon to spread risk and avoid brood failure in the presence of unpredictable environmental conditions (Bottom et al. 2009). A variety of habitat conditions are necessary for fish populations to express this life-history diversity. Providing a diversity of suitable habitats increases the likelihood that migratory fish species can successfully express life-history diversity. Fish habitat diversity may be achieved through a number of different conservation measures as listed on Table 3.3-1.

Objective L2.6 Rationale: Achieving this objective is intended to increase native species diversity to promote natural community resilience and resistance to disturbances such as drought and flooding.

Additionally, vegetation biodiversity in riparian and other natural communities provides the structural diversity necessary to provide suitable habitat for many wildlife species. Increasing the relative cover of native plant species also reduces potential negative effects of nonnative plants. The importance of native species diversity is further discussed for natural communities in Section 3.3.6, *Natural Communities Biological Goals and Objectives*. This objective is intended to achieve restoration of natural communities with native vegetation as described in *CM3 Natural Communities Protection and Restoration*, and through nonnative plant monitoring and management as described in *CM11 Natural Communities Enhancement and Management*. It is also intended to minimize the introduction and spread of invasive nonnative species as described in *CM13 Invasive Aquatic Vegetation Control* and *CM20 Recreational Users Invasive Species Program*.

Objective L2.7 Rationale: Achieving this objective is intended to restore a dense network of sinuous channels in restored tidal brackish and freshwater marshes to reintroduce some of this historically dominant habitat element in the Delta, and promote the effective tidal exchange throughout the marsh plain that is needed to transport important food resources (plankton, invertebrates, and other organic material) to tidal perennial aquatic fish habitat. This will be implemented through marsh restoration as described in *CM4 Tidal Natural Communities Restoration.*

Objective L2.8 Rationale: Achieving this objective is intended to provide refuge habitats for migrating and resident fish species, refuge habitats include inundated floodplains and localized microhabitats or zones within a channel that provide favorable conditions (e.g., water temperature, depth, or velocity) or other forms of cover that fish use to escape or hide from predators. Natural channel processes and conditions—such as lateral channel migration, connection to the floodplain, groundwater recharge, and presence of riparian vegetation as a source of organic matter—all contribute to the formation of a complex aquatic habitat mosaic, which when coupled with appropriate water quality provides a variety of fish refugia in river systems (Sedell et al. 1990; Peterson 2003). This objective is intended to be achieved through implementation of *CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement,* and *CM7 Riparian Natural Community Restoration*.

Objective L2.9 Rationale: Achieving this objective is intended to enhance the production and export of phytoplankton and zooplankton from tidal channels into adjacent Delta waterways in support of the aquatic foodweb. Loss of intertidal communities and riparian vegetation in the Delta has probably greatly reduced the production of food resources for fish leaving the system with only an open-water foodweb that is highly regulated by nonnative clams. Habitat restoration with effective tidal exchange (*CM4 Tidal Natural Communities Restoration*) is expected to enhance food production. Restoration of riparian vegetation along channel margins and in floodplains (*CM6 Channel Margin Enhancement* and *CM5 Seasonally Inundated Floodplain Restoration*) and seasonal inundation in the Yolo Bypass (*CM2 Yolo Bypass Fisheries Enhancement*) are expected to provide similar benefits on a seasonal basis.

Objective L2.10 Rationale: Achieving this objective will ensure that tidal restoration (*CM4 Tidal Natural Communities Restoration*) includes transitional intertidal areas including tidal mudflat natural community and patches of subtidal and lower marsh. This transitional tidal area typically occurs as a linear fringe and is the area where tidal marsh is most subject to the influence of marine or estuarine conditions, as it is flooded daily. This is, therefore, where fish and other aquatic organisms will most frequently interface with the marsh edge and have access to organic material associated with marsh vegetation. This intertidal zone is also where sediment deposition is most likely to occur and result in formation of tidal mudflats (See Section 3.3.6.2, *Tidal Mudflat*, for a description of the ecological benefits of the tidal mudflat natural community.) Lower marsh supports a unique assemblage of plant species adapted to highly saline conditions, including Mason's lilaeopsis and Suisun marsh aster.

Objective L2.11 Rationale: Achieving this objective will provide 10,000 acres of restored seasonally inundated floodplains. This will be achieved through construction of setback levees along rivers, as described in *CM5 Seasonally Inundated Floodplain Restoration.* The benefits of that restoration are described above in the rationale for Objectives L2.2 and L2.3.

Objective L2.12 Rationale: Achieving this objective will result in 20 miles of enhanced channel margin in the Sacramento and San Joaquin River systems that will provide shallow-water rearing habitat along important migratory routes for covered fish species. The anticipated benefits of channel margin enhancement include provision of delta and longfin smelt spawning habitat, improvement of habitat connectivity, and improvement of salmonid, splittail, and perhaps sturgeon rearing habitat. These benefits are detailed in the following paragraphs.

Channel margin enhancement might generate spawning habitat for delta and longfin smelt. There is limited certainty in this outcome, because spawning activity for delta smelt has only been observed in captivity and longfin spawning activity in the Delta has not been documented. Channel margins or small streams may be used by delta smelt in freshwater systems (Nobriga and Herbold 2009), given that the substrate is suitable (i.e., sand or gravel). The exact location of longfin smelt spawning sites is not well-understood in the estuary, but longfin smelt eggs, like delta smelt eggs, are adhesive and are probably deposited on sandy substrates (Rosenfield 2010). Longfin smelt are believed to spawn in or near the mixing zone between fresh and brackish water in the estuary, and while juvenile and subadult longfin smelt aggregate in deep water, it is not clear that spawning occurs in deep-water habitats (Rosenfield 2010). It may be that gravid adult longfin smelt aggregate in deep water and spawn in shallow water. Thus, while speculative, channel margin enhancement may, depending upon its location, increase spawning habitat for delta smelt and longfin smelt, as well as increase the amount of shallow-water refugia along steeply banked and riprapped Delta channels in the Plan Area.

Channel margin enhancement is also expected to improve connectivity along primary channels. This is particularly valuable for reaches that currently have low habitat value for covered fishes and are heavily used by migrating adult and juvenile covered fish species as well as rearing fish—for example, the Sacramento River between Freeport and Georgiana Slough. Enhancing channel margins in the vicinity of the proposed north Delta intakes (upstream, between the intakes, and downstream) would provide resting spots and refuge for fish moving through this reach.

Primary Delta channels serve as migration corridors for the covered fish species and provide salmonid, sturgeon, and splittail rearing habitat. Chinook salmon and sturgeon use channel margin habitat along these corridors for rearing and protection from predators. Vegetation along channel margins can contribute woody material, both instream and on channel banks, which can increase instream cover for fish, provide a substrate for growth of benthic organisms that juvenile salmon feed upon, and also enhance habitat for western pond turtle.

Channel margin enhancement is expected to increase rearing habitat for Chinook salmon fry in particular, through enhancement and creation of additional shallow-water habitat intended to provide foraging opportunities and refuge from unfavorable hydraulic conditions and predation. Benefits for Chinook salmon and steelhead smolts may be somewhat less than for Chinook salmon fry, as smolts use channel margin habitats less frequently than fry. However, enhanced channel margins are expected to facilitate safe downstream migration by increasing the habitat complexity that is needed for both smolts and fry to escape predators. Rearing habitat for Sacramento splittail is also expected to increase through channel margin enhancement (Feyrer et al. 2005). Conversely, Delta smelt and longfin smelt are not expected to experience measurable increases in rearing habitat due to channel margin enhancement, because monitoring suggests that these species tend to occupy areas away from shore and are largely found downstream of the main channels proposed for channel margin enhancement. The DRERIP evaluations suggested that there may be some rearing benefit for green and white sturgeon from channel margin enhancement (Israel and Klimley 2008 and Israel et al. 2009). Little is known about use of channel margin habitat by Pacific lamprey and river lamprey; however, these species may benefit from enhancement that increases the area of nonrevetted substrate into which ammocoetes can burrow.

Spawning habitat for Sacramento splittail may increase through enhancement of channel margins. This would be derived chiefly from an increase in the extent of inundated vegetation to which the splittail's eggs may adhere. This function may be particularly important in drier years when inundated floodplains may not be available or may be reduced in terms of extent or duration of inundation, but enhanced channel margins are inundated and may be used by splittail for spawning (Moyle et al. 2004). Any channel margin enhancements that increase the area of low-slope, sandy substrate may also provide increases in delta smelt and longfin smelt spawning habitat; however, at present the spawning distribution of these species is mostly found downstream and west of the main channels where the emphasis of channel margin enhancement is likely to be placed (e.g., Sacramento River from Freeport to Georgiana Slough, Steamboat and Sutter Sloughs, the lower Mokelumne River, and the San Joaquin River from Vernalis to Mossdale). The remaining covered fish species spawn upstream of the Plan Area; therefore, no increase in spawning habitat is anticipated for these species as a result of channel margin enhancement.

3.3.5.3 Fish and Wildlife Movement

Goal L3 and its associated objectives address protection of fish and wildlife movement within the reserve system. This goal is met for wildlife through acquisition of lands to assemble an interconnected reserve system (*CM3 Natural Communities Protection and Restoration*) and through enhancement of acquired lands to increase the ability for wildlife to move through these areas (*CM11 Natural Communities Enhancement and Management*). This goal is met for covered fish through *CM1 Water Facilities and Operation*, which is intended to improve conditions for covered species and natural communities, while improving water supply; by addressing known fish passage impediments in the Plan Area (*CM2 Yolo Bypass Fisheries Enhancement* and *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*); and by restoring connectivity between aquatic habitats that provide suitable habitat for various life stages of covered fish species (*CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement*). Landscape linkages to provide fish and wildlife habitat connectivity and facilitate movement are described in Section 3.2.5, *Landscape Linkages*.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area. • **Objective L3.2:** Promote connectivity between low-salinity zone habitats and upstream freshwater habitats, and availability of spawning habitats for covered fish species. • **Objective L3.3:** Provide flows that support the movement juvenile life stages of covered fish species to downstream rearing habitats. • **Objective L3.4:** Provide flows that support the movement of adult life stages of native fish species to natal spawning habitats.

Objective L3.1 Rationale: This objective is intended to protect the large, interconnected blocks of habitat required by relatively wide-ranging species such as San Joaquin kit fox. Movement by such species is impaired by barriers such as some fences or roads. The dispersal and local movements of California tiger salamander and other amphibians can be impeded by dense grasses and lack of burrows, soil cracks, or other refugia. Achieving this objective will contribute to the establishment of linkages between reserves within and adjacent to the Plan Area, consistent with Section 2820(a)(4)(B) of the NCCPA. It is also intended to sustain effective movement and interchange of organisms between habitat areas to maintain ecological integrity of habitat within the Plan Area, consistent with Section 2820(a)(4)(E) of the NCCPA. Habitat linkages for covered wildlife species will be protected as described in *CM3 Natural Communities Protection and Restoration*, and linkages will be improved and maintained through management measures as described in *CM11 Natural Communities Enhancement and Management.*

Objective L3.2 Rationale: Achieving this objective will increase connectivity between freshwater spawning habitat and low-salinity zone rearing habitat to benefit covered fish species. Anadromous salmonid juveniles are expected to benefit from having a large area of connected habitat along an extended salinity gradient within which to forage and find refuge while rearing and undergoing smoltification (adaptation to the saltwater environment). To a lesser degree, sturgeons and lampreys are also expected to benefit from habitat connectivity within the estuarine environment, and an extended salinity gradient within which they can simply adapt to transitions between oceanic and freshwater environments. Achieving this objective is intended to contribute to sustaining the effective movement and interchange of organisms between habitat areas to maintain ecological integrity of habitat within the Plan Area, consistent with Section 2820(a)(4)(E) of the NCCPA. Habitat connectivity in these areas is supported by *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement,* and *CM7 Riparian Natural Community Restoration*, while salinity gradients are subject to modification through *CM1 Water Facilities and Operation.*

Objective L3.3 Rationale: Achieving this objective will support the movement of juvenile fish life stages to suitable downstream foraging areas, and thus increase their survival. Juvenile salmonids and sturgeons benefit from access to a variety of habitats suitable for refuge and foraging during their downriver migration and estuarine rearing periods. Achieving this objective is intended to contribute to sustaining the effective movement and interchange of organisms between habitat areas in the Plan Area, consistent with Section 2820(a)(4)(E) of the NCCPA. Movements of juvenile covered fish species will be influenced through *CM1 Water Facilities and Operation,* while habitats along the migration route are expected to be protected or restored through *CM3 Natural Communities Protection and Restoration, CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated*

Floodplain Restoration, CM6 Channel Margin Enhancement, and *CM7 Riparian Natural Community Restoration.*

Objective L3.4 Rationale: Achieving this objective will support the movement of adult fish to and from spawning habitats. Achieving this objective is intended to contribute to sustaining effective movement and interchange of organisms between habitat areas to maintain ecological integrity of habitat within the Plan Area, consistent with Section 2820(a)(4)(E) of the NCCPA. A number of covered fish species, including Chinook salmon, steelhead, delta smelt, longfin smelt, sturgeon, lamprey, and splittail, use hydrodynamic cues (e.g., channel flow direction and magnitude) to help guide movement through the Delta. Reverse flows in rivers and channels associated with operation of the SWP and CVP are thought to contribute to false attraction to migration cues for returning Chinook salmon and longer migration routes that may expose these fish to increased stress from migrating through the interior Delta. Operations of the Delta Cross Channel may redirect postspawn green sturgeon into the interior Delta, which may delay migrations and expose fish to adverse conditions (Israel and Klimley 2008). Adult white sturgeon may be delayed in reaching spawning grounds in the early winter due to misleading water flows through the south and central Delta, and fish headed up the San Joaquin River may be confused due to the shifted Sacramento River flows entering the south Delta via the Delta Cross Channel (Israel et al. 2009). Low Delta outlfows during the longfin smelt spawning period may cause sexually mature adults to spawn further upstream than they would if outflow rates were high, which may place larvae (and spawning adults) at greater risk of entrainment at the south Delta export pumps by shifting spawning locations eastward (Rosenfield 2010). Winter entrainment of migrating adult delta smelt commonly occurs during early wet season rain events that generate abrupt increases in river flow and turbidity. Such increases in inflow also trigger increased export pumping at the SWP/CVP facilities, historically producing reverse flows in Old and Middle Rivers (Nobriga and Herbold 2009). North Delta diversions (*CM1 Water Facilities and Operation*) will reduce the need to export water at the south Delta diversion facilities, which is expected to reduce the occurrence of reverse flows in the Plan Area.

3.3.5.4 Increasing Habitat Suitability for Covered Fish Species

Goal L4 and its associated objectives address improved habitat suitability for covered fish species in the reserve system. Objectives for this goal focus on two widely recognized stressors affecting the covered fish species: predation and entrainment. Both are anthropogenic stressors, predation risk having been greatly increased by the introduction of nonnative fishes, and entrainment risk having been created by the installation of thousands of diversions that use Delta waters for a wide variety of purposes including agriculture, industry, municipal water supply, and wetlands management.

Goal L4: Increased habitat suitability for covered fish species in the Plan Area.
• **Objective L4.1:** Manage the distribution and abundance of nonnative predators in the Delta to reduce predation on covered fishes. • **Objective L4.2:** Manage the distribution of covered fish species to minimize movements into areas of high predation risk in the Delta. • **Objective L4.3:** Reduce entrainment losses of covered fish species.

Objectives L4.1 and L4.2 Rationale: These objectives are intended to address predation by nonnative species to reduce effects on covered fishes. Although a natural part of the estuarine ecosystem, predation in the Delta has been identified as a stressor to covered fish species (Essex Partnership 2009). Naturally occurring predation rates often cannot be sustained by fish and wildlife whose habitats have been greatly simplified and fragmented. Habitat for fish predators generally provides a specific suite of attributes that allow them to forage more efficiently, such as dark locations adjacent to light locations or deep pools that allow the predator to hide and ambush their prey from below; however, different predators each have their niche, so most habitats have some kind of predator that can take advantage of elevated prey vulnerability. Most of the Delta contains physical attributes that provide predatory fish an advantage over covered fish species. The key examples are extensive steeply banked and riprapped channels and large beds of Brazilian waterweed (*Egeria densa*) and similar invasive submerged aquatic vegetation (SAV) that have overgrown many of the remnant shallow areas (Santos et al. 2011).

Fish predators tend to be attracted to instream structures (Gingras 1997), and new diversion structures in the Sacramento River may attract predators (Essex Partnership 2009). Striped bass, for example, have been shown to aggregate around instream structures in the Sacramento River from Red Bluff to the Delta. New intake structures in the Sacramento River may create a local hydraulic discontinuity that may provide ambush sites for striped bass. If this occurs, predation rates on Chinook salmon, steelhead, white sturgeon, and Sacramento splittail may increase as a result of installing intake structures and other instream structures (Essex Partnership 2009). To offset these effects and provide for the conservation and management of covered fishes in the Plan Area, localized predator reduction measures will be implemented at predator "hotspots" (holding habitat where predators are known to occur in relatively large numbers) in the Delta, as described in *CM15 Localized Reduction of Predatory Fishes.* This is expected to reduce local predator abundance, thus reducing localized predation-related mortality of Chinook salmon (Temple et al. 1998; Lindley and Mohr 2003), steelhead (Temple et al. 1998), Sacramento splittail (Moyle et al. 2004), delta smelt (Stevens 1966; Thomas 1967; Moyle 2002), and possibly longfin smelt (Nowak et al. 2004), green sturgeon, and white sturgeon. The distribution of covered fish species will also be managed to minimize fish movement into portions of the Plan Area with high predation risk or areas that are otherwise known to have reduced survival, and to encourage covered fish species to use migration routes and portions of the Plan Area known or expected to contribute to increased survival (*CM1 Water Facilities and Operation*, *CM2 Yolo Bypass Fisheries Enhancement*, and *CM16 Nonphysical Fish Barriers*). As these conditions are addressed and improve through implementation of the BDCP, management of the distribution of covered fish may become unnecessary, and thus may be an interim strategy.

Objective L4.3 Rationale: This objective is intended to reduce fish mortality caused by entrainment. Water diverted directly from the south Delta through the CVP/SWP facilities creates an artificial net north-to-south water flow through the Delta, compared to the net east-to-west flow pattern that prevailed prior to the development of the south Delta diversion facilities. This has resulted in reverse flows in some major Delta channels, which contribute to entrainment of covered fish species. Existing diversion facilities are equipped with louvers that guide juvenile and adult fish into salvage facilities, and salvaged fish are subsequently released in the lower Sacramento and San Joaquin Rivers. However, salvage of planktonic eggs, larvae, and small juveniles and small adult fish is not efficient or effective and these smaller fish/life stages often do not survive when transported to release sites. Fish mortality as a result of these factors is expected to be reduced as described in *CM1 Water Facilities and Operation.* There are also thousands of nonproject diversions in the Delta, the majority of which are small unscreened diversions serving small users with agricultural and wetland lands. These uses are detailed in *CM21 Nonproject Diversions*, which supports progressive remediation of a large fraction of these diversions. Also, many small nonproject diversions would become unnecessary and would be closed as the affected lands are incorporated into the reserve system. This gradual removal of nonproject diversions will reduce covered fish species mortality from various causes including entrainment, impingement, and predation associated with predator congregation near intakes.

3.3.6 Natural Community Biological Goals and Objectives

Natural community goals and objectives are outlined below. Applicable landscape-scale goals and objectives are listed, followed by a description of the benefits to the natural community that would result from achieving each objective. Natural community goals and objectives are then listed, followed by a description of the rationale for establishing each objective. Conservation measures designed to meet all objectives are found in Section 3.4, *Conservation Measures*. The extent of conserved natural communities expected with full implementation of the BDCP is shown in Table 3.3-2.

3.3.6.1 Tidal Perennial Aquatic

Tidal perennial aquatic natural community includes both deep and shallow tidal aquatic environments, with deep habitat occurring below the −10-foot elevation relative to mean lower low water (i.e., the mean of the lowest of the low tides in a day) and shallow habitat occurring below the mean lower low water elevation (CALFED Bay-Delta Program 2000). The tidal perennial aquatic natural community is largely unvegetated; however, where vegetation exists, it is either rooted and frequently submerged or unrooted and floating. SAV includes native water primrose and eelgrass. See Section 2.3.4.1, *Tidal Perennial Aquatic*, for more detail on the current state of the tidal perennial aquatic natural community.

The tidal perennial aquatic community occurs throughout the Plan Area in all conservation zones (Figure 3.2-3). In the historical Delta, prior to anthropogenic modification, tidal processes played an important role in forming and maintaining an expansive, complex mosaic of marshes with dendritic tidal channels, sloughs, and lakes (Whipple 2010). Currently, much of the tidal perennial aquatic natural community in the Plan Area exists in the form of channelized waterways with little or no connection to other tidal natural communities (e.g., tidal mudflat, tidal freshwater emergent wetland). Under current water operation conditions in the Plan Area, the tidal perennial aquatic natural community is predominantly fresh water, with brackish conditions occurring in Suisun Bay and extending upstream of the confluence zone of the Sacramento and San Joaquin Rivers at times of high tides and low river flows. The natural community occurs as large, open water bodies such as the Suisun Bay, flooded Delta Islands such as Franks Tract and Liberty Island, reservoirs such as Clifton Court Forebay, perennial water courses such as the Sacramento, San Joaquin, and Mokelumne Rivers, and also as smaller open-water areas in the many distributaries, sloughs, and channels of the Plan Area.

Table 3.3-2. Expected Extent of Conserved Natural Communities in Plan Area with BDCP Implementation

	Existing Conditions		BDCP Implementation[1]		
	Total Extent	Total Unprotected[2]	Protected by BDCP	Restored by BDCP	Total Conserved by BDCP (BDCP Protected + Restored)
Tidal perennial aquatic	86,263	45,003	0	N/A[3]	N/A
Tidal mudflat[4]	N/A	N/A	N/A	N/A	N/A
Tidal brackish emergent wetland	8,501	122	0	6,000[3]	6,000
Tidal freshwater emergent wetland	8,856	3,929	0	24,000[3]	24,000
Tidal wetland of any type or transitional upland to accommodate sea level rise	N/A	N/A	N/A	35,000	35,000
Valley/foothill riparian	17,644	12,136	750	5,000	5,750
Nontidal freshwater perennial emergent wetland/nontidal perennial aquatic[5]	6,874	4,796	50[6]	1,200	1,250
Alkali seasonal wetland complex	3,723	813	150	Approx. 72[7]	Approx. 222
Vernal pool complex	11,284	4,992	600	Approx. 67[8]	Approx. 667
Managed wetlands	70,698	5,714	8,100	500[9]	8,600
Other natural seasonal wetland	276	50	0	0	0
Grassland	76,315	55,499	8,000	2,000	10,000
Inland dune scrub	19	6	0	0	0
Cultivated lands	481,909	419,968	48,625	0	48,625
Additional natural communities to provide giant garter snake habitat[10]	N/A	N/A	N/A	N/A	3,000
Total	772,364	553,028	66,275	73,839[11]	142,225

	Existing Conditions			BDCP Implementation[1]		
	Total Extent	Total Unprotected[2]		Protected by BDCP	Restored by BDCP	Total Conserved by BDCP (BDCP Protected + Restored)

1 Only natural community protection and restoration are factored into this table. The net conservation achieved through the BDCP (factoring in natural protection, restoration, and loss) is provided in Table 5.4-3, *Net Effects of BDCP Implementation on Natural Communities*, in Chapter 5, *Effects Analysis*.

2 Unprotected is defined as areas that are not currently protected and managed for species benefit and are therefore available for protection through the BDCP.

3 These acres are minimum restoration commitments for each natural community. Tidal restoration will total 65,000 acres, including adjacent upland areas that could be inundated with sea level rise. To meet the 65,000-acre commitment, acreage in excess of these minimums may be restored. There is no minimum commitment for tidal perennial aquatic natural community.

4 Tidal mudflats are not delineated in the BDCP land cover type GIS database, but are subsumed in acreages shown for tidal communities.

5 Up to an additional 1,540 acres may be restored to meet the "rice or equivalent" objective for giant garter snake (Objective GGS1.4), if that requirement cannot be met through a combination of tidal marsh restoration and rice protection.

6 This is a commitment under a species-specific objective for tricolored blackbird (Objective TRBL1.1), not under natural community objectives.

7 Sufficient alkali seasonal wetland will be restored to provide no net loss of wetted alkali seasonal wetland acres.

8 Sufficient vernal pool complex will be restored to achieve no net loss of vernal pool wetted acres.

9 This is a commitment under a species-specific objectives for greater sandhill crane (Objectives GSHC1.3 and 1.4), not under natural community objectives.

10 There is a requirement for 4,240 acres of giant garter snake habitat consisting of rice land or equivalent-value habitat under Objectives GGS1.4 (1,500 acres) and GGS3.1 (2,740 acres). The 4,240 acres may consist of protected or restored rice land, nontidal marsh, muted tidal marsh, or adjacent uplands. Up to 1,415 acres (one-third) of the 4,240 acres may consist of uplands, up to 1,500 acres may consist of muted tidal marsh in the Cosumnes/Mokelumne ROA, up to 500 acres may consist of muted tidal marsh in the Cache Slough ROA, and up to 1,700 acres may consist of rice land in the Yolo Bypass. The remainder must consist of rice land or nontidal marsh outside the Yolo Bypass, in Conservation Zones 1, 2, 4, and/or 5. The 4,240 acres are based on an assumption that 1,250 acres overlap with other objective requirements (i.e., 1,250 acres of tidal marsh restoration, which is a subset of the 24,000-acre restoration minimum for tidal freshwater emergent wetlands). This was rounded to the nearest hundred for 3,000 acres.

11 10,000 acres of seasonally inundated floodplain restoration are not counted in this table because (1) it is not a natural community; and (2) it overlaps with restoration of riparian and other natural communities, therefore adding this acreage to the total would be double counting.

The tidal perennial aquatic natural community in the Delta has been substantially reduced through channelization and levee construction, which has modified tidal flows and tidal influence throughout the Delta. Most of this reduction in the tidal perennial aquatic natural community resulted from the construction of a system of levees built to reclaim wetlands for agricultural uses beginning with the passage of the Swamp Land Act of 1850. Introduction of nonnative aquatic predators and invasive aquatic plant species, such as *Egeria* and Eurasian watermilfoil (*Myriophyllum spicatum*) that provide habitat for nonnative predators, have reduced this community's function as habitat for native fish. Contaminants have also reduced the water quality function of the tidal aquatic natural community in the Delta. For example, pyrethroid insecticides in the Delta may be associated with tissue abnormalities found in delta smelt and striped bass (U.S. Environmental Protection Agency 2011). Additionally, mercury from historical gold mining activities in the Sierra Nevada foothills has been transported via streams and rivers to the Delta, where it occurs in the sediment and becomes toxic when periodic drying and flooding activate a process that converts the mercury to methylmercury.

The tidal perennial aquatic natural community supports a diverse community of invertebrates and microorganisms (e.g., phytoplankton and zooplankton), which supports the aquatic foodweb. This foodweb supports a diverse fish community of over 50 species of fish, approximately 50% of which are native. It is used by covered fish species for foraging, spawning, egg incubation and larval development, juvenile rearing, and migratory corridors. In addition to its value as habitat for fish, the tidal perennial aquatic natural community provides reproduction, feeding, and resting habitat for many species of wildlife. The tidal perennial aquatic natural community is used by shorebirds, wading birds, and waterfowl for foraging, resting, and escape cover. Also, the community borders tidal marsh communities and contains structural elements such as woody debris that serve as basking sites for giant garter snakes and western pond turtles.

The conservation approach for the tidal perennial aquatic community is to restore this natural community in the Plan Area, and manage it to benefit covered species and native aquatic vertebrates and maintain or increase native biodiversity.

The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.1.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the tidal perennial aquatic natural community are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objective L1.4 Benefits: Achieving this objective will provide elevation gradients within the reserve system, thus providing the opportunity for the tidal perennial aquatic natural community to expand as sea level rises with climate change. This objective will be achieved through land protection as described in *CM3 Natural Communities Protection and Restoration.*

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species

- **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system.
- **Objective L2.6:** Increase native species diversity and relative cover of native plant species and reduce the introduction and proliferation of nonnative species.
- **Objective L2.7:** Produce sinuous, high-density, dendritic networks through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.
- **Objective L2.9:** Increase the abundance and productivity of plankton and invertebrate species that provide food for covered fish species in the Delta waterways.

Objective L2.4 Benefits: Achieving this objective will address the primary water quality issues of DO and methylmercury. These two factors affect covered fish species and other aquatic organisms in the Delta. The rationale provided in Section 3.3.5, *Landscape-Scale Biological Goals and Objectives*, includes additional detail regarding the benefits of this objective to the tidal perennial aquatic natural community.

Objective L2.6 Benefits: Achieving this objective will promote species diversity and thus contribute to natural community resilience and resistance to disturbances. This objective will also minimize the introduction and spread of invasive aquatic species such as invasive SAV, the Asian clam (*Corbicula fluminea*), the overbite clam (*Potamocorbula amurensis*), quagga mussel (*Dreissena bugensis*), and zebra mussel (*Dreissena polymorpha*), as described in *CM13 Invasive Aquatic Vegetation Control* and *CM20 Recreational Users Invasive Species Program.* The rationale provided in Section 3.3.5, *Landscape-Scale Biological Goals and Objectives*, includes additional detail regarding the benefits of this objective to the tidal perennial aquatic natural community.

Objective L2.7 Benefits: Achieving this objective will result in a dense network of sinuous channels in tidal brackish and freshwater marsh, which will promote effective tidal exchange throughout the marsh plain, transporting important food resources (plankton, invertebrates, and other organic material) to the tidal perennial aquatic natural community. This will be implemented through marsh restoration as described in *CM4 Tidal Natural Communities Restoration.*

Objective L2.9 Benefits: Achieving this objective will enhance the aquatic habitat functions of tidal perennial aquatic natural community by increasing food abundance and productivity for aquatic species. This objective will be achieved through promoting effective tidal exchange (*CM4 Tidal Natural Communities Restoration*), restoring vegetation adjacent to waterways for organic input (*CM6 Channel Margin Enhancement* and *CM7 Riparian Natural Community Restoration*) and promoting fluvial conditions that flush organic matter into tidal aquatic areas (*CM5 Seasonally Inundated Floodplain Restoration* and *CM2 Yolo Bypass Fisheries Enhancement*).

3.3.6.1.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the tidal perennial aquatic natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Rationale: Achieving this objective will provide aquatic species habitat conducive to primary productivity, which is essential to maintaining a robust food base for covered fish species. Restoring tidal perennial aquatic habitat adjacent to open water habitats occupied by covered fish species will increase the amount of habitat contributing to primary productivity and food resources important to covered fish species, such as calanoid copepods. These food resources may be transported from restored or created tidal perennial aquatic natural community to adjacent open-water habitats occupied by covered fish species such as delta smelt.

Of the Delta habitats, the tidal marsh sloughs have the highest particulate organic matter and phytoplankton concentrations and support the greatest zooplankton growth rates (Müller-Solger et al. 2002; Sobczak et al. 2002). Tidal perennial aquatic restoration in the Cache Slough ROA at the southern end of the Yolo Bypass, in combination with floodplain enhancement, is expected to provide tidal freshwater wetland structure and functions adjacent to open-water habitat occupied by covered fish species. Tidal wetlands also have the capacity to export food resources to adjacent channels and to downstream systems (Cloern et al. 2007; Lehman et al. 2008). The export of food may include movement of phytoplankton and zooplankton by advection and tidal exchanges as well as the export of productivity in the form of macroinvertebrates, small fishes, and other larger organisms (Kneib 1997, 2003).

Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.
• **Objective TPANC2.1:** Control invasive aquatic vegetation that adversely affects native fish habitat.

Objective TPANC2.1 Rationale: This objective will address the nonnative plant species that limit turbidity in the Delta, which has decreased over time (Jassby et al. 2002). It is hypothesized that one of the primary causes of the decrease in turbidity is biological filtration by SAV (Brown and Michniuk 2007). Controlling invasive plants, especially invasive SAV, is anticipated to result in some degree of increased turbidity. Some covered fish species, such as delta and longfin smelt, have evolved in turbid waters and have adapted to life in turbid waters to avoid predators and to successfully forage on prey organisms, so increases in turbidity are expected to improve survival and growth for these species.

3.3.6.2 Tidal Mudflat

The tidal mudflat natural community generally consists of bare, unvegetated areas of mud substrate and typically occupies a narrow transition zone in the intertidal zone of various natural communities in the Plan Area. Tidal mudflats typically consist of exposed mud during low tide and shallow aquatic areas during high tide. Tidal mudflat occurs in areas of disturbance or sediment deposition associated with various intertidal elevations of tidal brackish and tidal freshwater emergent wetlands, and with the upper elevations of the tidal perennial aquatic natural community. To a lesser degree, it also occupies microhabitats in areas of sediment deposition along natural and artificial levees in the valley/foothill riparian natural community, and seasonal floodplain and channel margin natural communities. Tidal mudflat often shifts in distribution over time and is sustained through disturbances to other nearby communities or through the deposition of mineral soil within the intertidal zone.

The extent of tidal mudflat has been substantially reduced in the Plan Area with the construction of levees and dikes, the channelization of waterways, and the conversion of tidal marshes to cultivation and other land uses. As of 1998, tidal mudflats in the Bay-Delta area had declined to approximately 58% of the historical extent present in 1800 (San Francisco Estuary Institute 1998). This reduction in the extent of tidal mudflat has reduced the availability of foraging habitat that supports shorebird migrations along the Pacific Flyway and has reduced the extent of silt substrate at the interface of tidal perennial aquatic and tidal emergent wetland that supports habitat for covered species. See Section 2.3.4.2, *Tidal Mudflat*, in Chapter 2, *Existing Ecological Conditions*, for more detail on the current state of this natural community.

While mudflats are no longer being filled for diking or development, their extent is likely to continue shrinking due to the absence of sediment influx from upstream and continued shoreline erosion from wave action, primarily during storms. Most major rivers upstream have been dammed, trapping sediment behind upstream reservoirs (The Bay Institute 2004). Sea level rise resulting from climate change is also likely to diminish tidal mudflats (The Bay Institute 2004).

When exposed at low tide, lower elevation tidal mudflats serve as important foraging habitat for a wide variety of shorebirds, both resident and migratory, which consume the crustaceans, bivalves, gastropods, aquatic insects, and polychaetes. When covered at high tide, these same areas serve as shallow open-water habitat for several covered pelagic fish species, including splittail, salmonids, delta smelt, and sturgeon. These species use the area as a shallow-water refuge from predators and also to forage on benthic invertebrates. Tidal mudflats also provide an important source of sediment for restoration of subsided tidal marshes (The Bay Institute 2004). At the microhabitat level, mudflats along river channels provide important habitat for covered plant species, including Mason's lilaeopsis, delta mudwort, Delta tule pea, and Suisun Marsh aster.

The conservation approach for this natural community relies primarily on landscape-scale objectives related to tidal restoration, floodplain restoration, and channel margin enhancement. The establishment of tidal communities along an elevation gradient and tidal and fluvial processes that result in sediment transport and deposition, in addition to invasive plant control, are expected to promote and maintain this natural community in the Plan Area. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.2.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the tidal mudflat natural community are included below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.
- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objectives L1.3 and L1.4 Benefits: Tidal restoration along an elevation gradient consistent with these objectives will result in a range of intertidal zones, within which tidal mudflat is expected to develop between shallow subtidal aquatic areas and emergent marsh plains.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.

- **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances.
- **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.
- **Objective L2.10:** Restore or create 20 linear miles of transitional intertidal areas including tidal mudflat natural community and patches of subtidal and lower marsh.

Objective L2.1 Benefits: Achieving this objective as described in *CM5 Seasonally Inundated Floodplain Restoration* and *CM6 Channel Margin Enhancement* is expected to promote development of the types of mudflats that occur adjacent to riparian natural communities along channel margins. These mudflats develop as a result of fluvial processes and sediment deposition, and provide substrate that supports covered plant species including delta mudwort, Delta tule pea, Mason's lilaeopsis and Suisun Marsh aster. Furthermore, fluvial processes are instrumental in the production of tidal mudflat through sediment transport to intertidal areas.

Objective L2.6 Benefits: Nonnative invasive plants can encroach into tidal mudflats and thereby diminish the extent of this natural community. Invasive plants will be managed as needed to protect tidal mudflats, as described in *CM11 Natural Communities Enhancement and Management.*

Objective L2.10 Benefits: Tidal mudflat is expected to develop along the narrow transition zone between the tidal perennial aquatic natural community and the brackish and freshwater tidal emergent wetland natural communities. Consistent with this objective and as described in *CM4 Tidal Natural Communities Restoration*, tidal restoration will include the restoration of 20 linear miles of transitional intertidal area, of which tidal mudflat will be a component.

3.3.6.2.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of the tidal mudflat natural community in the Plan Area. Tidal restoration will result in an estimated 932-acre increase in this natural community in the Plan Area (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*). Additional goals and objectives are not necessary for this natural community.

3.3.6.3 Tidal Brackish Emergent Wetland

The tidal brackish emergent wetland natural community is a transitional community between the tidal perennial aquatic natural community and terrestrial upland natural communities; it can also exist as isolated patches on islands (e.g., islands within Suisun Bay). In the Plan Area, tidal brackish emergent wetland natural community is located in Suisun Marsh and along the shore and on islands in the saltwater/freshwater mixing zone that extends from near Collinsville westward to the Carquinez Strait (Figure 3.2-4). However, despite its large potential extent, most tidal brackish emergent wetland is present in undiked areas of Suisun Marsh, such as Rush Ranch and Hill Slough. Smaller patches also occur along undiked shorelines on the north shore of Suisun Bay, and on undiked in-channel islands such as Brown's Island. See Section 2.3.4.3, *Tidal Brackish Emergent Wetland,* for more detail on the current state of this natural community.

The tidal brackish emergent wetland community is characterized by three transition zones: high, middle, and low marsh. The high marsh has been defined as the area from approximately mean higher high water to extreme high water (Josselyn 1983), and is dominated by saline-tolerant pickleweed and saltgrass. Fat hen and alkali heath are important community components. The middle marsh has been defined as the region from approximately mean high water to mean higher high water (Josselyn 1983). Here, pickleweed and saltgrass codominate with American bulrush, and there is an increase in other species of rushes as well. Because of daily tidal flushing, soil salinity is not as high in this zone as in the high marsh. The low marsh occurs from approximately the mean lower high water to mean high water (Josselyn 1983). Low, brackish tidal marsh vegetation typically is dominated by emergent plants tolerant of extended periods of tidal submergence, such as native cordgrass, hardstem bulrush, and California bulrush. These plants tend to occur in large, monospecific stands.

Substantial reductions in the extent, distribution, and condition of the historical tidal brackish emergent wetland natural community in Suisun Marsh have reduced the extent and diversity of this natural community for associated covered and other native species. Prior to extensive anthropogenic modifications of Suisun Marsh that included dike building and drainage, the tidal brackish emergent wetland natural community comprised an estimated 69,000 acres of what was the largest tidal brackish water marsh complex in the western United States (Boul and Keeler-Wolf 2008). Today, only 8,501 acres (12%) remain; of this, 8,380 acres (99%) are currently under protected status. The biodiversity in the tidal brackish emergent wetland community is high, because it represents a convergence of salt- and freshwater-tolerant species, and Suisun Marsh is the largest contiguous brackish marsh on the west coast of North America. Several species of plants and wildlife are endemic to this community, including the salt marsh harvest mouse, Suisun shrew, Suisun song sparrow, and Mason's lilaeopsis. Other species occurring in this community include California clapper rail, California black rail, delta tule pea, Suisun thistle, Suisun Marsh aster, and soft bird's-beak. The long-term survival of these species may depend on restoring this natural community.

Conservation of the tidal brackish emergent wetland natural community will be achieved by increasing the extent and connectivity of the community, by establishing connectivity with other natural communities along an environmental gradient from aquatic to upland areas, by reestablishing ecological conditions and processes that sustain the community, and by enhancing native biodiversity. Tidal brackish emergent wetland restoration will be implemented in Suisun Marsh through breaching dikes around managed wetlands and through site-specific contouring to speed the establishment of natural tidal channels. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.3.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the tidal brackish emergent wetland natural community are included below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.
- **Objective L1.8:** To accommodate sea level rise, provide potential tidal marsh plain within the anticipated future eastward position of the low-salinity zone of the estuary.

Objective L1.4 Benefits: Providing elevation and hydrologic gradients in restored tidal brackish emergent wetland consistent with this objective will contribute to the range of habitat requisites for the five covered wildlife species associated with tidal brackish marsh. Tidal brackish emergent wetland is a complex of high, middle, and low marsh, each of which provides some form of habitat function for the tidal brackish marsh covered species. The distribution of these habitat features is driven by differences in tidal inundation, which is a function of elevation gradients. Restoration measures will incorporate an elevation gradient to achieve a range of high, middle, and low marsh conditions, including the relatively brackish channel margin with tall bulrushes, tules, and cattails; the more brackish transition zone with species-rich vegetation containing a diversity of structural habitats; and the marsh plain that is dominated by low stature salt-tolerant species such as pickleweed and saltgrass and may include bare patches of very saline soil.

Objective L1.8 Benefits: Achieving this objective will protect upland transitional areas adjacent to restored brackish and freshwater tidal emergent wetland to permit the future migration of tidal emergent wetland communities in response to sea level rise. As sea level rises, and existing tidal lands are flooded more frequently and with longer duration, there will be a need for freshwater and brackish tidal communities to also shift upwards in mean elevation. Without the ability of these habitat types to migrate upward, the existing tidal wetland community will become subtidal communities without being replaced in other, more upland locations.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species. • **Objective L2.7**: Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.

Objective L2.6 Benefits: Achieving this objective will increase species diversity in the tidal brackish emergent wetland natural community which will, in turn, contribute to community stability and resilience. Reducing invasive plants such perennial pepperweed and smooth cordgrass will promote diversity of native plant species. Additionally, reducing the introduction and proliferation of nonnative wildlife will benefit native wildlife using the tidal brackish emergent wetland natural community. Nonnative predators of concern in tidal brackish emergent wetlands include red fox and Norway rat, which have been identified as potential threats to nesting rails and song sparrows. These species will be monitored and controlled if they pose a threat to covered species populations or native plant diversity, as described in *CM11 Natural Communities Enhancement and Management.*

Objective L2.7 Benefits: Producing a network of channels in the tidal brackish emergent wetland will provide important foraging habitat for several covered wildlife species in Suisun Marsh, especially those species that remain close to protective cover along channel banks when foraging. Tidal channels also convey marine nutrients into the marsh, and facilitate organic material produced in the marsh to be transported to the tidal perennial aquatic natural community and support the aquatic foodweb.

3.3.6.3.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the tidal brackish emergent wetland natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them. • **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objective TBEWNC1.1 Rationale: Restoring at least 6,000 acres of tidal brackish emergent wetland in Suisun Marsh (Conservation Zone 11), consistent with this objective, will increase the extent and connectivity of this natural community. It will substantially increase suitable habitat for the salt marsh harvest mouse, Suisun shrew, California clapper rail, California black rail, and covered endemic plant species such Suisun thistle, Suisun Marsh aster, and soft bird's-beak, in addition to a diversity of noncovered plant and wildlife species. Restored tidal brackish emergent wetland will also benefit covered fish species and other aquatic organisms through increased production of invertebrates and other organic material that will be transported through tidal action into areas where covered fish feed. Tidal brackish emergent wetlands are also expected to filter nonpoint source pollution from surface runoff or subsurface infiltration that otherwise would flow into Suisun Bay. The potential restoration areas in Suisun Marsh are extensive and interconnected and will allow for the foraging and dispersal dynamics of a wide range of covered and other native species (Nobriga 2008).

Restored tidal brackish emergent wetland will displace existing managed wetland. Managed wetland is not sustainable for wildlife in Suisun Marsh with projected sea level rise and levee instability, which will likely lead to extensive flooding of managed wetland areas. Tidal brackish emergent wetland, on the other hand, will provide habitat with long-term stability and persistence in Suisun Marsh (U.S. Fish and Wildlife Service 2010).

The tidal brackish emergent wetland strategy will focus on restoration rather than on protection because of the very limited extent of this community compared to historical conditions, and because almost all of the existing natural community has either been protected or is unlikely to be developed. The restoration of at least 6,000 acres of tidal brackish emergent wetland will increase the extent of this community in the Plan Area by 70% (from 8,501 acres to approximately 14,501 acres).

The extent of tidal brackish emergent wetland targeted for restoration is based, in part, on the availability of sites that are appropriate for restoration as a function of marsh plain elevations, hydrodynamic conditions, historical conditions, and environmental gradients. Restoring at least 6,000 acres is consistent with the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Draft Tidal Marsh Recovery Plan) (U.S. Fish and Wildlife Service 2010). This minimum acreage of tidal brackish emergent wetland restoration also ensures that the total extent of wetlands in Suisun Marsh (tidal brackish emergent wetland and managed wetland combined) is not diminished by the establishment of tidal perennial aquatic natural community, which would adversely affect species such as the salt marsh harvest mouse that depend on both these wetland community types and would be displaced by encroachment of the tidal perennial aquatic natural community.

Objective TBEWNC1.2 Rationale: The objective of restoring at least 1,500 acres of the 6,000-acre goal as high and middle marsh ensures that suitable habitat is provided for the suite of wildlife and plant species that are more dependent on these marsh types than low marsh. Suisun thistle, Suisun marsh aster, Delta tule pea, and soft bird's-beak are found only in the middle and high marsh zones, and the California clapper rail is dependent on these higher marsh zones for nesting. The at least 1,500 acres of high and middle marsh are targeted for restoration to benefit salt marsh harvest mouse consistent with the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010). Viable habitat for the salt marsh harvest mouse is described in the Draft Tidal Marsh Recovery Plan as the "mid and high marsh plain" (U.S. Fish and Wildlife Service 2010). Given the current subsidence of managed wetlands in Suisun Marsh, any passive restoration would result in a dominance of lesser-quality low marsh. Active management for high and middle marsh, as described in *CM4 Tidal Natural Communities Restoration*, would ensure that the quality and diversity of the restored tidal brackish marsh would remain high, and is consistent with the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

Objective TBEWNC1.3 Rationale: Restoring connectivity of tidal brackish emergent wetland, consistent with this objective, is necessary to provide dispersal pathways between populations allowing for healthy gene flow, as well as avenues for escape for during catastrophic flood events. This objective is based on the recognition that past development has fragmented what was once a well-connected tidal brackish emergent wetland in Suisun Marsh. Restoration of the tidal brackish emergent wetland natural community in Suisun Marsh will improve foraging and/or dispersal dynamics for a variety of wildlife species. Unfragmented communities are at less risk from long-term population loss to stochastic events than isolated ones because corridors of connection allow rapid colonization after loss. Opportunities for meeting this objective include providing a more contiguous connection between Hill and Peytonia Sloughs, and between Cutoff and Suisun Sloughs.

Objective TBEWNC1.4 Rationale: Creating topographic heterogeneity in restored tidal brackish emergent wetlands will result in a diversity of inundation characteristics and vegetative composition. Topographic heterogeneity is an important ecological factor influencing species richness and diversity in tidal natural communities (Collin et al. 2010; Mozaria-Luna et al. 2004). Although creation of a network of tidal channels, consistent with Objective L2.7, will contribute toward this topographic heterogeneity (Mozaria-Luna et al. 2004), mounds and depressions will also be integrated into the restoration design to increase topographic heterogeneity as described in *CM4 Tidal Natural Communities Restoration.* Elevated areas, especially in the interior portions of the marsh, provide refugial habitat for terrestrial wildlife during high-tide events.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Rationale: Perennial pepperweed is an aggressive nonnative plant that poses a significant threat to biodiversity in the tidal brackish emergent wetland natural community.

Once established, perennial pepperweed forms dense, single-species stands and out-competes local flora. Control of perennial pepperweed will help to sustain native biodiversity within the tidal brackish emergent wetland natural community on the reserve lands. Limiting perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system is consistent with conservation objectives outlined in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

3.3.6.4 Tidal Freshwater Emergent Wetland

The tidal freshwater emergent wetland natural community is typically a transitional community between the tidal perennial aquatic natural community and valley/foothill riparian or terrestrial upland communities, such as grasslands and cultivated lands. There are 17 plant community alliances (i.e., unique species assemblages) mapped in the Plan Area that fall within the tidal freshwater emergent wetland natural community (Table 2-8, *Map Classifications in the Tidal Freshwater Emergent Wetland Natural Community in the Plan Area*, in Chapter 2, *Existing Ecological Conditions*) (Sawyer and Keeler-Wolf 1995; Hickson and Keeler-Wolf 2007). In tidal freshwater emergent wetlands, tules, cattails, and willows (*Salix* spp.) dominate the vegetation along the Sacramento River. In the San Joaquin River area of the Delta, bulrushes, tules, common reed (*Phragmites australis*), and willows are more often the dominant species (Atwater 1980; Watson 2006; EDAW 2007; Hickson and Keeler-Wolf 2007; Watson and Byrne 2009). In the Plan Area, the tidal freshwater emergent wetland natural community occurs across a range of hydrologic and soil conditions, often occurring at the shallow, slow-moving or stagnant edges of freshwater waterways in the intertidal zone (Figure 3.2-5). It frequently experiences long-duration flooding.

Prior to the 1860s, the tidal freshwater emergent wetland natural community covered an estimated 87% of the Delta, with extensive marshes forming dense stands of vegetation bisected by meandering channels (The Bay Institute 1998). Today, the distribution of the tidal freshwater emergent wetland natural community in the Plan Area is limited to narrow fragmented bands or small patches along island levees, in-channel islands, shorelines, sloughs, and shoals. A total of 8,856 acres of this natural community remain within the Plan Area (approximately 1% of the Plan Area), 4,927 acres (56%) of which are currently under protected status. A portion of the existing 8,856 acres is expected to be lost as a result of sea level rise during the permit term.

Channelization, levee-building, agricultural conversion, urban development, removal of vegetation to stabilize levees, and upstream flood control have reduced the extent of the tidal freshwater emergent wetland natural community and altered its ecological function through changes to flooding frequency, inundation, depth, and duration, and the quantity of sediment deposition. These substantial reductions in the extent, distribution, and condition of tidal freshwater marshes that historically covered most of the Delta have reduced the extent and diversity of tidal freshwater habitats for associated covered and other native plant and wildlife species. See Section 2.3.4.4, *Tidal Freshwater Emergent Wetland* in Chapter 2, *Existing Ecological Conditions,* for more detail on the current state of this natural community.

Although reduced in extent, the remaining tidal perennial emergent wetland natural community in the Plan Area provides considerable ecological function and value. It serves to recharge groundwater and filter pollutants, and it produces invertebrates and other organic matter that is introduced into the water column via tidal action to provide food for fish and other aquatic organisms. The vegetation and associated waterways of the tidal freshwater emergent wetland natural community in the Plan Area provide food and cover for numerous species of birds (e.g., waterfowl, shorebirds, wading birds), mammals, reptiles, emergent aquatic insects, amphibians, and fish. Many tidal freshwater emergent wetlands remaining in the Plan Area are highly altered. This has substantially reduced their value as habitat for many plant and wildlife species. However, the remaining tidal freshwater emergent wetlands are essential habitat for migratory birds. Many fish in the tidal perennial aquatic natural community also use tidal freshwater emergent wetland habitat when it is inundated. Younger stages (e.g., larvae, fry) of some fish species rear in shallower waters that support the emergent vegetation of the tidal freshwater emergent wetland natural community; and some fish species use the emergent vegetation as refuge from predation and high flows (The Bay Institute 1998).

The conservation for tidal freshwater emergent wetland involves restoration or creation of at least 24,000 acres of this community distributed among several conservation zones and along an elevation gradient, and managing this community to provide a diversity of native species and vegetation characteristics. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.4.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the tidal freshwater emergent wetland natural community are included below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.
- **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objectives L1.4 and L1.7 Benefits: Restoring tidal freshwater emergent wetlands along an environmental gradient extending from the tidal perennial aquatic natural community to upland natural communities is expected to increase the abundance and distribution of associated native species, provide nutrients and food to adjacent subtidal aquatic habitat, and contribute to the long-term conservation of tidal freshwater marsh-associated covered species.

Incorporating transitional uplands adjacent to restored freshwater tidal marshes ensures that tidal freshwater emergent wetlands are sustainable in the event of predicted future rises in sea level. Without transitional uplands with shoreline gradients allowing expansion of shallow-water zones, water levels at both existing emergent wetlands and future wetlands would become too deep to support emergent vegetation. Achieving Objective L1.7 will help to ensure the persistence of tidal freshwater marsh in the face of rising sea levels.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species. • **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.

Objective L2.6 Benefits: Achieving this objective will increase species diversity in the tidal freshwater emergent wetland natural community which will, in turn, contribute to community stability and resilience. Reducing invasive plants will promote diversity of native plant species. Additionally, reducing the introduction and proliferation of nonnative wildlife will benefit native wildlife using the tidal freshwater emergent wetland natural community. The tidal marsh will be monitored and nonnative invasive species will be controlled if they pose a threat to covered species populations or native plant diversity, as described in *CM11 Natural Communities Enhancement and Management.*

Objective L2.7 Benefits: Tidal channels also expected to convey nutrients into the marsh, and allow organic material produced in the marsh to be transported to the tidal perennial aquatic natural community and support the aquatic foodweb.

3.3.6.4.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the tidal freshwater emergent wetland natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7. • **Objective TFEWNC1.2:** Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.

Objectives TFEWNC1.1 and TFEWNC1.2 Rationale: Achieving these objectives will result in the restoration of at least 24,000 acres of tidal freshwater emergent wetland in large, interconnected patches. It will result in an estimated 271% increase in protected tidal freshwater emergent wetland in the Plan Area. Remnant patches of tidal freshwater emergent wetlands can currently be found near the confluence of the Sacramento and San Joaquin Rivers, along Cache and Lindsey Sloughs and the Yolo Bypass, along the mainstem and several channels of the San Joaquin, Old, and Middle Rivers, Dutch Slough, Lost Slough, and near the confluence of the Cosumnes and Mokelumne Rivers. Priority will be given to sites that will increase connectivity among conservation lands.

The modification of natural Delta hydrology through levees, drainage, and water exports has reduced the extent and diversity of tidal freshwater habitats for associated covered and other native plant and wildlife species. Restoring tidal freshwater marsh habitats along an environmental gradient extending from the subtidal perennial aquatic natural community to upland natural communities is expected to increase the abundance and distribution of associated native wildlife and plant species, improve connectivity among habitat areas within the Plan Area, provide nutrients and food to adjacent subtidal perennial aquatic habitat, and contribute to the long-term conservation of tidal freshwater marsh-associated covered species.

Goal TFEWNC2: Biologically diverse tidal freshwater emergent wetland that is enhanced for native species and sustained by natural ecological processes and functions.
• **Objective TFEWNC2.1:** Restore and sustain a diversity of marsh vegetation that reflects historical species compositions and high structural complexity. • **Objective TFEWNC2.2:** Create topographic heterogeneity in restored tidal freshwater emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objective TFEWNC2.1 Rationale: Achieving this objective will promote vegetation diversity and structural complexity in restored tidal freshwater marsh. High plant diversity and vegetation structure creates a variety of ecological niches to support high wildlife diversity. The diversity of plant types in freshwater tidal marshes provides complex structure that supports a greater diversity of animals, especially birds and insects, than in saline marshes (Nobriga 2008). This objective will be achieved by incorporating a diversity of plant species into restoration design as described in *CM4 Tidal Natural Communities Restoration.*

Objective TFEWNC2.2 Rationale: Creating topographic heterogeneity in restored tidal freshwater emergent wetlands will result in a diversity of inundation characteristics and vegetative composition. Topographic heterogeneity is an important ecological factor influencing species richness and diversity in tidal natural communities (Collin et al. 2010; Mozaria-Luna et al. 2004). Although creation of a network of tidal channels, consistent with Objective L2.7, will contribute toward this topographic heterogeneity (Mozaria-Luna et al. 2004), mounds and depressions will also be integrated into the restoration design to increase topographic heterogeneity as described in *CM4 Tidal Natural Communities Restoration.* Elevated areas, especially in the interior portions of the marsh, provide refugial habitat for terrestrial wildlife during high-tide events.

3.3.6.5 Valley/Foothill Riparian

Before European settlement, the Central Valley supported close to 1 million acres of riparian forest. Today, only 2 to 6% of that acreage remains (Katibah 1984). Historical accounts of the Delta describe lower portions of the rivers where they flow into the Delta as being surrounded by wide swaths of riparian forest. Riparian forests in more interior portions of the Delta occurred in narrow bands along the high points of natural levees (Fremier et al. 2008). Today, the valley/foothill riparian natural community represents approximately 2% of the Plan Area with 17,644 acres, 31% of which (5,508 acres) are currently protected. In general, riparian areas are distributed across the Plan Area as narrow corridors along watercourses or as isolated remnant patches near watercourses (Figure 3.2-6).

Substantial reductions in the extent, distribution, and condition of valley/foothill riparian communities have resulted from agricultural conversion, stream channelization and armoring, and urbanization. These factors, coupled with reduced flood flows and the impoundment of sediment behind upstream dams, reduce the spread of new sediment strata during peak flows, have greatly reduced the open floodplain and nursery sites for pioneer vegetation (Sands 1980).

More than 225 species of birds, mammals, reptiles, and amphibians use riparian areas in California for forage, water, thermal and escape cover, nesting and breeding, and migration and dispersal (Riparian Habitat Joint Venture 2004). Riparian communities are critical for the conservation of resident and migratory land birds in California (Gains 1980). Remnant valley/foothill riparian communities in the Plan Area, while highly degraded relative to their historical state, provide habitat for many covered species, including riparian brush rabbit, Swainson's hawk, white-tailed kite, yellow-breasted chat, and valley elderberry longhorn beetle. Riparian areas also serve an important function as movement corridors for mammals and other wildlife if they provide suitable connections between larger blocks of habitat (Fischer et al. 2000). Additionally, riparian vegetation adjacent to streams moderates water temperature for fish and other aquatic wildlife, produces invertebrates that serve as a vital food source for fish and other wildlife, and is a source of coarse woody and other organic material that provides habitat and substrate and food for the aquatic foodweb for macroinvertebrates and fish (Pusey and Arthington 2003).

Riparian conservation is intended to increase the protection, extent, and connectivity of riparian areas, restore processes necessary to sustain this community, and create important structural conditions that provide habitat for a diversity of wildlife. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.5.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the valley/foothill riparian natural community are included below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.5:** In restored floodplains, provide a range of elevations that transition from frequently flooded (e.g., every 1 to 2 years) to infrequently flooded (e.g., every 10 years or more) areas to provide a range of habitat conditions, upland habitat values, and refugia from flooding during most flood events. • **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.5 Benefits: Achieving this objective will provide a transitional gradient, as described in *CM5 Seasonally Inundated Floodplain Restoration,* from areas that frequently flood to areas that seldom flood*.* A number of riparian covered species and other native wildlife species depend on lands that seldom or never flood. The least Bell's vireo, western yellow-billed cuckoo, yellow-breasted chat and other riparian birds use such areas as flood refugia and for supplemental foraging. Riparian brush rabbits and riparian woodrats require upland refugia during flood events. As described in *CM7 Riparian Natural Community Restoration*, mounds will also be created and managed in riparian brush rabbit and riparian woodrat habitat and grasslands may be protected on the landward sides of levees to provide additional refugia during high-flood events that might occasionally flood even in these higher transitional uplands.

Objective L1.6 Benefits: Achieving this objective will restore and protect the riparian natural community in areas that increase size and connectivity of protected riparian areas as described in *CM3 Natural Communities Protection and Restoration.* Fragmentation of the riparian natural community has adverse effects on wildlife populations (Whitcomb et al. 1981; Terborgh 1992) by increasing exposure to noise, lighting, pets and human disturbance, increasing susceptibility to predation, and reducing habitat patch size to below wildlife territory size or below acreage necessary to support minimum viable populations. Increasing the size and connectivity of protected riparian natural community will eliminate this stressor within the reserve system.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances. • **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers. • **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species. • **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain.

Objectives L2.1, L2.3, and L2.11 Benefits: Achieving these objectives will restore natural flooding regimes along rivers as described in, *CM5 Seasonally Inundated Floodplain Restoration.* Flooding is one of the primary factors influencing riparian structural diversity. Fluvial geomorphic processes such as channel migration, erosion and deposition, and overland scour determine the form of river channels and floodplains and deposit sediment that provides soil for riparian plant growth. These disturbance processes as well as seasonal inundation patterns drive plant succession and vegetation structure and are especially important in maintaining early seral stage vegetation The riparian natural community is temporally and spatially heterogeneous and dynamic as a result of fluvial disturbances.

Most riparian plant species with long-lived seeds germinate during waterlogged conditions following floodwater recession. Flood flows also contribute to riparian seed dispersal (Capon and Dove 2006). Riparian plants are adapted to particular inundation regimes and the recruitment and/or survival of each species changes seasonally, annually, and decadally (Fremier et al. 2008). Many nonnative plant species are flood-intolerant, and the loss of regular scouring floods has facilitated their invasion throughout the Central Valley (Riparian Habitat Joint Venture 2004).

Historically, riparian areas around the margins of the Delta and in the lower Yolo Basin were subject to strong fluvial control from adjacent rivers—notably the Sacramento, Cosumnes, Mokelumne, and the San Joaquin. More tidally influenced areas of the Delta likely exhibited slower rates of geomorphic disturbance. In these areas, vegetation structure was heavily influenced by long periods of runoff and inundation from spring snowmelt along with tidal action and salinity (Fremier et al. 2008). Channelization and levee construction in the Delta have since diminished the natural fluvial processes upon which healthy riparian natural communities depend. Floodplain restoration will promote regeneration of riparian natural community vegetation and structural diversity. It will also promote fluvial processes that create fresh sediment deposits, making bare mineral soils available for colonization by native vegetation.

Connecting rivers to their floodplains will also replenish groundwater supplies on which some riparian plants may be partially or totally dependent (Capon and Dove 2006).

Objective L2.6 Benefits: Achieving this objective will increase the native biodiversity and relative cover of native plant species through riparian restoration (e.g., planting a diversity of native species), and through enhancement and management (e.g., invasive plant management) as described in *CM7 Riparian Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management.* High species diversity promotes natural community resilience, and native biodiversity in riparian systems generates structural diversity that constitutes habitat for many riparian wildlife species.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: Achieving this objective will improve habitat linkages by protecting large blocks of habitat. Riparian areas serve an important function as movement corridors for mammals and other wildlife if they provide suitable connections between larger blocks of habitat (Fischer et al. 2000). However, the existing riparian vegetation in the Plan Area is highly fragmented and provides few opportunities for long-distance wildlife movement through contiguous riparian corridors. Habitat linkages will be improved as described in *CM3 Natural Communities Protection and Restoration*, and *CM7 Riparian Natural Community Restoration.*

3.3.6.5.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the valley/foothill riparian natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian natural community, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objective VFRNC1.1 Rationale: Achieving this objective will restore 5,000 acres of riparian forest and scrub in Conservation Zones 1, 2, 4, 5, 6, and 7. The majority of existing riparian acreage is distributed among Conservation Zones 2 through 7. Much of the riparian acreage in the north (Sacramento River system) and east (Cosumnes and Mokelumne Rivers) Delta is protected; greater than two-thirds of the existing acreage in Conservation Zones 2 and 4 is protected and a large portion of the riparian natural community at higher elevations in Conservation Zone 5 is protected. Most of the remaining unprotected riparian areas in Conservation Zones 5 and 6 are in deeply subsided portions of the Delta where the long-term persistence of any terrestrial vegetation is unlikely, or on small mid-channel islands that are at little risk of development, and therefore protection is not a high priority. Conservation Zone 7 in the south Delta has relatively large patches of unprotected riparian natural community associated with the San Joaquin, Old, and Middle Rivers. These patches and the existing corridors of riparian natural community between them provide habitat for several covered and other native species and could be connected to existing conservation lands south of the Delta. Protection of existing riparian community is therefore focused in Conservation Zone 7.

Approximately 2,000 acres of riparian restoration will be distributed in tidal and channel margin restoration areas and will occur generally as long narrow strips. The majority of restoration, at least 3,000 acres, will occur in the south Delta seasonal floodplain restoration site in Conservation Zone 7, where the lack of existing constraints allows restoration of larger tracts of riparian natural community. Large tracts of this vegetation are an important component of habitat for covered species such as the yellow-billed cuckoo, which only breed in large patches (minimum 100 acres) of habitat. The establishment of large tracts of riparian community will also establish large core areas that are better buffered from encroachment of humans, invasive plants, and nonnative animals as well as from noise and other disturbances associated with surrounding agricultural and urban land uses. Restoration of riparian community in Conservation Zone 7 will also provide habitat for riparian brush rabbit and riparian woodrat which have very limited distributions, restricted only to areas within and adjacent to Conservation Zone 7.

Riparian restoration in the Plan Area will create the potential for many species to recolonize some of their historical range. Several covered species, such as yellow-billed cuckoo, least Bell's vireo, riparian brush rabbit, side-flowering skullcap, and valley elderberry longhorn beetle are riparian obligates and are found almost exclusively within this natural community. Other species, such as Swainson's hawk and white-tailed kite, forage in open country, but nest in tall trees, often in patches of riparian forest. For many of the covered species, as well as numerous other native riparian species, population declines and/or range contractions have been linked to loss of riparian habitat. The restoration or creation of 5,000 acres and protection of 750 existing acres of valley/foothill riparian natural community in the Plan Area will be an important step toward the conservation and recovery of those species. Restoration will increase the total amount of valley/foothill riparian natural community in the Plan Area by 24%, as well as increase the amount under protected status by 95%. This objective will be met through *CM7 Riparian Natural Community Restoration.* For the implementation schedule of valley/foothill restoration, see Chapter 6, *Plan Implementation.*

Objective VFRNC1.2 Rationale: Achieving this objective will protect 750 acres of valley/foothill riparian forest in the near term to compensate for the temporal loss of the community resulting from a delay between riparian loss and riparian restoration. Approximately 750 acres of riparian natural community will be lost in the near term implementation period, while most of the riparian restoration will take place after the near term implementation period. After the restoration construction is completed, it can take several years for the restored community to become functional. Riparian protection will take place in Conservation Zone 7 because this zone supports one of only two remaining populations of riparian brush rabbit, is adjacent to nesting locations for least Bell's vireo and riparian woodrat occurrences to the south, and provides habitat for many riparian wildlife species. This objective will be met through *CM3 Natural Communities Protection and Restoration*.

Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.

- **Objective VFRNC2.1:** Restore, maintain and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands.
- **Objective VFRNC2.2:** Maintain 1,000 acres of early- to midsuccessional vegetation with a well-developed understory of dense shrubs on restored seasonally inundated floodplain.
- **Objective VFRNC2.3:** Maintain at least 500 acres of mature riparian forest in Conservation Zones 4 or 7.
- **Objective VFRNC2.4:** Maintain the at least 500 acres of mature riparian forest (VFRNC2.3) intermixed with a portion of the early- to midsuccessional riparian vegetation (VFRNC.2.2) in large blocks with a minimum patch size of 50 acres and minimum width of 330 feet.

Objective VFRNC2.1 Rationale: Achieving this objective will restore, maintain, and enhance the structural heterogeneity of riparian vegetation in the reserve system as described in *CM7 Riparian Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management.* Structural complexity, including understory (low shrubs), midstory (large shrubs and small trees) and overstory (upper canopy formed from large trees) is important to provide habitat requirements for a diversity of wildlife species. Different bird species nest and forage at different vegetation heights, necessitating the presence of multiple vegetation layers. Low shrubs provide cover for many wildlife species, tall trees provide perching opportunities, and canopy cover provides shading. Multiple vegetation layers also enhance hydrologic functions, including rainfall interception, filtration of floodwaters, and flood-stage desynchronization (Collins et al. 2006). Horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands increases opportunities for insects produced in riparian vegetation to be distributed into channels and other communities to provide food supply for wildlife.

Objectives VFRNC2.2 and VFRNC2.3 Rationale: Both early- to midsuccessional and late-successional riparian vegetation will be maintained as described in *CM5 Seasonally Inundated Floodplain Restoration*, *CM7 Riparian Natural Community Restoration*, and *CM11 Natural Communities Enhancement and Management.* Under these objectives, 1,000 acres of early- to midsuccessional vegetation and at least 500 acres of late-successional vegetation will be maintained within the 750 acres of protected riparian natural community, the 5,000 acres of restored riparian natural community, or a combination of both the protected and restored riparian natural community. Wildlife species require certain types of vegetation structure for breeding, foraging, and nesting. Vegetation structure can be defined as the foliage volume (or cover of foliage) by height for a given area (Riparian Habitat Joint Venture 2009). Where natural processes dominate (as in intact floodplains), riparian natural communities tend to vary widely in terms of both vegetation structure and composition, representing areas that are at different successional (temporal) stages. To meet the ecological requirements of a variety of wildlife species, riparian communities should include the full range of seral stages that are characterized by a mixture and diversity of trees and shrubs and vegetative cover at a wide range of heights and volumes (Riparian Habitat Joint Venture 2009). For example, least Bell's vireo is more likely to occur in willow-dominated, early seral stage riparian forest, whereas yellow-billed cuckoo is more likely to occur in a relatively dense, mature cottonwood/willow forest with light gaps and a heavy shrub component (Efseaff et al. 2008). Objective VFRNC2.3 requires the at least 500 acres of mature riparian forest to be concentrated in a single conservation zone (either Conservation Zone 4 or 7) to ensure large or closely spaced blocks to maximize value for western yellow-billed cuckoo and other riparian species that favor large, contiguous or closely spaced tracts of riparian habitat. The specific characteristics of early- to midsuccessional and mature riparian forest that will be restored and maintained are described in *CM7 Riparian Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management.*

Objective VFRNC2.4: This objective ensures that the at least 500 acres of mature riparian natural community are interspersed with early- to midsuccessional riparian vegetation to provide large, structurally diverse patches of riparian natural community. Extent, patch size, and width parameters in Objective VFRNC2.4 are determined primarily by the breeding requirements of western yellow-billed cuckoo; the rationale for these parameters is described in Section 3.3.7.24, *Western Yellow-Billed Cuckoo,* and additional details regarding western yellow-billed cuckoo habitat requirements are provided in *CM7 Riparian Natural Community Restoration.*

Goal VFRNC3: Maintenance or increase of native biodiversity that is characteristic of the valley/foothill riparian natural community.
• **Objective VFRNC3.1:** Maintain or increase abundance and distribution of valley/foothill riparian natural community vegetation alliances that are rare or uncommon as recognized by California Department of Fish and Game (2010), such as *Cephalanthus occidentalis* (button willow thickets) alliance and *Sambucus nigra* (blue elderberry stands) alliance.

Objective VFRNC3.1 Rationale: Achieving this objective will ensure that riparian restoration projects are designed to maintain or increase the abundance and distribution of rare or uncommon vegetation alliances characteristic of riparian communities, as described in *CM7 Riparian Natural Community Restoration.* The maintenance or increase of these rare or uncommon alliances will maintain or increase riparian biodiversity. The importance of biodiversity is described above, under the rationale for Objective L2.6. Although Objective L2.6 addresses the need for biodiversity, Objective VFRNC3.1 is specific to the riparian natural community, ensuring that the naturally high biodiversity of this community is restored and maintained.

3.3.6.6 Nontidal Perennial Aquatic and Nontidal Freshwater Perennial Emergent Wetland

The nontidal freshwater perennial emergent wetland community is closely associated with the nontidal perennial aquatic community. These two communities typically co-occur as a complex mosaic collectively referred to as nontidal marsh.

The nontidal perennial aquatic community includes freshwater open water, streams, sloughs, canals, ditches, ponds, and marshes that are located above tidal influence. This community does not include managed permanent and semipermanent aquatic areas in managed wetlands in the Yolo Bypass and Suisun Marsh. In the Delta, nontidal perennial aquatic habitat ranges in size from small farm ponds to small lakes such as the north and south Stone Lakes located at the northern end of the study area. Fringes of nontidal perennial aquatic communities often merge into emergent wetlands.

The nontidal freshwater perennial emergent wetland natural community is composed of perennially saturated wetlands dominated by emergent plant species that do not tolerate saline or brackish conditions (CALFED Bay-Delta Program 2000). Nontidal freshwater perennial emergent wetland communities in the Plan Area occur in small fragments in association with the nontidal perennial aquatic natural community.

Currently, the nontidal perennial aquatic and nontidal freshwater perennial emergent natural communities make up 6,874 acres (less than 1%) of the Plan Area (Figure 3.2-7). Prior to agricultural development of the Delta, there was more extensive tidal influence in the Delta than there is today (San Francisco Estuary Institute 2010), so nontidal marsh was probably never common.

Nontidal marsh currently provides habitat functions for a variety of species. Covered species that use nontidal marsh include giant garter snake, western pond turtle, and California red-legged frog. A variety of native and nonnative freshwater invertebrates and resident fish species, waterfowl, pisciverous birds, semi-aquatic mammals, insectivorous birds, also inhabit or forage in nontidal marsh. Invertebrates and organic material produced in the nontidal freshwater perennial emergent wetland community supports the aquatic foodweb and production of food for covered fish and other native aquatic organisms.

The conservation approach for nontidal marsh is restoration of a mosaic of nontidal freshwater perennial emergent wetland and nontidal perennial aquatic natural communities, and protection and management to provide habitat values for covered species and other native wildlife. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.6.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the nontidal perennial aquatic and nontidal freshwater perennial emergent wetland natural communities are included below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: Consistent with this objective, nonnative invasive plants and wildlife will be managed and controlled as needed to sustain native biodiversity and protect covered species in the nontidal marsh. Nonnative fish and other invasive predators will be reduced as needed to protect populations of native amphibians and aquatic reptiles.

3.3.6.6.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the nontidal perennial aquatic and nontidal freshwater perennial emergent wetland natural communities within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal NFEW/NPANC1: Nontidal marsh consisting of a mosaic of nontidal freshwater emergent perennial wetland and nontidal perennial aquatic natural communities, and providing habitat for covered and other native species.
• **Objective NFEW/NPANC1.1:** Create 1,200 acres of nontidal marsh consisting of a mosaic of nontidal perennial aquatic and nontidal freshwater emergent wetland natural communities, with suitable habitat characteristics for giant garter snake and western pond turtle.

Objective NFEW/NPANC1.1 Rationale: The creation of 1,200 acres of nontidal marsh, consisting of a mosaic of nontidal perennial aquatic and nontidal freshwater emergent wetland natural communities will result in a net increase of each component natural community. Furthermore, the restoration will occur in blocks that will be contiguous with the larger reserve system compared to the small, fragmented patches that will be lost as a result of covered activities. The net effect is expected to be an increase in acreage and ecological function of nontidal marsh in the Delta for giant garter snake, western pond turtle, and a diversity of native species that use nontidal marsh.

3.3.6.7 Alkali Seasonal Wetland Complex

The alkali seasonal wetland complex natural community occurs on areas of clay soils that contain a relatively high concentration of dissolved salts. These wetlands remain saturated throughout the wet season and during the early part of the dry season, with areas of shallow ponding often present during the wet season. Two contrasting types of vegetation are represented in this natural community: the more common saltgrass-dominated association and the much rarer woody iodine bush scrub found near the Clifton Court Forebay. Depending on its location, the alkali seasonal wetland complex often transitions into other natural communities such as tidal brackish emergent wetland, vernal pool complex, grassland, valley/foothill riparian, and cultivated landscapes. For more information on ecological characteristics of the alkali seasonal wetlands natural community, see Section 2.3.4.8, *Alkali Seasonal Wetland Complex*, in Chapter 2, *Existing Ecological Conditions.*

Alkali seasonal wetlands were once very common in the Central Valley and in portions of the Plan Area. However, conversion of land to agriculture, livestock grazing, commercial uses, and urban uses has reduced the extent and degraded the condition of this community throughout much of its historical range. Within the Plan Area, this community is associated with seasonally saturated alkali soils along the northwestern and southwestern margins of the Delta and around the perimeter of Suisun Marsh (Figure 3.2-8). An estimated 3,723 acres of alkali seasonal wetland complex natural community remain in the Plan Area. Alkali seasonal wetlands have been subject to fragmentation, hydrologic alteration, and invasion by nonnative species. The decline in the extent, distribution, and condition of alkali seasonal wetland complex has reduced the diversity of native plant species uniquely associated with alkali soils, as well as habitat for associated covered and other native wildlife.

The remaining alkali seasonal wetland complexes support many native, endemic, and rare species. This natural community provides habitat for covered plant species, including heartscale, brittlescale, San Joaquin spearscale, Delta button celery, and Carquinez goldenbush. Grassland-dependent covered wildlife species such as western burrowing owl and San Joaquin kit fox use the grassland component of alkali seasonal wetlands. Alkali seasonal wetlands also enhance groundwater recharge, moderate seasonal flooding, and provide valuable foraging habitat for migrating and wintering waterfowl and other bird species.

Of the 3,723 acres of alkali seasonal wetland complex in the Plan Area, 3,723 acres (78%) is currently under protected status. The BDCP takes two general approaches to alkali seasonal wetlands conservation: protect larger, interconnected expanses of natural communities, including alkali seasonal wetland complex within a matrix of other vegetation types; and restore, maintain and enhance ecological functions necessary to sustain native alkali seasonal wetland species. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.7.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the alkali seasonal wetland complex natural community are included below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.6 Benefits: Achieving this objective will increase the size and connectivity of conservation lands, including alkali seasonal wetland complexes within a matrix of other natural community types. This will be achieved through implementation of *CM3 Natural Communities Protection and Restoration*, building on the existing reserve system and applying the principles described in Section 3.2.4.2.1, *Reserve System Assembly Principles*. Protecting alkali seasonal wetlands within a large, interconnected reserve system prevents further habitat fragmentation within the reserve system that can disrupt hydrologic processes and gene flow. Size and connectivity of the reserves that include alkali seasonal wetland are also important in order to provide sufficient upland habitat for the protection of plant pollinators, provide for the dispersal of alkali seasonal wetland-associated plants and animals, and sustain important predators of herbivores such as rodents and rabbits (U.S. Fish and Wildlife Service 2005). Furthermore, with interconnected reserves, alkali seasonal wetlands are less likely to be adversely affected by adjacent disturbances related to urban development such as urban runoff.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.

- **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: Achieving this objective will maintain or increase native biodiversity in alkali seasonal wetlands. This is expected to maintain or increase the stability of this natural community in the Plan Area. (See Section 3.3.5, *Landscape-Scale Biological Goals and Objectives*, for a description of how biodiversity increases the stability of a natural community.) Furthermore, increasing the cover of native alkali seasonal wetland plants relative to invasive species will minimize competition posed by invasive plants to native plant species, and improve overall habitat suitability for native wildlife. Control of bullfrogs and nonnative predatory fish in aquatic wildlife habitat within the alkali seasonal wetlands will promote native aquatic wildlife biodiversity. Native biodiversity will be maintained and enhanced through *CM11 Natural Communities Enhancement and Management*, which will include activities such as control of invasive plants and nonnative aquatic wildlife predators, and fencing alkali seasonal wetland areas to protect them from adverse effects of grazing livestock.

3.3.6.7.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the alkali seasonal wetland complex natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.

- **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.
- **Objective ASWNC1.2**: Restore or create alkali seasonal wetlands in Conservation Zones 1, 8, and/or 11 to achieve no net loss of wetted acres (up to 72 acres of alkali seasonal wetland complex restoration, assuming all anticipated impacts occur).

Objective ASWNC1.1 Rationale: Achieving this objective will provide 150 acres of protected alkali seasonal wetland within a mosaic of protected grasslands and vernal pool complex. In determining the extent and distribution of alkali seasonal wetland complex natural community to be protected, the following criteria were considered: the extent and level of fragmentation of alkali seasonal wetland in the Plan Area; the extent, proportion, and distribution of the community in the Plan Area that is currently under protected status; the interspersion of alkali seasonal wetlands with other high-value habitats (e.g., vernal pool complex) that warrant protection; and the projected effects on the community resulting from implementation of the BDCP.

Alkali seasonal wetland complex natural community in the Plan Area is currently found in Conservation Zones 1, 2, 4, 5, 6, 8, 9, 10, and 11. The largest contiguous areas of alkali seasonal wetlands are in Conservation Zone 2, where most of this community is already protected. The alkali seasonal wetland in Conservation Zone 5 is also already protected. Only small, isolated patches of alkali seasonal wetland surrounded by cultivated and developed lands are present in Conservation Zones 4, 6, 9, and 10. While alkali seasonal wetlands in Conservation Zones 1, 8, and 11 also consists of small patches, these patches are within a larger mosaic of grasslands and vernal pool complex. Conservation Zones 1, 8, and 11 provide the greatest opportunity for conserving alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex, adjacent to existing conservation lands. Furthermore, Conservation Zone 8 provides the only opportunity in the Plan Area to protect the rarer woody iodine bush scrub.

There are 3,723 acres of alkali seasonal wetland complex in the Plan Area, of which 3,723 acres (78%) are currently in protected status. With protection of an additional 150 acres, 82% of the alkali seasonal wetland complex in the Plan Area will be protected. Because the unprotected alkali seasonal wetlands in the Plan Area are in small, widely dispersed patches, opportunities to protect large areas of alkali seasonal wetland are limited. Protecting and enhancing alkali seasonal wetlands that support the highest concentrations of rare and sensitive plant species in conjunction with other adjoining natural communities, is expected to maintain or increase the abundance of native wildlife and plant species, improve connectivity among habitat areas both within and adjacent to the Plan Area, and contribute to the long-term conservation of this native community and its associated covered species.

Objectives ASWNC1.2 Rationale: Achieving this objective will result in no net loss of alkali seasonal wetland acreage. This is consistent with the federal policy on no net loss of wetlands. Restoration will be implemented, as described in *Vernal Pool and Alkali Seasonal Wetland Complex Restoration*, to replace any alkali seasonal wetland acreage lost as a result of covered activities, in areas that build on the larger alkali seasonal wetland complex areas in the reserve system. This will maintain the acreage of habitat for alkali seasonal wetland species in the Plan Area.

Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.
• **Objective ASWNC2.1:** Provide appropriate seasonal flooding characteristics for supporting and sustaining alkali seasonal wetland species. • **Objective ASWNC2.2:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs. • **Objective ASWNC2.3:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase burrow availability for burrow-dependent species. • **Objective ASWNC2.4:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Objective ASWNC2.1 Rationale: Achieving this objective will ensure that appropriate hydrologic conditions are maintained to support alkali seasonal wetlands in the reserve system. These conditions include seasonal flooding with overland flow and some ephemeral ponding. These conditions are necessary to sustain native species adapted to seasonally wet conditions in alkaline soils. Diversion of urban or agricultural runoff into alkali seasonal wetland, or topographic alteration, can alter duration of inundation or saturation of soils, rendering these areas unsuitable for some alkali seasonal wetland species. Topographic alteration and habitat fragmentation through placement of roads, canals, and other hydrologic barriers can disrupt both subsurface water exchange and surface water conveyance.

Objective ASWNC2.2 Rationale: Achieving this objective will increase the extent and diversity of native grassland plant species in the grassland matrix within the restored and protected alkali seasonal wetland complex. The rationale for increasing native species diversity in grasslands is provided under Objective GNC2.2, below**.**

If alkali seasonal wetland restoration takes place in areas that do not currently support grasslands (e.g., cultivated lands or ruderal areas), then grasslands will be restored in the upland matrix and Objective ASWNC2.2 will be met by incorporating native species into grassland restoration design as described in *CM8 Grassland Natural Community Restoration.* If alkali seasonal wetland restoration takes place in areas that already support grasslands, then Objective ASWNC2.2 will be met through grassland management and enhancement practices that promote native species, as described in *CM11 Natural Communities Enhancement and Management.*

Objective ASWNC2.3 Rationale: Achieving this objective will increase burrow availability in protected grasslands within the upland matrix of the restored and protected alkali seasonal wetland complex. A large proportion of animal species that inhabit the uplands surrounding alkali seasonal wetlands are either fossorial (i.e., adapted to digging and life underground) or burrow-dependent, attributes that require access to constant underground habitats, presumably for temperature regulation and for protection from fire and predators. California ground squirrels excavate burrows that provide substantial benefits to covered species, including California tiger salamander (upland aestivation sites). However, ground squirrels have been the target of widespread poisoning campaigns in California, where they threaten levees or are perceived as pests. Loss and fragmentation of grasslands have also reduced ground squirrel distribution and abundance. By increasing the abundance and distribution of host burrows in grasslands within the alkali seasonal wetland complex natural community, many native species will benefit. This objective will be achieved through grazing to promote favorable conditions for ground squirrels and elimination of ground squirrel control in the reserve systems, as described in *CM11 Natural Communities Enhancement and Management.*

Objective ASWNC2.4 Rationale: Achieving this objective will increase prey for grassland-dependent species in the upland matrix surrounding alkali seasonal wetlands. Uplands in the alkali seasonal wetland complex natural community provide foraging habitat for predators by supporting populations of small animals (e.g., mice, voles, rabbits, insects, amphibians, reptiles) on which they prey. Sufficient prey populations are critical to the health and persistence of predator populations. Enhancing the extent and abundance of rodent, lagomorph, and insect (e.g., grasshopper) populations will increase the prey base for San Joaquin kit fox and other carnivores, and raptor species, including Swainson's hawks, other hawks, and golden eagles. Conservation of grasslands within the alkali seasonal wetland complex natural community will also help offset effects on cultivated lands (e.g., alfalfa) that produce prey for covered species.

This objective will be achieved through grassland restoration and management as described in *CM8 Grassland Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management.*

3.3.6.8 Vernal Pool Complex

Vernal pools are ephemeral wetlands that form in shallow depressions underlain by bedrock or by an impervious, near-surface soil horizon. These depressions fill with rainwater and runoff during the winter and may remain inundated until spring or early summer, sometimes filling and emptying repeatedly during the wet season. The vernal pool complex natural community consists of both interconnected and isolated groups of vernal pools and seasonal swales that are generally within a matrix of either grassland or alkali seasonal wetland vegetation. For more information on ecological characteristics of the vernal pool natural community, see Section 2.3.4.9, *Vernal Pool Complex* in Chapter 2, *Existing Ecological Conditions.*

Vernal pool complexes in the western United States are distributed from eastern Washington to northern Baja California, Mexico (Moran 1984). Within this range, the remaining vernal pool acreage represents less than 10% of that prior to anthropogenic alteration of these landscapes, which began in the 1800s (Keeley and Zedler 1998). Most of the remaining vernal pool complexes are highly fragmented and degraded (U.S. Fish and Wildlife Service 2005). Vernal pool complexes historically occurred around the perimeter of the Plan Area, within a continuous, intact mosaic of meadows, nontidal wetlands and channels, alkali grasslands, and alkali sink scrub, which transitioned to tidal wetlands and mudflats. Today, the Plan Area contains 11,284 acres of vernal pool complex consisting of fragmented complexes in four distinct regions in the upper elevations along the margins of the Plan Area (Figure 3.2-9) (Witham 2003; Leigh Fisher Associates 2005; Williamson et al. 2005; Witham 2006; Kleinschmidt Associates 2008; Rains et al. 2008).

- West of the Sacramento River from Putah Creek south to the gently sloped terraces immediately to the north and east of the Montezuma Hills.
- On the north and eastern margins of Suisun Marsh.
- East of the Sacramento River in the Stone Lakes area.
- West of the San Joaquin River from Byron to Discovery Bay.

Anthropogenic influences on the vernal pool landscape have resulted in the reduction, fragmentation, loss of biodiversity, and degradation of this natural community type. The remaining natural community has been degraded by the invasion of nonnative species and hydrologic alteration. In many areas, vernal pool connectivity and hydrology have been altered by physical barriers such as roads, canals, and urban development. Elsewhere, vernal pools have been degraded by increased surface and subsurface flow from increased urban runoff (e.g., impervious surfaces, storm drains) and agricultural runoff (U.S. Fish and Wildlife Service 2005). Disking, leveling, and deep ripping activities have also resulted in alteration or elimination of vernal pool hydrology and species diversity. See Section 2.3.4.9, *Vernal Pool Complex*, in Chapter 2, *Existing Ecological Conditions,* for more detail on the current state of this natural community in the Plan Area.

The vernal pool complexes that remain are still rich in biodiversity, and have many native, endemic, and rare species. Vernal pools provide all life-history requirements for some covered plant and invertebrate species (e.g., vernal pool shrimp) as well as requirements for a specific part of the life history of other covered wildlife species (e.g., California tiger salamander). See Table 2-4 (Chapter 2, *Existing Ecological Conditions*) for covered species that are supported by vernal pool complexes. Vernal pools also enhance groundwater recharge, moderate seasonal flooding, and provide valuable foraging habitat for migrating and wintering waterfowl (Medeiros 1976; Reiner and Swenson 2000) and other bird species.

Of the 11,284 acres of vernal pool complex in the Plan Area, 6,292 acres (56%) are currently under protected status. The BDCP takes three general approaches to vernal pool conservation: protect and restore vernal pool complex extent and connectivity, recover native biodiversity of vernal pool species through restoration and improved management, and maintain and enhance ecological functions such as local hydrology necessary to sustain this natural community. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.8.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the vernal pool complex natural community are included below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.6 Benefits: This objective will provide sufficient upland habitat to protect plant pollinators, provide for the dispersal of vernal pool complex-associated plants and animals, and sustain important predators of herbivores such as rodents and rabbits (U.S. Fish and Wildlife Service 2005). Furthermore, with larger reserves in association with grasslands and alkali seasonal wetlands, vernal pool complexes are less likely to be adversely affected by adjacent disturbances related to urban development such as urban runoff. Refer to *CM3 Natural Communities Protection and Restoration* for a description of how the size and connectivity of reserves, including vernal pool complexes within a matrix of other natural community types, will be increased by adding to existing conservation lands and applying reserve system assembly principles.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: This objective will contribute to the resiliency and long-term stability of this natural community. Biodiversity is relatively high in vernal pools; a single vernal pool may support over 100 species of native plants and animals (U.S. Fish and Wildlife Service 2007). However, habitat loss has been, and continues to be, a threat to vernal pool complexes. Agricultural and urban impacts on vernal pools have resulted in an estimated 15 to 33% of the original biodiversity of Central Valley vernal pool crustaceans since the 1800s (King 1998). Many ecosystem processes are sensitive to declines in biodiversity: declines in regional and local biodiversity can reduce ecosystem resistance to environmental perturbations such as drought. Ecosystem processes such as soil nitrogen levels, water use, plant productivity, and pest and disease cycles can become more variable as diversity declines (Naeem et al. 1999:2). Although the maintenance and increase of native biodiversity in vernal pools (Objective VPNC2.1) will not restore vernal pool complexes to presettlement levels of biodiversity, it is expected to maintain or increase the stability of vernal pool complexes in the Plan Area. Furthermore, increasing the cover of vernal pool plants relative to invasive species will help to minimize competition posed by invasive plants with native plant species, and improve overall habitat suitability for native wildlife. Control of nonnative aquatic predators such as bullfrogs in some of the deeper pools that might support these species will also benefit biodiversity by reducing competition and predation on native amphibians such as California tiger salamander and other native aquatic wildlife. Refer to *CM11 Natural Communities Enhancement and Management* for a description of activities such as control of invasive plants and nonnative aquatic predators that would be implemented to achieve this objective.

3.3.6.8.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the vernal pool complex natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal VPNC1: Vernal pool complexes composed of large, interconnected or contiguous expanses that represent a range of environmental conditions.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). • **Objective VPNC1.2:** Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools). • **Objective VPNC1.3:** Increase the size and connectivity of protected vernal pool complex within the Plan Area and increase connectivity with protected vernal pool complex adjacent to the Plan Area. • **Objective VPNC1.4:** Protect the range of inundation characteristics that are currently represented by vernal pools throughout the Plan Area.

The vernal pool objectives under Goal VPNC1 will dictate the extent, distribution, and configuration of vernal pool complexes in the reserve system. In determining the extent of vernal pool complex natural community to be protected and restored, the following criteria were considered: opportunities to expand and connect existing conservation lands; the extent and proportion of the community in the Plan Area that is currently under protected status; and the feasibility of acquiring unprotected vernal pools and suitable restoration areas for conservation on a willing-seller basis. Covered activities will increase the amount or extent of vernal pool complex natural community in protected status in the Plan Area by 600 acres from 6,292 acres to 6,892 acres, or 5% of the total 11,284 acres of vernal pool complex.

The BDCP will also restore additional vernal pool complex natural community in the Plan Area to achieve no net loss of vernal pool acres. The maximum potential impact on wetted area of vernal pools is 10 acres. Assuming that the restored vernal pool complex will have a 15% density of vernal pools, 67 acres of vernal pool complex will be restored[22], a net increase in the area of both restored and protected vernal pool complex will result in protecting a total of 62% of the vernal pool complex. Consistent with Objective L1.6, the 600 acres of protected vernal pool complex and additional restored vernal pool complex will be components of a large, interconnected reserve system incorporating a mosaic of grasslands, vernal pool complex, and alkali seasonal wetlands to optimize protection of plant pollinators, provide for the dispersal of plants and animals, sustain important

[22] Acreage of restored vernal pools will depend on the actual acreage of vernal pool impact from covered activities.

predators of herbivores such as rodents and rabbits (U.S. Fish and Wildlife Service 2005), and minimize effects of adjacent urbanization.

Objectives VPNC1.1 and VPNC1.2 Rationale: These objectives will target spatial distribution of areas for vernal pool conservation (Figure 3.2-9) that correspond closely to core vernal pool recovery areas as identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (Vernal Pool Recovery Plan) (U.S. Fish and Wildlife Service 2005). Vernal pool complex natural community in the Plan Area is currently found in Conservation Zones 1, 2, 4, 8, 9, and 11, while core recovery areas are only found in Conservation Zones 1 (Jepson Prairie core recovery area), 11 (Jepson Prairie and Suisun core recovery areas), and 8 (Altamont Hills core recovery area). These targeted conservation areas are situated at elevations that are suitable as upland habitats adjacent to restored tidal habitats, and can be protected to build on existing and planned conservation lands in Solano County between Conservation Zones 1 and 11. Protection of additional vernal pool complex natural community in Conservation Zones 1 and 11 will protect an important connection between Suisun Marsh and the Cache Slough area. Vernal pool complex natural community in Conservation Zone 8 consists of relatively rare alkaline sink/meadow vernal pools that warrant protection. Vernal pool complexes in Conservation Zones 2, 4, and 9 are not targeted for protection because they do not support core recovery areas and most of the community present in Conservation Zones 2 and 4 is already protected. In Conservation Zone 9, it consists of small patches that are isolated among developed areas and cultivated land.

To maximize the probability that vernal pool plants and wildlife will persist despite weather variations, climate change, or catastrophic events, it is important to retain vernal pools with a range of conditions such as soil and landform, geographic distribution, and the size and type of vernal pool (U.S. Fish and Wildlife Service 2005). The strategic distribution of vernal pool protection provided by this objective will ensure that the reserve system within the Plan Area (including currently protected areas and areas to be protected and restored under the BDCP) conserves a range of landforms, hydrogeomorphic conditions, and vegetation alliances. The vernal pool complex natural community in the Plan Area consists of four fairly uniform types. These vernal pool types differ in characteristics of geomorphology, hydrology, and vegetation (e.g., the alkaline sink/meadow vernal pools support halophytic vegetation, while the annual grassland vernal pools in the Stones Lakes area generally support species adapted to nonalkaline soils) as described in detail in Section 2.3.4.9.1. *Vernal Pool Complex, Vegetation.* All four vernal pool types will be conserved in the Plan Area (through the reserve system and existing conservation lands).

- Annual grassland vernal pools in the Stone Lakes area: this type is in Conservation Zone 4, where all 1,082 acres of vernal pool complex are already protected.
- Clay alluvium vernal pools and playa pools running from Putah Creek south to Cache Slough: this type is in Conservation Zones 1 and 2, where all but an isolated patch is already protected.
- Montezuma Block vernal pools and playa pools in the Jepson Prairie/Montezuma Hills area: this type is targeted for conservation in Conservation Zones 1 and 11, and is where all the BDCP-related effects on vernal pool complex will occur.
- Alkaline sink/meadow vernal pools in the Byron/Clifton Court Forebay area: this type is targeted for protection in Conservation Zone 8, although no vernal pools in this area will be affected by covered activities.

Refer to *CM3 Natural Communities Protection and Restoration* for a description of the protection requirements and reserve design criteria that will be applied to meet this objective.

Objective VPNC1.1 will protect the full range of vernal pool types in the Plan Area and a range of vernal pool inundation characteristics. The protection of larger, deeper pools with long inundation periods and smaller, shallower pools with short inundation periods will increase the probability of sustaining species during both long-term high and low rainfall periods. The protection of a range of vernal pool inundation characteristics will also contribute to biodiversity, since many vernal pool species depend on a narrow range of inundation periods (U.S. Fish and Wildlife Service 2005).

Objective VPNC1.2 will restore vernal pools to achieve no net loss of vernal pool acreage. This is consistent with the federal policy on no-net-loss of wetlands. Restoration will be implemented, as part of *CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration*, to replace any vernal pool acreage lost as a result of covered activities, in areas that build on the larger vernal pool complex reserve system. This will maintain the acreage of habitat for vernal pool species in the Plan Area.

Objective VPNC1.3 Rationale: Conserving intact vernal pool complexes prevents further habitat fragmentation that can disrupt hydrologic processes and gene flow (see discussion on hydrology, below). Size and connectivity of vernal pool reserves are also important in order to provide sufficient upland habitat for the protection of vernal pool plant pollinators, provide for dispersal of vernal pool plants and animals, and sustain important predators of herbivores such as rodents and rabbits (U.S. Fish and Wildlife Service 2005). For example, establishing a protected corridor between Suisun Marsh and the Cache Slough area will facilitate movement of several covered species, including California tiger salamander, from occupied habitats in the Montezuma Hills and Jepson Prairie into the grassland and vernal pool complex habitats in Conservation Zone 1. This objective will be achieved by implementation of *CM3 Natural Communities Protection and Restoration*, by adding to the existing reserve system, and applying the conservation land assembly principles described in Section 3.2.4.2.1, *Reserve System Assembly Principles.*

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.
• **Objective VPNC2.1:** Maintain or enhance vernal pool complexes to provide the appropriate inundation (ponding) characteristics for supporting and sustaining vernal pool species. • **Objective VPNC2.2:** Maintain and enhance pollination service in the vernal pool complex, especially by native invertebrates including native solitary bees. • **Objective VPNC2.3:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs. • **Objective VPNC2.4:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase burrow availability for burrow-dependent species. • **Objective VPNC2.5:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Protected and restored vernal pool complexes in the Plan Area will be managed and enhanced to optimize biodiversity and ecological processes (e.g., hydrology, pollination) that are characteristic of a vernal pool natural community, as part of *CM11 Natural Communities Enhancement and Management*, to meet Objectives VPNC2.1 and VPNC2.2.

Objective VPNC2.1 Rationale: Hydrologic functions in vernal pool complexes include surface water storage in the pool, subsurface water exchange, and surface water conveyance (Butterwick 1998:52). Aspects of surface water storage such as timing, frequency, and duration of inundation are critical to the survival of vernal pool plants and wildlife. Subsurface water exchange (i.e., lateral flow between pools through subsurface soil) is important within some vernal pool complexes for the purpose of damping water level fluctuations during the late winter and early spring (Hanes and Stromberg 1998:38). Surface water conveyance, through sheet flow or swales, is important for the purpose of filling pools at lower elevations in the watershed, and for dispersal of seeds and vernal pool invertebrates.

Various environmental stressors adversely affect the duration of vernal pool inundation. The percentage of nonnative vegetation in a vernal pool is closely tied to length of inundation (Bauder 1997 in U.S. Fish and Wildlife Service 2005:I-20). Invasion of nonnative plants can lead to excessive vegetation in pools, which can lead to increased evapotranspiration and early drying of pools (Barry 1998 in U.S. Fish and Wildlife Service 2005:I-20). Alternatively, diversion of urban or agricultural runoff into vernal pools or topographic alteration can result in longer inundation periods that are unsuitable for many vernal pool species. Topographic alteration and habitat fragmentation through placement of roads, canals, and other hydrologic barriers can disrupt both subsurface water exchange and surface water conveyance. Invasive species control and other management and enhancement described in *CM11 Natural Communities Enhancement and Management* to maintain or enhance vernal pool hydrology will benefit the vernal pool complex natural community by reducing or eliminating these stressors in the reserve system.

Objective VPNC2.2 Rationale: Many rare and endemic vernal pool plant species depend on insects such as bees, flies, and beetles for pollination. Solitary bees, important pollinators for many native vernal pool plants (Eaton 2001), are limited in their flight and dispersal capabilities (Thorp and Leong 1995) and may not be able to travel substantial distances to disperse or re-colonize areas where they have been locally extirpated. Assembling a large, interconnected reserve system consistent with Goal VPNC1, including optimization of connectivity between upland and lower portions of the watersheds within vernal pool complexes, will contribute to solitary bee conservation by reducing fragmentation effects. Vernal pool complexes will be managed and enhanced consistent with *CM11 Natural Communities Enhancement and Management*, and monitored and adaptively managed as described in Section 3.6, *Adaptive Management and Monitoring Program*, to achieve Objective VPNC2.2.

Objective VPNC2.3 Rationale: Achieving this objective will increase the extent and diversity of native grassland plant species in the grassland matrix within the restored and protected vernal pool complex. The rationale for increasing native species diversity in grasslands is provided under Objective GNC2.2, below.

If vernal pool restoration takes place in areas that do not currently support grasslands (e.g., cultivated lands or ruderal areas), then grasslands will be restored in the upland matrix and Objective VPNC2.3 will be met by incorporating native species into grassland restoration design as described in *CM8 Grassland Natural Community Restoration.* If vernal pool restoration takes place in areas that already support grasslands, then Objective VPNC2.3 will be met through grassland management and enhancement practices that promote native species, as described in *CM11 Natural Communities Enhancement and Management.*

Objective VPNC2.4 Rationale: Achieving this objective will increase burrow availability in protected grasslands within the upland matrix of the restored and protected vernal pool complex. A large proportion of animal species that inhabit the uplands surrounding vernal pools are either fossorial or burrow-dependent, attributes that require access to constant underground habitats, presumably for temperature regulation and for protection from fire and predators. California ground squirrels excavate burrows that provide substantial benefits to native species, including California tiger salamander (upland aestivation sites). However, ground squirrels have been the target of widespread poisoning campaigns in California, where they threaten levees or are perceived as pests. Loss and fragmentation of grasslands have also reduced ground squirrel distribution and abundance. By increasing the abundance and distribution of host burrows in grasslands within the vernal pool natural community, many native species will benefit. This objective will be achieved through grazing to promote favorable conditions for ground squirrels and elimination of ground squirrel control in the reserve system, as described in *CM11 Natural Communities Enhancement and Management.*

Objective VPNC2.5 Rationale: Achieving this objective will increase prey for grassland-dependent species in the upland matrix surrounding vernal pools. Uplands in the vernal pool complex natural community provide foraging habitat for predators by supporting populations of small animals (e.g., mice, voles, rabbits, insects, amphibians, reptiles) on which they prey. Sufficient prey populations are critical to the health and persistence of predator populations. Enhancing the extent and abundance of rodent, lagomorph, and insect (e.g., grasshopper) populations will increase the prey base for San Joaquin kit fox and other carnivores, and raptor species, including Swainson's hawks, other hawks, and golden eagles. Conservation of grasslands within the vernal pool complex natural community will also help offset effects on cultivated lands (e.g., alfalfa) that produce prey for covered species.

This objective will be achieved through grassland restoration and management as described in *CM8 Grassland Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management.*

3.3.6.9 Managed Wetland

The managed wetland natural community consists of areas that are intentionally flooded and managed (including associated ditches and drains) during specific seasonal periods to enhance habitat values primarily for waterfowl. Hydrology within managed wetlands is managed by operating floodgates on dikes and levees. Undesirable plants are controlled by a combination of discing and controlled flooding. Typically, managed wetlands are flooded during the winter in anticipation of the arrival of migratory birds. See Section 2.3.4.10, *Managed Wetland*, in Chapter 2, *Existing Ecological Conditions,* for more detail on managed wetlands. Although this community is artificially created and managed, it is considered a natural community because of the habitat values it provides for native wildlife, including some covered species.

In the 1800s, the Central Valley of California supported 4 million acres of tidal and nontidal wetland habitat. After the passage of the Swamp Land Act of 1850, these wetlands began to be reclaimed; i.e., converted to urban or agricultural development. Today, only 5% of the original wetland acreage remains. Many of these wetlands are managed wetlands, which are former cultivated lands that have been managed back to emergent wetland by controlling seasonal flooding. Currently, the managed wetland natural community in the Plan Area is largely in the northern, central, and western portions of the Delta, as well as in Suisun Marsh (Figure 3.2-10). Most of this natural community in the Plan Area can be found in the Yolo Bypass, the Stone Lakes National Wildlife Refuge, the Cosumnes River Preserve, and in Suisun Marsh. Delta islands that support areas of managed wetland include Mandeville, Medford, Bradford, Van Sickle and Chipps Islands, and Holland Tract. The Plan Area includes 70,698 acres of managed wetland, of which 92% (64,984 acres) are currently protected. Of the 64,984 acres of currently protected managed wetlands, 71% (49,999 acres) are found within the

Suisun Marsh complex. Managed wetlands in Suisun Marsh are protected *in perpetuity* from development[23] by the Suisun Marsh Preservation Act of 1977.

A wide variety of waterfowl and other birds migrating along the Pacific Flyway use the managed wetland natural community when it is inundated. In the Plan Area, covered species such as greater sandhill cranes forage and roost in managed wetlands; many ducks, geese, wading birds, and shorebirds forage and loaf in managed wetlands. Abundant and diverse plant and invertebrate populations in managed wetlands provide important food resources for migrating waterfowl, bats, and many other wildlife species that forage in and over these wetlands.

The primary stressors to the community are invasive species such as perennial pepperweed, and aging floodgate structures that no longer effectively control water flow. The primary threat to the existence of managed wetlands is flooding as a result of the breaching of the levees that maintain the community, with an increased threat from sea level rise. Managed wetlands are also under threat from projected sea level rise, which is expected to increase risk of levee failures and resultant tidal flooding of these lands.

Tidal restoration will result in the conversion of some areas of managed wetlands back to their historical tidal brackish or freshwater emergent marsh. The conservation approach for this natural community focuses on managed wetland protection, creation, management and enhancement for the benefit of covered and other native species. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.9.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the managed wetland natural community are included below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: Management of nonnative invasive plants consistent with this objective will benefit the managed wetland natural community. This natural community is subjected to the same invasive plant species as the tidal brackish emergent wetland and tidal freshwater emergent wetland natural communities. However, because management operations include discing and manipulating flooding duration, there are more opportunities to control invasive species in this natural community than in others. One managed wetland invasive, perennial pepperweed, is a serious threat that may be spread through discing, thereby adding complexity to land management. Other problematic invasive plant species include pampas grass (*Cortaderia selloana*), giant reed (*Arundo donax*), and the nonnative genotype of common reed (*Phragmites australis*). Objective L2.6 initiates enhancement operations that promote the biological diversity of native species.

[23] Development is defined specifically by the Suisun Marsh Act and includes the erection of any solid material or structure, discharge or disposal of material or waste, grading or extraction of material, change in density or intensity of land use, change in the intensity of water use, change in the size of any structure, and the removal of vegetation other than for agricultural purposes except where these activities are related to improving waterfowl habitat and do not have a significant, adverse effect on wildlife or plant resources.

3.3.6.9.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the managed wetlands natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species.
• **Objective MWNC1.1:** Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.

Objective MWNC1.1 Rationale: Achieving this objective is expected to benefit the managed wetland natural community and the diversity of species that use it, including migratory waterfowl. Even though the managed wetlands in Suisun Marsh are already protected from development, protection under the BDCP involves placement of conservation easements with land use restrictions aimed specifically at maintaining suitable conditions for the target resources, and allows the Implementation Office to manage and enhance these lands consistent with the biological goals and objectives. Covered species expected to benefit from protection and enhancement of managed wetlands include salt marsh harvest mouse, black rail (secondary habitat), Suisun song sparrow (secondary habitat), and the western pond turtle. Portions of the managed wetlands are also expected to provide foraging habitat for Swainson's hawk and white-tailed kite. At least 1,500 acres of the protected managed wetland will be managed specifically for salt marsh harvest mouse. The remaining 6,600 acres will be managed for waterfowl. Of the 6,600 acres managed for waterfowl, at least 5,000 acres will be managed as seasonal wetlands (dry in summer) specifically to increase the food density and value for overwintering waterfowl. To provide habitat for breeding waterfowl, 1,600 acres of permanent wetlands (in which the wetted area persists year-round) will be managed and enhanced. Of the 8,100 acres to be protected, at least 1,500 acres will be protected in the Grizzly Island Marsh Complex specifically to benefit salt marsh harvest mouse, consistent with the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010), as described further in Section 3.3.7.13, *Salt Marsh Harvest Mouse*. The 8,100 acres will significantly improve existing conditions by maximizing food biomass and food value for overwintering waterfowl and improving habitat for breeding waterfowl. By acquiring 8,100 acres of managed wetland for protection, the Implementation Office will be able to manage and enhance these lands as needed to achieve biological goals and objectives, as described in *CM11 Natural Communities Enhancement and Management.*

3.3.6.10 Other Natural Seasonal Wetlands

Other natural seasonal wetlands in the Plan Area consist of 276 acres of temporarily flooded perennial forbs and Santa Barbara sedge (*Carex barbarae*) stands located in Conservation Zones 4, 7, and 11. Approximately 82% (227 of 276 acres) of this natural community in the Plan Area occurs on existing conservation lands. Covered activities will not remove or adversely affect this natural community. Covered species that potentially use other natural seasonal wetlands in the Plan Area include greater sandhill crane, tricolored blackbird, western burrowing owl, and white-tailed kite; these species are conserved under the conservation strategies for the grassland natural community and cultivated lands. For these reasons, there are no biological goals and objectives for other natural seasonal wetlands.

3.3.6.11 Grassland

Although California native grassland originally covered approximately 25% of the landmass of the state (Barbour et al. 2007), it has recently been identified as one of the 20 most endangered ecosystems in the United States (Noss et al. 1995). Once occurring in the Central Valley as widespread, species-rich prairies (Keeler-Wolf et al. 2007) with a high density of perennial grasses, valley grasslands today are highly fragmented and dominated by nonnative annual grasses and other nonnative plant species. In the Plan Area, valley grassland is one of the two most common natural or seminatural vegetation communities, occupying approximately 9% of the Plan Area (76,315 acres) and 20% of noncultivated lands (Figure 3.2-11).

Direct and indirect anthropogenic influences on this landscape have resulted in the reduction, conversion, and fragmentation of valley grassland. These changes in turn have led to diminished ecological conditions necessary to sustain a well-functioning grassland natural community. Degradation of grassland quality and quantity has contributed to almost complete conversion of the vegetation community from perennial to annual grasses in fewer than 200 years.

Many native grassland species have been reduced in abundance or distribution through these processes. However, native plant species remain rich in number, persisting and coexisting with nonnative plants in traditional locations with remaining grasslands. Some animal species have also adjusted well to nonnative grassland. Thus, the current grassland community still offers highly valuable habitats to many grassland dependent species.

The conservation strategy for grasslands involves increasing protection of grassland, including connectivity to improve habitat quality; recovering native biodiversity; and restoring ecological functions necessary to sustain this natural community. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.11.1 Applicable Landscape-Scale Goals and Objectives

Those landscape-scale biological goals and objectives that are integral to the conservation strategy for the grassland natural community are included below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.
- **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objective L1.6 Benefits: Achieving this objective will increase the size and connectivity of protected grasslands in association with vernal pool complex, alkali seasonal wetland complex, and other natural communities, and will eliminate grassland fragmentation in the reserve system. Grassland fragmentation limits movement of widely ranging wildlife, and limits dispersal of covered species such as California red-legged frog and California tiger salamander. It also limits dispersal of some grassland insects (Collinge and Palmer 2002) and grassland plant species with wind-dispersed seeds

(Soons et al. 2005). Vernal pool complex and alkali seasonal wetland complex natural communities consist of vernal pools and seasonal wetlands within a grassland matrix that accounts for a substantial proportion of the large, unfragmented grassland areas in the Plan Area. Protecting a large, interconnected mosaic of these three natural community types will provide landscape-scale benefits to a grassland-dependent species.

Objective L1.7 Benefits: Achieving this objective will provide grassland and other noncultivated natural lands adjacent to tidally restored areas to accommodate sea level rise and to provide habitat and high-tide refugia for native wildlife during the period following tidal restoration but prior to these areas being inundated as a result of sea level rise. Protected and restored grasslands will include areas adjacent to restored tidal marsh to reestablish an important historical environmental gradient, along the water-to-land interface, that has been largely lost as a result of levee construction and wetland reclamation. Grassland functions and values will be maintained within the protected area until these areas are converted to tidal natural communities as a result of sea level rise. The acreage of grassland protected and restored within the sea level rise accommodation area to meet this objective is a subset of the 65,000 acres of tidal restoration and will not count toward the 8,000 acres of grassland protection (Objective GNC1.1) or 2,000 acres of grassland restoration (Objective GNC1.2). This objective will be achieved through implementation of *CM3 Natural Communities Protection and Restoration.*

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6**: Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: Achieving this objective in grasslands will increase diversity and relative cover of native plant species. Nonnative grass species such as wild oats (*Avena* spp.) and bromes (*Bromus* spp.) are so well established in California grasslands that they are considered naturalized, and are unlikely to ever be eradicated (Reiner 1999). Management practices such as controlled livestock grazing, however, can reduce nonnative species in favor of native species, and grassland management is necessary to reduce or eradicate aggressive nonnatives that provide unfavorable habitat conditions for native wildlife such as star thistle (*Centaurea solstitialis*) (Reiner 1999). Additionally, bullfrogs and nonnative predatory fishes will be controlled in stock ponds and seasonal wetlands associated with grasslands to improve native aquatic wildlife biodiversity. This objective will be achieved through grassland management as described in *CM11 Natural Communities Enhancement and Management*.

Goal L.3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: Achieving this objective will protect and restore grasslands to improve opportunities for the movement of native organisms within and between natural communities inside and connecting to areas outside of the Plan Area. Grasslands will be protected and restored in Conservation Zones 1 and 11 to build on existing and planned reserves between these two zones in Solano County. Protection of additional grasslands in this area will maintain an important connection between Suisun Marsh and the Cache Slough area. Grassland protection in Conservation Zone 8 will link protected grasslands with large areas of protected grasslands near the Bryon Airport in eastern Contra Costa County, including those associated with the *East Contra Costa County HCP/NCCP*.

3.3.6.11.2 Natural Community Goals and Objectives

The landscape-scale biological goals and objectives, and associated conservation measures, discussed above, are expected to contribute to the conservation of the grassland natural community within the reserve system. The goals and objectives below address additional needs specific to this natural community that will not otherwise be met at the landscape scale.

Goal GNC1: Extensive grasslands composed of large interconnected patches or contiguous expanses.

- **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11.
- **Objective GNC1.2:** Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian, tidal, and nontidal natural communities for wildlife foraging and upland refugia.
- **Objective GNC1.3**: Protect stock ponds and other aquatic features within protected grasslands to provide aquatic breeding habitat for native amphibians and aquatic reptiles.
- **Objective GNC1.4**: Of the 8,000 acres of grassland protected under Objective GNC1.1 and 2,000 acres of grassland restored under Objective GNC1.2, protect or restore grasslands adjacent to restored tidal brackish emergent wetlands to provide at least 200 feet of adjacent grasslands beyond the sea level rise accommodation.

Objectives GNC1.1 and GNC1.2 Rationale: Achieving these objectives will increase the protected grassland in Conservation Zones 1, 8, and 11 from 27% to 38%, comparable with Conservation Zones 2 and 4 (79% and 59%, respectively). This would increase the proportion of protected grassland in the Plan Area from 27% to 42%. In determining the aerial extent and spatial configuration of grassland to be conserved, the following criteria were considered: habitat value of the grassland currently in the Plan Area; ecological and evolutionary processes that sustain grasslands; and spatial and functional needs of covered grassland species, including genetic exchange.

Large, contiguous grasslands are present in Conservation Zones 1, 2, 4, 6, 8, and 11. Zones 3, 5, and 7 contain few large patches of grassland and Zones 9 and 10 only have many small fragments of grassland distributed throughout a matrix of urban and cultivated land. Of those zones with large areas of existing grasslands, grasslands in Zones 2 and 4 have been largely protected: Approximately 79% of grassland in Zone 2 (Yolo Bypass Wildlife Area) and 59% of grassland in Zone 4 (Stone Lakes National Wildlife Refuge and Cosumnes River Preserve) are currently protected.

Conservation Zone 6 contains large areas of unprotected grassland, but this zone is in the deeply subsided portion of the Delta and is intersected by large channels that make connections to adjacent islands impossible for ground-dwelling grassland species. The fact that the grasslands occur on deeply subsided areas also makes them susceptible to future levee failures and does not allow for establishing natural environmental gradients of uplands to marsh and aquatic habitats. Grasslands in this zone do not support many covered species.

Most critical for grassland conservation are Conservation Zones 1, 8, and 11. These zones are situated at the periphery of the Delta where elevations are suitable for upland habitats adjacent to restored tidal marsh, as described above for Objective GNC1.4. Grasslands in these zones often co-occur with vernal pool or seasonal wetland natural communities. Some protection of grasslands in Conservation Zones 1 and 11 can build on existing and planned conservation lands between these two zones in

Solano County. Conservation Zone 8 has little protected grassland but is located near important areas for conservation that were identified in the *East Contra Costa County HCP/NCCP* (and not all of which will be acquired by that plan). Habitats in these three zones support a variety of covered species and are especially important areas in the Plan Area for vernal pool plant and animal species, California tiger salamander, burrowing owl, and rare grassland plant species. In addition to providing habitat for these species, Conservation Zone 8 supports and is adjacent to the best habitats in the Plan Area for California red-legged frog and San Joaquin kit fox. To a lesser extent, the strategy includes grassland protection in Conservation Zone 7 to provide upland refugia and foraging habitat for riparian brush rabbit and other wildlife species occurring in restored floodplains.

Although the majority of grassland protection and restoration will occur in Conservation Zones 1, 8, and 11, grassland protection or restoration will also occur in Conservation Zones 2, 4, or 5 where upland habitat for giant garter snake is needed adjacent to restored tidal and nontidal freshwater emergent wetland natural communities. Grasslands will also be protected and restored in Conservation Zone 7 as needed to provide upland refugia on the landward side of levees adjacent to protected and restored habitat for riparian brush rabbit.

Objective GNC1.3 Rationale: Achieving this objective will protect aquatic habitat for California red-legged frog, California tiger salamander, western pond turtle, and other native amphibians and reptiles within the protected grasslands in the reserve system. Stock ponds, intermittent drainages, and other aquatic features are common in grasslands throughout the Plan Area. No quantitative target for stock ponds and other aquatic features is included in this objective because these features tend to be small (less than 0.5 acre) and are largely unmapped at the scale of the land cover mapping for the Plan. Therefore, their extent and distribution in the Plan Area is unknown. However, the experience with land acquisition for the *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan* (*San Joaquin County MSHCP*) and the *East Contra Costa County HCP/NCCP* suggests that these features will be consistently supported in the grasslands acquired for the reserve system. Grasslands that support suitable aquatic features for covered and other native amphibian species will be prioritized for acquisition, as described in *CM11 Natural Communities Enhancement and Management*.

Objective GNC1.4 Rationale: Achieving this objective will provide grassland adjacent to restored tidal brackish emergent wetland in Suisun Marsh, to provide upland habitat and high-tide refugia for native wildlife beyond the area of sea level rise accommodation. Sufficient grassland will be protected and restored beyond the elevation of projected sea level rise (that is, beyond the up to 10,000 acres of transitional upland provided through Objective L1.7) to provide long-term upland habitat values adjacent to tidally influenced areas. Protected and restored grasslands adjacent to restored tidal marsh will reestablish an important historical environmental gradient, along the water-to-land interface, that has been largely lost as a result of levee construction and wetland reclamation.

Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.
• **Objective GNC2.1:** Restore and sustain a mosaic of grassland vegetation alliances, reflecting localized water availability, soil chemistry, soil texture, topography, and disturbance regimes, with consideration of historical states. • **Objective GNC2.2:** Increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs. • **Objective GNC2.3:** Increase burrow availability for burrow-dependent species. • **Objective GNC2.4:** Increase prey abundance and accessibility, especially of small mammals and insects, for grassland-foraging species. • **Objective GNC2.5**: Maintain and enhance aquatic features in grasslands to provide suitable inundation depth and duration and suitable composition of vegetative cover to support breeding for covered amphibian and aquatic reptile species.

Objectives GNC2.1 and GNC2.2 Rationale: Achieving these objectives will increase the extent and diversity of native grassland plant species and grassland vegetation alliances in the reserve system. Valley grassland is species-rich, with 50 plant species typically found in 30-by-30-meter plots (Heady et al. 1991). Grassland plant species exist in patches of plant associations called vegetation alliances, which are unevenly distributed throughout the grassland and sometimes extend into other nearby natural communities. Valley grassland is an extremely productive natural community, but is still not well understood.

Before the introduction of livestock grazing and modern agricultural practices, vegetation alliances characterized by perennial grasses were common in the Central Valley. Barry (1972) estimated that 99% of the precontact purple needlegrass (*Nassella pulchra*) alliance has disappeared from the valley grassland community. While its historical extent and abundance are still under debate (and classification of subassociations under this alliance remains incomplete), perennial grasses are assumed to have been widely distributed in the Central Valley before changes in land use affected this natural community (D'Antonio et al. 2007). Native grassland vegetation alliances are likely to be found in the Plan Area, but these grasslands are expected to be degraded (i.e., low relative cover of native species) resulting from past and current land use practices (e.g., deep soil disturbance and heavy grazing) and the competitive spread of nonnative plants.

In the Plan Area, there is now a limited distribution of purple needlegrass, along with several other perennial grass alliances. Another bunchgrass, alkali sacaton (*Sporobolus airoides*), is often found on an alkali or sodic (high sodium) stratum. In contrast, stolonous (nonbunching) creeping ryegrass (*Leymus triticoides*) covers wetter areas at the margins of riparian and emergent wetland communities. Valley grasslands, in this sense, are transitional zones that reflect underlying environmental gradients and create ecotones in the Bay Delta region.

Recent studies show that purple needlegrass influences soil chemistry and soil structure and contributes to underground soil heterogeneity (Parker and Schemel 2010). These soils are enriched by critical microorganisms (fungi, bacteria, nematodes) and bioturbation by burrowing rodents. In native grasslands, these subterranean processes in turn contribute to the diversity of aboveground plant composition. On the other hand, annual nonnative grasses cause local soil homogenization which is thought to create a feedback loop encouraging further invasion by nonnative grasses.

Grassland communities in the Plan Area exhibit complexity and diversity at all spatial scales, and perennial grasses and related ecological processes play a pivotal role in dynamically sustaining that complexity. Successful restoration of grassland alliances, especially those composed of native perennial grasses, will likely benefit not only the characteristic species, but valley grassland as integrated communities (as well as nearby natural communities) by promoting essential ecological functions.

This objective will be met by incorporating native species into grassland restoration design as described in *CM8 Grassland Natural Community Restoration* and through grassland management and enhancement practices that promote native species, as described in *CM11 Natural Communities Enhancement and Management.*

Objective GNC2.3 Rationale: Achieving this objective will increase burrow availability in protected grasslands. A large proportion of animal species that inhabit grasslands are either fossorial or burrow-dependent, attributes that require access to constant underground habitats, presumably for temperature regulation and for protection from fire and predators. Some fossorial grassland mammals can be considered keystone species because the burrows they dig are critical to the survival of many other species and are essential for a well-functioning grassland community. For example, California ground squirrels excavate burrows that provide substantial benefits to native covered species, including San Joaquin kit fox (den sites), western burrowing owl (nesting and roosting habitat), California red-legged frog, and California tiger salamander (upland aestivation sites). However, ground squirrels have been the target of widespread poisoning campaigns in California, where they threaten levees or are perceived as pests. Loss and fragmentation of grasslands have also reduced ground squirrel distribution and abundance. By increasing the extent of grassland and the abundance and distribution of host burrows, many native species will benefit. This objective will be achieved through grazing to promote favorable conditions for ground squirrels and elimination of ground squirrel control in the reserve system, as described in *CM11 Natural Communities Enhancement and Management.*

Objective GNC2.4 Rationale: Achieving this objective will increase prey for grassland-dependent species. Grasslands in the planning area provide foraging habitat for predators by supporting populations of small animals (e.g., mice, voles, rabbits, insects, amphibians, reptiles) on which they prey. Sufficient prey populations are critical to the health and persistence of predator populations. Enhancing the extent and abundance of rodent, lagomorph, and insect (e.g., grasshopper) populations will increase the prey base for San Joaquin kit fox and other carnivores, and raptor species, including Swainson's hawks, other hawks, and golden eagles. Grassland conservation and restoration will also help offset effects on cultivated lands (e.g., alfalfa) that produce prey for covered species. This objective will be achieved through grassland restoration and management as described in *CM8 Grassland Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management.*

Objective GNC2.5 Rationale: Achieving this objective will increase the native diversity and value of protected grasslands for covered and other native amphibian species, including California red-legged frog, California tiger salamander, Pacific chorus frog, and western pond turtle. Maintaining appropriate depth and duration of aquatic features is important for native amphibians to ensure that conditions are favorable for supporting the entire aquatic life cycle from breeding through metamorphosis from larval to adult stages. Furthermore, features that are dry in late summer are less likely to support bullfrogs and nonnative fish that prey on native amphibians. Additionally, livestock exclusion and other measures will be implemented as described in *CM11 Natural Communities Enhancement and Management* to promote growth of aquatic vegetation with appropriate cover characteristics favorable to native amphibians and aquatic reptiles.

3.3.6.12 Inland Dune Scrub

Inland dune scrub occurs in only one location in the Plan Area, consisting of approximately 20 acres along the south shore of the San Joaquin River immediately east of the city of Antioch, within the 67-acre Antioch Dunes National Wildlife Refuge. The refuge is completely isolated from other terrestrial natural communities by development to the west, south, and east, and by the San Joaquin River to the north, and there are no opportunities for dune restoration in these surrounding, developed areas. Endangered and special-status species endemic to this natural community include Lange's metalmark butterfly (*Apodemiz mormo langei*), Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*), and Antioch Dunes evening primrose (*Oenothera deltoids* ssp. *howellii*); these are not covered species under the BDCP. Because covered activities will not adversely affect any inland dune scrub, none of the endemic inland dune scrub species are covered under the BDCP, and all inland dune scrub in the Plan Area is protected and managed by USFWS to sustain the suite of native species dependent on this natural community, there are no biological goals and objectives for this natural community or implementation actions targeting this community.

3.3.6.13 Cultivated Lands

Cultivated lands in the Plan Area consist of a dynamic matrix of a variety of land cover types, including perennial, semiperennial, and seasonally or annually rotated crops. The large extent of rotated crops results in a cover type matrix that is subject to change annually based primarily on agricultural economic conditions.

The Plan Area formerly supported extensive brackish and freshwater wetlands, open grasslands, broad riparian systems, and oak woodlands. By the mid-1800s, conversion of wetlands began to transform the Delta into an agricultural region with a complex system of channelized waterways and Delta "islands." The majority (56%) of lands in the Plan Area are currently cultivated (Figure 3.2-12). Cultivated lands total 481,909 acres, of which less than 13% (61,942 acres) is currently protected.

Although the conversion of natural vegetation to cultivated lands has eliminated large areas of native habitats, some agricultural systems continue to support abundant wildlife and provide important breeding, foraging, and roosting habitat for many resident and migrant wildlife species. Upland and seasonally flooded cultivated lands and wetlands of the Delta support an estimated 10% of the waterfowl population that annually winter in California (CALFED 1998). Covered species that use cultivated lands include Swainson's hawk, giant garter snake, and sandhill crane. These species have come to rely on the habitat value of certain cultivated lands, farming practices, and crop types. Swainson's hawks in the Central Valley and Delta rely on cultivated lands for foraging, given the lack of grassland foraging habitat remaining in California (Hartman and Kyle 2010). Cultivated lands, however, support a less diverse and less dense community of wildlife compared with natural communities (Fleskes et al. 2005; EDAW 2007; U.S. Fish and Wildlife Service 2007; Kleinschmidt Associates 2008).

The dynamic cropping patterns in the Plan Area result in regular changes in habitat values at the site level for cultivated land-associated covered species. These dynamic cropping patterns can be compatible with wildlife use as long as the overall amount of crops and types of agricultural practices that provide high-value habitat for covered species remains relatively constant at the regional scale. Major regional shifts in crop types or agricultural practices may diminish wildlife habitat values at a regional level. Changes in crop production can have substantial effects on the habitat value of cultivated lands for wildlife, particularly birds. Hay, grain, row crops, and irrigated pastures support abundant rodent populations, providing a prey base for many wildlife species. Conversion of these cultivated lands to orchards and vineyards has been noted as a factor adversely affecting native wildlife, including raptors such as Swainson's hawk (Estep Environmental Consulting 2008). Orchards and vineyards develop a dense overstory canopy that generally precludes access to ground-dwelling prey by foraging Swainson's hawks, white-tailed kites, western burrowing owls, and other covered species associated with cultivated lands.

The conservation approach for cultivated lands is to protect at a regional scale cultivated lands that provide high-value foraging and other habitat values for covered species in the Plan Area.

The goals and objectives that will benefit cultivated lands are included below. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective.

3.3.6.13.1 Applicable Landscape-Scale Goals and Objectives

No landscape-scale biological goals and objectives are integral to the conservation strategy for cultivated lands.

3.3.6.13.2 Natural Community Goals and Objectives

The goals and objectives below address needs specific to the conservation of cultivated lands.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.
• **Objective CLNC1.1:** Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species. • **Objective CLNC1.2**: Target cultivated land conservation to provide connectivity between other conservation lands. • **Objective CLNC1.3:** Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objective CLNC1.1 Rationale: Cultivated landscapes are highly dynamic and subject to seasonal and annual changes in overall crop patterns and vegetation type and structure. Wildlife species that use these habitats have learned to exploit those elements within this landscape that provide them with suitable and accessible food or other resource values. The sustainability of these habitats is a function of agricultural economics and thus long-term security of a suitable cultivated landscape that provides essential habitat for covered species is also uncertain.

Achieving this objective will ensure maintenance of cultivated lands in the reserve system that provide the highest habitat values for covered species. Irrigated pastures, alfalfa, and annually cultivated irrigated cropland provide foraging habitat for covered species including Swainson's hawk, white-tailed kite, western burrowing owl, greater sandhill crane, and tricolored blackbird. Alfalfa and pasture crop types provide high-value Swainson's hawk and tricolored blackbird foraging habitat. Grain, corn, and rice fields provide foraging habitats for sandhill cranes, waterfowl, wading birds, and shorebirds. Rice fields provide foraging habitat for many bird species as well as important aquatic habitat for giant garter snakes and western pond turtle.

Objective CLNC1.2 Rationale: While some covered species associated with cultivated lands, such as Swainson's hawk, are highly mobile and do not necessarily require connectivity of large habitat patches, other species, such as giant garter snake and western pond turtle, will benefit from acquiring parcels that facilitate expansion of existing populations and dispersal and other movements between occupied areas and connectivity to suitable unoccupied areas, consistent with this objective. For example, protected cultivated lands (and restored tidal and nontidal marsh) in Conservation Zone 4 will maintain existing connectivity to Stone Lakes National Wildlife Refuge and facilitate northward expansion of the Coldani Marsh/White Slough giant garter snake subpopulation.

Objective CLNC1.3 Rationale: Cropland vegetation is typically grown as a monoculture using tillage or herbicides to eliminate unwanted plants. Interspersed within cultivated lands, however, are small patches or linear corridors of natural vegetation and other natural features that provide important habitat for a wide variety of native species. Small patches of riparian woodland and scrub, wetlands, ponds, hedgerows, tree rows, and isolated native or nonnative trees support songbirds, raptors, reptiles, amphibians, and small mammals. Maintenance of these small but important wildlife habitats, consistent with this objective, will benefit covered wildlife species as well as a diversity of noncovered native wildlife. Cultivated lands are used primarily for foraging by several species that nest in riparian areas, roadside trees, or isolated trees and groves. Swainson's hawks use grassland remnants in the cultivated lands matrix for foraging early in the season, before cultivated lands provide peak foraging value; grasslands also provide a stable habitat that is accessible during times when the management of cultivated lands results in lower prey abundance and availability. Wetlands, streams, ponds, hedgerows, groves, and other remnant natural or created habitats must be maintained to provide the full range of habitat elements necessary to support covered species in cultivated lands. Therefore, consistent with this objective, protection and management of cultivated lands will include maintenance of these key elements.

3.3.7 Species Biological Goals and Objectives

Biological goals and objectives applicable to the individual covered species are outlined below. The applicable landscape-scale and natural community goals and objectives are listed first, with descriptions of how achieving them would benefit the species. Species-specific biological goals and objectives are then listed followed by descriptions of the approach and rationale with which they were established. Further detail regarding how biological goals and objectives for covered fish species were developed can be found in Section 3.2.3, *Developing Aquatic Resources Component of the Conservation Strategy*. Conservation measures designed to meet all objectives are found in Section 3.4, *Conservation Measures*. Table 3.3-3 shows the habitat functions of the natural communities that support the covered species.

For a complete description of status, range, life history, threats, and modeled habitat for each species, see Appendix 2.A, *Covered Species Accounts*. For terrestrial species, Appendix 2.A also includes figures depicting range within the state and the Plan Area, modeled habitat, and occurrences; these figures are referenced below.

Table 3.3-3. Habitat Functions of Natural Communities That Support Primary Habitats of Covered Terrestrial Wildlife and Plant Species

Covered Species	Tidal Perennial Aquatic	Tidal Mudflat	Tidal Brackish Emergent Wetland	Tidal Freshwater Emergent Wetland	Valley/Foothill Riparian	Nontidal Perennial Aquatic	Nontidal Freshwater Perennial Emergent Wetland	Alkali Seasonal Wetland Complex	Vernal Pool Complex	Managed Wetland	Other Natural Seasonal Wetlands	Grassland	Inland Dune Scrub	Cultivated Lands
Mammals														
Riparian brush rabbit[1]					All life-history requirements							Foraging		
Riparian woodrat (San Joaquin Valley)					All life-history requirements									
Salt marsh harvest mouse			All life-history requirements							All life-history requirements		Upland refugia during high tides		
San Joaquin kit fox									All life-history requirements			All life-history requirements		
Suisun shrew			All life-history requirements							All life-history requirements		Upland refugia during high tides		
Birds														
California black rail			All life-history requirements	All life-history requirements			All life-history requirements			All life-history requirements				
California clapper rail		Foraging	All life-history requirements	All life-history requirements										
Greater sandhill crane								Foraging	Foraging	Foraging and roosting	Foraging	Foraging		Roosting and foraging
Least Bell's vireo					All life-history requirements.									
Suisun song sparrow			All life-history requirements	All life-history requirements						All life-history requirements				
Swainson's hawk					Breeding			Foraging	Foraging	Foraging	Foraging	Foraging		Foraging
Tricolored blackbird			Winter roosting	Winter roosting	Breeding		Breeding	Foraging	Foraging	Winter roosting	Foraging	Foraging		Foraging
Western burrowing owl								Foraging	Breeding and Foraging	Foraging	Foraging	Breeding and foraging		Breeding and foraging
Western yellow-billed cuckoo					All life-history requirements									
White-tailed kite					Breeding			Foraging	Foraging	Foraging	Foraging	Foraging		Foraging
Yellow-breasted chat					All life-history requirements									

Covered Species	Tidal Perennial Aquatic	Tidal Mudflat	Tidal Brackish Emergent Wetland	Tidal Freshwater Emergent Wetland	Valley/Foothill Riparian	Nontidal Perennial Aquatic	Nontidal Freshwater Perennial Emergent Wetland	Alkali Seasonal Wetland Complex	Vernal Pool Complex	Managed Wetland	Other Natural Seasonal Wetlands	Grassland	Inland Dune Scrub	Cultivated Lands
Reptiles														
Giant garter snake	Breeding, foraging, and movement			Breeding, foraging, and movement		Breeding, foraging, and movement	Breeding, foraging, and movement	Aestivation and movement	Aestivation and movement	Breeding, foraging. aestivation and movement		Aestivation and movement		Breeding (rice), foraging, aestivation, and movement
Western pond turtle	Foraging and movement		Foraging and movement	Foraging and movement	Breeding, foraging, aestivation, and movement	Foraging and movement	Foraging and movement			Foraging and movement		Breeding, foraging, aestivation, and movement		Foraging, and movement
Amphibians														
California red-legged frog				Breeding, foraging and movement	Foraging, aestivation, and movement	Breeding, foraging	Breeding, foraging and movement	Movement	Foraging, aestivation, and movement	Foraging and movement		Foraging, aestivation, and movement		Foraging and movement
California tiger salamander								Foraging and movement	Breeding and foraging			Foraging, cover, and movement		
Invertebrates														
California linderiella									All life-history requirements					
Conservancy fairy shrimp									All life-history requirements					
Longhorn fairy shrimp									All life-history requirements					
Midvalley fairy shrimp									All life-history requirements					
Valley elderberry longhorn beetle					All life-history requirements							All life-history requirements		
Vernal pool fairy shrimp									All life-history requirements					
Vernal pool tadpole shrimp									All life-history requirements					
Plants														
Alkali milk-vetch[2]									All life-history requirements					
Boggs Lake hedge-hyssop									All life-history requirements					
Brittlescale[3]								All life-history requirements	All life-history requirements			All life-history requirements		
Carquinez goldenbush[4]								All life-history requirements	All life-history requirements			All life-history requirements		
Delta button celery[5]					All life-history requirements			All life-history requirements	All life-history requirements			All life-history requirements		
Delta mudwort		All life-history requirements	All life-history requirements	All life-history requirements	All life-history requirements									

Covered Species	Tidal Perennial Aquatic	Tidal Mudflat	Tidal Brackish Emergent Wetland	Tidal Freshwater Emergent Wetland	Valley/Foothill Riparian	Nontidal Perennial Aquatic	Nontidal Freshwater Perennial Emergent Wetland	Alkali Seasonal Wetland Complex	Vernal Pool Complex	Managed Wetland	Other Natural Seasonal Wetlands	Grassland	Inland Dune Scrub	Cultivated Lands
Delta tule pea[6]			All life-history requirements	All life-history requirements	All life-history requirements									
Dwarf downingia									All life-history requirements					
Heartscale								All life-history requirements	All life-history requirements			All life-history requirements		
Heckard's peppergrass[7]									All life-history requirements					
Legenere									All life-history requirements					
Mason's lilaeopsis[8]		All life-history requirements	All life-history requirements	All life-history requirements	All life-history requirements									
San Joaquin spearscale[9]								All life-history requirements	All life-history requirements			All life-history requirements		
Side-flowering skullcap					All life-history requirements									
Slough thistle[10]					All life-history requirements									
Soft bird's-beak[11]			All life-history requirements											
Suisun Marsh aster[12]			All life-history requirements	All life-history requirements	All life-history requirements									
Suisun thistle[13]			All life-history requirements											

1 Riparian brush rabbits will also use small grassland and seasonal wetlands that occur immediately adjacent to or as openings within riparian communities.

2 Occurs along the upper margins of vernal pools, playa pools, and in swales in the clay alluvium vernal pools and playas, Montezuma Block vernal pools and playas, and alkaline sink/meadow vernal pools in the BDCP vernal pool complex regions.

3 occurs along intermittent and perennial drainages and along the borders of playa pools in the clay alluvium vernal pools and playas, Montezuma Block vernal pools and playas, and alkaline sink/meadow vernal pools in the BDCP vernal pool complex regions. Also occurs in alkali seasonal wetland complex in the same areas.

4 Carquinez goldenbush occurs along seasonal drainages, adjacent to the margins of alkaline playa pools, and in association with vegetation that is transitional between the brackish marsh and the grasslands within the 3.4-4.3 meter NAVD88 elevation band along the eastern border of Suisun Marsh.

5 Delta button celery occurs in two habitat types. One habitat type is seasonally scoured and inundated swales, depressions, and clay flats in the floodplain of the San Joaquin River and the other alkaline clay deltas of Coast Range tributaries that are deposited immediately above the flood basin of the San Joaquin River where plant cover is typical alkaline sink vegetation.

6 Occurrences in open vegetation in freshwater areas are on the landward side of the landward boundary of tidal freshwater emergent wetland and in brackish water areas in and near Suisun Marsh, within a range of tidal elevations that are generally near drainages.

7 Occurs in all BDCP vernal pool complex regions on alkaline clays soils in areas that are not deeply inundated.

8 Occurs on open areas of tidal mudflats that are susceptible to scour and deposition and it colonizes new areas through water transported seed and vegetative parts.

9 Occurs in more saline or disturbed areas in the clay alluvium vernal pools and playas, Montezuma Block vernal pools and playas, and alkaline sink/meadow vernal pools in the BDCP vernal pool complex regions. Also occurs in grassland and alkali seasonal wetland complex in the same areas.

10 In the southern San Joaquin Valley, slough thistle occurs in the scoured and overflow areas of stream channels on alkaline soils. In the northern San Joaquin Valley the historical occurrences have been along tidal river channels or in wetland inclusions in agricultural fields.

11 In Suisun Marsh soft bird's-beak is distributed in bands at the lower margin of the brackish high marsh that are not correlated with elevation, but with soil pore water salinity during the dry season which is determined by distance to channel and varies from season to season depending on freshwater flows from creeks draining into the marsh. Where the topography is more complex, such as areas with ridges or mounds and on levee banks, soft bird's-beak can be found in a variety of patch shapes.

12 Occurrences in open vegetation in freshwater areas are on the landward side of the landward boundary of tidal freshwater emergent wetland and in brackish water areas in and near Suisun Marsh, within a range of tidal elevations that are generally near drainages. It is also found in less densely vegetated areas of valley/foothill riparian vegetation.

13 Endemic to the Suisun Marsh where it occurs adjacent to first-order channels or mosquito control ditches that link to first-order channels.

3.3.7.1 Delta Smelt

Delta smelt (*Hypomesus transpacificus*) occur throughout the Delta, Suisun Bay, Suisun Marsh, and, during high outflows, within the Napa and Petaluma Rivers (Moyle 2002; Kimmerer 2004; Bennett 2005). Delta smelt have most often been found in somewhat shallow (i.e., less than 12 to 15 feet) (Moyle et al. 1992; Aasen 1999), turbid, low-salinity water often at the upstream edge of the low-salinity zone; the low-salinity zone is defined as 0.5 to 6.0 practical salinity units (psu) (Kimmerer 2004; Nobriga and Herbold 2009). In recent years, delta smelt have colonized habitat in Liberty Island, a north Delta island that flooded in 1997 (Sommer 2012). Juvenile delta smelt are known to be most abundant where salinity is very low (< 3 psu), water transparency is low or turbidity is high (Secchi disk depth <0.5 m), and water temperatures are cool (peak capture probabilities have occurred at about 20°C [68°F]) (Feyrer et al. 2007, 2011; Nobriga et al. 2008). Subadult and adult delta smelt densities are positively correlated with turbidity. For larvae, this positive correlation reflects greater foraging effectiveness in turbid water (Baskerville-Bridges et al. 2004); for juveniles and adults, this association is widely assumed to reflect better predator avoidance in more turbid waters (Nobriga et al. 2005; Miller 2007; Feyrer et al. 2007).

Results of fishery surveys conducted by CDFW and USFWS using many different collection methods, in addition to past records and habitat conditions for delta smelt, have been used to determine the current abundance trends (Figure 3.3-1) (California Department of Fish and Game 2012). The delta smelt population size is at a historical low from 2004 to 2012. However, in 2011, the population size was estimated to be at its highest level since 2001.

Sommer (2012) noted that current abundance trends rely on long-term surveys in geographically fixed locations and that there is new evidence that catch in these surveys is affected by shifts in distribution away from the core channels where sampling occurs. It is unclear whether the distribution shifts are a result of active behavioral choices or an apparent change caused by higher mortality in the low-salinity zone channels. Thus, results indicating longitudinal shifts in distribution to areas that have not historically been sampled suggest that management of delta smelt should consider not just the low-salinity zone, but also the Cache Slough complex. Sommer (2012) also noted that at least some delta smelt occur year-round in the region. These findings were relatively unexpected as there had previously been a general assumption that delta smelt leave the north Delta after the larval stage (Moyle et al. 1992; Sommer et al. 2011a). Moreover, flooded islands are generally considered low-value habitat for delta smelt in the central and southern Delta (e.g., Grimaldo et al. 2009; Nobriga et al. 2005 in Sommer 2012), yet results from the USFWS beach seine and larval fish surveys show consistent use of Liberty Island and Sacramento DWSC, two major features of the Cache Slough ROA (Sommer et al. 2011a; Sommer and Mejia in review in Sommer 2012), which is well upstream of the low-salinity zone. Studies (Baxter et al. 2010; Hobbs et al. 2010; Sommer et al. 2011a; Sommer et al. 2011b) indicate that the current long-term trawls in the channels and shoals of the low-salinity zone appear to underestimate the distribution and abundance of delta smelt, longfin smelt, and striped bass. This does not mean, however, that the distribution shifts fully explain the pelagic organism decline (POD), as the declines in these fishes are too extreme to be fully explained by the apparent moderate distribution shifts (Sommer 2012). In addition, the evidence that delta smelt, as well as longfin smelt, are increasingly rare in some of the main channels of the low-salinity zone may be cause for concern, because this was historically an important part of their rearing habitat. It is unclear whether the distribution shifts are a result of active behavioral choices or an apparent change caused by higher mortality in the low-salinity zone channels (Sommer 2012). Thus, results indicating lateral shifts in distribution to areas that may not be sampled suggest that management of delta smelt should consider not just the low-salinity zone, but also outside areas (Sommer 2012).

Multiple threats and stressors affect delta smelt and appear to act in complicated and synergistic ways to influence the distribution and abundance of the species (Moyle 2002; Maunder and Deriso 2011). Individual stressors affect delta smelt at different times based on environmental conditions and the distribution of particular life stages. Stressors that affect delta smelt include reduced food availability, reduced extent of suitable rearing habitat, elevated water temperature, reduced turbidity, reduced spawning habitat, predation by or competition with nonnative species, entrainment, and exposure to toxins. Refer to Appendix 2.A, *Covered Species Accounts*, for a detailed discussion of this species and its potential relationship to these stressors.

The USFWS recovery strategy for delta smelt is contained in the *Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes*[24] (Delta Native Fish Recovery Plan) (U.S. Fish and Wildlife Service 1996). The objective of this plan is to recover the species through restoration of its abundance and geographic distribution. The basic strategy for recovery is to manage the estuary in such a way that it provides better habitat for native fish in general and delta smelt in particular[25].

The conservation strategy for delta smelt focuses on three primary stressors for the species: food, excessive predation by (large) nonnative predators, and entrainment. The strategy includes creation, restoration, and enhancement of substantial tidal and nontidal perennial aquatic natural communities that will dramatically increase the extent of tidal, intertidal, freshwater, and shallow-water habitat. This is assumed to increase production of food important to delta smelt, both within habitat occupied by delta smelt and via tidal dispersion to offshore habitat (Müller-Solger et al. 2002; Lehman et al. 2010). Actions to control predation will focus on specific hotspots in the Plan Area. Reducing predation by species, such as striped bass, that prey on delta smelt and dramatically reducing invasive aquatic vegetation (IAV) that facilitates predation are expected to increase survival of delta smelt. Changing the primary point of diversion to the north Delta will contribute to further reducing the already low levels of entrainment of delta smelt (averaged across all water-year types) currently required under the USFWS (2008) BiOp. The entrainment levels required under the BiOp, which are much lower than historical levels, will be met or further reduced under the BDCP, depending on the water-year type. The installation of fish screens in the new north Delta intakes will limit entrainment of delta smelt and minimize impingement. As described in the species-specific goals and objectives, the conservation measures are expected to improve the performance of delta smelt by achieving the following benefits.

- Increased survival and thus abundance of adult and juvenile delta smelt.
- Increased growth of juvenile delta smelt.
- Increased spatial distribution of juvenile and prespawning adults.

The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C,

24 USFWS has the responsibility to review and update the recovery plan for this species.

25 Since 1996, scientific understanding of the biology of and threats to delta smelt has improved substantially. USFWS has formed the Delta Native Fishes Recovery Team to prepare an updated recovery plan, which is expected to be released in the near future.

Avoidance and Minimization Measures, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.1.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for delta smelt are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA. • **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities. • **Objective L1.8:** To accommodate sea level rise, provide potential tidal marsh plain within the anticipated future eastward position of the low-salinity zone of the estuary.

Objective L1.3 Benefits: Achieving this objective will contribute to enhancing the tidally influenced natural communities that may produce food important for delta smelt. A recent analysis by Miller et al. (2012) indicates that certain metrics of prey density are the best predictors of variations in delta smelt abundance from 1972 to 2006 and over the recent period of decline. This finding is broadly consistent with similar findings of other authors who found evidence for foodweb influences on delta smelt feeding, size, and abundance (Nobriga 2002; Bennett 2005; Kimmerer 2008; Maunder and Deriso 2011). The mean size of delta smelt captured in the fall declined shortly after the invasion of the estuary by *Potamocorbula* (Sweetnam 1999; Bennett 2005 in Nobriga and Herbold 2009). *Potamocorbula* filter large quantities of phytoplankton (Jassby et al. 2002), ciliates (Greene et al. 2011), and copepod larvae (Kimmerer et al. 1994) from the water column, thereby reducing the food resources of delta smelt. Restored tidal and subtidal natural communities are expected to increase emergent vegetation, nutrient cycling, and the production of phytoplankton, zooplankton, macroinvertebrates, and other aquatic organisms that provide food for delta smelt and other covered species.

Establishing a gradient of tidally influenced natural communities will provide a range of conditions suitable for food production, and in some locations may also provide additional habitat for spawning and rearing. The restoration of natural communities is intended to increase the extent of available habitat suitable for covered fish species and to rehabilitate some of the historical ecological functions of the Delta. Delta smelt are expected to particularly benefit from this restoration, because most individuals spend their entire life cycle in the Plan Area and are, therefore, significantly affected by the condition of natural communities and ecological processes occurring there.

Objective L1.4 Benefits: Achieving this objective is expected to contribute to an increase in the extent of environmental gradients in order to accommodate future climate change and resulting changes in temperature range and precipitation patterns, as well as sea level rise. Providing a broad range of habitat conditions (i.e., elevation, water depth, slope, aspect) is intended to provide suitable habitat for covered species, including delta smelt, in a changing system.

Objective L1.8 Benefits: Achieving this objective will contribute to providing a range of suitable habitat conditions for delta smelt in the future. Delta smelt distribution is strongly correlated to the low-salinity zone (Moyle et al. 1992; Sweetnam 1999; Dege and Brown 2004; Nobriga et al. 2008; Sommer et al. 2011a), and their distribution is expected to show an eastward shift over the long term in response to rising sea level and lower seasonal Delta outflows. Thus, it is hoped that providing tidal marsh plain adjacent to where the low-salinity zone is expected to frequently lie, will increase habitat suitability during periods of low flow above current baseline conditions. Specifically, the tidal marsh plain may contribute food resources important to delta smelt, which would be produced immediately adjacent to offshore areas occupied by delta smelt.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.

- **Objective L2.2:** Allow lateral river channel migration.
- **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers.
- **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system.
- **Objective L2.5:** Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity.
- **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.
- **Objective L2.8**: Provide refuge habitat for migrating and resident covered fish species.
- **Objective L2.9:** Increase the abundance and productivity of plankton and invertebrate species that provide food for covered fish species in the Delta waterways.
- **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain.

Objective L2.2 Benefits: Achieving this objective is intended to restore natural fluvial processes to improve habitat conditions through increased lateral river channel migration and floodplain connectivity/inundation, which can increase sediment inputs. Increased sediment inputs can increase turbidity, which facilitates delta smelt foraging effectiveness and predator avoidance (Nobriga and Herbold 2009).

Objective L2.3 Benefits: Achieving this objective will contribute to an increase in river-floodplain connectivity and potentially improve hyporheic processes, such as groundwater recharge, which can improve water quality, provide cool water inputs, and maintain groundwater input into surface waters. Achieving this objective may also contribute to an increase in allochthonous inputs, such as terrestrial insects and plant matter, and provide additional nutrients and increase the productivity of aquatic systems, which may contribute to a more diverse and robust forage base.

Objective L2.4 Benefits: Achieving this objective will contribute to a reduction in the amount of pollution in stormwater runoff entering Delta waterways. Such a reduction may benefit delta smelt by reducing pesticides and herbicides that can be highly toxic to plankton, which form the base of the foodweb, as well as by reducing sublethal effects of contaminants (e.g., effects on behavior, tissues and organs, reproduction, growth, and immune system) (Connon et al. 2010), such as pyrethroids and other chemicals from urban stormwater runoff. As described in *CM19 Urban Stormwater Treatment*, stormwater treatment measures are intended to decrease the discharge to the Delta of contaminants derived from urban stormwater. Decreasing the discharge of these contaminants is intended to improve water quality conditions in the Plan Area and thereby benefit covered species.

Objective L2.5 Benefits: Achieving this objective will contribute to providing a range of environmental gradients to ensure the long-term persistence of a diversity of spawning and rearing conditions exists for delta smelt in the Plan Area over the permit term. Because delta smelt are endemic to the Plan Area, providing a range of environmental gradients is critically important for the conservation of the species.

Objective L2.7 Benefits: Achieving this objective is intended to increase natural dendritic channels in tidal marsh natural communities to promote food production and transport, which may benefit juvenile delta smelt rearing in the low-salinity zone.

Objective L2.8 Benefits: Achieving this objective, possibly through restoration actions in the West Delta ROA, may contribute to providing cool-water refugia for delta smelt.

Objective L2.9 Benefits: Achieving this objective is expected to increase the supply of food important to delta smelt, such as mesozooplankton. Increased food resources may result in increased survival and growth and, consequently, increased fecundity in adults.

Objective L2.11 Benefits: Achieving this objective is also expected to increase the supply of food important to delta smelt. Restoring seasonally inundated floodplain may contribute to a seasonal increase in primary productivity and invertebrate production (Müller-Solger et al. 2002; Lehman et al. 2008) that will contribute to a more diverse and robust forage base for adult and juvenile delta smelt. Floodplain connectivity/inundation can also result in increased sediment inputs and thereby increase turbidity, which facilitates delta smelt foraging effectiveness and predator avoidance (Nobriga and Herbold 2009).

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.2:** Promote connectivity between low-salinity zone habitats and upstream freshwater habitats and availability of spawning habitats for native pelagic fish species.

Objective L3.2 Benefits: Achieving this objective will contribute to increased connectivity between low-salinity zone habitat and upstream freshwater spawning habitat. Currently, there are few if any physical barriers that block delta smelt migrations; the only possibilities are Suisun Marsh Salinity Control Gates and Delta Cross Channel, neither of which is considered to be a notable impediment to smelt movement. The largest potential impediment to delta smelt migration is the sometimes high risk of entrainment in the south Delta that can result from reverse flows in Old and Middle Rivers when delta smelt migrate up the San Joaquin River. The use of dual conveyance would be expected to lessen this risk. This increased connectivity would benefit delta smelt adults by improving access to spawning habitat in the San Joaquin River.

Further, the BDCP will address water quality issues in the Plan Area, such as the DO levels in the Stockton DWSC and urban stormwater runoff. The BDCP will include funding to the Port of Stockton to continue operation of the aerator facility in the Stockton DWSC, directly improving the connectivity between areas downstream of Turner Cut and the San Joaquin River upstream of Stockton by minimizing the low DO condition that persist in this area. The BDCP will also provide funding to urban centers that discharge stormwater to the Plan Area to assist them in reducing their inputs of polluted stormwater to the Delta. Reducing the inputs of pollution from urban stormwater will contribute to improved water quality and may improve the health of the Delta and the covered species that occur there.

Goal L4: Increased habitat suitability for covered fish species in the Plan Area.
• **Objective L4.1:** Manage the distribution and abundance of nonnative predators in the Delta to reduce predation on covered fishes. • **Objective L4.3:** Reduce entrainment losses of covered fish species.

Objective L4.1 Benefits: Achieving this objective is intended to reduce predation on delta smelt by nonnative predators. Although predation is a natural part of aquatic community dynamics, excessive predation has been identified as a stressor for covered fish species, including delta smelt (Bennett 1995; Baxter et al. 2008). Refer to *CM15 Localized Reduction of Predatory Fishes* for a discussion of the BDCP's contribution toward the management of nonnative predators in the Plan Area.

Objective L4.3 Benefits: Achieving this objective is intended to reduce the entrainment of delta smelt. As delta smelt have continued to decline, the population can only absorb very low entrainment loss (Kimmerer 2011). Maunder and Deriso (2011) concluded that entrainment of delta smelt does not always have an important effect on population growth when compared to other stressors. However, entrainment of delta smelt results in mortality, and lower levels of entrainment are desirable for the benefit of the species and to ensure the effects of water operations are minimized. A pelagic organism decline (POD) synthesis, prepared by the Interagency Ecological Program (2005), described entrainment as likely being important under certain conditions but not universally important in all years. Kimmerer (2008) had similar conclusions, that losses of adult delta smelt due to entrainment were important in certain years, while in other years the population-level effects were small. Historically, numbers of delta smelt salvaged have been substantial in some years, running in the tens of thousands for adults and hundreds of thousands for juveniles. In more recent years, entrainment has declined to significantly lower levels as a result of pumping restrictions imposed under the current USFWS (2008) BiOp and reduced population levels.

The BDCP will generally further reduce entrainment from south Delta pumping, when averaged across all water-year types, due to reduced use of the south Delta pumps. Refer to Objective DTSM1.2, below, and Appendix 5.B, *Entrainment*, for further discussion of entrainment of delta smelt.

3.3.7.1.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for delta smelt are stated below.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Benefits: Achieving this objective will contribute toward restoring tidal perennial aquatic natural communities that provide habitat conducive to primary productivity, which is essential to increasing the food base for delta smelt. Delta smelt larvae feed primarily on the larval stages of three copepods: *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and freshwater species of the family Cyclopidae (Nobriga 2002). Similarly, juvenile delta smelt also eat zooplankton, but they can capture larger varieties than larval stages including cladocerans, mysids, amphipods, and larval fish (Moyle et al. 1992; Lott 1998 in Nobriga and Herbold 2009). Restoring or creating at least 10,000 acres of tidal perennial aquatic natural communities in Conservation Zones 1, 2, 4, 5, 7, and 11 will substantially increase the area available to contribute to primary productivity and food resources important to delta smelt, such as copepods. This substantial increase in tidal perennial aquatic natural communities is anticipated to help offset the historical loss of similar habitat in the Plan Area. The targeted conservation zones include areas where substantial delta smelt spawning and rearing are expected to occur (Wang 1991).

Tidal natural communities in the Cache Slough ROA at the southern end of the Yolo Bypass, in combination with floodplain enhancement (see Objectives L2.2 and L2.3, above), are expected to provide tidal freshwater wetland structure and functions that exchange with and benefit adjacent open-water habitat (Lehman et al. 2010). Tidal wetlands also have the capacity to export food resources to adjacent channels and to downstream systems (Cloern et al. 2007; Lehman et al. 2008, 2010). The export of food to open-water areas may include movement of phytoplankton and zooplankton by advection and tidal exchanges and the export of productivity in the form of macroinvertebrates, small fishes, and other larger organisms (Kneib 1997, 2003). Of the Delta habitats, the tidal marsh sloughs have the highest particulate organic matter and phytoplankton concentrations and support the greatest zooplankton growth rates (Müller-Solger et al. 2002; Sobczak et al. 2002).

The export of marsh production can help transfer the higher production of shallow-water habitats to the less productive deepwater habitats preferred by pelagic fish species such as delta smelt, but this process can be interfered with by nonnative clams (Lucas et al. 2002; Lopez et al. 2006; Lucas and Thompson 2012). Nonetheless, there are local examples of tidal marsh production being advected and/or tidally dispersed to adjacent habitats (Lehman et al. 2008, 2010). Production from the lower Yolo Bypass, including Liberty Slough and Cache Slough marshes, stays relatively intact as it moves down the estuary (Monsen 2003). This production may contribute significantly to the greater foodweb, ultimately benefitting open-water species such as delta smelt (Brown 2004). Refer to Appendix 5.F, *Biological Stressors on Covered Fish*, for a detailed discussion of the foodweb.

Additionally, delta smelt probably spawn in shallow water, most often on sand or gravel (Nobriga and Herbold 2009). Providing a gradient of floodplain and tidally influenced natural communities will contribute to the ongoing likelihood that a range of suitable spawning habitats is available for the duration of permit term.

Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.
• **Objective TPANC2.1:** Control invasive aquatic vegetation that adversely affects native fish habitat.

Objective TPANC2.1 Benefits: Achieving this objective is anticipated to address the IAV that has contributed to declining turbidity in the Delta (Jassby et al. 2002). It is hypothesized that one of the primary causes of the decreased turbidity in the Delta is biological filtration by IAV (Brown and Michniuk 2007). For example, Santos et al. (2010) noted that stands of *Egeria* reduce turbidity, thus increasing available light through the water column. Controlling IAV is anticipated to help increase turbidity. Delta smelt have evolved in turbid waters and have adapted to life in turbid waters to avoid predators and to successfully forage on prey organisms, so increases in turbidity are expected to improve delta smelt survival.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands

(Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*.

- **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25.
- **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them.
- **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objectives TBEWNC1.1 and TBEWNC1.2 Benefits: Achieving these objectives will restore tidal brackish emergent wetlands, which is expected to result in increased primary productivity (Müller_Solger et al. 2002), which could in turn result in more food available to delta smelt. Restoring natural communities in Suisun Marsh will directly improve and expand some delta smelt habitat elements. Delta smelt are thought to have historically spawned in freshwater reaches of Suisun Marsh, and postlarval delta smelt of all sizes are found in the main channels of the Delta and Suisun Marsh and the open waters of Suisun Bay, where the waters are well-oxygenated and temperatures are relatively cool, usually lower than 20°C to 22°C (68°F to 72°F) in summer (Meng and Matern 2001; Moyle 2002; Dege and Brown 2004).

Objective TBEWNC1.3 Benefits: Achieving this objective will restore connectivity to isolated patches of tidal emergent marsh to potentially increase the transport of food from tidal marshes to areas occupied by delta smelt, thereby potentially increasing the food available to delta smelt. Greater availability of food may contribute to an increase in growth and fecundity.

Objective TBEWNC1.4 Benefits: Achieving this objective is anticipated to promote effective exchange throughout the marsh plain to increase transport of food from restored wetlands to low-salinity zone and other habitats occupied by delta smelt. Increasing the transport and delivery of food to habitats occupied by delta smelt is expected to contribute to an increase in growth and fecundity.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.

- **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.
- **Objective TFEWNC1.2:** Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.

Objective TFEWNC1.1 Benefits: Achieving this objective will restore tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7, which may result in increased primary productivity. Increased primary productivity could result in more food available to delta smelt and provide additional delta smelt spawning and early rearing habitat. These benefits will also affect areas where substantial delta smelt spawning and rearing habitat is expected to occur (Wang 1991).

Objective TFEWNC1.2 Benefits: Achieving this objective is anticipated to promote effective exchange throughout the marsh plain to increase transport and delivery of food to habitats occupied by delta smelt. Increasing the transport of food is anticipated to contribute to an increase in growth and fecundity.

3.3.7.1.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance some suitable habitat elements for delta smelt within the reserve system. The goals and objectives below are intended to represent specific, quantifiable biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during the BDCP permit term. The following global recovery goal and objectives are provided here for broader context of delta smelt recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal:** Remove delta smelt from the state and federal lists of endangered species through restoration of its abundance and distribution.
  - **Global Objective 1.1 (Abundance):** Achieve a Recovery Index equal to or greater than 239 for at least 2 years of any consecutive 5-year period; the midpoint of any two consecutive Recovery Index values cannot be lower than 84.
  - **Global Objective 1.2 (Entrainment):** Maintain a cumulative entrainment of equal to or less than 5%[26] per year across all life stages.
  - **Global Objective 1.3 (Spatial Distribution):** Collect delta smelt in the four zones where the FMWT occurs—north central Delta, Sacramento River, Montezuma Slough, and Suisun Bay—in at least 2 years of any consecutive 5-year period in the FMWT survey; in at least two of the four zones in at least 1 of the remaining 3 years in any consecutive 5-year period; and in at least one of the four zones in the remaining 2 years.

The biological goal and objectives presented below have been developed to provide for the conservation and management of delta smelt in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

[26] This proportion could be increased—possibly substantially—if carrying capacity and juvenile life-stage density-dependence are restored to historical levels.

Goal DTSM1: Increased end of year fecundity and improved survival of adult and juvenile delta smelt to support increased abundance and long-term population viability.
• **Objective DTSM1.1:** Increase fecundity of delta smelt over baseline conditions as measured through field investigations and laboratory studies conducted through year 10 and refined through adaptive management. • **Objective DTSM1.2:** Limit entrainment mortality associated with operations of water facilities (i.e., CVP and SWP) in the south Delta to ≤5% of the delta smelt population, calculated as a 5-year running average of entrainment for subadults and adults in the fall and winter and their progeny in the spring and summer. Assure that the proportional entrainment risk is evenly distributed over the adult migration and larval-juvenile rearing time periods. • **Objective DTSM1.3:** Achieve a Recovery Index ≥239 for delta smelt for at least 2 years of any consecutive 5-year period; measured from initial operations through the end of the permit term, the midpoint of any two consecutive Recovery Index values cannot be lower than 84.
Assumed stressors: Lack of food resources. **Stressor reduction targets:** • **Food.** Increase the density of copepods and other food resources that delta smelt prefer (currently calanoid copepods) and that co-occur with delta smelt in suitable habitat by year 40.

Objective DTSM1.1 Rationale: Achieving this objective will address the conditions that favor growth in juveniles, which is a critical fitness measure that transfers across life stages and has been shown to influence fecundity in the adult stage of many kinds of fishes.

Food availability is a limiting factor for delta smelt, and changes in food resources (lower abundance of historical prey, and high abundance of smaller prey interacting with warm water temperatures) have been identified as an important factor contributing to the delta smelt decline (Nobriga and Herbold 2009; Baxter et al. 2010; Maunder and Deriso 2011; Miller et al. 2012). Kimmerer (2008) also reported a statistically significant relationship between juvenile smelt survival and zooplankton biomass in the low-salinity zone. There has also been a decline in the mean size of young-of-the-year (YOY) delta smelt in December following the introduction of *Potamocorbula*, an invasive competitor for the delta smelt's zooplankton prey (Sweetnam 1999; Bennett 2005 in Nobriga and Herbold 2009). Small size in delta smelt at the end of the growing season may delay maturation and lower fecundity (Bennett et al. 2008). Delta smelt growth is chronically limited, at least during summer, by a combination of high water temperature and low food quality and quantity (Baxter et al. 2010).

Increasing the density of copepods and other food resources that delta smelt prefer (e.g., mysids, amphipods) that co-occur with delta smelt in suitable/occupied habitat is expected to help increase the growth and survival of delta smelt. Because fecundity increases as a function of increasing length of the female (Bennett 2005), an increase in growth rates is expected to contribute to increased fecundity. Increased density of food resources and increased growth rates of delta smelt should also result in improved survival and increased adult abundance, which would contribute directly to increased fecundity of the overall population.

Improved growth, assumed to lead to increased size and fecundity, will be achieved through actions to protect, restore, and enhance tidally influenced natural communities. These actions are expected to increase delta smelt growth rates by increasing the density of zooplankton in the Cache Slough, West Delta, and Suisun Marsh ROAs, where most delta smelt are expected to rear for extended periods. More specifically, the BDCP is expected to increase the density of zooplankton suitable for delta smelt as follows.

- Increase timing, frequency and duration of floodplain inundation in Yolo Bypass (*CM2 Yolo Bypass Fisheries Enhancement*).
- Construct new tidal wetlands (*CM4 Tidal Natural Communities Restoration*).
- Provide for greater floodplain inundation (*CM5 Seasonally Inundated Floodplain Restoration*).
- Enhance channel margin along up to 20 miles of currently leveed channel by restoring riparian, marsh, and mudflat natural communities along levees (*CM6 Channel Margin Enhancement*).
- Improve water quality conditions within the Plan Area (*CM12 Methylmercury Management* and *CM19 Urban Stormwater Treatment*)

In addition to contributing to an increase in the quantity and quality of zooplankton available to delta smelt, these actions have the potential to provide increased production of periphyton, phytoplankton, macroinvertebrates, insects, and small fish that contribute to the local and regional trophic foodweb associated with each ROA. Delta smelt may opportunistically take advantage of some of these alternative prey (Lott 1998).

The upgrade to the Sacramento Regional County Sanitation District, an important regional conservation action (i.e., an action not associated with the BDCP), may need to take place to fully realize the benefit of conservation measures for delta smelt. These upgrades are designed to reduce ammonia discharges (detailed in Section 3.5, *Important Regional Actions*).

Objective DTSM1.2 Rationale: Achieving this objective will address entrainment of delta smelt. The role of entrainment in the long-term and recent declines of delta smelt continues to be discussed (Baxter et al. 2010). Maunder and Deriso (2011) have concluded that entrainment of delta smelt does not have an important effect on population growth when compared to other stressors. However, entrainment of delta smelt results in mortality, and lower levels of entrainment are desirable for the benefit of the species and to ensure that the effects of water operations are minimized. A recent pelagic organism decline (POD) synthesis prepared by the Interagency Ecological Program (2005) described entrainment as likely being important under certain conditions but not universally important in all years. Kimmerer (2008) had similar conclusions, that losses of adult delta smelt due to entrainment were important in certain years, while in other years the population-level effects were small. Historically, numbers of delta smelt salvaged have been substantial in some years, running in the tens of thousands for adults and hundreds of thousands for juveniles. In more recent years, entrainment has declined to significantly lower levels as a result of pumping restrictions imposed under the current USFWS (2008) BiOp and reduced population levels.

The BDCP will generally further reduce entrainment from south Delta pumping, when averaged across all water-year types, by reducing use of the south Delta pumps. Refer to Objective DTSM1.2, below, and Appendix 5.B, *Entrainment*, for further discussion of entrainment of delta smelt.

This objective is expected to be achieved by relocating the primary point of SWP/CVP export diversion from the south Delta to the north Delta, under *CM1 Water Facilities and Operation*. Increasing the points of diversion will provide sufficient system flexibility to further reduce entrainment while meeting water supply needs. Reducing water diversions in the south Delta, which has greater overlap with typical delta smelt spawning distributions than the proposed sites in the north, is expected to reduce entrainment of delta smelt into exported water. Relocating the primary point of diversion for the SWP/CVP water facilities may also result in increased operational flexibility that contributes to a more frequent natural east-west flow pattern in parts of the Delta where this is currently uncommon. This will reduce the occurrence of reverse flows in the south Delta, which can contribute to adult and juvenile entrainment.

Sufficient information is available to set a numerical objective for reducing the entrainment of adult delta smelt at SWP/CVP water facilities. Entrainment can be estimated from salvage data, and both the fall midwater trawl (FMWT) index and the Spring Kodiak Trawl catch per unit effort provide a basis for expressing entrainment losses relative to the population. Different methods for estimation of past and future entrainment can produce significantly different entrainment level estimates (Miller 2011) as can different assumptions about cumulative predation loss prior to salvage (Kimmerer 2008; Castillo et al. 2012). However, as long as the entrainment target is projected and measured using the same method, the target can be compared relative to historical levels calculated with the same method.

The current regulatory requirements regarding entrainment at SWP/CVP water facilities established by the USFWS (2008) BiOp were imposed at a time when the delta smelt population had declined substantially; as a result, the requirements are highly restrictive. Based on data from 2002 through 2006, USFWS (2008) estimated that incidental take limits under the BiOp would be approximately 5% of the prespawning adult population. Such estimates were not made for the larval and juvenile population. Retrospective calculations were made of the average percentage of the larval and juvenile population lost to entrainment in years when incidental take would have been exceeded (16%, average proportion in years when incidental take limit was exceeded, calculated retrospectively) and years when incidental take would not have been exceeded (4%, average proportion in years not exceeding incidental take limit, calculated retrospectively). These data suggest that the current incidental take limits for larvae and juveniles may represent a similar proportion of the population as for adults and that, taken together, entrainment loss would be around 10% of the total population (larvae, juveniles, and adults). However, these data and the calculations do not and cannot account for real-time operational management decisions that are made to ensure entrainment is avoided and minimized (e.g., Delta Smelt Working Group recommendations, managing exports based on flows and turbidity). Thus, an objective to limit entrainment to ≤5% of the population is aggressive and will be achieved through modifications in water operations and real-time water operational management decisions. The loss reduction goal may not be met in every year, so it is applied to a 5-year running average to accommodate interannual variation in entrainment risk.

While this objective is appropriate based on the current delta smelt population size, it would need to be reexamined (and the entrainment limit potentially increased) should delta smelt abundance increase. Additionally, entrainment mortality at water facilities other than SWP/CVP facilities would be in addition to the 5% described within this objective and supporting rationale. However, due to the north Delta intakes being located upstream of the vast majority of delta smelt spawning, they are expected to increase total entrainment by <1%.

Objective DTSM1.3 Rationale: The recovery metrics for this objective are based on analyses developed in the mid-1990s using data from the FMWT surveys and included as delta smelt recovery criteria in the Delta Native Fish Recovery Plan (U.S. Fish and Wildlife Service 1996); thus, this is an interim objective. These metrics were met in the late 1990s when the delta smelt population was thought to be in suitable condition to qualify for species recovery (U.S. Fish and Wildlife Service 2004). However, these metrics, and FMWT indices (California Department of Fish and Wildlife 2013a) (Figure 3.3-1), do not reflect results of more recent surveys, including surveys of delta smelt inhabiting the Cache Slough ROA, that are not included in the FMWT index. Obviously, the current FMWT stations cannot reflect potential future dispersion of delta smelt into tidal habitat that would be restored under the BDCP (e.g., in Suisun Marsh, Cache Slough). USFWS recognizes the need to update this objective and is currently doing so as part of the update of the Delta Native Fishes Recovery Plan.

Ongoing and future efforts that increase our understanding of delta smelt abundance, abundance trends, and population dynamics will yield information that may lead to changes in recovery threshold metrics and the BDCP's contribution to those recovery threshold metrics. While these metrics provide the only accepted method to gage trends in population, they are considered interim; additional work will be needed to refine and validate them. In the interim, any contribution by the BDCP toward achievement of these metrics will be considered successful achievement of this objective.

Goal DTSM2: Increased quality and availability of habitat for all life stages of delta smelt and increased availability of high-quality food for delta smelt. The habitat objective can be met through a combination of Delta outflow and/or physical habitat restoration suitable for delta smelt.

- **Objective DTSM2.1**: Increase the extent of suitable habitat, as defined by flow, salinity, temperature, turbidity, food availability, and presence of delta smelt, to provide for the conservation and management of delta smelt in the Plan Area by the achieving the following subobjectives.[27]
  a) Provide a monthly average of at least 37,000 acres of open-water habitat in hydrologically wet years* and at least 20,000 acres of connected open-water habitat in hydrologically above-normal years* of 1 to 6 psu habitat surface area during July–November. This habitat will meet all of the following criteria: extensive vertical circulation including gravitational circulation, contiguous with other open-water habitat, lateral mixing, and other hydrodynamic processes keeping Secchi disk depths less than 0.5 meter, high calanoid copepod densities (over 7,000 per cubic meter) [28], hydrologically connected to substantial tidal marsh areas, and maximum water temperatures less than 25°C.
     * Because July–November crosses a water-year boundary, the water-year type criteria apply to the first 3 months of that period.
  b) Increase the extent of tidal wetlands of all types in the Plan Area by 10,000 acres by year 10, 17,000 acres by year 15, and 48,000 acres by year 40. In Suisun Marsh, West Delta, and Cache Slough ROAs, individual restoration projects must show a net-positive flux of calanoid copepods and mysids off of the restored wetlands into open water occupied by delta smelt. Food production targets and export distances will be determined through field investigations and modeling, and refined through adaptive management.
  c) Increase by 100% the surface area of open-water, very low-salinity (<1 psu) habitat in the Cache Slough ROA during July–November by 2060. This habitat will meet all of the following criteria: extensive lateral mixing, contiguous with other open-water habitat, hydrodynamic processes keeping Secchi depth less than 0.5 meter, high calanoid copepod density (over 7,000 per cubic meter), and temperature criteria described in item b, above.

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[27] The same restored tidal area can meet more than one of the subobjectives, but not necessarily all of the subobjectives. For example, the same area could satisfy subobjectives (a) and (b) or (b) and (c), but potentially not (a) and (c). The exact combination will be informed by the decision-tree process described in the rationale below.

[28] Specific metric of calanoid copepod densities were developed when the delta smelt population was crashing; thus this metric for copepod densities is considered interim and is expected to be adjusted as new information is obtained and the relationship of copepod density to delta smelt abundance and habitat suitability for delta smelt is better understood.

Assumed Stressor: Lack of suitable biotic and abiotic habitat.

Stressor Reduction Target: Increase the extent of suitable biotic and abiotic habitat within the Plan Area.

- **Habitat:** Increase the extent of suitable biotic and abiotic habitat that is suitable for delta smelt. Suitable habitat for delta smelt includes consideration of physical attributes such as water depth, turbidity, water circulation, and proximity and connectivity to open water habitat occupied by delta smelt. Suitable habitat for delta smelt also must meet water quality conditions, such as salinity, temperature, and dissolved oxygen concentrations, as well as availability of suitable zooplankton in sufficient density to serve as a food resource for delta smelt. The habitat should also minimize exposure of delta smelt to high levels of predation and competition with nonnative fishes. Suitable habitat for delta smelt should also be distributed geographically within the Plan Area to provide a diversity of habitat locations for delta smelt.

Objective DTSM2.1 Rationale: Subobjective (a) summarizes those features and conditions that are known to be important components of suitable delta smelt habitat and thus outline the desired water quality conditions that would ideally overlie restored tidal marshes (sensu Peterson 2003). The BDCP is premised on a hypothesis that the delta smelt population will greatly benefit from creation of new shallow-water habitat in the ROAs of the Plan Area that are part of the main delta smelt distribution: the Cache Slough, West Delta, and Suisun Marsh ROAs. This hypothesis also underlies the requirement of the USFWS (2008) BiOp that requires restoration of 8,000 acres of tidal natural communities to mitigate for productivity lost from the hydrodynamic influence of the south Delta export facilities. The tidal marsh targets in subobjectives (b) and (c) allow for investigation of this hypothesis and implementation of large investments in shallow-water habitat if the anticipated benefits are demonstrated. Until this hypothesis is resolved, the primary component (part (a) above) of the objective is intended to provide habitat benefits in the low-salinity zone (1 to 6 psu) of the Plan Area.

The objective recognizes that all tidal wetland restoration in the Plan Area (tidal freshwater marsh, tidal brackish marsh, intertidal mudflat, shallow subtidal, and deep subtidal) has the potential to contribute to delta smelt abundance by providing additional habitat area for the species' various life-history needs, increased food production that is exported to where delta smelt occur, or both. Tidal wetlands in the Suisun Marsh, West Delta, and Cache Slough ROAs have the greatest potential to contribute to delta smelt abundance because of their proximity to the largest concentrations of the species and their overlying water quality attributes. Additionally, restoration of aquatic natural communities in the South Delta ROA has the potential to seasonally increase the extent of productive delta smelt habitat within the Plan Area and contribute toward achieving this objective. Restoration of aquatic natural communities should avoid restoration that functions like present-day flooded islands in this region (e.g., Franks Tract, Mildred Island) that do not support delta smelt and are likely sinks for this species. The habitat targets outlined in the objective are based on the extent of tidal natural communities restoration actions proposed as part of the BDCP and consideration of those habitat elements that are meaningful to native covered fish. The objective further recognizes that the mix of tidal wetland habitat types will shift over time in response to many factors, including restoration implemented as part of the BDCP and other programs, sea level rise, and changing hydrodynamics of the Delta. Habitat targets are expressed at the scale of the Plan Area to account for the dynamic nature of these tidal wetland habitats.

If research, investigation, and monitoring indicate that increasing shallow-water habitat will provide significant benefits that will contribute to conserving delta smelt the metrics presented in this objective may be revised to adjust the mix of habitat targets in parts (a) through (c) through the adaptive management process described in Section 3.6.5. Any adjustments will be based on new information that may address uncertainty about species status, population trends, and habitat needs, including documented performance of new shallow-water marsh areas in producing and exporting suitable delta smelt food and/or providing other tangible benefits to delta smelt that are of sufficient magnitude that such an adjustment is justified and appropriate.

The BDCP will initially use operating criteria based on the best information available, and will use a decision tree approach (as described in *CM1 Water Facilities and Operation*) to address the ability of alternative operating criteria, in combination with other conservation measures, to meet the biological goals and objectives and ensure water supply reliability. The decision-tree process will be used to generate information for key flow criteria, such as fall and spring outflows, flow contribution to tidal natural community restoration areas, and the relationships between outflows and the function of habitat restoration areas and other conservation measures relative to the biological goals and objectives. The decision tree will include a range of flow criteria to provide a strong, defensible analysis of hypothesized outcomes in terms of take levels and species conservation, based on best available science. Therefore, the decision-tree process must be viewed in combination with the broader adaptive management program, the governance structure, and the science investment. These pieces together define the overall approach for gathering more information, refining the specific elements of the operating criteria, adapting restoration actions, and other components of the conservation measures, as necessary. The program will ensure the biological goals and objectives specified in regulatory permits are being met.

The same restored tidal area can meet more than one of the subobjectives described but does not necessarily need to meet all of them. The decision-tree approach will be used to determine the exact and appropriate combination of the subobjectives. As described above, subobjective (a) summarizes those conditions that are known, important components of suitable delta smelt habitat. Subobjective (b) outlines the means of providing the components of suitable delta smelt habitat. Those tidal wetlands restored to meet subobjective (b) should be located in areas where subobjective (a) can be met, if X2 or the low-salinity zone moves upstream to areas where levees and revetments confine channels. Subobjective (c) is specific to targeting restoration in the Cache Slough ROA. This geographic area has received relatively little research in terms of its importance to delta smelt; however, year-round occurrence of delta smelt in this area has led to a growing appreciation of its importance to the species (Sommer et al. 2011a).

The objective also recognizes that the mix of tidal wetland habitat types will shift over time in response to many factors, including restoration conducted under the BDCP and other programs, sea level rise, and changing hydrodynamics of the Delta. Habitat targets in subobjectives (a) and (b) are therefore expressed at the scale of the Plan Area to account for the expected dynamic nature of these habitat types over the permit term.

Outflow effects on delta smelt habitat quality and availability and the linkages of habitat to delta smelt survival, growth, and abundance, are active areas of research. Therefore, it is expected that the knowledge and understanding of outflow effects will improve in the coming years. Until then, it is important to note that while this objective is described in terms of habitat area at a range of salinities, turbidities, and other features, these attributes are currently being achieved by providing flows that position low-salinity habitat in or near Suisun Bay. It is uncertain whether these benefits can be provided at the levels specified in the objective by means other than augmenting flow. However, advances in science, especially investigations of the value of new shallow-water habitat areas adjacent to frequently occupied deepwater channels, may expand the available options to accomplish this objective. As indicated above, the decision-tree process will inform the most appropriate approach to meet the objective.

3.3.7.2 Longfin Smelt

Longfin smelt (*Spirinchus thaleichthys*) spawn in fresh or slightly brackish water over sandy or gravel substrates at temperatures ranging from 7°C to 14.5°C (44.6°F to 58.1°F) (Moyle 2002). Approximately 90% of juveniles inhabit areas with salinities lower than 18 parts per thousand (ppt) (Baxter 1999), while larger individuals have been captured in salinities of 32 ppt (Baxter 2010 in Rosenfield 2010). The survival of young longfin smelt may be influenced by salinity in early life with peak survival for larvae that reared in the low-salinity zone (~2–4 psu; Hobbs et al. 2010). The effect of turbidity on longfin smelt geographic distribution or habitat preferences is unknown, but turbidity is hypothesized to increase the survival of longfin smelt larvae in Lake Washington in Washington State (Chigbu 2000). Longfin smelt larvae hatch coincident with annual peak Delta outflows, which typically coincide with high turbidity.

Populations of longfin smelt occur along the Pacific Coast of North America, from Hinchinbrook Island, Prince William Sound, Alaska to the San Francisco Bay estuary (Lee et al. 1980). Longfin smelt is a pelagic species that inhabits the Delta for a relatively short period of its life cycle. Adult longfin smelt use a variety of Bay-Delta tributaries for spawning, including the Sacramento River, upper Suisun Marsh, the Napa River, and probably a number of other tributaries to San Pablo and Central Bays. Longfin smelt also spawn up the Pacific Coast as far as Alaska in various tributaries to the ocean, including the Russian River and Humboldt Bay. Individual longfin smelt have also been caught in Monterey Bay (Moyle 2002). The early juvenile life stages rear over a wide geographic area from the west Delta to Suisun Bay to the Napa River, to San Pablo Bay and even into South Bay during wet years. Data are scarce on the location and distribution of juvenile longfin smelt, because the traditional surveys cover only a fraction of the longfin smelt range. The only local tributary that is sampled is the Napa River.

The longfin smelt population in the Delta and San Francisco Bay is also the largest spawning population in California. In the Plan Area, longfin smelt occur primarily in the lower Sacramento River (downstream of Rio Vista), lower San Joaquin River, West Delta, and Suisun Bay and marsh. Longfin smelt occur in relatively low abundance in the north, east, and south Delta. The life stages of longfin smelt that are distributed extensively in the Plan Area are spawning adults, eggs, and larvae/small juveniles. Between about June and October the typical distribution of juvenile and adult longfin smelt is primarily in brackish water and coastal marine waters of San Pablo and San Francisco Bays downstream of the Plan Area. Longfin smelt abundance within the Bay-Delta estuary has been highly variable, but generally declining since regular surveys started as reflected in the CDFW FMWT surveys (Figure 3.3-2), recent FMWT indices are very low compared to prior years. Longfin smelt is included in the Delta Native Fish Recovery Plan (U.S. Fish and Wildlife Service 1996), is listed as threatened under CESA, and was recently deemed warranted but precluded from immediate listing by USFWS.

Individual stressors affect longfin smelt at different times based on environmental conditions. Important threats and stressors to longfin smelt include reduced quality of rearing habitat, decreases in the quality and availability of food, competition with and predation by nonnative species (e.g., competition with nonnative clams for food and predation on larvae that do not get enough to eat), reduced turbidity, entrainment at water diversion facilities, and degraded water quality conditions (i.e., high temperatures). Refer to Appendix 2.A, *Covered Species Accounts*, for a full species account and discussion of these stressors.

The conservation strategy for longfin smelt focuses on the same three primary stressors discussed for delta smelt (food, predators, and entrainment) (Section 3.3.7.1, *Delta Smelt*). The BDCP includes creation, restoration, and enhancement of substantial tidal and nontidal perennial aquatic natural communities, which is intended to increase production of food resources presumed important to the critical larval stage of longfin smelt. The food supply for juvenile and adult longfin smelt is likely to be regulated by *Potamocorbula* (Feyrer et al. 2003), which affects planktonic production in the bays during the summer months (Cloern et al. 2007; Greene et al. 2011). Restoration of tidal natural communities, seasonally inundated floodplain, channel margins, and riparian natural community is anticipated to contribute to an increase in primary productivity that may benefit longfin smelt in two major ways: an anticipated increase in copepod abundance and an indirect benefit to the extent that suitable food is exported downstream to rearing areas in the low-salinity zone.

Changing the primary point of diversion from the south Delta to the north Delta is expected to contribute to reduced entrainment of longfin smelt in the south Delta. The installation of fish screens in the new north Delta intakes is intended to minimize entrainment and impingement at these facilities, though longfin smelt only very seldom occur as far up the Sacramento River as the proposed north Delta intake sites.

The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.2.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for longfin smelt are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.
- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.
- **Objective L1.8:** To accommodate sea level rise, provide potential tidal marsh plain within the anticipated future eastward position of the low-salinity zone of the estuary.

Objectives L1.3, L1.4, and L1.8 Benefits: Benefits of these objectives for longfin smelt are similar to those described above for delta smelt. Achieving these objectives will contribute to enhancing the tidally influenced natural communities that may produce food important for longfin smelt. The restoration actions are intended to increase the extent of available habitat suitable for covered fish species, enhance the ecological function of the Delta, and offset declines in the longfin smelt population. After the 1987 invasion of *Potamocorbula,* there was a four-fold decline in abundance of longfin smelt and dramatic drop in food for the Delta's fish species (Kimmerer 2002a; Sommer et al. 2007; Thomson et al. 2010; 77 FR 19757).

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.2:** Allow lateral river channel migration. • **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers. • **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system. • **Objective L2.5:** Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity. • **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species. • **Objective L2.8:** Provide refuge habitat for migrating and resident covered fish species. • **Objective L2.9:** Increase the abundance and productivity of plankton and invertebrate species that provide food for covered fish species in the Delta waterways. • **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain.

Objectives L2.2 through L2.5 and L2.7 Benefits: Benefits of these objectives for longfin smelt are similar to those described above for delta smelt.

Objective L2.8 Benefits: Achieving this objective will provide refugia habitat for longfin smelt, which will contribute toward reducing potential predation effects.

Objective L2.9 Benefits: Benefits of this objective for longfin smelt are similar to those described above for delta smelt.

Objective L2.11 Benefits: Benefits of this objective for longfin smelt are similar to those described above for delta smelt.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.2:** Promote connectivity between low-salinity zone habitats and upstream freshwater habitats and availability of spawning habitats for native pelagic fish species.

Objective L3.2 Benefits: Achieving this objective will contribute to increased connectivity between low-salinity zone habitat and upstream freshwater spawning habitat. Currently, there are few if any physical barriers that block longfin smelt migration; the only possibilities are Suisun Marsh Salinity Control Gates and the Delta Cross Channel, neither of which is considered to be a notable impediment to longfin smelt movements. The largest potential impediment to longfin smelt migration is the sometimes high risk of entrainment in the south Delta that can result from reverse flows in Old and Middle Rivers when longfin smelt migrate up the San Joaquin River. The use of dual conveyance is expected to lessen this risk. This increased connectivity will benefit longfin smelt adults by improving access to spawning habitat in the San Joaquin River.

The BDCP will also provide funding to urban centers that discharge stormwater to the Plan Area to assist them in reducing their inputs of polluted stormwater to the Delta. Reducing the inputs of pollution from urban stormwater will contribute to improved water quality in the Delta and reduced stress from water pollutants on the covered species that occur in the Delta.

Goal L4: Increased habitat suitability for covered fish species in the Plan Area.
• **Objective L4.3:** Reduce entrainment losses of covered fish species.

Objective L4.3 Benefits: Achieving this objective will reduce the entrainment of longfin smelt. Overall, the BDCP will substantially reduce exports from the south Delta facilities in most months relative to the existing biological conditions. Entrainment is expected to be reduced most in wetter years when a greater percentage of flow will be diverted from the north Delta (Appendix 5.B, *Entrainment*).

Longfin smelt entrainment (and probably mortality) at the south Delta pumps is greatest during low-outflow years. As a result of the BDCP, overall entrainment of longfin smelt at the south Delta export facilities is expected to decrease relative to existing biological conditions (Appendix 5.B).

3.3.7.2.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for longfin smelt are stated below.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Benefits: Achieving this objective will restore tidal perennial aquatic natural community, which may provide habitat conducive to diatom production. Diatom production is essential to reestablish the pelagic food base for longfin smelt needed to increase growth and survival at the population level. The substantial decline in *Eurytemora affinis* (a copepod) over the last several decades (Kimmerer 2002a) may make successful first-feeding less likely for larval longfin smelt. Early-stage longfin smelt juveniles (i.e., those that have only recently begun exogenous feeding) probably rely on *Eurytomora affinis* as a prey item during April and May. As a result, early-stage longfin smelt juveniles may have a lower encounter rate with prey items, making successful first-feeding less likely (Rosenfield 2010). Restoring or creating at least 10,000 acres of tidal perennial aquatic natural community in Conservation Zones 1, 2, 4, 5, 7, and 11 will substantially increase the amount of habitat contributing to primary productivity and food resources important to longfin smelt, and help to offset the historical loss of such habitat in the Plan Area.

Of the Delta habitats, the tidal marsh sloughs have the highest particulate organic matter and phytoplankton concentrations and support the greatest zooplankton growth rates (Müller-Solger et al. 2002; Sobczak et al. 2002).

Restoration in the Cache Slough ROA at the southern end of the Yolo Bypass, in combination with floodplain enhancement, is expected to provide tidal freshwater wetland structure and functions adjacent to open-water habitat. Tidal wetlands also have the capacity to export food to adjacent channels and to downstream systems (Cloern et al. 2007; Lehman et al. 2008). The export of food may include movement of phytoplankton and zooplankton by advection and tidal exchanges as well as the export of macroinvertebrates, small fishes, and larger organisms (Kneib 1997, 2003).

The export of marsh production helps to transfer the higher production of shallow-water habitats to the deepwater habitats preferred by pelagic fish species such as longfin smelt (Lucas et al. 2002). Lehman et al. (2008) suggested that the quantity and quality of phytoplankton biomass available to the aquatic foodweb could be enhanced by passing river water through a floodplain, such as Yolo Bypass, during the flood season. This production may contribute significantly to the greater foodweb, ultimately benefitting open-water species such as longfin smelt (Brown 2004).

Although juvenile and subadult longfin smelt aggregate in deep water (Rosenfield and Baxter 2007), it is not clear that spawning occurs in deepwater habitats; sexually mature longfin smelt may migrate to shallower locations briefly to spawn (Rosenfield 2010). Thus, providing a broad range of tidally influenced natural communities will contribute to a greater range of potentially suitable spawning habitats for longfin smelt.

Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.
• **Objective TPANC2.1:** Control invasive aquatic vegetation that adversely affects native fish habitat.

Objective TPANC2.1 Benefits: Benefits of achieving this objective for longfin smelt are similar to those described above for delta smelt, based on the similarities of the species' life histories, pelagic foraging, and diet (Feyrer et al. 2007; California Resources Agency 2007; Nobriga et al. 2008; Grimaldo et al. 2009). Achieving this objective is anticipated to address the nonnative aquatic vegetation that limits turbidity in the Delta (Jassby et al. 2002). Therefore, increases in turbidity are expected to improve longfin smelt survival.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them. • **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objectives TBEWNC1.1 through TBEWNC1.4 Benefits: Benefits of achieving these objectives for longfin smelt are similar to those described above for delta smelt except that they might be somewhat higher for longfin smelt due to their more seaward distribution.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7. • **Objective TFEWNC1.2:** Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.

Objective TFEWNC1.1 and TFEWNC1.2 Benefits: Benefits of achieving these objectives for longfin smelt are similar to those described above for delta smelt, except that they might be somewhat lower for longfin smelt due to their more seaward distribution.

3.3.7.2.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat elements for longfin smelt within the reserve system. The goals and objectives below are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The conservation strategy for longfin smelt requires structural habitat restoration intended to bolster food supplies for the larvae and improved flow management intended to maximize the benefits of the structural part of the habitat restoration.

The following global recovery goal and objectives are provided here for broader context of longfin smelt recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Improve the foodweb productivity, and increase the abundance and distribution of longfin smelt.
    - **Global Objective 1.1 (Productivity):** Achieve productivity (abundance indices) equal to or greater than predicted for 5 of 10 years based upon a regression of 1967 to 1987 abundance on December through May mean outflow (or X2).
    - **Global Objective 1.2 (Abundance):** Implement actions to benefit longfin smelt abundance (winter-spring outflow enhancements), to minimize threats (reduce exports), and to improve the scientific understanding of their ecology to benefit future management.
    - **Global Objective 1.3 (Spatial Distribution):** (1) Longfin smelt must be captured in at least 40% of Carquinez Strait and Suisun Bay FMWT stations in at least 80% of years sampled, and (2) during each sampling year for the FMWT, individual trawl catches of 13 longfin smelt or more must be made at least once (this reflects a return to historical schooling behavior).

The biological goals and objectives presented below have been developed to provide for the conservation and management of longifn smelt in the Plan Area and contribute toward achievement of the global recovery goals and objectives.

Goal LFSM1: Increased fecundity and improved survival of adult and juvenile longfin smelt to support increased abundance and long-term population viability.

- **Objective LFSM1.1:** Achieve longfin smelt population growth, to be measured as follows.
  - Future indices of annual recruitment that are equal or exceed expected levels based on the 1980–2011 trend in recruitment relative to winter-spring flow conditions.
- **Objective LFSM1.2:** Limit entrainment mortality associated with operation of water facilities to ≤5% of the longfin smelt population, calculated as a 5-year running average of entrainment for subadults and adults in the fall and winter and their progeny in the winter and spring. Assure that the proportional entrainment risk is evenly distributed over the adult migration and larval-juvenile rearing periods.

Assumed stressors: Lack of food resources.

Stressor reduction targets:

- **Food.** Increase the average late-winter and early-spring (late February to April) density of zooplankton (target of 7,000/m^3 of calanoid copepods)[29] in the Cache Slough ROA, West Delta ROA, and Suisun Marsh ROA and/or supply adequate transport flows (sustained or pulse flows) to move longfin smelt larvae to areas with adequate food resources (target of 7,000/m^3 of calanoid copepods). Achieve this target by year 15. Increasing food abundance will contribute to increased longfin smelt juvenile survival immediately following yolk-sac absorption by providing food resources suitable for juvenile longfin smelt within the Plan Area.

Objectives LFSM1.1 and LFSM1.2 Rationale:

The metric proposed to assess annual recruitment performance toward achieving Objective LFSM1.1 was generally derived as follows. Although the metric presented here is specific in its details, the details (e.g., the relative weighting of indices) can be adjusted based on further analysis or availability of additional data.

7. First, the metric employs a composite recruitment index derived from individual indices calculated from FMWT, Bay Study otter trawl, and Bay Study midwater trawl sampling (Table 3.3-4). The period from 1980 through 2011 was used for developing the composite index, because this is the entire period for which all three individual survey indices are currently available. The year 1994 was excluded, because one of the Bay Study indices was not available for that year. The standard indices calculated each year by the Interagency Ecological Program were used to develop the annual abundance indices and calculate the composite index (Messineo et al. 2010).

   The FMWT index is derived from sampling that occurs during the months of September through December, and is based on catches of both age-0 and age-1 fish, but is generally dominated by the younger age group. The two Bay Study indices represent catches of age-0 fish only, and are based on sampling from May through October. For the purpose of the composite abundance metric proposed here, the three indices were individually log-transformed and normalized using Z-scoring, and then summed to form the composite index (Table 3.3-4). Log transformation reduces the extreme interannual variation in the indices, while Z-scoring sets the average value of each transformed survey dataset at zero and gives the indices from the three surveys equal weight in the composite index. By using sampling of the same cohort at different times and in different habitats, the composite index derived from the three surveys provides a more robust

[29] Specific metric of calanoid copepod densities were developed when the delta smelt population was crashing; thus this metric for copepod densities is considered interim and is expected to be adjusted as new information is obtained and the relationship of copepod density to delta smelt abundance and habitat suitability for delta smelt is better understood.

annual measure of recruitment than would be achieved by a single metric from a single survey program.

8. Annual composite indices were then regressed separately against average Delta outflow for four seasonal groupings of months to assess the relative capability of outflow levels in these periods to predict the composite index. The December through February ("winter") time period and the March through May ("spring") period both exhibited strong fits with the composite index (Table 3.3-5), with the winter period exhibiting the best fit. For the purpose of illustration and comparing possible alternative subobjective metrics, both predictive relationships are carried forward here. The relationships between seasonal outflow and the composite index are described by the following two linear equations.

    - Predicted Composite Index = (Log Winter Flow x 5.171) – 23.275
    - Predicted Composite Index = (Log Spring Flow x 4.7314) – 20.988

    Again, the period 1980 through 2011 is the entire period for which all three survey indices are currently available, thereby maximizing the data employed for the development of this metric. However, many additional years of data will presumably be available when BDCP effectiveness monitoring begins, so the approach illustrated here could be recalculated using additional years of pre-Plan survey indices. Also, during the 1980 through 2011 period, there were recognized declines in longfin smelt recruitment per unit of winter outflow (Kimmerer 2002; Thompson et al. 2010), including a shift in the late 1980s associated with introduction and establishment of the *Potamocorbula* and another shift in the early 2000s. An alternative approach to developing the metric would be to use data beginning in 1989, the approximate year when the clam-related shift became evident.

Table 3.3-4. Longfin Smelt Recruitment Composite Index Derivation, and Seasonally Averaged and Log-Transformed Delta Outflow Values (1980–2011)

	Survey Indices			Log-Transformed Indices			Z-Scored, Log Indices			CINDEX[a]	Seasonal Log-Transformed Average Flows			
Year	FMWT	BSMWT	BSOT	FMWT	BSMWT	BSOT	FMWT	BSMWT	BSOT		Dec–Feb	Mar–Apr	Jun–Aug	Sep–Oct
1980	31,184	190,790	128,321	4.4939	5.2806	5.1083	1.8153	1.8193	1.6624	5.2969	4.9206	4.6968	3.9974	3.8988
1981	2,202	1,959	4,139	3.3428	3.2919	3.6169	0.4466	-0.2783	-0.2858	-0.1175	4.6296	4.1987	3.6382	4.1816
1982	62,905	299,069	257,965	4.7987	5.4758	5.4116	2.1776	2.0252	2.0586	6.2613	4.9688	4.9677	4.2855	4.4660
1983	11,864	33,651	23,860	4.0742	4.5270	4.3777	1.3162	1.0244	0.7080	3.0486	5.1425	5.2084	4.6639	4.6609
1984	7,408	29218	44,329	3.8697	4.4657	4.6467	1.0731	0.9597	1.0594	3.0922	4.7648	4.3070	3.9421	4.2327
1985	992	2895	11,787	2.9965	3.4616	4.0714	0.0349	-0.0994	0.3079	0.2434	4.1241	3.9136	3.6079	3.6498
1986	6,160	24,908	12,070	3.7896	4.3963	4.0817	0.9778	0.8866	0.3214	2.1858	4.8588	4.8899	3.8554	3.9867
1987	1,520	2872	1,984	3.1818	3.4582	3.2975	0.2552	-0.1029	-0.7031	-0.5508	4.0873	4.0561	3.5174	3.5144
1988	791	1724	1,094	2.8982	3.2365	3.0390	-0.0821	-0.3368	-1.0407	-1.4600	4.0046	3.8327	3.4827	3.6015
1989	456	1137	971	2.6590	3.0556	2.9870	-0.3665	-0.5276	-1.1085	-2.0026	3.6759	4.2881	3.7474	3.7479
1990	243	745	681	2.3856	2.8719	2.8329	-0.6915	-0.7214	-1.3099	-2.7228	3.8874	3.7642	3.6454	3.5378
1991	134	131	245	2.1271	2.1176	2.3889	-0.9988	-1.5170	-1.8898	-4.4057	3.7983	4.0330	3.5165	3.5866
1992	76	370	620	1.8808	2.5681	2.7925	-1.2917	-1.0418	-1.3626	-3.6961	4.1848	3.8816	3.4877	3.5968
1993	798	5,086	7,006	2.9020	3.7063	3.8455	-0.0775	0.1588	0.0128	0.0941	4.6161	4.6482	4.1815	3.7727
1995[b]	8,205	555,398	152,973	3.9141	5.7446	5.1846	1.1258	2.3087	1.7621	5.1967	4.8403	5.1148	4.4462	4.1176
1996	1,346	666	11,045	3.1290	2.8237	4.0432	0.1924	-0.7722	0.2711	-0.3087	4.9041	4.7727	4.0529	3.8650
1997	690	4585	10,692	2.8388	3.6614	4.0290	-0.1526	0.1114	0.2526	0.2113	5.1225	4.3031	3.9402	3.7981
1998	6,654	62,853	20,605	3.8231	4.7983	4.3140	1.0176	1.3106	0.6248	2.9530	5.0521	4.9385	4.6074	4.2455
1999	5,243	59,040	57,980	3.7196	4.7711	4.7633	0.8946	1.2819	1.2117	3.3882	4.6762	4.6266	3.9991	3.7219
2000	3,437	12,326	16,079	3.5362	4.0908	4.2063	0.6765	0.5643	0.4841	1.7249	4.5951	4.6619	3.9021	3.7022
2001	247	2,107	812	2.3927	3.3237	2.9096	-0.6831	-0.2448	-1.2098	-2.1376	4.2977	4.1787	3.7026	3.7416
2002	707	1,173	18,132	2.8494	3.0691	4.2585	-0.1400	-0.5133	0.5523	-0.1011	4.4319	4.1504	3.7468	3.7158
2003	467	230	4,007	2.6693	2.3624	3.6028	-0.3542	-1.2588	-0.3042	-1.9171	4.5458	4.4250	3.9724	3.6796
2004	191	1,307	3,529	2.2810	3.1163	3.5477	-0.8158	-0.4636	-0.3762	-1.6556	4.5668	4.4811	3.7826	3.8229
2005	129	617	8,459	2.1106	2.7905	3.9273	-1.0185	-0.8073	0.1197	-1.7060	4.5324	4.6009	4.1498	3.7356
2006	1,949	2,780	21,517	3.2898	3.4440	4.3328	0.3836	-0.1179	0.6494	0.9150	4.8425	5.0960	4.2471	3.7540
2007	13	441	3,636	1.1139	2.6447	3.5607	-2.2035	-0.9610	-0.3592	-3.5237	4.0684	4.0610	3.7452	3.6166
2008	139	1,207	6,155	2.1430	3.0818	3.7892	-0.9799	-0.4500	-0.0607	-1.5406	4.2648	3.9976	3.6632	3.6218
2009	65	323	971	1.8129	2.5086	2.9871	-1.3724	-1.1046	-1.1084	-3.5854	4.0511	4.1975	3.7609	3.7016
2010	191	867	628	2.2810	2.9381	2.7982	-0.8158	-0.6516	-1.3553	-2.8226	4.5424	4.3253	3.9539	3.7869
2011	477	1,404	14,261	2.6785	3.1475	4.1542	-0.3432	-0.4307	0.4160	-0.3579	4.5305	4.8958	4.3576	4.0883

[a] Lists annual composite index values.
[b] 1994 was excluded, because Bay Study indices were not fully available for that year.
FMWT = fall midwater trawl survey; BSMWT = Bay Study midwater trawl; BSOT = Bay Study otter trawl.

As indicated earlier, the FMWT component of the composite index includes catches of both age-0 and age-1 fish, but is generally dominated by the younger age group, while the Bay Study components include only age-0 catches. Statistically stronger relationships between recruitment and previous winter-spring flow might be achieved if the regressions were limited to age-0 fish; although for existing data the differences in the strength of the relationships is very small. Constraining the analysis to that period where age-0 longfin smelt were distinguishable in the FMWT data would reduce the span of available data, because delineation of age groups was not possible until 1990, when survey staff began to consistently take representative measurements of fork-length for all fishes at all sampling stations. As baseline years available for analysis increase in the lead-up to BDCP implementation, consideration could be given to excluding pre-1990 data in developing outflow-recruitment relationships.

The relationship between longfin smelt recruitment and previous outflow levels has been found to be similar and strong for nearly any combination of months (Stevens and Miller 1983), because outflow levels between all four seasons are generally highly correlated (Table 3.3-5). However, the effect of outflow on recruitment is believed to take place during the egg and larval stages, which occur during winter and spring. Moreover, the spatial distribution of the longfin smelt population most strongly overlaps the Plan Area during December through June, so strong correlations of abundance with summer and fall flows are considered to be artifacts of the general correlation of Delta outflow from one month or one season to the next within a given year.

The primary purpose of this metric is to remove the climatically driven part of the freshwater flow effect on longfin smelt recruitment. This effect is best reflected in winter flows, because outflow during other seasons is more strongly influenced by the SWP/CVP operations. As described above, the correlation of the composite index with spring flow is nearly as strong as the correlation with winter flow, so the conceptual preference for basing the subobjective metric on the winter outflow regression equation is to some extent academic. Given the strong association between winter and spring outflow levels, it is not surprising that approaches using different analytical methods, different spans of years, or different indices of longfin smelt abundance would identify outflow in different months as having the greatest influence on recruitment. For example, the analysis targeting the spring period for enhanced outflow was based on analysis using FMWT indices alone and consideration of spawning stock size. To summarize, an Objective LFSM1.1 metric based on removing the climate-driven effect of outflow on longfin smelt recruitment is best based conceptually on winter outflow, while using spring outflow as a basis retains greater consistency with related aspects of the BDCP. Both approaches are carried forward below in developing a metric for Objective LFSM1.1; the two approaches result in only small differences in the metric and have essentially no practical effect on the objective.

Table 3.3-5. Correlation Coefficients for Relationship between Composite Index[a] of Longfin Smelt Abundance and Delta Outflow for Various Seasonal Time Periods (A), and Regression Statistics for the Composite Index Versus Winter (B) and Spring (C) Outflow Relationships

(A) Seasonal Outflow vs. Composite Abundance Index[b]					
	Index	**Winter**	**Spring**	**Summer**	**Fall**
Index	1				
Winter	0.7386	1			
Spring	0.6952	0.7834	1		
Summer	0.6257	0.7507	0.8992	1	
Fall	0.6827	0.6995	0.6937	0.7315	1
(B) Regressions Statistics for the Winter Outflow vs. Composite Index Association					
R	**R-Squared**	**Adj. R-Squared**	**Slope**	**Intercept**	**P-value**
0.7386	0.5455	0.53	5.1712	-23.2751	0.0000021
(C) Regressions Statistics for the Spring Outflow vs. Composite Index Association					
R	**R-Squared**	**Adj. R-Squared**	**Slope**	**Intercept**	**P-value**
0.6951	0.4832	0.4654	4.7314	-20.988	0.000015

[a] The composite index is the sum of individually log-transformed and z-scored fall midwater trawl, Bay Study otter trawl, and Bay Study midwater trawl longfin smelt annual abundance indices. Fall midwater trawl annual abundance is based on all ages collected, whereas Bay Study indices for both trawls are based on catches of age-0 fish only.

[b] The "Index" column contains correlation coefficients for the association between the composite index and seasonal outflows, whereas the columns to the right contain coefficients for association of outflows between seasons.

9. The proposed metric associated with Objective LFSM1.1 is the annual residual value between the observed composite index and calculated values based on the regression equations (see above), which provides a measure of population recruitment performance relative to outflow conditions.

10. Plotting historical residual values across time (Figure 3.3-3) clearly illustrates the declining trend in longfin smelt recruitment performance relative to Delta outflow, presumably due to foodweb degradation. The trend is essentially identical for the residuals derived from winter and spring outflow. During the recent POD period (i.e., since 2001), the metric has been persistently and substantially less than zero for every year. Objective LFSM1.1 requires the return of this metric to levels exceeding zero. The objective is being met if, after year 10, 50% (5 of each 10 consecutive years) or more of future indices fall above the zero line and the 10-year running average of the metric exceeds zero.

    Achieving Objective LFSM1.1 will require a substantial improvement in recruitment performance. Comparing the 2001 through 2011 (POD period) indices with those of the previous decade provides a rough indication of the magnitude of future raw survey index levels required to achieve the objective. During the POD period when the composite index–based metric consistently underperformed expectations, based on the 1980 through 2011 outflow – recruitment relationship (Figure 3.3-3), the average FMWT index was 416 (Table 3.3-4). By contrast, the previous 10 years of indices (1990–2000, excluding 1994) had a near-even mix of years when the metric met and did not meet expectations based on the outflow-recruitment relationship. During the earlier period, the FMWT indices averaged 2,683, or roughly six times the level observed during the POD period.

If conservation measures implemented under the BDCP or other Bay-Delta restoration initiatives are having a positive impact on longfin smelt production through greater food production, the composite index of abundance should first approach, and eventually consistently exceed, expected values from a baseline flow-abundance relationship. Within the Plan Area, intertidal/shallow subtidal habitat restoration in Suisun Marsh and the West Delta will have the greatest potential to contribute to enhancement of planktonic food for longfin smelt because of its proximity to the channels and embayments where the low-salinity zone usually lies when longfin smelt are using it. Habitat restoration under the BDCP, and the implementation of other conservation measures potentially beneficial to longfin smelt, will occur gradually over the permit term.

Assessment of achievement of Objective LFSM1.1 will be initiated at year 10, or once 7,000 acres in the Suisun Marsh ROA and 2,100 acres in the West Delta ROA have been restored, whichever comes first. Positive residuals between the baseline flow-abundance regression and observed abundance, as described under (4), above, are anticipated by year 16.

Since restoration will continue to accumulate over the entire permit term, Objective LFSM1.1 could be amended to require that the trend in the metric maintain a continuous positive trajectory beginning at year 10. However, such an approach would need to acknowledge the possibility that positive effects of the BDCP may flatten out over time as Plan implementation reaches completion and the population equilibrates to the level of habitat restoration. The population could also reach a limit due to, for example, density-dependent effects or competition with other species.

Future monitoring and research efforts may complement this composite index–based measure of population performance, independent of climatic variability in habitat conditions (e.g., studies that document successful larval rearing in restored habitats or improved recruitment per unit flow at low annual [drier year] outflow levels). Results of these future studies will be factored into the framework for assessing performance.

The rationale for Objective LFSM1.2 is that within the Bay-Delta, nearly all the longfin smelt recorded in annual surveys are found downstream of the confluence of the Sacramento and San Joaquin Rivers (Rosenfield and Baxter 2007). The fraction of the longfin smelt population found at or east of the lower San Joaquin River is low, averaging 0.5% for adult longfin smelt abundance from 2002 to 2008 and 6% of larvae and juvenile abundance from 1995 to 2007. Over those same periods, the average percentage of larval, juvenile, and adult longfin smelt found east of Franks Tract, where water export pumps most strongly affect flows in the Delta, was 0%. These data suggest that the threat of entrainment may be relatively low in years when Delta flow transports longfin smelt downstream into Suisun Bay where the risk of SWP/CVP entrainment is nil. In years when Delta outflow is low during the winter and early spring months, the risk of entrainment is increased in the south Delta export facilities. However, the species has exhibited changes in distribution over time, so it would be prudent to continue to track entrainment over time. Using a 5-year running average of entrainment losses helps address concerns regarding interannual variability in longfin smelt entrainment risk. Additionally, reducing water diversions in the south Delta is expected to reduce the risks of entrainment. Dual conveyance may also result in more natural east to west flow patterns in the Delta, reducing the occurrence of reverse flows, which can contribute to lower rates of entrainment.

Increased food production will contribute toward achieving both objectives; putting aside the possibility of spring outflow restoration per the decision tree, the foodweb contribution is the one element that is most needed and has the highest potential to make substantial population-level differences.

Researchers have hypothesized that a major factor in the decline of longfin smelt abundance is related to invasion by *Potamocorbula* and its subsequent disruption of the foodweb (Carlton et al. 1990; Alpine and Cloern 1992; Orsi and Mechum 1996; Kimmerer 2002a; Baxter et al. 2008:36). There is evidence that the disruption of the foodweb is the most significant change in the estuary's carrying capacity for other fishes (e.g., Kimmerer et al. 2000; Kimmerer 2006). Rosenfield and Baxter (2007) speculate that the estuary has experienced a fundamental change in its carrying capacity for pelagic fishes. Rosenfield and Baxter (2007) concluded that food limitation is consistent with their finding of reduced age-1 productivity and the reduction in age-2 recruitment. Hobbs et al. (2006) further documented poor growth and condition of longfin smelt in the south channel region of Suisun Bay where densities of *Potamocorbula* are high (Carlton et al. 1990).

For example, over the past several decades, substantial changes in the species' composition and reductions in the abundance of the preferred food resources for larval, juvenile, and adult longfin smelt have been observed (Kimmerer and Orsi 1996; Kimmerer 2002a; Feyrer et al. 2003; Thompson 2007). The FMWT index for longfin smelt is positively correlated in a multiple linear regression with the previous spring's *Eurytemora affinis* (an important zooplankton prey organism for larval longfin smelt) abundance[30] (California Department of Fish and Game 2010). The spring population abundance of *Eurytemora* has itself been positively correlated with outflow between March and May since the introduction of *Potamocorbula* (Kimmerer 2002a) as well as inversely correlated with mean ammonium concentrations and other variables depicting nutrient pollution in the low-salinity zone (Gilbert et al. 2011).

Total ammonia levels may be another factor affecting covered fish species by inhibiting primary productivity (Ballard et al. 2009; Dugdale et al. 2007; Dugdale et al. 2012 in Parker et al. 2012; Glibert 2010; Glibert et al. 2011; Parker et al. 2012; Wilkerson et al. 2006), altering the phytoplankton species assemblage (Baxter et al. 2010; Glibert 2010), or altering the role of invasive species (Ballard et al. 2009). The primary source of total ammonia in the Delta is effluent discharged from wastewater treatment plants, and the primary contributing facility is the Sacramento Regional Wastewater Treatment Plant. The frequency, severity, and distribution of effects from total ammonia levels are the subject of ongoing research, but current science indicates a high likelihood that decreasing loading of total ammonia from the Sacramento Regional Wastewater Treatment Plant would have beneficial consequences for phytoplankton productivity and thus the productivity of the pelagic foodweb in and downstream of the Sacramento River in the Plan Area. Section 3.5.1, *Ammonia Load Reduction*, describes the analysis underlying this conclusion.

Achieving an increase in the abundance and survival of longfin smelt will be accomplished by implementing conservation measures to protect, restore, and enhance floodplain (*CM2 Yolo Bypass Fisheries Enhancement; CM5 Seasonally Inundated Floodplain Restoration*) and tidal marsh habitats (*CM4 Tidal Natural Communities Restoration*), which in turn are expected to increase the density of zooplankton in the lower Sacramento River, lower San Joaquin River, confluence areas in low-outflow years, and confluence areas and Suisun Bay in high-outflow years. Increasing the density of zooplankton will be further achieved through reduced water diversions from the south Delta (and associated phytoplankton and zooplankton entrainment [Jassby et al. 2002; U.S. Fish and Wildlife Service 2008]) (CM1 Water Facilities and Operation).

[30] Positive correlation is obtained after weighting the data by the proportion of smelt at each *Eurytemora* sampling station and normalizing by the previous year's FMWT index.

Improvements to the Sacramento Regional Wastewater Treatment Plant to reduce its discharge of ammonia (Section 3.5.1, *Ammonia Load Reduction*) could also contribute to an increase in the abundance and survival of longfin smelt.

3.3.7.3 Chinook Salmon, Sacramento River Winter-Run Evolutionarily Significant Unit

Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) evolutionarily significant unit (ESU) is listed as endangered under the ESA. The distribution of winter-run Chinook salmon spawning and rearing was limited historically to the upper Sacramento River and tributaries, where cool spring-fed streams supported successful adult holding, spawning, egg incubation, and juvenile rearing (Slater 1963; Yoshiyama et al. 1998). Construction of Shasta Dam in 1943 and Keswick Dam in 1950 blocked access to nearly all of this historical habitat. As a result, spawning habitat for Sacramento River winter-run Chinook salmon is currently restricted to the Sacramento River primarily between Red Bluff Diversion Dam and Keswick Dam, where releases of water from Lake Shasta keep water temperatures cool (Williams 2009). Rearing habitat quality is strongly affected by water temperature, habitat diversity and complexity, food supply, and fish and avian predators. In contrast, the channelized, leveed, and riprapped river reaches and sloughs common along the Sacramento River and throughout the Delta typically have low complexity, low abundance of food organisms, and offer little protection from predation by fish and birds. Estuarine areas have a high conservation value because they function to support juvenile Chinook salmon growth, smolting, and avoidance of predators and provide a transition to the ocean environment.

Between the late 1960s and mid-1990s, winter-run Chinook salmon abundance declined from a high of about 120,000 adults to fewer than 500 fish in some years. Beginning in the 2001, adult escapement showed an upward trend, approaching 20,000 fish by 2006 (Figure 3.3-4). The trend until 2006 was likely due to improved water temperatures and water management in the Shasta Reservoir and the mainstem river, improved operations of the Red Bluff Diversion Dam (e.g., keeping holding gates open for a longer period), favorable hydrological and ocean-rearing conditions, habitat enhancements, reductions in loading of contaminants, improved fish screens on major water diversions, and reduced harvest rates. The subsequent decline to several thousand fish since 2006 may be due to reduced productivity of nearshore coastal waters and reduced prey availability in the ocean resulting in poor juvenile salmon growth and high mortality during the juvenile ocean-rearing phase (MacFarlane et al. 2008; Lindley et al. 2009).

Important threats to and stressors for winter-run Chinook salmon are summarized below. Refer to Appendix 2.A, *Covered Species Accounts,* for a full discussion of these stressors.

- **Reduced staging and spawning habitat.** Access to much of the historical upstream spawning habitat for winter-run Chinook salmon has been eliminated or degraded by human-made structures (e.g., dams and weirs) associated with water management operations. The remaining available habitat is currently maintained by cool water releases from Shasta and Keswick Dams in the mainstem Sacramento River. The construction and operation of the Red Bluff Diversion Dam has been identified as one of the primary factors contributing to the decline in winter-run Chinook salmon abundance that led to listing of the species under the ESA.
- **Reduced rearing and outmigration habitat.** Channel margins throughout the Delta have been leveed, channelized, and fortified with riprap for flood protection and island reclamation, reducing and degrading the quality of natural habitat available for juvenile Chinook salmon rearing (Brandes and McLain 2001). Human-made barriers and water diversions further reduce and

degrade rearing and migration habitat and delay juvenile outmigration, resulting in increased diversion screen impingement, entrainment, disease, and predation.

- **Predation by nonnative species.** Predation on juvenile salmon by nonnative fishes (e.g., small- and largemouth bass, striped bass, catfish, and northern pike) is an important threat to winter-run Chinook salmon, and changes in the system have enhanced suitable habitat for these species. Water temperatures are generally lower during outmigration of winter-run salmon compared to other salmonids. These lower temperatures potentially reduce predation pressures (Lindley and Mohr 2003).
- **Harvest.** Commercial and recreational harvest of winter-run Chinook salmon in the ocean and inland fisheries result in incidental, and potentially illegal, harvest of wild-origin Chinook salmon. The wild-origin Chinook are less able to withstand high harvest rates than hatchery-origin stocks.
- **Reduced genetic diversity and integrity.** Artificial propagation programs have resulted in genetic introgression with naturally spawning fish. Such introgressions introduce maladaptive genetic changes to the wild-origin winter-run Chinook salmon stocks and may reduce overall fitness (Myers et al. 2004; Araki et al. 2007).
- **Entrainment.** Entrainment and salvage at SWP/CVP export facilities, numerous nonproject diversions, and power plant intakes affect Chinook salmon populations (Kjelson and Brandes 1989). Juvenile winter-run Chinook salmon tend to be distributed in the central and south Delta where they have an increased risk of entrainment and salvage between February and April. These facilities also change the hydrodynamics in Delta channels and directly or indirectly increase vulnerability to entrainment at unscreened diversions. However, the effects of entrainment mortality on the population dynamics and overall adult abundance of winter-run Chinook salmon are not well understood.
- **Exposure to toxins.** Toxins from agricultural drainage and return flows, municipal wastewater treatment facilities, and other point and nonpoint discharges include mercury, selenium, copper, pyrethroids, and endocrine disruptors. These have the potential to affect fish health and condition and adversely affect salmon distribution and abundance. Sublethal concentrations may interact with other stressors (e.g., seasonally elevated water temperatures, predation, or disease) to increase the vulnerability of salmonids to stress, reduced fitness, or mortality.
- **Increased water temperature.** Higher water temperatures cause physiological stress, reduced growth rates, prespawning mortality, reduced spawning success, and increased mortality of salmon (Myrick and Cech 2001). Temperature can also indirectly influence disease incidence and predation (Waples et al. 2008). The installation of the Shasta Temperature Control Device in 1998 and improved reservoir management are believed to be important factors contributing to the increase in adult winter-run Chinook salmon abundance in the early 2000s. However, climate change patterns, which are expected to increase water temperatures in upstream reaches of the Sacramento River important to this run, in combination with current stressors, may adversely affect the long-term health and viability of Sacramento River winter-run Chinook salmon (Crozier et al. 2008).

The public draft recovery plan for Central Valley salmonids, including Sacramento River winter-run Chinook salmon, was released by NMFS on October 19, 2009. Although not final, the overarching goal in the public draft is the removal of, among other listed salmonids, Sacramento River winter-run Chinook salmon from the federal list of endangered and threatened wildlife (National Marine Fisheries Service 2009a). Several objectives and related criteria represent the components of the recovery goal, including the establishment of at least two viable populations within each historical diversity group, as well as other measurable biological criteria. The recovery plan is based on a stepwise strategy that first addresses more urgent near-term needs and builds toward full recovery. The strategic planning framework incorporates viability at both the ESU and population levels, prioritizes watersheds based on current occupancy, and prioritizes unoccupied watersheds for reintroductions. Winter-run Chinook salmon are also covered in the *Solano Multispecies Habitat Conservation Plan* (Solano HCP) and the *East Alameda County Conservation Strategy*.

The conservation strategy for winter-run Chinook salmon will focus on those life stages occurring in the Plan Area and ensure that the timing of efforts to benefit those specific life stages coincides with their presence in the Plan Area. The conservation strategy also focuses on habitat conditions upstream of the Plan Area, such as water temperature that could be affected by covered activities implemented within the Plan Area. The conservation strategy is explicit that covered activities be implemented so as to not result in a reduction of the primary constituent elements of designated critical habitat for winter-run Chinook salmon upstream of the Plan Area (see Objective WRCS3.1, below). Juvenile Chinook salmon foraging and rearing habitat has been compromised by floodplain modifications, contributing to reductions in Chinook salmon abundance and distribution. Therefore, the conservation strategy includes restoration of tidal natural communities to increase rearing habitat in the Suisun Marsh, Cache Slough, West Delta, and South Delta ROAs. Habitat restoration benefits will be derived chiefly from tidal natural community restoration, seasonally inundated floodplain restoration, channel margin enhancement, and riparian natural community restoration, which are expected to provide shallow-water, low-velocity rearing habitat for juvenile salmonids. To minimize the potential that such habitat becomes colonized by nonnative predators, *CM13 Invasive Aquatic Vegetation Control* will be employed. This conservation measure is intended to reduce the proliferation of IAV in aquatic restoration areas thereby reducing the potential suitability of restored aquatic habitat for nonnative predators, such as largemouth bass.

These actions are also expected to increase primary and secondary production, contributing to increased food resources for juvenile salmonids and increased habitat complexity. Increasing the availability of floodplain and channel margin habitat is anticipated to increase productivity within the Plan Area. More frequent access to floodplain that is seasonally inundated for longer durations than under current conditions is anticipated to increase the amount and quality of accessible rearing habitat for juvenile winter-run Chinook salmon. An ancillary benefit is the routing of a portion of the juvenile Chinook salmon outmigrant population away from the interior Delta and through areas with a reduced risk of predation mortality, such as the Yolo Bypass. These expected benefits are supported by a number of existing studies (e.g., Sommer, Nobriga, et al. 2001; Whitener and Kennedy 1999; Moyle et al. 2007).

The conservation strategy also includes reducing the relative percentage of juvenile outmigrants that are entrained at the SWP/CVP south Delta facilities, reducing passage delays at human-made barriers, and reducing predation levels in the Plan Area. Reduced entrainment is expected to be achieved primarily by relocating and operating the primary point of diversion intakes in the north Delta (*CM1 Water Facilities and Operation*), which will be equipped with state-of-the-art positive-barrier fish screens. Reducing passage delays at human-made barriers is expected to reduce migratory delays, exposure to stressors, and the risk of illegal harvest, and thereby increase survival of adult salmonids during their upstream migration to spawning areas. Reducing predation levels in the Plan Area is intended to result in increased juvenile survival. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.3.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for winter-run Chinook salmon are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.2:** Protect sufficient lands for the restoration of natural communities as described in Objective L1.3.
- **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.
- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objectives L1.2 and L1.3 Benefits: Achieving these objectives will contribute to restoring or protecting seasonally inundated floodplains and tidally influenced natural communities that are very important for winter-run Chinook salmon, as well as other salmonids. Achieving these objectives will restore 65,000 acres of tidal natural communities in the Plan Area, 10,000 acres of seasonally inundated floodplain, and at least 5,000 acres of riparian natural community, as well as enhance 20 miles of channel margin to benefit covered fish species (in addition to other restoration actions specific to covered terrestrial species). The restoration and enhancement actions have two principal objectives: to increase the amount of available habitat for covered fish species required at each life stage that occurs within the Plan Area and to enhance the ecological function of the Delta.

Restoring and protecting seasonally inundated floodplains and tidally influenced natural communities will contribute toward providing a broad gradient of environmental conditions and a range of potentially suitable habitats for juvenile Chinook salmon rearing within the Plan Area. Seasonally inundated floodplains and tidally influenced natural communities are important for primary productivity and food resources for Chinook salmon. Jeffres et al. (2008) found that juvenile Chinook salmon grew more rapidly on the vegetated Cosumnes River floodplain when it was inundated than in the mainstem river, either within or upstream of the tidally influenced area. Food was very abundant, and the fish grew well even though the water temperature averaged 21°C for a week, with daily maximums as high as 25°C, which are generally considered outside the 12 to 14°C preferred water temperature range of Chinook salmon (Meehan 1991). Additionally, Katz (2012) found in a study evaluating the growth of caged juvenile Chinook salmon in flooded agricultural fields on the Yolo Bypass that the growth rates for juvenile Chinook salmon in year one were among the highest recorded in freshwater Central Valley habitats. A number of studies in the Bay-Delta indicate that Chinook salmon and steelhead fry and juveniles forage in tidal marshes, channels, and sloughs (Williams 2006; Shreffler et al. 1990, 1992; Sommer et al. 2001a, 2001b; Moyle et al. 2002, 2004). Protecting and restoring tidal natural communities will reestablish tidal habitat important for juvenile salmonids.

Refer to Objectives TPANC1.1, TBEWNC1.1, 1.2, 1.3, and 1.4, and TFEWNC1.1 and 1.2, as well as VFRNC1.1 and 1.2 for more complete discussions of the benefits of restoring tidal natural communities, floodplains, and riparian natural community, respectively, for Chinook salmon.

Objective L1.4 Benefits: Achieving this objective is anticipated to increase the extent of environmental gradients to create a greater range of habitat conditions, food resources, and habitat complexity available for juvenile Chinook salmon during their outmigration and rearing phases. Providing a greater range of potentially suitable habitat conditions for juvenile Chinook salmon and the organisms upon which they prey is anticipated to benefit juvenile Chinook salmon by increasing the extent of habitats and prey resources available across a greater range of varied conditions of flow, water temperature, turbidity, and other habitat constituents.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.

- **Objective L2.2:** Allow lateral river channel migration.
- **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers.
- **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system.
- **Objective L2.5:** Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity.
- **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.
- **Objective L2.8:** Provide refuge habitat for migrating and resident covered fish species.
- **Objective L2.9:** Increase the abundance and productivity of plankton and invertebrate species that provide diversity of food for covered fish species in the Delta waterways.
- **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain.

Objective L2.2 Benefits: Achieving this objective will allow for the natural fluvial process of lateral channel migration to create a range of environmental gradients and potentially suitable habitat and channel conditions for winter-run Chinook salmon.

Objective L2.3 Benefits: Achieving this objective will contribute to an increase in river-floodplain connectivity and potentially improved hyporheic processes, such as groundwater recharge, which can improve water quality, provide cool water inputs, and maintain flow inputs to surface waters. Achieving this objective may also contribute to an increase in allochthonous inputs, such as terrestrial insects and plant matter, to provide a nutrient source increase for the productivity of aquatic systems. This increase in productivity may contribute to a more diverse and robust forage base.

Objective L2.4 Benefits: Achieving this objective is anticipated to reduce the amount of pollution in stormwater runoff entering Delta waterways. Such a reduction in the pollutants is expected to benefit Chinook salmon by reducing pesticides and herbicides, which can be highly toxic to the plankton that form the base of the foodweb, as well as by reducing sublethal effects (e.g., effects on behavior, tissues and organs, reproduction, growth, and immune system) of contaminants such as pyrethroids and other chemicals from urban and stormwater runoff. These water quality improvements may also support a more robust foodweb and contribute to increasing food resources for Chinook salmon.

Objective L2.5 Benefits: Achieving this objective is intended to provide a range of environmental gradients to ensure that a diversity of rearing and migration conditions exists for Chinook salmon in the Plan Area over the BDCP permit term. Maintaining or increasing life-history diversity is very applicable to species such as Chinook salmon, which has three races that occur within the Plan Area (winter-run, spring-run, and fall-run/late fall–run) that exhibit different life-history strategies, such as duration of rearing in freshwater environments before smoltification and migration from fresh water to the ocean. Providing a range of environmental gradients is intended to provide a range of suitable habitat conditions for the diversity of life-history strategies exhibited by the covered species.

Objective L2.7 Benefits: Achieving this objective is intended to increase natural dendritic channels in tidal marshes to promote food production and transport, which may benefit juvenile Chinook salmon rearing in or migrating through the Plan Area by transporting food to and providing food where juvenile Chinook salmon occur. This is intended to benefit juvenile Chinook salmon rearing in the freshwater and low-salinity zones of the Plan Area as they grow and develop critical osmoregulatory capacities that allow them to enter the ocean.

Objective L2.8 Benefits: Achieving this objective will contribute to expanding and improving available refuge habitat for juvenile Chinook salmon in the Plan Area, which may improve growth and survival of outmigrants. Juvenile Chinook salmon prefer to use natural stream banks, floodplains, marshes, and shallow-water habitats for rearing prior to their emigration to the ocean. However, much of the Delta has been leveed, channelized, and fortified with riprap, which has degraded the condition of these habitats. The low spatial complexity of the existing channelized waterways and the limited habitat diversity elsewhere in the Delta provide virtually no refuge cover or protection for salmon and steelhead from predators (Raleigh et al. 1984; Missildine et al. 2001). Diversity and richness of habitat and food in the estuary allow juveniles to attain a larger size before entering the ocean, thereby increasing their chances for survival in the marine environment. Flow modifications under the BDCP (*CM1 Water Facilities and Operation*), and the resulting changes to the extent and duration of inundation of floodplains and other flow-dependent habitats, are expected to benefit juvenile salmon and steelhead rearing and migration.

Objective L2.9 Benefits: Achieving this objective is expected to increase food important to Chinook salmon, which may contribute to increased survival rates. Juvenile Chinook salmon are opportunistic feeders; reports on diet vary from study to study, but broad patterns are evident (Williams 2009). Smaller juveniles occupying marsh channels often feed heavily on larval and pupal chironomids (Shreffler et al. 1992; Lott 2004). This has been observed in a remnant tidal marsh in the Delta (Simenstad et al. 2000), as well as in overbank habitats close to the Delta (Sommer et al. 2005; Sommer, Nobriga, et al. 2001; Jeffres et al. 2008). As the fish grow, larger prey becomes more important, and as they move farther offshore and into deeper water, their diets shifts toward other available food resources.

Objective L2.11 Benefits: Achieving this objective will contribute to an increase in river-floodplain connectivity and increase the extent of rearing habitat available to juvenile salmonids within the Plan Area. Restoring seasonally inundated floodplain may contribute to an increase in primary productivity, which will contribute to a more diverse and robust forage base for juvenile salmonids. Juvenile salmonids forage in Delta floodplains to put on critical weight before entering the ocean (Sommer, Nobriga, et al. 2001; Sommer, Harrell, et al. 2001 and Jeffres et al. 2008).

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.3:** Provide flows that support the movement of juvenile life stages of native fish species to downstream rearing habitats. • **Objective L3.4:** Provide flows that support the movement of adult life stages of native fish species to natal spawning habitats.

Objective L3.3 Benefits: Achieving this objective is intended to provide flow conditions that can better coincide with the timing of juvenile Chinook salmon outmigration and their arrival in the Delta. Flow conditions sufficient to provide connectivity to restored aquatic habitats along migratory corridors are intended to provide increased rearing habitat and improved rearing conditions and food for juvenile salmonids. Migratory corridors for winter-run Chinook salmon are located downstream of the spawning areas and include the lower Sacramento River and the Delta. These migratory corridors also function as rearing habitat for juveniles, which feed and grow before and during their outmigration. Factors affecting outmigration timing include variations in river flows, dam operations, seasonal water temperatures, and overall hydrologic conditions. Providing flow conditions, both in terms of timing and duration that coincide with juvenile Chinook salmon outmigration may contribute toward increasing connectivity with restored aquatic habitats that provide suitable rearing conditions and food, thereby contributing to increasing survival through the Delta and sustaining the genetic diversity within the population and between the races of Chinook salmon. Juvenile winter-run Chinook salmon remain in the Delta until they reach a fork-length of approximately 118 millimeters and are between 5 and 10 months of age (Myers et al. 1998).

Further, the BDCP will address water quality issues in the Plan Area, such as the low DO levels in the Stockton DWSC and urban stormwater. The BDCP will include funding to the Port of Stockton to continue operation of the aeration facility in the Stockton DWSC. Continued operation of the aeration facility is intended to directly improve the connectivity between areas downstream of Turner Cut and the San Joaquin River upstream of Stockton by minimizing the low DO conditions that persist in this area, thereby reducing potential migration delays for both adult and juvenile salmonids. The BDCP will also provide funding to urban centers that discharge stormwater to the Plan Area to assist them in reducing their Delta inputs of polluted stormwater. Reducing the inputs of pollution from urban stormwater may contribute to improved water quality and increased health of the Delta.

Objective L3.4 Benefits: Achieving this objective is intended to provide flow conditions that trigger upstream adult migration when conditions are suitable. Sacramento River winter-run Chinook salmon adults enter the Sacramento River Basin between December and July, with the peak typically occurring in March, but delay spawning until spring or early summer (Yoshiyama et al. 1998; Moyle 2002).

The BDCP is intended to provide greater flexibility in water operations, and is expected to provide flows that support the movement of adults through the Plan Area. Providing such flows will be coupled with increased connectivity between low-salinity habitat and freshwater habitat and an increase in suitable habitat along existing and potentially viable future migration corridors (i.e., Yolo Bypass). Such conditions will be provided through restoration of a range of aquatic natural communities (see Objective L3.2 and applicable natural community goals and objectives).

Goal L4: Increased habitat suitability for covered fish species in the Plan Area.
• **Objective L4.1:** Manage the distribution and abundance of nonnative predators in the Delta to reduce predation on covered fishes. • **Objective L4.2:** Manage the distribution of covered fish species to minimize movements into areas of high predation risk in the Delta. • **Objective L4.3:** Reduce entrainment losses of covered fish species.

Objective L4.1 Benefits: Achieving this objective is intended to reduce predation on Chinook salmon by nonnative predators. Although predation is a natural part of aquatic community dynamics, excessive predation has been identified as a stressor for covered fish species. The actual extent of predation on smaller juveniles remains uncertain (Williams 2009). Refer to *CM15 Localized Reduction of Predatory Fishes* for discussion of the management of nonnative predators within the Plan Area.

Objective L4.2 Benefits: Achieving this objective is also intended to reduce predation on Chinook salmon; but, rather than contributing to a reduction in the abundance of nonnative predators, achieving this objective will contribute to reducing encounters with nonnative predators. Actions include enhancing existing migration corridors (e.g., Yolo Bypass) and installing features (e.g., weirs and nonphysical fish barriers) to encourage juvenile Chinook salmon to avoid areas that have a high risk for predation or otherwise result in decreased survival.

Objective L4.3 Benefits: Achieving this objective is intended to reduce the entrainment of winter-run Chinook salmon, which is correlated with the amount of water exported from the south Delta. Across the five water-year types, exports from the south Delta decrease from 100% of total exports under the existing biological conditions to an average of about 55% under the BDCP. The proportion of total exports that will come from the south Delta facilities under the BDCP is lowest in wet water years (36–37%) and is highest in critical water years (80–81%). The BDCP will increase total exports over baseline during April, May, and June but will do so largely by taking water from the north Delta intakes. Exports from the south Delta facilities during the spring months are generally similar or reduced relative to the existing biological conditions. Under the BDCP, average total exports from combined north and south Delta intakes will increase in the early and late long-term relative to the existing biological conditions in wet, above-normal, and below-normal water years. Under dry and critical water years, total exports will decrease under the BDCP relative to existing biological conditions. Overall, the BDCP will substantially reduce exports from the south Delta facilities in most months relative to existing biological conditions. Entrainment is therefore expected to be reduced most in wetter years, because a greater percentage of flow will be diverted from the north Delta in wet years than in dry years.

3.3.7.3.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for winter-run Chinook salmon are stated below.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Benefits: Achieving this objective will contribute toward restoring tidal perennial aquatic natural communities that provide habitat conducive to primary productivity, which is essential to maintaining a robust food base for juvenile salmonids. Salmonid behaviors in the Delta can be generally categorized as foraging and migrating. Some populations, such as winter-run Chinook salmon and steelhead enter the Delta primarily as smolts and tend to migrate through relatively rapidly (2 to 3 weeks), while other populations, such as fall-run and spring-run Chinook salmon, tend to rear for an extended period of time (2 to 3 months) to feed and grow prior to smoltification and movement to the ocean (McLain and Castillo 2010). Timing of entry to the Delta and duration of residency in the Delta can vary considerably within populations (Appendix 2.A, *Covered Species Accounts*). Del Rosario et al. (in review), however, indicate that smolts move through the Delta much more slowly than previously thought. Based on analysis of winter-run-sized fish, average residence time is typically more than 1 month and often much longer. Other populations, such as some spring-run Chinook salmon, emigrate primarily as fry, with a relatively small portion migrating as yearlings.

Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and shallow-water areas with emergent aquatic vegetation. Most salmonid populations exhibit a mix of these behaviors, and all juvenile salmonids forage and migrate to varying degrees as they move through the Delta. The tidal marsh restoration under *CM4 Tidal Natural Communities Restoration* is likely to primarily benefit juvenile foraging salmon; those that are primarily migrating are usually in deeper water and spend less time in the tidal marsh areas of the Delta.

Fry migrants move quickly downstream from the gravel-bed reaches where spawning occurs and rear in low-gradient reaches in the valley floor before migrating relatively rapidly through the Delta (Williams 2009). The size of fish recaptured at Sherwood Harbor, near Sacramento, indicates that they mainly rear upstream of the Delta, presumably in the Butte Sinks or the Sutter Bypass, until they are larger than 70 millimeters; then they often move relatively rapidly through the Delta (Williams 2009). The Yolo Bypass offers similar habitat to Sacramento River populations when water spills into the bypass over the Freemont Weir, and several studies indicate that fish do well there (Sommer, Nobriga, et al. 2001; Sommer et al. 2005; Katz 2012).

Juvenile Chinook salmon, including Sacramento River winter-run Chinook salmon ESU, Central Valley spring-run Chinook salmon ESU, and Central Valley fall- and late fall–run ESU, as well as Central Valley steelhead (*Oncorhynchus mykiss*) feed on zooplankton, benthic macroinvertebrates, amphipods, chironomid larvae, terrestrial insect drift, and larval fish on Delta floodplains to put on critical weight before entering the ocean (Sommer, Nobriga, et al. 2001; Sommer, Harrell, et al. 2001; Jeffres et al. 2008). Young Chinook salmon also forage in tidal habitat as fry and juveniles. Calanoid copepods, which have declined substantially in abundance in the Delta, are a key food resource for juvenile Chinook salmon (Moyle 2002).

Restoration of tidal perennial aquatic natural community will increase the availability of this community in the Delta by an estimated 57%. This restoration is assumed to substantially increase available food resources for outmigrating smolts. While the magnitude of this benefit to migrating salmon is uncertain, it is expected to be relatively substantial for juvenile salmonids, because the juveniles are growing and an increase in food will contribute to larger juveniles, which are expected to have increased survival.

Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.
• **Objective TPANC2.1:** Control invasive aquatic vegetation that adversely affects native fish habitat.

Objective TPANC2.1 Benefits: Achieving this objective is intended to address the nonnative plant species that limit the turbidity in the Delta, which has decreased over time (Jassby et al. 2002). It is hypothesized that one of the primary causes of the decrease in turbidity is biological filtration by IAV (Brown and Michniuk 2007). Controlling IAV is expected to result in some degree of increased turbidity as well as reduce suitable habitat for nonnative predators. Habitat structure and heterogeneity can affect opportunities for encounter and capture by predators. IAV beds appear to provide habitat that is more favorable to nonnative nearshore fishes, such as largemouth bass and sunfish, which also can take advantage of increased water clarity to find prey (Brown 2003; Nobriga et al. 2005; Nobriga and Feyrer 2007).

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them. • **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objective TBEWNC1.1 and TBEWNC1.2 Benefits: Achieving these objectives is intended to restore tidal brackish emergent wetland and increase primary productivity and thereby yield more abundant food resources for juvenile salmonids. Benefits to salmonids from this restoration are similar to those discussed above under Objective TPANC1.1.

Objective TBEWNC1.3 Benefits: Achieving this objective is intended to restore connectivity to isolated patches of tidal emergent marsh to potentially increase the transport of food resources from tidal marshes to areas occupied by juvenile salmonids, thereby increasing food available to these fish. Greater availability of food may contribute to an increase in survival of covered salmonids, although spring-run Chinook salmon and steelhead tend to migrate relatively quickly through the Delta (Williams 2009). Del Rosario et al. (in review), however, indicate that smolts move through the Delta much more slowly than previously thought. Based on analysis of winter-run-sized fish, average residence time is typically more than 1 month and often much longer.

Objective TBEWNC1.4 Benefits: Achieving this objective is intended to increase transport of food resources from restored wetland habitats to low-salinity zone habitats. While spring-run Chinook salmon and steelhead tend to migrate relatively quickly through the Delta, which may result in fewer benefits to these salmonids, slower migrations have been observed with juvenile winter-run and fall-run/late fall–run Chinook salmon as they approach the Delta (Williams 2009). The benefits of this objective will vary by Chinook salmon race, depending on the duration of migration and habitat use during migration through the Delta and duration of rearing within the Delta. In general, spring-run Chinook salmon will benefit the least because of their relatively rapid migration through the Delta and use of deeper-water habitat during migration; whereas fall-run/late fall–run Chinook salmon are likely to benefit the most due to shorter migration time and more extensive use of a wider variety of habitats.

> **Goal TFEWNC1:** Large, interconnected patches of tidal freshwater emergent wetland natural community.
>
> - **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.
> - **Objective TFEWNC1.2:** Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.

Objective TFEWNC1.2 Benefits: Achieving this objective is intended to promote effective tidal exchange throughout the marsh plain, increasing transport of food for juvenile Chinook salmon from restored wetlands to main channel habitats occupied by juvenile salmonids. Increasing the transport of food available to covered salmonids may contribute to an increase in survival.

Refer to Objectives TPANC1.1 and TBEWNC1.1 through 1.4 for a more complete discussion of Chinook salmon benefits from tidal natural communities and floodplain restoration.

> **Goal VFRNC1:** Extensive wide bands or large patches of interconnected valley/foothill riparian natural community, with locations informed by both existing and historical distribution.
>
> - **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain.
> - **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objective VFRNC1.1 Benefits: Achieving this objective is intended to contribute directly and/or indirectly to the production of food in the aquatic system available to Chinook salmon, which is expected to contribute to an increase in survival. It also has other benefits, such as increased habitat complexity and thermal insulation, known to be important to juvenile salmonids. Riparian natural community contributes important functions to the aquatic system by providing large woody debris recruitment, increased bank stability, reduced erosion, flow attenuation during flood events, allochthonous inputs, and shade and thermal insulation, all of which provide benefits to covered salmonids.

Objective VFRNC1.2 Benefits: Achieving this objective is expected to contribute directly and/or indirectly to the production of food in the aquatic system, which may contribute to increased survival of juvenile Chinook salmon as well as steelhead.

3.3.7.3.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above are expected to protect, restore, and enhance suitable habitat for winter-run Chinook salmon within the reserve system. The goals and objectives below are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global recovery goals and objectives are provided here for broader context of winter-run Chinook salmon recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Increase winter-run Chinook salmon abundance.
  - **Global Objective 1.1:** Attainment of the winter-run Chinook salmon global abundance goal will occur by 2060 with achievement of 6-year geometric mean escapement levels of:
    - 20,000 in the mainstem Sacramento River, with no year below 5,000.
    - 3,000 in the Battle Creek watershed, with no year below 700.
    - 800 in a third viable population, with no year below 200.
- **Global Goal 2:** Increase spatial distribution of winter-run Chinook salmon.
  - **Global Objective 2.1:** Attainment of the winter-run Chinook salmon global spatial distribution goal will occur by 2060 with restoration of two self-sustaining, independent populations in two watersheds of the Sacramento River drainage, and a third dependent population in the Sacramento River drainage.
- **Global Goal 3:** Conserve and restore life-history and genetic diversity of winter-run Chinook salmon.
  - **Global Objective 3.1:** Protect and restore the full range of adult and juvenile life-history types migrating through the Delta.
  - **Global Objective 3.2:** Attainment of the winter-run Chinook salmon global life-history diversity goal will occur by 2060 with restoration of two self-sustaining, independent populations in two watersheds of the Sacramento River drainage, and a third dependent population in the Sacramento River drainage.

The biological goals and objectives presented below have been developed to provide for the conservation and management of winter-run Chinook salmon in the Plan Area and contribute toward the achievement of the global goals and objectives.

Goal WRCS1: Improved survival (to contribute to increased abundance) of immigrating and emigrating winter-run Chinook salmon throughout the Plan Area.
• **Objective WRCS1.1:** For winter-run Chinook salmon originating in the Sacramento River, achieve a 5-year geometric mean interim through-Delta survival objective of 52% by year 19 (from an estimated 40%), 54% by year 28, and 57% by year 40, measured between Knights Landing and Chipps Island. This survival metric is an interim value based on limited data from fall-run Chinook salmon in the Sacramento River. This survival metric will be revised to account for new monitoring data and improved modeling expected by year 10.[31] • **Objective WRCS1.2**: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating winter-run Chinook salmon juveniles by year 15. • **Objective WRCS1.3:** Reduce illegal harvest of adult winter-run Chinook salmon in the Plan Area by year 5.

[31] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Assumed stressors: Entrainment, predation, lack of rearing habitat, spatial structure, illegal harvest, and altered migration flows.

Stressor reduction targets:

- **Survival rates at north Delta intakes.** Maintain survival rates through the reach containing new north Delta intakes (0.25-mile upstream of the upstream-most intake to 0.25-mile downstream of the downstream-most intake) to 95% or more of the existing survival rate in this reach. The reduction in survival of up to 5% below the existing survival rate will be cumulative across all screens.[32]
- **Survival rates at south Delta export facilities**. Three levels of stressor reduction.
  - Reduce the fraction of juvenile winter-run Chinook salmon that migrate into the south Delta through use of nonphysical barriers and migration through the Yolo Bypass.
  - Reduce salvage loss in the south Delta export facilities to less than 1% of Sacramento River Basin fish entering the Delta (based on the estimated number of juvenile winter-run Chinook salmon entering the Delta annually from the Juvenile Production Estimate or comparable juvenile abundance estimates) within 5 years of north Delta intakes beginning routine operations. This salvage loss target is considered interim and will be revised, as needed, to provide consistency with best available science and ensure that it is consistent with and contributing to Goal WRCS1.
  - Improve salvage efficiency of entrained fish through predation reduction in Clifton Court Forebay, reduced mortality in south Delta salvage operations, and improved return to the Delta (incorporate predation target below).
- **Predation.** Reduce predation in Clifton Court Forebay and at the CVP trash-racks to achieve mortality rates across Clifton Court Forebay and past CVP trash-racks equivalent to no more than 40%, as reflected in the Reasonable and Prudent Alternative in the NMFS (2009) BiOp, by year 5. Reduction in predation mortality may be achieved through a variety of actions, including, but not limited to, modification to Clifton Court Forebay operations, modifications to physical habitat conditions within Clifton Court Forebay, as well as removal of predatory fish from Clifton Court Forebay and the CVP intake.[33]
  - **Lack of rearing habitat.** Provide access to at least 7,000 acres of inundated floodplain habitat within the Yolo Bypass and Cache Slough ROA for at least 30 days in at least 70% of years[34]. Achieve the goal extent, duration, and frequency of inundation by year 15.
  - **Spatial structure.** Increase the heterogeneity of habitat along key migration corridors to provide a greater extent of cover and holding areas and rearing habitat for juvenile salmonids by year 15. Improved habitat conditions are expected to increase fish growth and survival. In the case of the Yolo Bypass, a proportion of the population would be diverted away from potential predation in the Sacramento River and from entry into the low-survival interior Delta.
  - **Illegal harvest.** Increase enforcement efforts to reduce illegal take of adult winter-run Chinook salmon in the Plan Area by year 5.
  - **Migration flows.** Ensure that north Delta intake operations do not increase the incidence of reverse flows in the Sacramento River at the Georgiana Slough junction.

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[32] Monitoring will be required to define current survival rates through this reach and then to discern whether any reduction in survival is attributed to the intakes.

[33] The metric and the means of achieving the metric presented within this Stressor Reduction Target are consistent with the Reasonable and Prudent Alternative Action Suite IV.4 in the NMFS (2009) BiOp. Upon BDCP permit authorization, the Implementation Office will coordinate with the agencies, as necessary, and work toward shifting responsibility from under the BiOp to the BDCP. More work will be needed to determine whether/how this metric will be measured and achieved based on current work being implemented under the BiOp, as well as how to capture and account for predation reduction throughout the Plan Area under *CM15 Localized Reduction of Predatory Fishes*.

[34] This metric (i.e., 30 days in at least 70% of years) is subject to change based upon ongoing analysis of the duration and frequency of inundation likely to be achieved, particularly when juvenile winter-run Chinook salmon are likely to be present.

Objective WRCS1.1 Rationale: Appendix 3.G, *Proposed Interim Delta Salmonid Survival Objectives,* presents a 2012 technical memorandum prepared by NMFS outlining the framework for determining appropriate metrics for through-Delta survival based on limited data of current through-Delta survival rates. The technical memorandum outlines how NMFS estimated current through-Delta survival rates and the rationale for specific interim metrics defined within Objectives WRCS1.1, SRCS1.1, FRCS1.1, and STHD1.1. NMFS used a simple deterministic, stage-based life-cycle model and cohort replacement rates of 1.2, 1.3, and 1.4 (1.3, 1.4, and 1.5 for winter-run Chinook salmon) to define survival objectives in three time-steps: 19 years after permit issuance (19-year), 28 years after permit issuance (28-year), and 40 years after permit issuance (40-year). For each of the covered salmonids, the interim through-Delta survival objective represent 50% of the estimated increase in Delta survival required to achieve the modeled cohort replacement rates, based on improvements in through-Delta survival alone. That is, NMFS held pre- and post-Delta survival constant and calculated the improvement in Delta survival needed to achieve the target cohort replacement rates, assigning half of that improvement to the BDCP. The balance of the improvements required to achieve the modeled cohort replacement rates is expected to be derived from other recovery actions distributed throughout the entire range of covered salmonids, which could occur upstream, in the Delta, and/or in the ocean.

There have been no studies of through-Delta survival of winter-run Chinook salmon. Recent acoustic-tag survival studies of hatchery-reared late fall–run Chinook salmon estimate through-Delta survival at approximately 40%. This survival rate was used as a starting point for estimating Sacramento River winter-run Chinook salmon through-Delta survival. There are substantial differences in fish size and seasonal timing of migration between juvenile winter-run and late fall–run Chinook salmon that may affect their survival rates. Therefore, the level of uncertainty in using results of studies of juvenile late fall–run Chinook salmon survival to establish both existing conditions and objectives for winter-run Chinook salmon is relatively high. This issue will be the subject of additional experimental survival studies and analyses during the interim period.

NMFS acknowledges the limitations of this approach, but in balancing the risks to ESA-listed species, NMFS considered it better to proceed with interim targets and recognizes the need to periodically review these baseline estimates and document progress toward the 19-year, 28-year, and 40-year objectives. As new empirical survival estimates for Central Valley species become available, NMFS is prepared to review and revise these Interim Delta Survival Objectives as appropriate.

Increasing the through-Delta survival of juvenile salmonids will be accomplished by maximizing survival rates at the new north Delta intakes, increasing survival rates at the south Delta export facilities, reducing mortality at predation hotspots, increasing habitat complexity through restoration actions along key migration corridors, guiding fish originating in the Sacramento River away from entry into the interior Delta, and ensuring pumping operations do not increase the occurrence of reverse flows in the Sacramento River at the Georgiana Slough junction. The BDCP's contribution toward addressing these factors is anticipated to improve conditions for juvenile salmonids and thus increase survival throughout the Plan Area, thereby contributing to increased abundance of emigrating juvenile and immigrating adult salmonids. The increase in survival and resulting increase in abundance are intended to provide for the conservation and management of covered salmonids in the Plan Area.

Survival studies conducted in the Central Valley have generally focused on fall-run or late fall–run juvenile Chinook salmon of hatchery origin, many of which are of a larger size than juvenile winter-run or spring-run Chinook salmon (although spring-run Chinook salmon may migrate as YOY, juveniles, or yearlings, the majority appear to migrate as fry or YOY). Also, the various runs have different migration timing, so extrapolation of the measured survivals from surrogate hatchery-origin fall- or late fall–run juvenile Chinook salmon to wild-origin winter-run, spring-run, and even fall- and late fall–run Chinook salmon has some inherent uncertainty. Additionally, there is considerable uncertainty regarding current through-Delta survival rates for emigrating juvenile Chinook salmon.

This survival metric represents the survival necessary for the BDCP to contribute to Goal WRCS1. Achieving this Delta survival objective would provide approximately 50% of the improvement in survival deemed necessary to recover the species throughout its range. The BDCP would be responsible for this improvement. The remaining 50% of the improvement in juvenile survival are expected to be achieved through other recovery actions upstream of the Delta, within the Delta (i.e., outside of the BDCP), and downstream of the Delta. This objective is not intended to compensate for poor survival, which may occur at other life stages outside the Plan Area or as a result of factors not controlled by the BDCP.

While the BDCP would be responsible for the half of the improvements to achieve the Cohort Replacement Rate, it may not be feasible to separate out the BDCP's contribution from that of other current, ongoing, and future recovery and conservation efforts throughout the range of the species. However, the BDCP will be responsible for tracking survival through monitoring and adaptive management. The BDCP also may be able to parse out the factors affecting through-Delta survival and qualitatively frame its contribution to addressing these factors.

Ongoing work and BDCP monitoring conducted during early implementation are expected to provide important new data and modeling tools to improve the through-Delta survival targets for covered salmonids, particularly for winter-run Chinook salmon. As more data are collected and a greater understanding of through-Delta survival is gained, this information will be used to revise survival metrics to reflect actual conditions related to current through-Delta survival and the BDCP's potential contribution to increased survival. For example, NMFS, in collaboration with other investigators, has initiated a survival study intended to produce reach-specific survival estimates for juvenile winter-run and spring-run Chinook salmon and to test for differences in survival rates for wild- and hatchery-origin salmon.

This objective will be achieved by addressing the following stressors.

- **Maximizing survival rates at the north Delta Intakes.** The operational criteria for the north Delta intakes are intended to maximize survival through dual conveyance and screening of intakes to minimize entrainment and modification of the Fremont Weir to create a viable alternate migratory pathway for juvenile salmonids. Flows will be managed in real time to minimize adverse effects of water diversions at the north Delta intakes on downstream-migrating salmonids. Screening of the new north Delta intakes will incorporate screens with 1.75-millimeter mesh, which is intended to exclude fish with a body size below 15 millimeters. Final specifications have not been completed for the north Delta intake screens, but approach velocity will be less than 0.33 feet per second (criterion for salmonid fry) and may be limited to 0.2 feet per second (existing criterion for juvenile delta smelt). Additionally, modifications to the Fremont Weir will allow increased flow into the Yolo Bypass between mid-November and mid-May to coincide with juvenile salmonid outmigration. The modifications to the Fremont Weir are intended to increase the duration and extent of inundation of the Yolo Bypass as well as enhance the habitat conditions within the bypass. The proportion of the population that may use the Yolo Bypass as an alternate migration corridor, as opposed to the mainstem Sacramento River, may be relatively small, but those fish that do migrate through the Yolo Bypass will not be exposed to the north Delta intakes.

- **Increasing survival rates at the south Delta export facilities.** Appreciable losses of juvenile salmonids have occurred historically at the south Delta export facilities. Estimates of wild winter-run Chinook salmon loss at these facilities as a percentage of the wild-origin population entering the Delta have ranged from less than 0.1% in 2007 to over 5% in 2001 (Llaban 2011), under baseline conditions. Overall, entrainment/salvage loss of juvenile salmonids under the BDCP will be appreciably lower in the south Delta that under existing conditions, because operation of the north Delta intakes will reduce reliance on south Delta export facilities. See also benefits described under Objective L4.3.

- **Predation.** Reducing predation rates in the Plan Area at certain hotspots where predators are known or expected to congregate or have disproportionately large effects on covered fish is intended to contribute to an increase in the survival of emigrating juvenile salmonids. Striped bass may be the most significant predator of Chinook salmon due to its ubiquitous distribution in the estuary and tributary rivers and the tendency for individuals to aggregate around water diversion structures (Brown et al. 1996 in Nobriga and Feyrer 2007). A variety of other nonnative predatory fish also occur in the Delta. *CM15 Localized Reduction of Predatory Fishes* is intended to reduce the abundance of piscivorous fish at specific locations and eliminate or modify predator hotspots throughout the Delta, particularly along major migratory routes used by salmonids. *CM16 Nonphysical Fish Barriers* will be employed to discourage juvenile salmonids from entering channels/migration routes that are known to have high predator abundance and/or predation rates, further reducing predation rates within the Plan Area and contributing to an increase in survival.

  Foodweb dynamics are often complex, with indirect interactions that can mask or amplify top-down effects. For example, with competition between two prey species that share a common predator, predation rates on one prey species can increase in response to the presence of the alternative prey. In the Delta, it may be that nonnative prey (e.g., silverside, threadfin shad) maintain nonnative predator populations (e.g., striped bass, largemouth bass) at high levels, causing artificially high rates of predation on native fish, including covered salmonids. For these reasons, *CM15 Localized Reduction of Predatory Fishes* and *CM16 Nonphysical Fish Barriers* will be implemented through an experimental process guided by a strong adaptive management and monitoring program to ensure that the benefits of these measures are maximized and unintended adverse consequences are avoided.

- **Lack of rearing habitat.** Increasing habitat complexity along key migration corridors is expected to contribute to increased survival for juvenile salmonids. Juvenile winter-run Chinook salmon migrate downstream into the lower Sacramento River and Delta typically beginning in late December followed by an extended juvenile rearing period of 4 to 7 months prior to migrating into coastal marine waters (National Marine Fisheries Service 2009). Habitat conditions during juvenile rearing, including access to low-velocity, shallow-water habitat with few predators and abundant food supplies, are important for juvenile growth and survival. Providing enhanced access to seasonally inundated floodplain habitat in the Yolo Bypass (CM2) and other seasonally inundated floodplain habitat (CM5), a greater extent of tidal wetlands (CM4), and enhanced channel margin habitat (CM6) under the BDCP will improve juvenile rearing conditions and contribute to increased juvenile survival.

  Access to the Yolo Bypass, in addition to providing rearing habitat, serves as an alternative migration pathway for juvenile salmonids around those regions of the mainstem Sacramento River where the north Delta intakes will be located. This alternative migration route will avoid exposure of salmonids to the Delta Cross Channel and Georgiana Slough, which lead to the interior

Delta where survival has been shown to be lower than in the mainstem Sacramento River and Sutter and Steamboat Sloughs (Perry et al. 2010). The alternative route also will reduce the risk of exposure to striped bass and other predatory fish inhabiting the Sacramento River between the Fremont Weir and Rio Vista. Other studies indicate that the relative survival of Chinook fall-run fry migrating through Yolo Bypass to Chipps Island was on average 50% higher than fish passing over the comparable section of the Sacramento River (Sommer, Harrell, et al. 2001). Survival of Sacramento River fish passing through the interior Delta was lower than fish passing through the Sacramento River (0.35 mean ratio of survival probabilities) (Newman and Brandes 2010). Thus, while improved access to Yolo Bypass will provide increased rearing habitat, it will also be expected to contribute toward reduced predation and increased survival.

- **Migration flows.** The north Delta intakes will be operated so as to not increase the incidence of reverse flows in the Sacramento River at the Georgiana Slough junction, thereby limiting the potential for covered salmonids to inadvertently migrate into the interior Delta. Juvenile salmonids can be drawn into alternative channels, such as Georgiana Slough and the Delta Cross Channel, and into the interior Delta region where survival has generally been shown to be lower than in the Sacramento River mainstem or Sutter and Steamboat Sloughs (Perry et al. 2010; Brandes and McLain 2001). The importance of alternative channels that lead to the interior Delta region and the need to discourage their use by juvenile salmonids was recognized by NMFS (2009b) in the BiOp, which requires that engineered solutions be investigated to lessen the problem. Engineered solutions considered include physical and/or nonphysical barriers.

  The 5-year geometric mean survival objective is intended to exceed typical drought cycle of 2 years, and amortize across multiple generations (3- to 4-year lifespan). The timeframe for achieving the migration flow stressor reduction target is anticipated to be 15 years, to allow time to permit and construct Fremont Weir improvements and north Delta facilities and to complete further evaluation of nonphysical barriers. This timeframe balances the need to allow time to realize some of the BDCP benefits while providing an incentive to implement measures quickly.

Objective WRCS1.2 Rationale: Creating a viable alternative migratory pathway through the Yolo Bypass from December through March in more than 70% of years for emigrating juvenile winter-run Chinook salmon will contribute to increased salmonid survival. While this objective is expected to be met, the frequency, duration, and extent of inundation and the seasonal timing of this inundation in the Yolo Bypass are still being modeled. The effects may be revised with respect to migrating juvenile winter-run Chinook salmon and other runs of Chinook salmon (i.e., spring-run and fall-run/late fall–run). Thus, the specific metric may be refined based on additional modeling prior to improved operations of the Fremont Weir.

A viable migration route through the Yolo Bypass may be provided from mid-November through mid-May, but is not likely to be viable within this expanded timeframe in more than 70% of years. However, an increase in the frequency, duration, and extent of inundation of the Yolo Bypass will be achieved and will contribute to an increase in the extent of suitable rearing habitat and the abundance of food available to juvenile salmonids, which is expected to contribute to an increase in survival. Juvenile winter-run Chinook salmon outmigration generally occurs from November through May in the Sacramento River in the Yolo Bypass region, with peak abundance from December through March. The specific timing of the outmigration of juvenile salmonids typically coincides with high-flow events in the Sacramento River and its tributaries, which generally coincide with overtopping of the Fremont Weir. Modifications to the Fremont Weir to improve fish passage conditions and subsequent increases in overtopping events will take place by year 15. Once the modifications are implemented, overtopping of the Fremont Weir will be initiated as early as November and will be allowed to overtop and inundate the Yolo Bypass floodplain as late as April and into May, as conditions allow.

Increased frequency, duration, and extent of inundation of the Yolo Bypass are anticipated to increase primary productivity within the Yolo Bypass. Juvenile salmonids that rear on the Yolo Bypass have been shown to have growth rates that exceed those of fish migrating within the mainstem Sacramento River (Sommer et al. 2001a). Of the three races of Chinook salmon examined with the Delta Passage Model, winter-run Chinook salmon would tend to benefit most from increased Yolo Bypass inundation, because their outmigration period coincides most with the general period of bypass flooding.

Objective WRCS1.3 Rationale: The BDCP will address illegal harvest in the Plan Area to contribute to an increase in adult survival. Through *CM17 Illegal Harvest Reduction*, the BDCP intends to increase abundance of covered adult salmonids by decreasing the number of potential spawners taken illegally by recreational anglers and organized poaching rings. The scale of the illegal harvest issue within the Plan Area is unknown, but illegal harvest has been documented by the Delta-Bay Enhanced Enforcement Program (Department of Fish and Game 2012). Reducing this threat is anticipated to increase escapement of spawning adults.

While the specific number of contacts, warnings, citations, and arrests are documented, the number of violations that go undetected is unknown. An increase in enforcement is expected to result in a decrease in illegal harvest within the Plan Area over time; however, it will be difficult to definitively document or quantify the decrease in illegal harvest or conclude that an increase or decrease in the number of citations issued in a given year translates into a reduction in the extent of illegal harvest occurring within the Plan Area. Thus, the principal tool for monitoring will be tracking trends in the number and distribution of citations and arrests relative to level of effort.

Goal WRCS2: Substantial reduction of passage delays (to contribute to increased migration and spawning success, and thus abundance) at anthropogenic impediments for adult winter-run Chinook salmon migrating through the Delta.
• **Objective WRCS2.1:** Limit adult winter-run Chinook salmon passage delays in the Yolo Bypass to fewer than 36 hours by year 15.
Assumed Stressors: Adult fish passage barriers. Stressor Reduction Targets: • **Adult Passage:** Limit passage delays at human-made barriers and impediments (e.g., Fremont Weir) in the Yolo Bypass to fewer than 36 hours by year 15.

Objective WRCS2.1 Rationale: Information is limited regarding the number and proportion of covered adult salmonids migrating upstream within Yolo Bypass that may become stranded at the Fremont Weir. Adult salmonids entering the Yolo Bypass can become trapped at the Fremont Weir and face mortality or considerable delay in their migration upstream (Williams 2006; Harrell and Sommer 2003). Adults entering the downstream end of the Yolo Bypass migrate upstream until they encounter the Fremont Weir. The weir currently limits adult fish passage, and fish can be trapped or must migrate back downstream and reenter the Sacramento River to continue their upstream migration. The impediment to upstream migration is nearly 100% but only affects those fish entering the Yolo Bypass.

Reducing passage delays in the Yolo Bypass will increase connectivity between the Yolo Bypass and the Sacramento River and provide timely passage for actively migrating adult salmonids past the Fremont Weir. This can substantially reduce the risk of stress, which can contribute to weakness, sickness, reduced reproductive success, and mortality. Reducing passage delays will also contribute to a reduction in the risk of adult salmon, as well as other fishes, being harvested illegally in areas where their migration is impeded.

An inventory of other physical barriers that may contribute to migration delays (e.g., Lisbon Weir) will allow investigation of further opportunities to increase connectivity between the Yolo Bypass and the Sacramento River and reduce passage delays for migrating salmonids within Yolo Bypass through capital improvements under *CM2 Yolo Bypass Fisheries Enhancement*. The suite of actions proposed to improve adult fish passage as part of CM2 will benefit Sacramento River adult salmonids by reducing stranding and delay in the Yolo Bypass (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.9, *Nonphysical Barriers*). The efficacy of the passage improvements at the Fremont Weir and other locations in the Yolo Bypass (e.g., Lisbon Weir) cannot be estimated but will be monitored, and adjustments will be made through adaptive management. Resulting improvements in migration may vary by water-year type as a result of differing inundation frequencies and volumes. The DRERIP (Essex Partnership 2009) evaluation of improved passage at Fremont Weir suggests that the benefits of increased passage will greatly outweigh potential risks (e.g., increased stranding as a result of increased attraction in the bypass).

Goal WRCS3: No degradation of aquatic habitat conditions for winter-run Chinook salmon upstream of the water facilities.

- **Objective WRCS3.1:** Implement covered activities so as to not result in a reduction of the primary constituent elements of designated critical habitat for winter-run Chinook salmon upstream of the Plan Area.
- **Objective WRCS3.2:** Operate water facilities to support a wide range of life-history strategies for winter-run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area.).

Assumed Stressors: Habitat conditions, water temperatures.

Stressor Reduction Targets:

- **Habitat:** Avoid degradation of fish habitat conditions upstream of the Plan Area as a result of covered activities
- **Water Temperatures:** Covered activities will be implemented in such a way as to not result in an increase in water temperature upstream of the Plan Area, within the Study Area.

Objective WRCS3.1 Rationale: The primary constituent elements of salmonid designated critical habitat include sites for rearing, spawning, and migration, all of which occur upstream of the Plan Area (rearing sites and migration corridors also occur within the Plan Area). Implementing covered activities in a way that will not degrade the condition of rearing sites, spawning sites, or migration corridors upstream of the Plan Area will ensure that the BDCP is not degrading conditions upstream of the Plan Area. This will ensure that the effort the BDCP contributes toward improving conditions and increasing the abundance of juvenile and adult salmonids within the Plan Area is also contributing toward maintaining, and not degrading, conditions upstream of the Plan Area.

Objective WRCS3.2 Rationale: Implementing covered activities is intended to support a wide range of life-history strategies (i.e., early migrants as well as later migrants) without favoring any one particular life-history strategy. The greater diversity of life-history strategies is expected to contribute to a more resilient population capable of adapting to fluctuations in conditions (e.g., timing of peak outflow, shifts in the period of floodplain inundation, shifts in the timing of optimum spawning and rearing conditions) that may occur from year to year.

Additionally, this objective may contribute to achieving Global Goal 3, to conserve and restore life-history and genetic diversity of winter-run Chinook salmon. Part of the recovery planning effort focuses on applying Viable Salmonid Population parameters of abundance, productivity, spatial structure, and diversity for determining whether a population is viable (McElhancy et al. 2000 in National Marine Fisheries Service 2009). The intent of the biological goals and objectives is to provide for the conservation and management of covered salmonids in the Plan Area, in part by providing conditions that may support a diversity of life-history strategies, both within and between races (i.e., winter-run, spring-run and fall-run/late fall–run Chinook salmon) and species (i.e., Chinook salmon and steelhead) through management of water operations to support a broad range of variation in traits such as run timing, age structure, behavior, and genetic characteristics. Additionally, conservation measures related to restoration and enhancement of natural communities in the Plan Area will contribute to increasing the spatial structure of the species by providing habitat patches that are highly productive in terms of growth. Moreover, water operations will be managed to maintain the condition of habitat patches upstream of the Plan Area.

3.3.7.4 Chinook Salmon, Central Valley Spring-Run Evolutionarily Significant Unit

Historically, spring-run Chinook salmon (*Oncorhynchus tshawytscha*) occurred throughout the Central Valley, occupying the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit Rivers and most of their tributaries, with sufficient habitat. Completion of Friant Dam extirpated the native spring-run Chinook salmon population from the San Joaquin River and its tributaries. Naturally spawning populations are currently restricted to Butte, Deer, and Mill Creeks. No spawning habitat for Chinook salmon is found in the Plan Area. Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and shallow-water areas with emergent aquatic vegetation.

Central Valley spring-run Chinook salmon ESU was once the most abundant run of salmon in the Central Valley. The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s. Broad fluctuations in adult abundance occurred between 1961 and 2009, with a generally positive trend in escapement in these waterways between 1992 and 2005, followed by a steep decline. The Central Valley spring-run Chinook salmon ESU is composed of three diversity groups, with fish exhibiting spring-run Chinook salmon life histories occurring in 12 watersheds, although only 3 of those 12 watersheds contain viable populations.

Important threats and stressors to the Central Valley spring-run Chinook salmon ESU are summarized below. Refer to Appendix 2.A, *Covered Species Accounts*, for a full discussion of these stressors.

- **Population effects.** Access to historical spawning areas is primarily restricted to Butte, Deer, Chico, and Mill Creeks, making the ESU susceptible to environmental changes. Only three of the estimated 17 historical populations remain.
- **Reduced staging and spawning habitat.** Access to much of the high-value historical upstream spawning habitat for spring-run Chinook salmon has been eliminated or degraded by human-made structures (e.g., dams and weirs) associated with water management operations.
- **Reduced rearing and outmigration habitat.** Channel margins throughout the Delta have been leveed, channelized, and fortified with riprap for flood protection and island reclamation, reducing and degrading the quality and connectivity of natural habitat available for juvenile Chinook

salmon rearing (Brandes and McLain 2001). Human-made barriers and water diversions further reduce and degrade rearing and migration habitat, delay juvenile outmigration, and result in increased diversion screen impingement, entrainment, disease, and predation.

- **Predation by nonnative species.** Predation on juvenile salmon by nonnative fishes (e.g., small- and largemouth bass, striped bass, catfish, Sacramento pikeminnow, and northern pike) has been identified as an important threat, particularly to YOY fry emigrating through the Delta, and changes in the system have enhanced suitable habitat for these species.
- **Harvest.** Commercial and recreational harvest of spring-run Chinook salmon in the ocean and inland fisheries, as well as illegal poaching, result in harvest of wild-origin Chinook salmon.
- **Reduced genetic diversity/integrity.** Their small and limited populations and their restricted distribution make spring-run Chinook salmon particularly sensitive to environmental changes and genetic introgression from artificial propagation programs. Reducing the effects of introgression is part of recovery planning and conservation of the species.
- **Entrainment.** The loss of juvenile spring-run Chinook salmon to entrainment and salvage at SWP/CVP export facilities, numerous other nonproject diversions, and power plant intakes affects Chinook salmon populations. The small size of many of the juvenile emigrants increases their vulnerability to entrainment at unscreened diversions; however, the effects of entrainment mortality on the population dynamics and overall adult abundance of spring-run Chinook salmon is not well understood.
- **Exposure to toxins.** Toxins from agricultural drainage and return flows, municipal wastewater treatment facilities, and other point and nonpoint discharges include mercury, selenium, copper, pyrethroids, and endocrine disruptors. These have the potential to affect fish health and condition, and adversely affect salmon distribution and abundance. Sublethal concentrations may interact with other stressors (e.g., seasonally elevated water temperatures, predation or disease) to increase vulnerability of salmonids to mortality.
- **Increased water temperature.** Higher water temperatures cause physiological stress, reduced growth rates, prespawning mortality, reduced spawning success, and increased mortality of salmon. Juvenile spring-run Chinook outmigrate earlier in the season than other juvenile Chinook salmon, reducing the influence of increased water temperatures; the early-returning adults, however, are susceptible to mortality related to high water temperatures during prespawning holding periods.

The public draft recovery plan for Central Valley salmonids, including Central Valley spring-run Chinook salmon, was released by NMFS on October 19, 2009. Although not final, the overarching goal in the public draft is the removal of, among other listed salmonids, Central Valley spring-run Chinook salmon from the federal list of threatened and endangered species (National Marine Fisheries Service 2009a). Several objectives and related criteria represent the components of the recovery goal, including the establishment of at least two viable populations within each historical diversity group. The recovery plan is based on a stepwise strategy that first addresses more urgent near-term needs and builds toward full recovery. The strategic planning framework incorporates viability at both the ESU and population levels, prioritizes watersheds based on current occupancy, and prioritizes unoccupied watersheds for reintroductions. Spring-run Chinook are also covered under the *Solano County Multispecies Habitat Conservation Plan* and the *East Alameda County Conservation Strategy*, and efforts are also underway to reestablish spring-run Chinook salmon in the San Joaquin River under the *San Joaquin River Litigation Settlement*.

The conservation of Chinook salmon under BDCP will be achieved via improved flow management and habitat restoration. Improved flow management will be achieved primarily through relocation and operation of the primary point of diversion to the north Delta. This change in water operations is expected to reduce entrainment in the south Delta but may increase impingement and predation-related losses in the north Delta depending upon water- year type and model used to evaluate these elements (Appendix 5.B, *Entrainment*). Habitat restoration benefits will be derived chiefly from tidal natural communities restoration, seasonally inundated floodplain restoration, channel margin enhancement, and riparian natural community restoration, which are expected to increase primary and secondary production to contribute to increased food for salmonids and to increase habitat complexity.

Increasing the availability of floodplain and channel margin habitat for salmonids is anticipated to increase productivity within the Plan Area. More frequent access to floodplain habitat that is seasonally inundated for longer durations than currently occurs is anticipated to increase the amount and quality of accessible rearing habitat for juvenile Chinook salmon. An ancillary benefit is the routing of a portion of the juvenile Chinook salmon outmigrant population away from the interior Delta and through habitat that is favorable for growth and survival, such as Yolo Bypass. These expected benefits are supported by a number of existing studies (e.g., Sommer, Nobriga, et al. 2001; Whitener and Kennedy 1999; Moyle et al. 2007).

Additionally, reducing passage delays at human-made barriers is expected to reduce migratory delays and increase survival of adult salmonids during their upstream migration to spawning areas. Reducing migratory delays will contribute to an increase in survival of adult salmonids as they are exposed to less potential stress, stranding, and illegal harvest.

The conservation strategy for spring-run Chinook salmon will focus on those life stages occurring in the Plan Area and ensure the timing of actions to benefit those specific life stages coincides with when they would be present in the Plan Area. The conservation strategy also focuses on habitat conditions upstream of the Plan Area, such as water temperature that could be affected by covered activities implemented within the Plan Area. The conservation strategy is explicit that covered activities be implemented so as to not result in a reduction of the primary constituent elements of designated critical habitat for spring-run Chinook salmon upstream of the Plan Area (see Objective SRCS3.1, below). For spring-run Chinook salmon, the focus is on improving juvenile survival rates, which includes reducing the relative percentage of juvenile outmigrants that are entrained at the south Delta export facilities and reducing predation levels in the Plan Area. The strategy also minimizing fish passage delays for adult spring-run Chinook salmon at human-made barriers and impediments. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.4.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for spring-run Chinook salmon are the same as those presented for winter-run Chinook salmon, and the associated benefits are similar. See Section 3.3.7.3.1, *Applicable Landscape-Scale Goals and Objectives*.

3.3.7.4.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for spring-run Chinook salmon are the same as those presented for winter-run Chinook salmon, and the associated benefits are similar. See Section 3.3.7.3.2, *Applicable Natural Community Goals and Objectives*.

3.3.7.4.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for spring-run Chinook salmon within the reserve system. The goals and objectives below are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global recovery goals and objectives are provided here for broader context of spring-run Chinook salmon recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Increase spring-run Chinook salmon abundance.
  - **Global Objective 1.1:** Achievement of 6-year geometric mean escapement levels of: 59,000 naturally produced adults in the Sacramento River and its tributaries,[35] with no year below 30,000, and a 5-year annual average escapement of 30,000 naturally produced adults in the San Joaquin River and its tributaries,[36] with no year below 10,000. (These numbers do not include hatchery produced fish).
- **Global Goal 2:** Increase spatial distribution of spring-run Chinook salmon.
  - **Global Objective 2.1:** Restore six self-sustaining, independent populations of wild spring-run Chinook salmon in watersheds of the Sacramento River drainage, including viable populations in the following locations.
    - Northwestern California Region (Clear Creek to Stony Creek).
    - Basalt and Porous Lava Region (Lower Sacramento River to Battle Creek).
    - Northern Sierra Region (Antelope Creek to Mokelumne River.
    - Two populations in watersheds of the San Joaquin River drainage; maintenance of Core 2 populations at moderate risk of extinction.
- **Global Goal 3:** Conserve and restore life-history and genetic diversity of spring-run Chinook salmon.
  - **Global Objective 3.1:** Protect and restore the full range of adult and juvenile life-history types migrating through the Delta.

The biological goals and objectives presented below have been developed to provide for the conservation and management of spring-run Chinook in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

[35] From Anadromous Fish Restoration Program doubling goal.

[36] From San Joaquin River Restoration Program.

Goal SRCS1: Increased spring-run Chinook salmon abundance.
• **Objective SRCS1.1:** For spring-run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 49% by year 19 (from an estimated 40%), 52% by year 28, and 54% by year 40, measured between Knights Landing and Chipps Island. The Sacramento River survival metric is an interim value based on limited data from fall-run Chinook salmon in the Sacramento River. This survival metric will be revised to account for new monitoring data and improved modeling expected by year 10.[37] For spring-run Chinook salmon originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 33% by year 19, 35% by year 28, and 38% by year 40, measured between Mossdale and Chipps Island. Spring-run Chinook salmon do not currently exist in the San Joaquin subbasin, thus these survival metrics are considered very interim. • **Objective SRCS1.2:** Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating spring-run Chinook salmon juveniles by year 15. • **Objective SRCS1.3:** Reduce illegal harvest of adult spring-run Chinook salmon in the Plan Area by year 5.

[37] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Assumed stressors: Entrainment, predation, spatial structure, lack of rearing habitat, illegal take, and altered migration flows.

Stressor reduction targets:

- **Survival rates at north Delta intakes.** Maintain survival rates through the reach containing new north Delta intakes (0.25-mile upstream of the upstream-most intake to 0.25-mile downstream of the downstream-most intake) to 95% or more of the existing survival rate in this reach. The reduction in survival of up to 5% below the existing survival rate will be cumulative across all screens.[38]
- Survival rates at south Delta export facilities—three levels of stressor reduction.
  - Reduce the fraction of juvenile spring-run Chinook salmon that migrate into the south Delta through use of nonphysical barriers and migration through the Yolo Bypass.
  - Reduce salvage loss in the SWP/CVP south Delta export facilities to less than 1% of Sacramento River Basin fish entering the Delta (using coded-wire-tagged Feather River Hatchery spring-run Chinook salmon as surrogates for wild-origin Sacramento River fish salvaged at the south Delta export facilities) within 5 years of the beginning of the north Delta intakes operations. This salvage loss target is considered interim and will be revised as needed to provide consistency with the best available science and ensure the numeric salvage loss target is consistent with and contributing to Goal SRCS1.
  - Improve salvage efficiency of entrained fish through predation reduction in south Delta salvage operations, reduce mortality in Clifton Court Forebay, and improve return to the Delta (incorporate predation target below).
- **Predation.** Reduce predation in Clifton Court Forebay and at the CVP trash-racks to achieve mortality rates across Clifton Court Forebay and past CVP trash-racks equivalent to no more than 40%, as reflected in the NMFS Reasonable and Prudent Alternative in the NMFS (2009) BiOp by year 5. Reduction in predation mortality may be achieved through a variety of actions including, but not limited to, modification to Clifton Court Forebay operations, modifications to physical habitat conditions within Clifton Court Forebay, as well as removal of predatory fish from Clifton Court Forebay and the CVP intake.[39]
- **Lack of rearing habitat in the North delta.** Provide access to at least 7,000 acres of floodplain habitat within the Yolo Bypass and Cache Slough ROA that is inundated for at least 30 days in at least 70% of years.[40] The extent, duration, and frequency of inundation will occur by year 15.
- **Lack of rearing habitat in the south Delta.** Provide access to at least 1,000 acres of floodplain habitat, primarily within the south Delta. On average, 50 acres of floodplain will be inundated a minimum of every other year, 500 acres will be inundated a minimum of every 5 years, and all 1,000 acres will be inundated a minimum of once every 10 years. Floodplains will be inundated for a minimum of 1 week between December and June. The extent, duration, and frequency of inundation will occur by year 15.
- **Spatial structure.** Increase the heterogeneity of habitat along key migration corridors to provide a greater extent cover and holding areas and rearing habitat for juvenile salmonids by year 15. Improved habitat conditions are expected to increase fish growth and survival. In the case of the Yolo Bypass and Cache Slough ROA, a proportion of the population would be diverted away from potential predation in the Sacramento River and entry into the low-survival interior Delta, thereby contributing to Objective SRCS1.1.
- **Illegal harvest.** Increase enforcement efforts to reduce illegal take of adult spring-run Chinook salmon in

[38] Monitoring will be required to define the current survival rate through this reach and then to discern whether any reduction in survival is attributed to the intakes.

[39] The metric and means of achieving the metric presented within this Objective are consistent with the RPA Action Suite IV.4 in the NMFS (2009) BiOp. Upon BDCP permit authorization, the Implementation Office will coordinate with the agencies as necessary and work toward shifting responsibility from the under the BiOp to BDCP. More work will be needed to determine whether/how this metric will be measured and achieved based on current work being implemented under the BiOp, as well as how to capture and account for predation reduction throughout the Plan Area from *CM15 Localized Reduction of Predatory Fishes*.

[40] This metric (i.e., 30 days in at least 70% of years) is subject to change based upon ongoing analysis of the duration and frequency of inundation likely to be achieved, particularly when juvenile spring-run Chinook salmon is likely to be present.

the Plan Area by year 15.

- **Migration flows.** Ensure that north Delta intake operations do not increase the incidence of reverse flows in the Sacramento River at the Georgiana Slough junction.

Objective SRCS1.1 Rationale: See rationale for Objective WRCS1.1 above for a general discussion of the framework for developing the metrics presented within this objective and rationale for the objective.

Spring-run Chinook salmon juvenile downstream migration timing is highly variable, as individuals may migrate downstream as YOY, juveniles, or yearlings. Juvenile spring-run Chinook salmon are generally found in the Plan Area from November through April, with peak abundance November through January.

The variability in the timing of the juvenile life stage and the corresponding outmigration make defining objectives and associated metrics for spring-run Chinook salmon difficult. The habitat preference and use is quite different depending upon the duration of time spent rearing in fresh water and the subsequent size of the fish attained during this time, which can vary.

Recent acoustic-tag survival studies of hatchery-reared late fall–run Chinook salmon estimate through-Delta survival at approximately 40%. This estimate was used as a starting point for through-Delta survival for Sacramento River spring-run Chinook salmon. As a result of differences in fish size and the seasonal timing of juvenile migration, there are substantial differences between juvenile spring-run and late fall–run Chinook salmon that may affect their survival rates. Therefore, the level of uncertainty in using currently available study results to establish both existing conditions and objectives for spring-run Chinook salmon is relatively high and will be the subject of additional experimental survival studies and analyses during the interim period. Spring-run Chinook salmon do not currently exist within the San Joaquin subbasin; thus, there is significant uncertainty in projecting any through-Delta survival rates in this subbasin, and thus these metrics are considered interim. NMFS and others are initiating survival studies in 2013 to determine survival of juvenile spring-run Chinook salmon. These interim survival values are intended to represent those necessary to contribute toward Goal SRCS1. This objective is not intended to compensate for poor survival, which may result at other life stages occurring outside the Plan Area or as a result of factors not controlled by the BDCP. The survival metrics will be revised as needed to account for new information and incorporate best available science, as appropriate.

In general, increasing the through-Delta survival of juvenile salmonids will be accomplished by maximizing survival rates at the new north Delta intakes, increasing survival rates at the south Delta export facilities, reducing predation rates in the Plan Area, increasing habitat complexity along key migration corridors, and ensuring that pumping operations do not increase the incidence of reverse flows in the Sacramento River at the Georgiana Slough junction. The BDCP's contribution toward addressing these factors is anticipated to improve survival throughout the Plan Area and contribute to increased abundance of emigrating juvenile salmonids.

Objective SRCS1.2 Rationale: See rationale for Objective WRCS1.2 for general rationale for this objective.

Objective SRCS1.3 Rationale: See rationale for Objective WRCS1.3 for general rationale for this objective.

Goal SRCS2: Substantial reduction of passage delays (to contribute to increased migration and spawning success, and thus abundance) at human-made impediments for adult spring-run Chinook salmon migrating through the Delta.
• **Objective SRCS2.1:** Limit adult spring-run Chinook salmon passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton DWSC) to fewer than 36 hours by year 15.
Assumed Stressors: Adult fish passage barriers. Stressor Reduction Targets: • **Adult Passage:** Limit passage delays at human-made barriers and impediments in the Delta to fewer than 36 hours by year 15.

Objective SRCS2.1 Rationale: See rationale for Objective WRCS2.1 for general rationale for this objective.

Evaluations of the impacts of improvements to the Fremont Weir to increase inundation of the Yolo Bypass and reduce passage delays at the Fremont Weir have shown positive and negative effects. Resulting improvements in migration may vary by water-year type as a result of differing inundation frequencies and volumes. The DRERIP (2009) evaluation of improved passage at Fremont Weir suggested that the benefits of increased passage will greatly outweigh potential risks (e.g., increased stranding as a result of increased attraction in the bypass).

Goal SRCS3: No degradation of aquatic habitat conditions for spring-run Chinook salmon upstream of water facilities.
• **Objective SRCS3.1:** Implement covered activities so as to not result in a reduction in the primary constituent elements of designated critical habitat for spring-run Chinook salmon upstream of the Plan Area. • **Objective SRCS3.2:** Operate water facilities to support a wide range of life-history strategies for spring-run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., Real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area.).
Assumed Stressors: Habitat conditions, water temperatures Stressor Reduction Targets: • **Habitat:** Avoid degradation of fish habitat conditions upstream of the Plan Area as a result of covered activities • **Water Temperatures:** Covered activities will be implemented in such a way as to not result in an increase in water temperature upstream of the Plan Area.

Objective SRCS3.1 Rationale: See rationale for Objective WRCS3.1 for general rationale for this objective.

Objective SRCS3.2 Rationale: See rationale for Objective WRCS3.2 for general rationale for this objective.

3.3.7.5 Chinook Salmon, Central Valley Fall- and Late Fall–Run Evolutionarily Significant Unit

The Central Valley fall-run and late fall–run Chinook salmon (*Oncorhynchus tshawytscha*) ESU includes all naturally spawned populations of fall-run and late fall–run Chinook salmon in the Sacramento and San Joaquin River Basins and their tributaries east of Carquinez Strait, California (64 FR 50394).

The abundance of Central Valley fall-run/late fall–run Chinook salmon escapement before 1952 is poorly documented. Reynolds et al. (1993) estimated that production of fall-run/late fall–run Chinook salmon on the San Joaquin River historically approached 300,000 adults and probably averaged approximately 150,000 adults.

Long-term trends in adult fall-run Chinook salmon escapement indicate that abundance in the Sacramento River has been consistently higher than abundance in the San Joaquin River (Figure 3.3-5). Escapement on the Sacramento River has been characterized by relatively high interannual variability ranging from approximately 100,000 to over 800,000 fish. Sacramento River escapement showed a marked increase in abundance between 1990 and 2003 followed by a decline in abundance between 2004 and the present. In 2009, adult fall-run Chinook salmon returns to the Central Valley rivers showed a substantial decline in both the Sacramento and San Joaquin River systems. Similar declines in adult escapement were observed for coho salmon and Chinook salmon returning to other river systems in California (MacFarlane et al. 2008), suggesting that worsening ocean conditions contributed to widespread population declines in all salmon runs.

Important threats and stressors to fall-run/late fall–run Chinook salmon are summarized below. Refer to Appendix 2.A, *Covered Species Accounts,* for a full discussion of these stressors.

- **Reduced staging and spawning habitat.** Access to the upper extent of the historical upstream spawning habitat for fall-run/late fall–run Chinook has been eliminated or degraded by human-made structures (e.g., dams and weirs) associated with water storage and conveyance, flood control, and diversions and exports for municipal, industrial, agricultural, and hydropower purposes (Yoshiyama et al. 1998). Because spawning locations of fall-run/late fall–run Chinook salmon are typically in the lower reaches of rivers, fall-run/late fall–run Chinook salmon have been less affected by dam construction relative to other Central Valley salmonids.
- **Reduced rearing and outmigration habitat.** Many of the Sacramento and San Joaquin River corridors and much the Delta have been leveed, channelized, and modified with riprap for flood protection, thereby reducing and degrading the quality and availability of natural habitat for rearing and emigrating juvenile Chinook salmon (Brandes and McLain 2001). Juvenile outmigration delays associated with human-made passage impediments can reduce fitness and increase susceptibility to diversion screen impingement, entrainment, disease, and predation.
- **Predation by nonnative species.** Predation on juvenile salmon by nonnative fishes has been identified as an important threat to fall-run/late fall–run Chinook salmon in areas with high densities of nonnative fishes (e.g., small- and largemouth bass, striped bass, and catfish) that prey on outmigrating juvenile salmon (Lindley and Mohr 2003). Nonnative aquatic vegetation, such as *Egeria* and water hyacinth, provides suitable habitat for nonnative predators (Nobriga et al. 2005; Brown and Michniuk 2007).
- **Harvest.** Commercial and recreational harvest of fall-run/late fall–run Chinook salmon in the ocean and inland fisheries, as well as illegal poaching, result in incidental harvest of wild-origin Chinook salmon, which are less able to withstand high harvest rates than hatchery-origin stocks. Harvest as a result of the commercial and recreational fisheries may be having detrimental effects on wild spawners in this mixed-stock fishery (Pyper et al. 2012; California Hatchery Scientific Review Group 2012).
- **Reduced genetic diversity and integrity.** Artificial propagation programs (hatchery production) for fall-run/late fall–run Chinook salmon in the Central Valley present multiple threats to wild-origin Chinook salmon populations, including genetic introgression by hatchery-origin fish that

spawn naturally and interbreed with local wild-origin populations (U.S. Fish and Wildlife Service 2001; Bureau of Reclamation 2004; Goodman 2005). The potential for interbreeding between Central Valley spring- and fall-run salmon stocks may also be a genetic concern (Yoshiyama et al. 1998); however, some studies indicate no evidence of natural hybridization among Chinook salmon runs despite the spatial and temporal overlap (Banks et al. 2000).

- **Entrainment.** Losses to entrainment mortality at diversions and intakes affect Chinook salmon populations (Kjelson and Brandes 1989). Juvenile fall-run Chinook salmon tend to be distributed in the central and south Delta where they have an increased risk of entrainment or salvage between January and April. Juvenile late fall–run Chinook salmon tend to be distributed within the Delta primarily between December and January and again between April and May. The effect of changing hydrodynamics in Delta channels, such as reversed flows in OMR resulting from SWP/CVP export operations, has the potential to increase attraction of emigrating juveniles into false migration pathways and delay emigration through the Delta. Changing Delta hydrodynamics in this way can also directly or indirectly increase risk of predation, the duration of exposure to seasonally elevated water temperatures and other water quality impairments, and vulnerability to entrainment at unscreened diversions. SWP/CVP exports have been shown to affect tidal hydrodynamics (e.g., water current velocities and direction). In addition to SWP/CVP exports, over 2,500 nonproject diversions exist throughout the Plan Area, some with the potential to entrain or impinge fish.
- **Exposure to toxins.** Toxic chemicals occurring in the Delta include mercury, selenium, copper, pyrethroids, and endocrine disruptors. These contaminants have the potential to affect fish health and condition and adversely affect salmon distribution and abundance. Sublethal concentrations of contaminants may interact with other stressors to cause adverse effects on salmonids, such as increasing their vulnerability to mortality as a result of exposure to seasonally elevated water temperatures, predation, or disease (Werner 2007).
- **Increased water temperature.** Higher water temperatures can lead to physiological stress, reduced growth rate, delayed passage, *in vivo* egg mortality in spawning females, prespawning mortality, reduced spawning success, and increased mortality of salmon (Myrick and Cech 2001). Temperature can also indirectly influence disease incidence and predation (Waples et al. 2008). The effects of climate change patterns, in combination with changes in precipitation and seasonal hydrology in the future, have been identified as important factors that may adversely affect the health and long-term viability of Central Valley spring-run Chinook salmon (Crozier et al. 2008). The rate and magnitude of these potential future environmental changes, and their effect on habitat quality and availability for fall-run/late fall–run Chinook salmon, however, are subject to a high degree of uncertainty.

The conservation of Chinook salmon in the Plan Area under the BDCP will be achieved via restoration and improved flow management. Restoration benefits will be derived chiefly from tidal natural communities restoration, seasonally inundated floodplain restoration, channel margin enhancement, and riparian natural community restoration. These actions are expected to increase primary and secondary production, contributing to increased food resources for salmonids as well as increased habitat complexity. Improved flow management will be achieved primarily through conservation measures to relocate and operate the primary point of water diversion to the north Delta. This change is expected to reduce the spatial overlap of diversion intakes and Chinook salmon occurrence, thereby substantially reducing entrainment.

Increasing the availability of floodplain and channel margin habitat is anticipated to increase productivity within the Plan Area. More frequent access to floodplain habitat that is seasonally inundated for longer durations than under current conditions in anticipated to increase the amount and quality of accessible rearing habitat for juvenile fall-run/late fall–run Chinook salmon. An ancillary benefit is the routing of a portion of the juvenile Chinook salmon outmigrant population away from the interior Delta and through habitat that is favorable for growth and increased survival and abundance, such as the Yolo Bypass. These expected benefits are supported by a number of existing studies (e.g., Sommer, Nobriga, et al. 2001; Whitener and Kennedy 1999; Moyle et al. 2007).

Reducing passage delays at human-made barriers will reduce migratory delays and increase survival of adult salmonids during their upstream migration to spawning areas. Reducing migratory delays will contribute to an increase in survival of adult salmonids as they are exposed to less potential stress, stranding, and illegal harvest.

The conservation strategy for fall-run/late fall–run Chinook salmon will focus on those life stages occurring in the Plan Area and ensured the timing of conservation efforts to benefit those life stages coincides with when they would be present in the Plan Area. The conservation strategy also focuses on habitat conditions upstream of the Plan Area, such as water temperature that could be affected by covered activities implemented within the Plan Area. The conservation strategy is explicit that covered activities be implemented so as to not result in degradation of current habitat conditions for fall-run/late fall-run Chinook salmon upstream of the Plan Area (see Objective FRCS3.1, below). Juvenile Chinook salmon foraging and rearing habitat has been compromised by floodplain modifications, contributing to reductions in the abundance and distribution of Chinook salmon. Therefore, the conservation strategy will include restoration of tidal natural communities to increase rearing habitat in the Suisun Marsh, Cache Slough, West Delta, and South Delta ROAs. The strategy also includes reducing the relative percentage of juvenile outmigrants that are entrained at the SWP/CVP south Delta facilities and reducing the predation levels in the Plan Area. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.5.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for fall-run/late fall–run Chinook salmon are the same as those presented for winter-run Chinook salmon, and the associated benefits are similar. See Section 3.3.7.3.1, *Applicable Landscape-Scale Goals and Objectives*.

3.3.7.5.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for fall-run/late fall–run Chinook salmon are the same as those presented for winter-run Chinook salmon, and the associated benefits are similar. See Section 3.3.7.3.2, *Applicable Natural Community Goals and Objectives*. Benefits specific to fall-run/late fall–run Chinook salmon are described below.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Benefits: Benefits of this objective for fall-run/late fall–run Chinook salmon are similar to those described for winter-run Chinook salmon, with the exception of the timing. Most fall-run/late fall–run Chinook salmon fry rear in fresh water from December through June, with emigration as smolts occurring from April through June. Smolts that arrive in the estuary after rearing upstream migrate relatively quickly through the Delta and Suisun and San Pablo Bays. A very small percentage (generally less than 5%) of fall-run juveniles spend over a year in fresh water and emigrate as yearling smolts the following November through April. Late fall–run fry rear in fresh water from April through the following April and emigrate as smolts from November through April. The timing of migration varies somewhat due to changes in river flows, dam operations, seasonal water temperatures, and hydrologic conditions (water-year type).

3.3.7.5.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for fall-run/late fall–run Chinook salmon within the reserve system. The goals and objectives below are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global recovery goals and objectives are provided here for broader context of fall-run/late fall–run Chinook salmon recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Increase fall-run/late fall–run Chinook salmon abundance.
    - **Global Objective 1.1:** Increase the life-history and genetic diversity within the ESU.
    - **Global Objective 1.2:** Reduce in-river and in-Delta loss of juvenile Chinook salmon.
    - **Global Objective 1.3:** Improve the quality and extent of freshwater rearing habitat.
    - **Global Objective 1.4:** Improve juvenile outmigration success.
- **Global Goal 2:** Increase spatial distribution of fall-run/late fall–run Chinook salmon.
    - **Global Objective 2.1:** Increase the life-history and genetic diversity within the ESU.
    - **Global Objective 2.2:** Promote the utilization and escapement of fall-run/late fall–run Chinook salmon in smaller, lesser known tributaries.
    - **Global Objective 2.3:** Improve the quality and extent of freshwater rearing habitat.
    - **Global Objective 2.4:** Reduce cyclical fluctuations in population abundance from non-ocean driven events.
    - **Global Objective 2.5:** Stabilize and reverse dramatic population declines of the San Joaquin River watershed.

The biological goals and objectives presented below have been developed to provide for the conservation and management of fall-run/late fall–run Chinook salmon in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

Goal FRCS1: Increased fall-run/late fall–run Chinook salmon abundance.
• **Objective FRCS1.1:** For fall-run Chinook salmon originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 27% by year 19 (from an estimated 5%), 29% by year 28, and 31% by year 40, measured between Mossdale and Chipps Island. For fall-run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 42% by year 19 (from an estimated 40%), 44% by year 28, and 46% by year 40, measured between Knights Landing and Chipps Island. For late fall–run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 49% by year 19 (from an estimated 40%), 51% by year 28, and 53% by year 40, measured between Knights Landing and Chipps Island. These survival metrics are interim values, based on limited data from fall-run Chinook salmon in the San Joaquin and Sacramento Rivers, and will be revised to account for new monitoring data and improved modeling expected by year 10.[41] • **Objective FRCS1.2:** Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating fall-run/late fall–run Chinook salmon juveniles by year 15. • **Objective FRCS1.3:** Reduce illegal harvest of adult fall-run/late fall–run Chinook salmon in the Plan Area by year 5.

Assumed stressors: Entrainment, predation, spatial structure, lack of rearing habitat, illegal take, and altered migration flow.
Stressor reduction targets:
• **Survival rates at north Delta intakes.** Maintain survival rates through the reach containing new north Delta intakes (0.25-mile upstream of the upstream-most intake to 0.25-mile downstream of the downstream-most intake) to 95% or more of the existing survival rate in this reach. The reduction in survival of up to 5% below the existing survival rate will be cumulative across all screens.[42]
• Survival rates at south Delta export facilities—three levels of stressor reduction.
  ○ Reduce the fraction of juvenile fall-run/late fall–run Chinook salmon that migrate into the south Delta through use of nonphysical barriers and migration through the Yolo Bypass.
  ○ Limit salvage loss to levels (as a percentage of the estimated abundance of wild-origin juvenile fall-run/late fall–run Chinook salmon) at or below the baseline condition in all water-year types or as necessary to contribute to Goal FRCS1 and supporting objectives. The salvage loss targets used will be determined and revised as needed to account for increases in the population, to provide consistency with best available science, and to ensure the numeric salvage loss target is consistent with and contributing to achieving Goal FRCS1.
  ○ Improve salvage efficiency of entrained fish through predation reduction in south Delta salvage operations, reduced mortality in Clifton Court Forebay, and improved return to the Delta (incorporate predation target below).
• **Predation.** Reduce predation in Clifton Court Forebay and at the CVP trash-racks to achieve a reduction in mortality rates across Clifton Court Forebay and past CVP trash-racks to no more than 40%, as reflected in the NMFS (2009) BiOp, by year 5. Reduction in predation mortality may be achieved through a variety of actions, including, but not limited to, modification to Clifton Court Forebay operations, modifications to physical habitat conditions within Clifton Court Forebay, and removal of predatory fish from Clifton Court Forebay and the CVP intake.[43]

[41] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

[42] Monitoring will be required to define the current survival rate through this reach and discern whether any reduction in survival is attributed to the intakes.

[43] The metric and means of achieving the metric presented within this objective are consistent with the RPA Action Suite IV.4 in the NMFS (2009) BiOp. While the fall-run and late fall–run Chinook salmon ESU is not listed, the RPA was determined to be protective of essential fish habitat and commercially valuable the CV fall-run and late fall–run

- **Spatial structure.** Increase the heterogeneity of habitat along key migration corridors to provide a greater extent of cover, holding areas, and rearing habitat for juvenile salmonids by year 15. Improved habitat conditions are expected to increase fish growth and survival. In the case of the Yolo Bypass, a proportion of the population would be diverted away from potential predation in the Sacramento River and entry into the low-survival interior Delta, thereby contributing to Objective FRCS1.1.
- **Lack of rearing habitat in the north Delta.** Provide access to at least 7,000 acres of floodplain habitat within the Yolo Bypass and Cache Slough ROA that is inundated for at least 30 days in at least 70% of years[44]. The extent, duration, and frequency of inundation will occur by year 15.
- **Lack of rearing habitat in the south Delta.** Provide access to at least 1,000 acres of inundated floodplain habitat, primarily within the South Delta ROA. On average, 50 acres of floodplain will be inundated a minimum of every other year, 500 acres will be inundated a minimum of every 5 years, and all 1,000 acres will be inundated a minimum of once every 10 years. Floodplains will be inundated for a minimum of 1 week between December and June. The extent, duration, and frequency of inundation will occur by year 15.
- **Illegal harvest.** Increase enforcement efforts to reduce illegal take of adult fall-run Chinook salmon in the Plan Area by year 5.
- **Migration flows.** Ensure that north Delta intake operations do not increase the incidence of reverse flows in the Sacramento River at the Georgiana Slough junction.

Objective FRCS1.1 Rationale: See Objective WRCS1.1 rationale above for a general discussion of the framework for developing the metrics presented within this objective and the rationale for the objective.

Juvenile fall-run Chinook salmon migrate downstream into the lower Sacramento River in the vicinity of the Yolo Bypass typically beginning in January and continuing through June, with the peak outmigration occurring from February through May. Juvenile late fall–run Chinook salmon migrate downstream into the lower Sacramento River in the vicinity of the Yolo Bypass, typically emigrating as smolts from November through February; however, juvenile late fall–run Chinook salmon may occur in the Sacramento River in the vicinity of Yolo Bypass most of the year, at various sizes. This difference in timing and sizes of the juvenile life stages of these two races of the ESU makes defining objectives and associated metrics for the ESU difficult.

Through-Delta survival for fall-run Chinook salmon originating in the San Joaquin River tributaries has declined in recent years based on results of VAMP testing, with current through-Delta survival at approximately 5%, based on the most recent years (2008 to 2010) of VAMP studies. It has been hypothesized that predation on juvenile salmon in the lower San Joaquin River and Delta by species such as largemouth bass and striped bass has increased in recent years. The hypothesis is supported by observations of increased catch-per-unit effort of warm water, nonnative, predatory fish in electrofishing surveys conducted since the early 1980s by CDFW and University of California, Davis. The hypothesis is also supported by results of acoustic-tag studies in recent years showing high rates of juvenile fall-run Chinook salmon mortality and predation at a variety of locations, including the

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Chinook salmon ESU. Upon BDCP permit authorization, the Implementation Office will coordinate with the agencies as necessary and work toward shifting responsibility from the under the NMFS (2009) BiOp to the BDCP. More work will be needed to determine whether/how this metric will be measured and achieved based on current work being implemented under the BiOp, as well as how to capture and account for predation reduction throughout the Plan Area from *CM15 Localized Reduction of Predatory Fishes*.

[44] This metric (i.e., 30 days in at least 70% of years) is subject to change based upon ongoing analysis of the duration and frequency of inundation likely to be achieved, particularly when juvenile fall-run and late fall–run Chinook salmon are likely to be present.

scour hole located immediately downstream of the confluence of the lower San Joaquin River and Head of Old River.

Although *CM15 Localized Reductions of Predatory Fishes* is intended to reduce predation on juvenile salmon at specific locations (e.g., Clifton Court Forebay), large-scale regional changes in the risk of predation in the lower San Joaquin River and Delta may significantly affect juvenile survival and the ability of the BDCP to achieve the survival objective outlined in Objective FRCS1.1. Changes in fishing regulations have been proposed, but not approved, as a complementary action that would result in regional changes in recreational angler harvest and assist the BDCP in achieving Objective FRCS1.1 as a method of contributing to increased survival of juvenile Chinook salmon and other covered fish. If regional increases in predation mortality are documented through acoustic-tag and other studies in the future, the relative allocation of responsibility assigned to the BDCP in meeting Objective FRCS1.1 may need to be adjusted through adaptive management.

Recent coded-wire-tag and -tag survival studies of hatchery-origin fall-run and late fall–run Chinook salmon were used as a starting point for estimating through-Delta survival for wild-origin Sacramento River fall-run Chinook salmon. As a result of differences in fish size and the seasonal timing of juvenile migration, there are substantial differences between wild- and hatchery-origin juvenile fall-run and late fall–run Chinook salmon that may affect their survival rates. Therefore, the level of uncertainty in using results of currently available acoustic-tag studies to establish both existing conditions and metrics within the objectives for wild-origin fall-run and late fall–run Chinook salmon is relatively high and will be the subject of additional experimental survival studies, monitoring, and analyses during the interim period. The through-Delta survival metrics presented here are considered interim, because they are based upon current data, which are limited, but are considered the best available science at this time.

Objective FRCS1.2 Rationale: See rationale for Objective WRCS1.2 for general rationale for this objective.

As mentioned above, juvenile fall-run Chinook salmon downstream migration timing occurs from January through June, with peak migration occurring from February through May. Based on model results presented in the effect analysis, inundation of the Yolo Bypass is expected to occur relatively infrequently during the primary fall-run Chinook salmon emigration period, resulting in a relatively low proportion of emigrating smolts entering the Yolo Bypass. However, creating an alternative migratory pathway through the Yolo Bypass in >70% of years for emigrating juvenile fall-run Chinook salmon is expected to be achievable based upon the general timing of outmigrating juveniles (January through June, with the peak occurring February through May) and the timing of Yolo Bypass inundation (generally December to mid-April). The overtopping of the Fremont Weir and inundation of the Yolo Bypass will not cover the entire duration of the emigration period, but it will cover the majority of this period and most of the peak migration. While it is expected that modifications to the Fremont Weir will provide conditions conducive to Sacramento River flow to enter and inundate the Yolo Bypass in >70% of years, this is still being modeled, and thus the frequency, duration, and extent of inundation and the seasonal timing with respect to migrating juvenile fall-run and late fall–run Chinook salmon, as well as other runs of Chinook salmon (i.e., winter-run and spring-run) may change. Therefore, while it is currently anticipated that a viable migratory pathway through the Yolo Bypass will be achievable in >70% of years, the specific metric is not certain.

The emigration period for juvenile late fall–run Chinook salmon occurs from November through February after rearing for a period of 1 year in fresh water. Based on modeling results presented in the effects analysis, increases in inundation of the Yolo Bypass associated with modifications of the Fremont Weir had relatively small effects on the percentage of late fall–run Chinook salmon entering the Yolo Bypass because peak emigration of smolts occurs in the fall before the period of peak winter flows in the Sacramento River. However, creating an alternative migratory pathway through the Yolo Bypass in >70% of years for emigrating juvenile late fall–run Chinook salmon is expected to be achievable based upon the general timing of outmigrating juveniles (November through February) and the timing of Yolo Bypass inundation (mid-November to May). While the overtopping of the Fremont Weir and inundation of the Yolo Bypass will not cover the entire duration of the emigration period for the late fall–run Chinook salmon, it is expected to cover most of the emigration period, particularly the peak.

Increasing the frequency, duration, and extent of inundation of the Yolo Bypass will contribute to an increase in the extent and quality of suitable rearing habitat and food resources available to those juvenile late fall–run Chinook salmon that do access the Yolo Bypass, which is expected to contribute to an increase in survival for those fish. The overall increase may be relatively small, but will be a contribution toward achieving the goal of increased abundance of fall-run/late fall–run Chinook salmon.

Objective FRCS1.3 Rationale: See rationale for Objective WRCS1.3 for general rationale for this objective.

In general, the BDCP will address several factors affecting adult survival within the Plan Area, including illegal harvest. The BDCP's contribution toward addressing illegal harvest is anticipated to improve survival through the Plan Area. Reducing illegal harvest is expected to contribute to increased abundance of covered adult salmonids that may successfully spawn. The scale of the illegal harvest issue within the Plan Area is unknown, but illegal harvest is known to occur, and contributing to a decrease in this problem under the BDCP is anticipated to increase escapement of spawning adults.

Goal FRCS2: Substantial reduction in passage delays (to contribute to increased migration and spawning success and thus abundance) at human-made impediments for adult fall-run/late fall–run Chinook salmon migrating through the Delta.
• **Objective FRCS2.1:** Limit adult fall-run/late fall–run Chinook salmon passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton DWSC) to fewer than 36 hours by year 15.
Assumed Stressors: Adult fish passage barriers. Stressor Reduction Targets: • **Adult Passage:** Limit passage delays at human-made barriers and impediments in the Delta to fewer than 36 hours, by year 15.

Objective FRCS2.1 Rationale: See rationale for Objective WRCS2.1 for general rationale for this objective.

Reducing passage delays in the Yolo Bypass will increase connectivity between the Yolo Bypass and the Sacramento River and provide timely passage for actively migrating adult salmonids past the Fremont Weir. Reducing passage delays will substantially reduce the risk of stress, which can contribute to weakness, sickness, reproductive success, and mortality in individuals. Reducing passage delays will also contribute to a reduction in the risk of adult salmon, as well as other fishes, being harvested illegally in areas where adult migration is impeded. Providing greater connectivity between the Yolo Bypass and the Sacramento River will increase the number of adult salmonids that will successfully navigate past the Fremont Weir and may successfully spawn.

Evaluations of the impacts that improvements to the Fremont Weir have on increasing inundation of the Yolo Bypass and reducing passage delays at the Fremont Weir have shown positive and negative effects. Resulting improvements in migration may vary by water-year type as a result of differing inundation frequencies and volumes. The DRERIP (2009) evaluation of improved passage at Fremont Weir suggested that the benefits of increased passage outweigh the potential risks (e.g., increased stranding as a result of increased attraction in the bypass).

Goal FRCS3: No degradation of aquatic habitat conditions for fall-run/late fall–run Chinook salmon upstream of water facilities.

- **Objective FRCS3.1:** Implement covered activities so as to not result in a degradation of current habitat conditions for fall-run/late fall–run Chinook salmon (e.g., spawning sites, rearing sites, migration corridors) upstream of the Plan Area.
- **Objective FRCS3.2:** Operate water facilities to support a wide range of life-history strategies for fall-run/late fall–run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., Real-time operation of water facilities will have an implementation window covering at least 95% of life stages present in the Plan Area.).

Assumed Stressors: Habitat conditions, water temperatures

Stressor Reduction Targets:

- **Habitat:** Avoid degradation of fish habitat conditions upstream of the Plan Area as a result of covered activities.
- **Water Temperatures:** Covered activities will be implemented in such a way as to not result in an increase in water temperature upstream of the Plan Area.

Objective FRCS3.1 Rationale: See rationale for Objective WRCS3.1 for general rationale for this objective.

The primary constituent elements of salmonid designated critical habitat include sites for rearing, spawning, and migration, all of which occur upstream of the Plan Area (rearing sites and migration corridors also occur within the Plan Area). Implementing covered activities in a way that will not degrade the condition of rearing sites, spawning sites, or migration corridors upstream of the Plan Area will ensure that the BDCP is not degrading conditions upstream of the Plan Area. This will ensure that the effort BDCP contributes toward improving conditions and increasing the abundance of juvenile and adult salmonids within the Plan Area is also contributing toward maintaining, and not degrading, conditions upstream of the Plan Area.

Objective FRCS3.2 Rationale: See rationale for Objective WRCS3.2 for general rationale for this objective.

Implementing covered activities in a way that will support a wide range of life-history strategies (i.e., early migrants as well as later migrants) without favoring any one particular life-history strategy will ensure that the BDCP contributes to a diversity of conditions that supports greater genetic diversity. The greater diversity of life-history strategies is expected to contribute to a more resilient population capable of adapting to fluctuations in conditions (i.e., timing of peak outflow, shifts in the period of floodplain inundation, shifts in the timing of optimum spawning and rearing conditions) that may occur from year to year.

3.3.7.6 Steelhead, Central Valley Distinct Population Segment

Within the Plan Area, habitat for steelhead (*Oncorhynchus mykiss*) consists of freshwater spawning, rearing, and migration habitat, as well as estuarine migration and rearing habitat.

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, egg incubation, and larval development. Spawning habitat for Central Valley steelhead distinct population segment (DPS) primarily occurs in mid- to upper-elevation reaches or immediately downstream of dams located throughout the Central Valley, areas which contain suitable environmental conditions (e.g., seasonal water temperatures, substrate, DO) for spawning and egg incubation. Spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of steelhead.

Freshwater steelhead rearing sites are those with suitable instream flows, water quality (e.g., water temperatures) and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; provide forage species; and include cover such as shade, submerged and overhanging large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Spawning areas and migratory corridors may also function as rearing habitat for juveniles, which feed and grow before and during their outmigration. Rearing habitat quality is strongly affected by habitat complexity, food supply, and the presence of predators. Some of these more complex and productive habitats with floodplain connectivity are still present in the Central Valley (e.g., the lower Cosumnes River and Sacramento River reaches with setback levees, primarily upstream of Colusa). The channelized, leveed, and riprapped river reaches and sloughs common in the lower Sacramento and San Joaquin Rivers and throughout the Delta, however, typically have low habitat complexity, low abundance of food organisms, and offer little protection from predation by other fishes and birds.

Historically, Central Valley steelhead were widely distributed throughout the Sacramento and San Joaquin Rivers (Busby et al. 1996; McEwan 2001). Steelhead inhabited waterways from the upper Sacramento and Pit River systems (now inaccessible due to Shasta and Keswick Dams) south to the Kings River and possibly the Kern River systems, and in both east- and westside Sacramento River tributaries (Yoshiyama et al. 1996). Lindley et al. (2006) estimated that at least 81 distinct Central Valley steelhead populations were distributed primarily throughout the eastside tributaries of the Sacramento and San Joaquin Rivers.

The geographic distribution of spawning and juvenile rearing habitat for Central Valley steelhead has been greatly reduced by the construction of dams (McEwan and Jackson 1996; McEwan 2001). Currently, impassable dams block access to 80% of historically available habitat (Lindley et al. 2006). Existing wild-origin steelhead stocks in the Central Valley inhabit the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks, and the Yuba River. Populations may exist in Big Chico and Butte Creeks, and a few wild-origin steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996).

Historical Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s, steelhead run size had declined to approximately 40,000 adults (McEwan 2001). Over the past 30 years, naturally spawned steelhead populations in the upper Sacramento River have declined substantially. Until recently, Central Valley steelhead were thought to be extirpated from the San Joaquin River system. However, recent monitoring has detected small, self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras Rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread throughout accessible streams and rivers in the Central

Valley (Good et al. 2005). Some of these fish, however, may have been resident rainbow trout, which are the same species but are not anadromous.

Important threats and stressors to steelhead are summarized below. Refer to Appendix 2.A, *Covered Species Accounts,* for a full discussion of these stressors.

- **Reduced staging and spawning habitat.** Adult steelhead historically migrated upstream into higher-gradient reaches of rivers and tributaries where water temperatures were cooler, turbidity was lower, and gravel substrate size was suitable for spawning and egg incubation (McEwan 2001). The majority of historical adult staging, holding, and spawning habitat for Central Valley steelhead is no longer accessible to upstream migrating steelhead or has been eliminated or degraded by human-made structures (e.g., dams and weirs) associated with water storage and conveyance, diversions, flood control, municipal, industrial, agricultural, and hydropower purposes (McEwan and Jackson 1996; McEwan 2001; Bureau of Reclamation 2004; Lindley et al. 2006; National Marine Fisheries Service 2007). Reduced flows from dams and upstream water diversions can lower attraction cues for adult spawners, causing straying and delays in spawning or the inability to spawn (California Department of Water Resources 2005). Adult steelhead migration delays can reduce fecundity and egg viability and increase susceptibility to disease and harvest.
- **Reduced rearing and outmigration habitat.** Juvenile steelhead prefer to use natural stream banks, floodplains, marshes, and shallow-water habitats for rearing during outmigration. Much of the Delta has been leveed, channelized, and fortified with riprap for flood protection, reducing and degrading the quality and availability of natural habitat for use by steelhead during migration (McEwan 2001). Furthermore, effects on the quality, quantity, and availability of suitable habitat are likely to reduce fitness and increase susceptibility to entrainment, disease, exposure to contaminants, and predation.
- **Predation by nonnative species.** In general, the effect of nonnative predation on the Central Valley steelhead DPS is unknown. However, nonnative predation is likely an important threat to Central Valley steelhead in areas with high densities of nonnative fishes (e.g., small- and largemouth bass, striped bass, and catfish), which are thought to prey on outmigrating juvenile steelhead. Nonnative aquatic vegetation, such as *Egeria* and water hyacinth, provide suitable habitat for nonnative predators (Brown and Michniuk 2007). The low spatial complexity of channelized waterways (e.g., riprap-lined levees that provide virtually no cover protection from predators) and general low habitat diversity elsewhere in the Delta reduce refuge cover and protection of steelhead from predators (Raleigh et al. 1984; Missildine et al. 2001; 70 FR 52488).
- **Harvest.** Steelhead has been, and continues to be, an important recreational fishery within inland rivers throughout the Central Valley. Although no commercial fisheries exist for steelhead, tribal and recreational steelhead fisheries exist inland. The effects of recreational fishing and the unknown level of illegal harvest on the abundance and population dynamics of wild-origin Central Valley steelhead have not been quantified. The effects of illegal harvest occurring in the Delta and tributary rivers are thought to be relatively minor for steelhead.
- **Reduced genetic diversity and integrity.** It is now recognized that Central Valley hatcheries are a significant and persistent threat to wild-origin steelhead populations and fisheries (National Marine Fisheries Service 2009a). One major concern with hatchery operations is the genetic introgression by hatchery-origin fish that spawn naturally and interbreed with local wild-origin populations (U.S. Fish and Wildlife Service 2001; Bureau of Reclamation 2004; Goodman 2005). Such introgression introduces maladaptive genetic changes to the wild-origin steelhead stocks (McEwan and Jackson 1996; Myers et al. 2004).

- **Entrainment.** Juvenile steelhead migrating downstream through the Delta are vulnerable to entrainment and salvage at the SWP/CVP export facilities, primarily between March and May. Multiple factors can influence the vulnerability of juvenile steelhead to entrainment by SWP/CVP export facilities. These factors include the geographic distribution of steelhead within the Delta and hydrodynamic factors, such as reverse flows in OMR (which are a function of export operations relative to San Joaquin River inflows), and southward flows of Sacramento River water toward pumps through an open Delta Cross Channel and Georgiana Slough. In addition to SWP/CVP export facilities, there are over 2,200 small water diversions within the Delta, the majority of which are unscreened (Herren and Kawasaki 2001). The risk of entrainment is a function of the size of juvenile fish and the slot opening of the screen mesh (Tomljanovich et al. 1978; Schneeberger and Jude 1981; Zeitoun et al. 1981; Weisberg et al. 1987). Although entrainment or salvage of steelhead at the SWP/CVP export facilities is well documented, it is unclear how many juvenile steelhead are entrained at other unscreened Delta diversions.

- **Exposure to toxins.** Toxic chemicals are widespread throughout the Delta and may be present at a more localized scale in response to episodic events (e.g., stormwater runoff, point-source discharges). These toxic substances include mercury, selenium, copper, pyrethroids, and endocrine disruptors with the potential to affect fish health and condition and negatively affect steelhead distribution and abundance directly or indirectly. Sublethal concentrations may interact with other stressors (e.g., seasonally elevated water temperatures, predation, or disease) to increase vulnerability of steelhead to mortality.

- **Increased water temperature.** Higher water temperatures can lead to physiological stress, reduced growth rate, reduced spawning success, and increased mortality of steelhead (Myrick and Cech 2001). Temperature can also indirectly influence disease incidence and predation (Waples et al. 2008). Exposure to seasonally elevated water temperatures may occur as a result of reductions in flow resulting from upstream reservoir operations, reductions in riparian vegetation, channel shading, local climate, and solar radiation.

The public draft recovery plan for Central Valley salmonids, including steelhead, was released by NMFS on October 19, 2009. Although not final, the overarching goal in the public draft is the removal of salmonids, including the Central Valley steelhead DPS, from the federal list of endangered and threatened wildlife (National Marine Fisheries Service 2009a). Several objectives and related criteria represent the components of the recovery goal, including the establishment of at least two viable populations within each historical diversity group.

The conservation strategy for steelhead will include restoration and improved flow management. Restoration benefits will be derived chiefly from tidal natural communities restoration, seasonally inundated floodplain restoration, channel margin enhancement, and riparian natural community restoration. These restoration actions are expected to increase primary and secondary production, contributing to increased food for salmonids as well as increased habitat complexity. Improved flow management will be achieved primarily through conservation measures to relocate and operate the primary point of water diversion to the north Delta. This change is expected to reduce the spatial overlap of diversion intakes and steelhead occurrence, thereby substantially reducing entrainment and predation.

Increasing the availability of floodplain and channel margin habitat is expected to increase productivity within the Plan Area. More frequent access to floodplain habitat that is seasonally inundated for longer durations than under current conditions is anticipated to increase the amount and quality of accessible rearing and foraging habitat for juvenile steelhead. An ancillary benefit is the routing of a portion of the outmigrating steelhead away from the interior Delta and through habitat that is favorable for growth. To put on critical weight before entering the ocean, juvenile steelhead feed on zooplankton, benthic macroinvertebrates, amphipods, chironomid larvae, terrestrial insect drift, and larval fish on Delta floodplains (Sommer, Harrell, et al. 2001; Moyle 2002; Moyle et al. 2004; Jeffres et al. 2008). However, juvenile steelhead are also actively migrating out of the system so they may not access inundated floodplain habitat to a great extent or to the extent juvenile Chinook salmon do. Thus the benefit for steelhead may not be as great as it is for juvenile Chinook salmon.

The conservation strategy for steelhead will focus on those life stages occurring in the Plan Area, and ensure that the timing of efforts to benefit those specific life stages coincides with their presence in the Plan Area. The conservation strategy also focuses on habitat conditions upstream of the Plan Area, such as water temperature that could be affected by covered activities implemented within the Plan Area. The conservation strategy is explicit that covered activities be implemented so as to not result in a reduction of the primary constituent elements of designated critical habitat for steelhead upstream of the Plan Area (see Objective STHD3.1, below). Steelhead are generally thought to move quickly through estuarine habitats due to their larger size at outmigration; however, young steelhead forage in tidal habitat and will benefit from the increase in production at the base of the foodweb. Emergent vegetation communities support invertebrate populations and provide refuge from water currents and predation. Juveniles forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs. (Healey 1982; Levy and Northcote 1981; Simenstad et al. 1982; Moyle 2002). Some studies have found when juvenile steelhead rear in estuarine marshes, there is a benefit to size at ocean entry and survival (Bond 2006). Therefore, the conservation strategy will include reducing the relative percentage of outmigrants that are entrained at the SWP/CVP south Delta facilities and increasing the spatial distribution of steelhead habitat, such as floodplain and channel margin, within the Plan Area. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.6.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for steelhead are the same as those presented for winter-run Chinook salmon, and the benefits are similar. See Section 3.3.7.3.1, *Applicable Landscape-Scale Goals and Objectives*.

3.3.7.6.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for steelhead are the same as those presented for winter-run Chinook salmon, and the benefits are similar. See Section 3.3.7.3.2, *Applicable Natural Community Goals and Objectives*. Benefits specific to steelhead are described below.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Benefits: Benefits of this objective for steelhead are similar to those described above for winter-run Chinook salmon, with the exception of timing. Most juvenile steelhead generally spend 1 (29%) or 2 (70%) years rearing in their natal streams, with a small percentage (1%) spending 3 years before becoming smolts and migrating out of the Sacramento–San Joaquin River system (Hallock et al. 1961). Smolts that arrive in the estuary after rearing upstream migrate relatively quickly through the Delta and Suisun and San Pablo Bays. The timing of migration varies somewhat due to changes in river flows, dam operations, seasonal water temperatures, and hydrologic conditions (water-year type).

3.3.7.6.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for steelhead within the reserve system. The goals and objectives below are intended to represent specific, quantificable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global recovery goals and objectives are provided here for broader context of steelhead recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Increase Central Valley steelhead abundance.
    - **Global Objective 1.1:** Attainment of the Central Valley steelhead global abundance goal will occur with achievement of 6-year geometric mean escapement levels of: [45]
        - 11, 000 naturally produced adult steelhead in the Sacramento River and its tributaries, with no year below 5,000 fish, and
        - 1,700 in the San Joaquin River and its tributaries, with no year below 800.
- **Global Goal 2:** Increase spatial distribution of Central Valley steelhead.
    - **Global Objective 2.1:** Attainment of the Central Valley steelhead global spatial distribution goal will occur with restoration of eight self–sustaining, independent populations of naturally produced steelhead in watersheds of the Sacramento and San Joaquin River drainages, broken down by region.
        - One viable population in the Northwestern California Region (Clear Creek to Stony Creek).
        - Two viable populations in Basalt and Porous Lava Region (Little Sacramento River to Battle Creek).
        - Five viable populations in Northern Sierra Region (Antelope Creek to Mokelumne River).
        - Two self-sustaining, independent populations in watersheds of the San Joaquin River drainage (roughly the Southern Sierra Region).
- **Global Goal 3:** Protect and increase life-history and genetic diversity of Central Valley steelhead.
    - **Global Objective 3.1:** Attainment of the Central Valley steelhead global life-history diversity goal will occur with restoration of eight self-sustaining independent populations of naturally produced steelhead in the Sacramento River drainage, broken down by region.

[45] These numbers do not include hatchery-produced steelhead.

- One viable population in the Northwestern California Region (Clear Creek to Stony Creek).
- Two viable populations in Basalt and Porous Lava Region (Little Sacramento River to Battle Creek).
- Five viable populations in Northern Sierra Region (Antelope Creek to Mokelumne River).
- Two self-sustaining, independent populations in watersheds of the San Joaquin River drainage (roughly the Southern Sierra Region).

The biological goals and objectives presented below have been developed to provide for the conservation and management of for steelhead in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

Goal STHD1: Increased steelhead abundance.

- **Objective STHD1.1:** For steelhead originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 44% by year 19 (from an estimated 10%), 47% by year 28, and 51% by year 40, measured between Mossdale and Chipps Island. For steelhead originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 54% by year 19 (from an estimated 45%), 56% by year 28, and 59% by year 40, measured between Knights Landing and Chipps Island. These survival metrics are interim values based on limited data from fall-run Chinook salmon in the San Joaquin and Sacramento Rivers. These survival metrics will be revised to account for new monitoring data and improved modeling expected by year 10.[46]
- **Objective STHD1.2:** Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating steelhead juveniles by year 15.
- **Objective STHD1.3:** Reduce illegal harvest of adult steelhead in the Plan Area by year 5.

Assumed stressors: Entrainment, predation, spatial structure, lack of rearing habitat, illegal take, and altered migration flows.

Stressor reduction targets:

- **Survival rates at north Delta intakes.** Maintain survival rates through the reach containing new north Delta intakes (0.25-mile upstream of the upstream-most intake to 0.25-mile downstream of the downstream-most intake) to 95% or more of the existing survival rate in this reach. The reduction in survival of up to 5% below the existing survival rate will be cumulative across all screens.[47]
- Survival rates at south Delta export facilities—three levels of stressor reduction.
  - Reduce the fraction of juvenile steelhead that migrate into the south Delta through use of nonphysical barriers and migration through the Yolo Bypass.
  - Limit salvage loss to levels (as a percentage of the estimated abundance of juvenile steelhead) at or below the baseline condition in all water-type years or as necessary to contribute to Goal STHD1 and supporting objectives. The salvage loss targets used will be determined and revised as needed to account for increases in the population, to provide consistency with best available science, and to ensure the numeric salvage loss target is consistent with and contributing to achieving Goal STHD1.
  - Improve salvage efficiency of entrained fish through predation reduction in south Delta salvage facilities and elsewhere in the Delta, reduced mortality in Clifton Court Forebay, and improved return to the Delta.[48]

[46] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

[47] Monitoring will be required to define the current survival rate through this reach and to discern whether any reduction in survival is attributed to the intakes.

[48] The metrics presented here are considered interim and may be revised as new data and information warrant to ensure the metric for the salvage loss target is contributing toward achieving the overall BDCP Goal STHD1.

- **Predation.** Reduce predation in Clifton Court Forebay and at the CVP trash-racks to achieve mortality rates across Clifton Court Forebay and past CVP trash-racks to no more than 40%, as reflected in the NMFS Reasonable and Prudent Alternative in the NMFS (2009) BiOp by year 5. Reduction in predation mortality may be achieved through a variety of actions, including, but not limited to, modification to Clifton Court Forebay operations, modifications to physical habitat conditions within Clifton Court Forebay, as well as removal of predatory fishes from Clifton Court Forebay and the CVP intake.[49]
- **Spatial structure.** Increase the heterogeneity of habitat along key migration corridors to provide a greater extent of cover and holding areas, and rearing habitat for juvenile steelhead by year 15. Improved habitat conditions are expected to increase fish growth and survival. In the case of the Yolo Bypass and Cache Slough ROA, a proportion of the population would be diverted away from potential predation in the Sacramento River and entry into the low-survival interior Delta, thereby contributing to Objective STHD1.1.
- **Lack of rearing habitat in the north Delta.** Provide access to at least 7,000 acres of floodplain habitat within the Yolo Bypass and Cache Slough ROA that is inundated for at least 30 days in more than 70% of years[50]. The extent, duration, and frequency of inundation will occur by year 15.
- **Lack of rearing habitat in the south Delta.** Provide access to at least 1,000 acres of inundated floodplain habitat, primarily within the south Delta. On average, 50 acres of floodplain will be inundated a minimum of every other year, 500 acres will be inundated a minimum of every 5 years, and all 1,000 acres will be inundated a minimum of once every 10 years. Floodplains will be inundated for a minimum of 1 week between December and June. The extent, duration, and frequency of inundation will occur by year 15.
- **Illegal harvest.** Increase enforcement efforts to reduce illegal take of adult steelhead in the Plan Area by year 15.
- **Migration flows.** Ensure that north Delta intake operations do not increase the incidence of reverse flows in the Sacramento River at the Georgiana Slough junction.

Objective STHD1.1 Rationale: See Objective WRCS1.1 above for general discussion of the framework for developing the metrics presented within the objective and the rationale for this objective.

Juvenile steelhead migrate downstream into the lower Sacramento River and Delta in the vicinity of the Yolo Bypass typically beginning in November and continuing through May, with the peak outmigration occurring from February into May. Juvenile outmigration timing is similar in the San Joaquin River, with emigration occurring from January through June, with peak emigration occurring from March into May.

Current through-Delta survival for steelhead originating in the San Joaquin River was set by NMFS at 10%, based on extrapolation of survival results for juvenile fall-run Chinook salmon in the most recent years (2008 through 2010) of VAMP Studies. As a result of differences in fish size and the seasonal timing of juvenile migration, there are substantial differences between juvenile fall-run and steelhead migrating downstream in the San Joaquin River that may affect their survival rates. Therefore, the level of uncertainty in using results of VAMP studies currently available to establish both existing

[49] The metric and means of achieving the metric presented within this objective are consistent with the RPA Action Suite IV.4 in the NMFS (2009) BiOp. Upon BDCP permit authorization, the Implementation Office will coordinate with the agencies as necessary and work toward shifting responsibility from the under the NMFS (2009) BiOp to BDCP. More work will be needed to determine whether/how this metric will be measured and achieved based on current work being implemented under the NMFS (2009) BiOp, as well as how to capture and account for predation reduction throughout the Plan Area from *CM15 Localized Reduction of Predatory Fishes*.

[50] This metric (i.e., 30 days in at least 70% of years) is subject to change based upon ongoing analysis of the duration and frequency of inundation likely to be achieved, particularly when juvenile steelhead are likely to be present.

conditions and objectives for steelhead is relatively high and will be the subject of additional experimental survival studies and analyses during the interim period. Additional information on survival of juvenile steelhead migrating from the San Joaquin River is currently being collected as part of the Bureau of Reclamation 6-year survival studies and the Stipulation Study that occurred in 2012.

Survival estimates for steelhead originating in Battle Creek were set at 45% by NMFS; Battle Creek steelhead were used as representative of the Sacramento River steelhead as a whole, because, according to NMFS, they are most likely to be used to monitor survival (Appendix 3.G, *Proposed Interim Delta Salmonid Survival Objectives*). The through-Delta survival metrics presented here are considered interim, based upon current data, which is limited and not necessarily applicable, but is considered the best available science at this time. These objectives are not intended to compensate for poor survival, which may occur at other life stages outside the Plan Area or as a result of factors not controlled by the BDCP. The survival metrics will be revised as needed to account for new information and incorporate the best available science, as appropriate.

Objective STHD1.2 Rationale: See rationale for Objective WRCS1.2 for general rationale for this objective.

As mentioned above, steelhead smolts downstream migration timing is generally from November through May, with the peak outmigration occurring from February into May. Creating an alternative migratory pathway through the Yolo Bypass in >70% of years for emigrating steelhead smolts is expected to be achievable based upon the general timing of outmigrating juveniles (November through May) and the timing of Yolo Bypass inundation (mid-November to May). While it is expected that modifications to the Fremont Weir will provide conditions conducive to Sacramento River flow to enter and inundate the Yolo Bypass in >70% of years, this is still being modeled and thus the frequency, duration, and extent of inundation and the seasonal timing with respect to migrating juvenile steelhead, as well as other runs of Chinook salmon (i.e., winter-run, spring-run, and fall-run/late fall–run), may change. Thus, while it is currently anticipated that a viable migratory pathway through the Yolo Bypass will be achievable in >70% of years, the specific metric is not certain. However, an increase in the frequency, duration, and extent of inundation of the Yolo Bypass will be achieved and will contribute to an increase in the extent and quality of suitable rearing habitat and food resources available to steelhead smolts, which is expected to contribute to an increase in survival.

However, the extent to which steelhead smolts may benefit from inundation of the Yolo Bypass floodplain is uncertain. It is expected that a relatively small fraction of the emigrating steelhead smolts will spend significant time on the inundated bypass foraging and feeding. The majority of steelhead smolts are expected to migrate through the Plan Area relatively quickly and enter the ocean.

Objective SRCS1.3 Rationale: See rationale for Objective WRCS1.3 above. In general, the BDCP will address several factors affecting adult survival within the Plan Area, including illegal harvest. The BDCP's contribution toward addressing illegal harvest is anticipated to improve survival through the Plan Area and contribute to increased abundance of covered adult salmonids by decreasing the number of potential spawners taken illegally by recreational anglers and poaching rings. The scale of the illegal harvest issue within the Plan Area is unknown, but illegal harvest is known to occur, and contributing to decrease in this problem under the BDCP is anticipated to increase escapement of spawning adults.

Goal STHD2: Substantial reduction in passage delays (to contribute to increased migration and spawning success and thus abundance) at human-made impediments for adult steelhead migrating through the Delta.
• **Objective STHD2.1:** Limit adult steelhead passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton DWSC) to fewer than 36 hours by year 15.
Assumed Stressor: Adult fish passage barriers. **Stressor Reduction Target:** • **Fish Passage.** Limit passage delays at human-made barriers and impediments in the Delta to fewer than 36 hours by year 15.

Objective STHD2.1 Rationale: See rationale for Objective WRCS2.1. Evaluations of the impacts of improvements to the Fremont Weir to increase inundation of the Yolo Bypass and reduce passage delays at the Fremont Weir have shown positive and negative effects. Positive outcomes from improving passage at the Fremont Weir would far outweigh the potential increase in numbers of fish stranding at the weirs because the magnitude of the positive outcome to the population was greater (high) than the magnitude of the negative outcome (low) (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*).

Goal STHD3: No degradation of aquatic habitat conditions for steelhead upstream of the water facilities.
• **Objective STHD3.1:** Implement covered activities so as to not result in a reduction to the primary constituent elements of designated critical habitat for steelhead upstream of the Plan Area. • **Objective STHD3.2:** Operate water facilities to support a wide range of life-history strategies for steelhead without favoring any one life-history strategy or trait over another (e.g., real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area).
Assumed Stressors: Habitat conditions, water temperatures Stressor Reduction Targets: • **Habitat:** Avoid degradation of fish habitat conditions upstream of the Plan Area as a result of covered activities. • **Water Temperatures:** Covered activities will be implemented in such a way as to not result in an increase in water temperature upstream of the Plan Area, within the Study Area.

Objective STHD3.1 Rationale: See Objective WRCS1.1 above for detailed discussion. The primary constituent elements of salmonid designated critical habitat include sites for rearing, spawning, and migration, all of which occur upstream of the Plan Area (rearing sites and migration corridors also occur within the Plan Area). Implementing covered activities in a way that will not degrade the condition of rearing sites, spawning sites, or migration corridors upstream of the Plan Area will ensure that the BDCP is not degrading conditions upstream of the Plan Area.

Objective STHD3.2 Rationale: See rationale for Objective WRCS3.2 for general rationale for this objective.

Implementing covered activities in a way that will support a wide range of life-history strategies (i.e., early migrants as well as later migrants) without favoring any one particular life-history strategy, will ensure that the BDCP contributes to a diversity of conditions that supports a broad range of life-history strategies, with greater genetic diversity. The greater diversity of life-history strategies is expected to contribute to a more resilient population capable of adapting to fluctuations in conditions (e.g., timing of peak outflow, shifts in the period of floodplain inundation, shifts in the timing of optimum spawning and rearing conditions) that may occur from year to year.

3.3.7.7 Sacramento Splittail

Sacramento splittail (*Pogonichthys macrolepidotus*) spawn in shallow water (fewer than 2 meters deep) over flooded vegetated habitat in the Yolo and Sutter Bypasses and along the Cosumnes and San Joaquin Rivers. In lower flow years, when these floodplains have limited inundation, spawning also occurs in the Sacramento and San Joaquin Rivers upstream of the bypasses (Feyrer et al. 2005). Relatively warm temperatures and an abundance of food allow rapid growth and development. Maintaining and increasing this seasonally inundated floodplain habitat suitable for splittail spawning and juvenile rearing has been identified as a factor that will help maintain successful reproduction and increase juvenile abundance and genetic diversity during prolonged drought events (Sommer et al. 2002).

Juvenile and subadult splittail can inhabit regions of the estuary characterized by salinities of 10 to 18 ppt, while adult splittail can survive salinities up to 29 ppt; however, most individuals occupy habitats with salinities less than 10 ppt (Kimmerer 2004). Splittail also inhabit a broad range of temperature and DO levels, making them well suited to slow-moving sections of sloughs and rivers. Channel margin and backwater habitats can be critical to the survival of splittail, providing refugia from predatory fishes and feeding sites as fish grow in upstream regions before and during downstream migration (Feyrer et al. 2005). Channel margins also provide potential spawning habitat for Sacramento splittail and may gain additional importance in drier years when floodplain habitat is not available; however, these low-flow-year spawning habitats occur upstream of the Plan Area.

While accurate abundance estimates of the splittail population are not available, data from various sampling efforts indicate that splittail abundance for age-0 fish varies widely between years and water-year types, primarily in response to freshwater flow variation (Kimmerer 2002b), that is widely thought to mechanistically represent spawning success on the Central Valley's major floodplains (Sommer et al. 1997; Moyle et al. 2004; Feyrer et al. 2006a, 2006b). Generally, the data indicated that in years with substantial amounts of floodplain inundation (wet years) the abundance of age-0 fish is typically high, but low in dry years (Kratville 2008). In contrast, the abundance of adult fish (age-2+) is much less variable from year to year, implying strongly density-dependent population dynamics. While the results of FMWT surveys indicate a marked decline in overall splittail abundance and consistently low population levels since 2002 (Kimmerer et al. 2009) (Figure 3.3-6), this represents data from only one sampling program and may not accurately reflect the status of the population, because the FMWT is an inefficient sampling program for this principally nearshore species. Splittail do achieve high reproductive success in years with significant floodplain inundation (Sommer et al. 1997, 2007).

Important threats and stressors to Sacramento splittail include water exports, habitat-changing structures, reduced habitat for all life stages, reduced food, exposure to toxins (particularly selenium), predation, and harvest. Refer to Appendix 2.A, *Covered Species Accounts*, for a full discussion of these stressors.

Although Sacramento splittail is not listed under the ESA or CESA, it is included in the USFWS (1996) Delta Native Fish Recovery Plan, which also includes the delta smelt, green sturgeon, Sacramento perch, and three races of Chinook salmon (U.S. Fish and Wildlife Service 1996). An updated recovery plan from USFWS currently under development will likewise include a plan for splittail. Splittail is also covered under the *San Joaquin County MSHCP* and *Solano HCP*.

The conservation strategy for Sacramento splittail includes minimizing entrainment, increasing available tidal mudflat, floodplain, and low-velocity, shallow side-channel habitat to create spawning and rearing habitat; increasing available food resources; providing important linkages between current and future upstream restored habitat; and improving the inundation regime in Plan Area floodplains. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.7.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for Sacramento splittail are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.
- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.
- **Objective L1.8:** To accommodate sea level rise, provide potential tidal marsh plain within the anticipated future eastward position of the low-salinity zone of the estuary.

Objective L1.3, L1.4, and L1.8 Benefits: Achievement of these objectives is expected to create a mosaic of natural communities with a broad range of environmental gradients in areas where splittal occur. Small-scale floodplain wetland studies suggest that young splittail are associated with shallow areas (<1 meter depth), but that juvenile distribution varies on a diel basis (Sommer et al. 2002). Young splittail may become entirely benthic at night, so the inundation of large areas of shallow-water habitat, which creates more benthic resting areas, may help support high splittail production (Sommer et al. 2007). Growth rates, especially in the first year or two of life, may be strongly dependent on availability of high-quality food, as suggested by changes in growth rate following the invasion of *Potamocorbula* into the marsh in the 1980s (Kratville 2008). Creating a reserve system with a mosaic of natural communities and a variety of environmental gradients is expected to support an increase in primary productivity, which may benefit splittail.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.2:** Allow lateral river channel migration. • **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers. • **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system. • **Objective L2.5:** Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity. • **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species. • **Objective L2.8:** Provide refuge habitat for migrating and resident covered fish species. • **Objective L2.9:** Increase the abundance and productivity of plankton and invertebrate species that provide diversity of food for covered fish species in the Delta waterways. • **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain.

Objective L2.2 Benefits: Achieving this objective is expected to contribute to improving habitat conditions for Sacramento splittail. Floodplains are important habitat for splittail, and increasing their connectivity as well as the frequency and extent of their inundation can increase the potential for lateral channel migration while also potentially increasing the extent of spawning habitat and spawning success. Inundation and lateral channel migration also provide sediment inputs, thereby increasing turbidity, which may be important to Sacramento splittail for predator avoidance, and spawning (Kratville 2008). Splittail populations show a remarkable recruitment response to periods of extended floodplain inundation (Moyle et al. 2004). Mature, ripe splittail have been found in association with high turbidity, temperatures below 15°C, and flooded terrestrial vegetation (Moyle et al. 2004).

Objective L2.3 Benefits: Achieving this objective is expected to increase the extent of floodplain habitat that may provide suitable spawning and rearing habitat for splittail. Construction of levees along Delta waterways has degraded or eliminated large areas of seasonally inundated floodplains that once served as spawning and larval rearing habitat for splittail. Connecting rivers to their floodplains as part of the conservation strategy is expected to increase the extent of floodplain habitat critical to spawning success and improved rearing conditions.

Objective L2.4 Benefits: Achieving this objective is intended to reduce the amount of pollution in stormwater runoff entering Delta waterways, thereby improving water quality conditions to contribute to increasing food for Sacramento splittail. Reducing the amount of pollution in stormwater runoff entering Delta waterways may benefit Sacramento splittail by improving larval survival and increasing survival of chironomids and other invertebrates, an important food source for splittail on the floodplain (Kratville 2008). A reduction in stormwater pollution is anticipated to benefit larvae and eggs primarily.

Objective L2.5 Benefits: Achieving this objective is intended to provide suitable splittail spawning and rearing conditions within the Plan Area. Splittail spawn and rear on inundated floodplains and flooded channel margins. Increasing the extent of these types of habitat is expected to increase the extent of suitable spawning and rearing habitat for splittail as well as increase important food resources. Lack of spawning and rearing habitat and reduced food availability have been identified as stressors to splittail.

Objective L2.7 Benefits: Achieving this objective is intended to support sinuous, high-density, dendritic networks through tidal areas to promote effective exchange throughout the marsh plain to provide rearing habitat for splittail.

Objective L2.8 Benefits: Achieving this objective is intended to enhance floodplain connectivity and inundation, which provides appropriate refuge from predators and migration corridors for Sacramento splittail. Splittail are dependent on inundated floodplains for spawning success and adequate connectivity to perennial channels to prevent stranding of eggs, larvae, and juveniles (Kratville 2008). In addition to local access to the floodplain, both adult and juvenile splittail need adequate natural edge habitats in the channels between rearing and spawning areas (Kratville 2008). Shallow-water channel margins (i.e., <1 meter deep) provide refugia from predators and access to food for growth and survival (Feyrer et al. 2005). Age-0 Sacramento splittail production is substantially reduced in low-flow years as a result of limited availability of spawning and early rearing habitat (Moyle et al. 2004).

Objective L2.9 Benefits: Benefits of this objective for larval Sacramento splittail may be similar to those described above for delta smelt. After the larval period, the diet of splittail diverges notably from delta smelt's pelagic zooplankton diet. See Section 3.3.7.1.1, *Applicable Landscape-Scale Goals and Objectives*.

Objective L2.11 Benefits: Achieving this objective is expected to improve spawning opportunities for splittail in the Plan Area, contributing to higher average recruitment. See Section 3.3.7.1.1, *Applicable Landscape-Scale Goals and Objectives*.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.

- **Objective L3.2:** Promote connectivity between low-salinity zone habitats and upstream freshwater habitats and availability of spawning habitats for native pelagic fish species.
- **Objective L3.4:** Provide flows that support the movement of adult life stages of native fish species to natal spawning habitats.

Objective L3.2 Benefits: Achieving this objective is intended to increase connectivity between upstream freshwater spawning habitat anticipated to benefit Sacramento splittail and tidal marsh restoration in and near locations of the low-salinity zone, which juvenile and adult splittail use as rearing habitat. Overall, juvenile and adult Sacramento splittail have a high tolerance for a wide variety of water quality parameters, including salinity, temperature, and DO. They also exhibit a dynamic life-history regime, allowing the use of various spawning and rearing habitats, depending on annual variations in flow (Daniels and Moyle 1983; Kratville 2008).

Objective L3.4 Benefits: Achieving this objective is intended to provide increased flexibility for water operations using dual conveyance. Such flexibility may allow the BDCP to provide flow conditions that can provide appropriate cues and adult access to preferred spawning habitats upstream of the water diversions.

Goal L4: Increased habitat suitability for covered fish species in the Plan Area.
• **Objective L4.1:** Manage the distribution and abundance of nonnative predators in the Delta to reduce predation on covered fishes. • **Objective L4.3:** Reduce entrainment losses of covered fish species.

Objective L4.1 Benefits: Achieving this objective is intended to reduce predation on splittail in the Plan Area. Juvenile splittail may benefit from proposed predator removal in the reach where the north Delta intakes will be located in the Sacramento River as well as in areas where IAV is treated or mechanically removed.

Objective L4.3 Benefits: Achieving this objective is intended to reduce the entrainment of covered fish species, including Sacramento splittail. While small water diversions are not likely to cause substantial entrainment, the SWP/CVP export facilities have relatively high rates of salvage when splittail populations are at high levels. Entrainment reduction helps to minimize incidental take of splittail, although it is not thought to greatly influence splittail recruitment (Sommer et al. 1997). YOY have critical swimming velocities that are below or near the water velocities of the large pumps and are entrained at these facilities (Young and Cech 1996). Overall, the BDCP is expected to substantially reduce exports from the south Delta facilities in most months relative to existing biological conditions. Entrainment is expected to be reduced most in wetter years because a greater percentage of flow will be diverted from the north Delta in wet years than in dry years (Appendix 5.B, *Entrainment*). This may enable a larger contribution to total recruitment from the San Joaquin River in wet years. However, this potential gain will need to be evaluated against potential impingement at the proposed north Delta intakes.

3.3.7.7.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for Sacramento splittail are stated below.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Benefits: Achieving this objective is intended to increase the extent of suitable rearing habitat and food available to Sacramento splittail. Larval splittail feed extensively on zooplankton, while larger fish feed primarily on detritus, chironomid larvae, calanoid, and harpactocoid copepods (Kurth and Nobriga 2001; Moyle et al. 2004; Kratville 2008).

Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.
• **Objective TPANC2.1:** Control invasive aquatic vegetation that adversely affects native fish habitat.

Objective TPANC2.1 Benefits: Achieving this objective is anticipated to address the IAV that has contributed to declining turbidity in the Delta (Jassby et al. 2002). It is hypothesized that one of the primary causes of the decreased turbidity in the Delta is biological filtration by IAV (Brown and Michniuk 2007). For example, Santos et al. (2010) noted that stands of *Egeria* reduce turbidity, thus increasing available light through the water column. Controlling IAV is anticipated to help increase turbidity. Mature, ripe splittail have been found in association with high turbidity, temperature below

15°C, and flooded terrestrial vegetation (Moyle et al. 2004 in Kratville 2008). Juveniles are most abundant in shallow (<2 meters), turbid water with a current, and are often found in small narrow sloughs lined with tules and other emergent plants (Moyle et al. 2004 in Kratville 2008). Controlling IAV may contribute to an increase in turbidity, if IAV can be controlled in sufficient quantities.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them. • **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objectives TBEWNC1.1 through TBEWNC1.4 Benefits: Achieving these objectives is expected to increase the extent of suitable habitat for splittail as well as increase primary productivity within these habitats. Nonreproductive splittail are abundant in moderately shallow (<4 meters) brackish and freshwater tidal sloughs and shoals such as found in Suisun Marsh and the margins of the lower Sacramento River (Feyrer et al. 2005; Moyle et al. 2004 in Kratville 2008). Within the Plan Area, most late-stage juveniles and adult splittail inhabitat tidal fresh and brackish water in the Delta, Suisun Bay, and Suisun Marsh (Moyle et al. 2004 in Kratville 2008). The loss of highly productive brackish-water habitat has been identified by USFWS (1999) as a threat to splittail (Sommer et al. 2007). Moyle et al. (2004) also identified food availability as a stressor and noted that growth rates, especially in the first year or two of life, may be strongly dependent on availability of high-quality food, as suggested by changes in growth rates following the invasion of *Potamocorbula* into the marsh in the 1980s. Providing large expanses of interconnected patches of tidal brackish emergent wetland natural community is expected to increase the extent of suitable habitat for juvenile and adult splittail and provide high-quality food within those habitats.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7. • **Objective TFEWNC1.2:** Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.

Objectives TFEWNC1.1 and TFEWNC1.2 Benefits: Achieving these objectives is expected to contribute to an increase in suitable splittail habitat and high-quality food. As mentioned previously for Objectives L1.3, L1.4 and L1.8, small-scale floodplain wetland studies suggest that young splittail are associated with shallow areas (<1 meter depth), but that juvenile distribution varies on a diet basis (Sommer et al. 2002). Young splittail may become entirely benthic at night, so the inundation of large areas of shallow-water habitat, which creates more benthic resting areas, may help support high splittail production (Sommer et al. 2007). Growth rates, especially in the first year or two of life, may be strongly dependent on availability of high-quality food, as suggested by changes in growth rate following the invasion of *Potamocorbula* into the marsh in the 1980s (Kratville 2008). Restoration of large, interconnected patches of tidal freshwater emergent wetland natural communities is anticipated to increase primary productivity, which may contribute to an increase in suitable food for splittail.

3.3.7.7.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for Sacramento splittail within the reserve system. The goals and objectives below are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global recovery goals and objectives are provided here for broader context of Sacramento splittail recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Manage the estuary to improve foodweb productivity for splittail.
    - **Global Objective 1.1:** Enhance the pelagic foodweb to increase mysid numbers and increase foraging opportunities.
- **Global Goal 2:** Restore habitat linkages both to new marshes and along migratory pathways into and within the Sacramento, San Joaquin, Mokelumne, Cosumnes, Napa, and Petaluma Rivers. Improve riparian natural community and river-to-floodplain access to enhance splittail survival and reproduction, and enhance the current broad spawning and rearing distribution.
    - **Global Objective 2.1**: Identify and ameliorate reaches of poor habitat quality along spawning migration and juvenile emigration pathways.

The biological goal and objective presented below have been developed to increase the abundance of Sacramento splittail in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

Goal SAST1: Increased abundance of Sacramento splittail in the Plan Area.
• **Objective SAST1.1:** Maintain 5-year running average of age-0 splittail index of abundance in the Plan Area of 150% of baseline conditions by providing increased access to suitable spawning and rearing habitat in the Plan Area by year 15.

Assumed Stressors: Limited flood recurrence intervals on major Central Valley floodplains, particularly Yolo Bypass, that serve as spawning and rearing habitat.

Stressor Reduction Targets:

- **Spawning Habitat.** Increase the connectivity and availability of floodplain habitat that meets the following criteria beginning in year 15 and continuing through the permit term.
  - Ensure floodplain inundation occurs in the Yolo Bypass at least once every 5 years between March 1 and May 15.
  - Provide access to at least 1,000 acres of new inundated floodplain habitat, primarily within the south Delta. On average, 50 acres will be inundated a minimum of every other year, 500 acres will be inundated a minimum of every 5 years, and all 1,000 acres will be inundated a minimum of once every 10 years. Floodplains will be inundated for a minimum of 1 week between December and June. The extent, duration, and frequency of inundation will occur during years 15 through 50.
  - Provide continuous area of floodplain habitat in Yolo Bypass of at least 7,000 acres annually between November 10 and March 23.
  - Ensure floodplain inundation persists in the Yolo Bypass for at least 30 days (Sommer pers. comm.)
  - Ensure areas of floodplain habitat include water depths less than 2 meters (Moyle et al. 2004; Sommer et al. 2008).
  - Establish channel margins with floodplain benches and areas of native riparian and emergent vegetation with large woody debris (habitat complexity).
- **Rearing Habitat.** Restore habitat with the following criteria beginning in year 15 and continuing through the permit term.
  - Manage flood recession in the Yolo Bypass of the inundated floodplain to minimize fish stranding (e.g., flow regulation, altered topography to ensure volitional fish movement and access to escape channels).

Objective SAST1.1 Rationale: Achieving this objective will contribute to an increase in splittail abundance through the protection and enhancement of spawning and rearing habitat in the Plan Area. Sacramento splittail typically spawn in inundated floodplain and riparian areas within submerged terrestrial vegetation (Moyle 2002). Splittail juveniles rear extensively in channel margins over a wide range of water quality conditions, foraying into offshore habitats as they transition to adults. The abundance of YOY splittail is highly variable from one year to the next and positively correlated with hydrologic conditions within the rivers and Delta during the late winter and spring spawning period, and the extent and duration of floodplain inundation (Sommer et al. 1997; Feyrer et al. 2006a). Evidence from CDFW fishery surveys, salvage data from the south Delta export facilities, and USFWS beach seine data demonstrates that splittail spawn in all years, but spawning success, as reflected in juvenile abundance, is typically greatest in wet years (when floodplains are inundated extensively for a prolonged period) (Baxter 1999; Moyle et al. 2004). No sampling program is specifically intended to assess the population size of splittail, but the age-0 abundance index for splittail collected in the FMWT is positively correlated with high Delta inflows and associated outflows (Kimmerer 2002b). Both inflows and outflows are correlated with the amount of inundated floodplain within the Delta (Baxter et al. 1996; Sommer et al. 1997) and upstream (Moyle et al. 2004). The BDCP will increase the extent and duration of floodplain inundation, particularly in the Yolo Bypass.

The typical lifespan of splittail is about 5 years, but they may live up to 7 or more years. Based on the hydrologic record, a 5-year period is likely to include at least 1 year that results in strong splittail recruitment. Based on the 1906 to 2010 hydrologic record, any 5-year period has about a 77% chance of including at least one wet or above-normal year. Therefore, the odds are good that a 5-year average estimate of abundance would represent the parametric (i.e., true) mean of age-0 abundance with good precision. It will be especially important to include at least one wet or above-normal water-year type in evaluating the effects of the BDCP on splittail because age-0 recruitment is largely driven by production on inundated floodplains. Any 5-year period in the hydrologic record has a 90% chance of including a wet or above-normal water year.

The index of abundance referred to in Objective SAST1.1 is the USFWS beach seine annual index for age-0 splittail, which is based on the results of a regular sampling survey conducted by the USFWS since 1994 at about 40 stations in the Delta, including the lower Sacramento and San Joaquin Rivers (Contreras et al. 2011). The FMWT abundance index, which is used to monitor trends in abundance of a number Delta fish species, is less than ideal for monitoring splittail abundance, because trawling requires fishing in open, moderately deep water, and young splittail possess a strong affinity for shallow water (Feyrer et al. 2005; Contreras et al. 2011). Furthermore, as splittail's historical prey, mysids, have become less abundant, it is presumed that splittail of all ages are found less frequently in open water. The USFWS beach seine specifically targets Chinook salmon fry; other species, including splittail, are collected incidentally (Brown and May 2006).

Age-0 splittail numbers are expected to be most responsive to the habitat enhancements under *CM2 Yolo Bypass Fisheries Enhancement*. Results of Yolo Bypass inundation modeling (MIKE21) indicate that CM2 would result in a 121% to 139% increase (i.e., 221% to 239% of baseline) in the number of days per year that the Yolo Bypass is inundated February through June. The effect of such an increase in days of inundation on the abundance of age-0 splittail, as estimated by the beach seine index, was assessed by regressing the 1994 through 2008 annual splittail index on number of days of inundation. Splittail are considered to need at least 30 days of inundation to complete egg and larval development, so regressions were computed for the years with more than 30 days of inundation only, as well as for all years. Days of bypass inundation were estimated based on days of Fremont Weir overtopping, which underestimates actual inundation somewhat.

The results of the regression for years with greater than 30 days of Fremont Weir overtopping are more applicable than the results for all years for assessing the potential effect on splittail recruitment of *CM2 Yolo Bypass Fisheries Enhancement*, because the principal benefit to splittail is the expected increase in the frequency of years with greater than 30 days of weir overtopping. Therefore, the regression equation obtained from the analysis for greater than 30 days of overtopping was used to compute the estimated increases in the splittail seine index that may occur from the 121% to 139% modeled increase in days of inundation. The estimated increases in the seine index range from about 150% to 170% for increases in the days of inundation of 121% and 139%, respectively. Based on the results of the regression equation, a 50% increase in the total splittail seine index from baseline conditions (i.e., 150% of baseline conditions) was selected as a reasonable target for the objective.

In wet years, there is usually sufficient floodplain habitat in the Yolo Bypass to support spawning and early rearing of splittail. Because splittail typically live 5 years, as long as wet years occur at no less than 5- to 7-year intervals, the splittail population will likely continue to thrive. In dry years, when inundated floodplain habitat in the Yolo Bypass and elsewhere is scarce, shallow, vegetated channel margins that are not armored by riprap provide some spawning and nursery habitat for splittail (Moyle et al. 2004; Feyrer et al. 2005). Increasing the availability of inundated floodplain and vegetated channel margin habitats, particularly in dry years, is expected to support greater spawning and rearing success.

Although the Yolo Bypass floods in nearly 70% of all years (Sommer et al. 2008), the acreage flooded and the number of consecutive days the floodplain is inundated are critical for high production of splittail (Sommer et al. 1997; Feyrer et al. 2006a). Sacramento splittail will also benefit directly from increased food web production and better rearing habitat elements in restored wetlands within Cache

Slough ROA, as well as from similar food web production and rearing habitat elements in highly used areas such as Suisun Bay and Suisun Marsh, where it will support splittail rearing.

Growth is highly important for splittail survival, especially the larvae and young juveniles, because, as is true for most fish species, the smallest splittail are the most vulnerable to predation and other mortality factors. The increased growth rates improve the chances of juveniles attaining the size at which emigration from floodplain habitats normally occurs (30 to 40 millimeters) before the floodwaters recede (Feyrer et al. 2006a). However, measuring the growth rate of larval and juvenile splittail would be difficult and/or results would be difficult to interpret. Therefore, while improved growth is identified as a goal, it is not recommended as a specific, measurable objective. Based on the species conceptual model, achieving the objective of increasing the quantity and quality of spawning and rearing habitat is expected to contribute to achieving the overall goal of enhanced survival, reproduction, and distribution of splittail.

Anticipated benefits of floodplain restoration and enhancements of wetland habitat elements are based on the premise that these restored areas will improve the aquatic foodweb. Splittail will occupy these shallow marsh channels, giving them direct access to food produced within restored wetlands; splittail are omnivorous, so they may capitalize on both detrital and invertebrate resources. Extensive research on the Yolo Bypass and lower Cosumnes River, in addition to some research in the Sutter Bypass, indicates that Sacramento splittail exhibit enhanced growth and fitness when they have access to floodplain habitats (Swenson et al. 2003; Moyle and Grosholz 2003; Sommer et al. 2001b, 2004; Crain et al. 2004; Ribeiro et al. 2004; Feyrer et al. 2004).

Increasing the extent of suitable spawning and rearing habitat, through creation, restoration, enhancement, and protection of tidal wetland, seasonally inundated floodplain, and channel margin is anticipated to contribute to an increase in splittail abundance in the Plan Area. A degree of uncertainty is associated with the anticipated benefits; monitoring and adaptive management are necessary as part of the conservation strategy to ensure that splittail are using these habitats and that the habitats are functioning in a way that benefits these fish (e.g., duration of inundation is sufficient for incubation and some inundation occurs during dry years).

3.3.7.8 Green Sturgeon, Southern Distinct Population Segment

North American green sturgeon (*Acipenser medirostris*) spawning areas are currently limited to accessible reaches of the Sacramento River upstream of Hamilton City and downstream of Keswick Dam. Preferred spawning habitats are thought to contain large cobble in deep and cool pools with turbulent water (California Department of Fish and Game 2002; Moyle 2002; Adams et al. 2002). After hatching, green sturgeon larvae rear for 1 to 2 months in the Sacramento River, between Keswick Dam and Hamilton City. Green sturgeon larvae are present in the lower Sacramento and north Delta regions between May and October but primarily in June and July (California Department of Fish and Game 2002). Juvenile green sturgeon migrate into seawater portions of natal estuaries as early as 1.5 years of age (Allen and Cech 2007 in Israel and Klimley 2008) and eventually emigrate to nearshore coastal waters by 3 years of age. In the ocean, they primarily move northward and commingle with other sturgeon populations, spending much of their lives in the ocean or in Oregon and Washington estuaries (California Department of Fish and Game 2002; Kelly et al. 2007). Green sturgeon are long-lived (up to 60 to 70 years), sexually mature at about 15 years of age (Van Eenennaam et al. 2006), and may subsequently spawn every 3 to 5 years (Kelly et al. 2009; National Marine Fisheries Service 2010). Juvenile, subadult and adult green sturgeon spend a relatively short period of time within the Plan Area. However, the juvenile rearing period is important to their overall life history.

North American green sturgeon populations have declined throughout much of the species' range over the last century (Cech et al. 2000). The estimated abundance within the Bay-Delta estuary has ranged between 175 and 8,000 adults between 1954 and 2001, with an annual average of 1,509 adults. In the Sacramento River, the green sturgeon population has declined over the last two decades, with fewer than 50 spawning green sturgeon sighted annually in the best spawning habitat (Corwin pers. comm.). In addition, the small San Joaquin River population has experienced heavy fishing pressure in the past, particularly from illegal fishing (U.S. Fish and Wildlife Service 1995), and no juveniles have been observed in the river in during recent years. When combined with the changes in habitat, including dam construction, the San Joaquin River population appears extirpated (Israel and Klimley 2008).

Important threats and stressors to green sturgeon are summarized below. Refer to Appendix 2.A, *Covered Species Accounts*, for a full discussion of these stressors.

- **Reduced spawning habitat.** Access to historical spawning habitat has been reduced by construction of migration barriers, such as Keswick Dam on the Sacramento River and Oroville Dam on the Feather River (Lindley et al. 2004; National Marine Fisheries Service 2005). In the Central Valley, approximately 5% of the total river length has suitable spawning habitat characteristics, although only 12% of this habitat is currently occupied by sturgeon. Of the 88% that is unoccupied, half of it (44%) is currently inaccessible due to dams (Neuman et al. 2007).
- **Exposure to toxins.** Exposure to toxins can lower reproductive success, decrease early life-stage survival, and cause abnormal development, even at low concentrations. Improved treatment and drainage management in recent years have reduced Iron Mountain Mine runoff toxicity, although negative effects of trace elements are suspected. Organic contaminants from agricultural returns and urban runoff and high concentrations of trace elements (boron, selenium, and molybdenum) can decrease early life-stage survival, causing abnormal development and high mortality in yolk-sac fry at concentrations of only a few parts per billion. Contaminants that adsorb to sediments, such as pyrethroids, selenium, and mercury are of particular concern. Although unquantified, the consumption of *Potamocorbula* and Asian clams, known to bioaccumulate selenium, could cause mortality of green sturgeon larvae. Sediment concentrations of methylmercury can also increase juvenile mortality.
- **Harvest.** As a long-lived, late-maturing fish with relatively low fecundity and periodic spawning, green sturgeon is particularly susceptible to threats from overfishing related to by-catch from ocean fisheries. Green sturgeon is also vulnerable to recreational sport fishers in the Bay-Delta estuary, Sacramento River, and San Pablo and Suisun Bays, particularly those targeting the more desirable white sturgeon. Poaching of sturgeon is known to occur in the Sacramento River, particularly in areas where sturgeon have been stranded (e.g., Fremont Weir).
- **Reduced rearing habitat.** Historical reclamation of wetlands and islands, as well as channelization and hardening of levees with riprap, have reduced and degraded the availability of suitable in- and off-channel rearing habitat for green sturgeon.
- **Increased water temperature.** High temperatures in the Sacramento River from February to June were historically a problem, reducing sturgeon spawning, egg incubation, and juvenile rearing success. Water temperatures have been reduced through improvements in water management in the upper Sacramento River and no longer appear to be an issue; however, high temperatures will continue to affect habitat quality for green sturgeon on the lower Feather River and the mainstem San Joaquin River. Juvenile sturgeon are also exposed to increased water temperatures in the Delta during the late spring and summer.

- **Nonnative species.** Green sturgeon have been affected both positively and negatively by nonnative species introductions in the Delta and Suisun Bay. *Potamocorbula* and Asian clams provide an important food source for sturgeon. However, the high methylmercury and selenium bioaccumulation rates of these clams raise concerns that sturgeon may also be concentrating this toxin in their tissues. Nonnative IAV may contribute to raising temperatures, reducing turbidity and DO levels (thereby enhancing habitat for predator species), and inhibiting access to shallow-water habitat by juvenile sturgeon.
- **Dredging.** Hydraulic dredging is a common practice in the Sacramento and San Joaquin Rivers, navigation channels within the Delta, and Suisun, San Pablo, and San Francisco Bays to allow commercial and recreational vessel traffic. Such dredging operations pose risks to bottom-oriented fish such as green sturgeon. Such risks include mortality, reduced benthic prey, and resuspended toxins.
- **Reduction in turbidity.** Reduced turbidity levels in the Delta may have had detrimental effects on green sturgeon, due to their increased susceptibility to predation.
- **Entrainment.** Although unquanitified, larval sturgeon are susceptible to entrainment from nonproject water diversion facilities as a result of their migratory behavior and habitat selection within the rivers and Bay-Delta estuary. In addition, the effectiveness of NMFS and CDFW screening criteria for salmonids is unknown for green and white sturgeon. Unscreened water diversions operated on the Feather River are also a possible threat to juvenile green sturgeon. The larger SWP/CVP export facilities are located where a low number of juvenile green sturgeon have been recorded.
- **Stranding.** Migrating adult green sturgeon that are attracted by high flows in the Yolo Bypass move onto the floodplain and eventually concentrate behind Fremont Weir, where they are blocked from further upstream migration. As waters in the Yolo Bypass recede, these sturgeon can become stranded behind the flashboards of the weir and can be subjected to illegal fishing.
- **Flow operations.** Historically, increased flows in the Sacramento, Feather, and San Joaquin Rivers caused by winter rainstorms and spring melting of the snowpack coincided with the upstream migration period of adult green sturgeon (March through July). These increased flows enabled green sturgeon to migrate into the upper portions of these rivers. Current flow management may inhibit the return of green sturgeon to the Sacramento River and Bay-Delta estuary by restricting seasonal flow that serves as cues for spawning and by misdirecting juveniles during their outmigration (Israel and Klimley 2008).

While NMFS has begun recovery planning efforts, a recovery plan has not yet been developed for this species. However, ongoing conservation efforts in the Plan Area are expected to provide some benefit to sturgeon. These include Anadromous Fish Restoration Program, Central Valley Project Improvement Act, and CALFED programs. The combination of increased law enforcement and new sportfishing regulations adopted over the past several years specifically to protect sturgeon and reduce their harvest is expected to further reduce illegal fishing practices as well as the effects of incidental harvest of green sturgeon by recreational anglers throughout the range of the species.

The conservation strategy for green sturgeon focuses on those life stages occurring within the Plan Area. The strategy includes increasing the extent and quality of rearing habitat; increasing the local production of food and availability of food by exporting organic material from the marsh plain and phytoplankton, zooplankton, and other organisms produced in tidal channels; minimizing entrainment; and improving upstream adult passage conditions. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.8.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for green sturgeon are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.
- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objective L1.3 Benefits: Achieving this objective is intended to restore or create tidally influenced natural communities that are very important for green sturgeon. The BDCP will restore 65,000 acres of tidal natural communities in the Delta, where historical reclamation of wetlands and islands and construction of riprap-hardened channel levees have reduced and degraded the availability of suitable in- and off-channel rearing habitat for green sturgeon (Sweeney et al. 2004).

Restoration of tidal natural communities is expected to produce food and export food, which is expected to benefit sturgeon by providing year-round suitable foraging/rearing habitat. Juvenile and sub-adult sturgeon have been observed in the lower Sacramento River and north Delta between May and October and in the Delta throughout the year and spend up to 3 years in freshwater and brackish habitats before migrating to the San Francisco Bay and the ocean (Allen et al. 2006a, 2006b). Providing a gradient of floodplain and tidally influenced natural communities is intended to provide a greater range of conditions suitable for food production during the sturgeon’ s extensive juvenile rearing stage. Refer to the rationale for Objective TPANC1.1 (Section 3.3.6.1.2, *Natural Community Goals and Objectives*) for further discussion of the benefits of tidal restoration for sturgeon.

Objective L1.4 Benefits: Achieving this objective is intended to increase the extent of environmental gradients and provide a greater range of habitat conditions, food resources, and habitat complexity available to green sturgeon during their juvenile rearing phase. A greater extent of habitats and prey resources available across a greater range of varied conditions of flow, water temperature, turbidity, and other habitat constituents is expected to benefit the species. Juveniles are fairly tolerant of variable temperature and DO conditions and are likely mobile enough to select favorable habitats if conditions change (Israel and Klimley 2008).

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.2:** Allow lateral river channel migration. • **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers. • **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system. • **Objective L2.5:** Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity. • **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species. • **Objective L2.9:** Increase the abundance and productivity of plankton and invertebrate species that provide food for covered fish species in the Delta waterways. • **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain. • **Objective L2.12:** Enhance 20 miles of channel margin in the Sacramento River and San Joaquin River systems to provide habitat along important migratory routes for anadromous fish and improve wildlife movement.

Objective L2.2 Benefits: Lateral channel migration is a natural fluvial process that creates a range of environmental gradients and potentially suitable habitat and channel conditions for green sturgeon. Once larvae grow into juveniles, their survival may be limited by lack of rearing habitat, insufficient food, and possibly contaminants. Restoring natural fluvial processes, which create suitable habitat and conditions, is expected to benefit the species.

Objective L2.3 Benefits: Achieving this objective is intended to support increased river-floodplain connectivity, which may improve hyporheic processes, such as groundwater recharge, and thus may improve water quality, provide cool water inputs, and maintain groundwater inputs to surface waters. Achieving this objective may also contribute to an increase in allochthonous inputs, such as terrestrial insects and plant matter, which provide nutrient sources. Added nutrient sources may increase the productivity of aquatic systems, thereby contributing to a more diverse and robust forage base.

Objective L2.4 Benefits: Achieving this objective is expected to reduce the amount of pollution in stormwater runoff entering Delta waterways, thus reducing pesticide and herbicide loading, which can be highly toxic to plankton that form the base of the foodweb. Reducing pollutant loads of pyrethroids and other chemicals from urban stormwater runoff may also reduce potential sublethal effects (e.g., effects on behavior, tissues and organs, reproduction, growth, and immune system). Water quality improvements may contribute to a more robust foodweb and thus may contribute to increasing food resources for green sturgeon.

Water releases from SWP/CVP facilities help to maintain water temperatures and flows on the Sacramento and Feather Rivers during the spring and summer, which benefits downstream sturgeon spawning, incubation, and rearing (Cech et al. 2000 in COSEWIC 2004; Mayfield and Cech 2004; Van Eenennaam et al. 2005; Allen et al. 2006b). However, elevated or fluctuating temperatures do not appear to have adverse effects on postlarval juveniles if food is abundant and DO levels are adequate (Israel and Klimley 2008).

Objective L2.5 Benefits: Achieving this objective is intended to provide a diversity of spawning, rearing, and migration conditions for green sturgeon, as well as other covered fish species. Data suggest that females spawn regardless of whether preferred physical conditions are present (Israel and Klimley 2008). Therefore, increasing the diversity of spawning conditions is expected to increase the diversity within the population. The estimated number of green sturgeon contributing to juvenile samples collected at Red Bluff Diversion Dam between 2002 and 2006 increased with greater flows at Bend Bridge (Israel 2007). This increased spawning success may be due to higher flows that increase turbulence in optimal spawning habitats, which may increase fertilization rates, or it may be due to more reproductive individuals reaching optimal spawning habitats, or altered migration opportunities and increased spawning habitat availability.

Objective L2.7 Benefits: Achieving this objective is intended to promote food production and transport, which may benefit juvenile green sturgeon rearing in the freshwater and low-salinity zones of the Plan Area, as they grow and develop critical osmoregulatory capacities that allow them to enter the ocean. Juvenile green sturgeon develop these capacities between their first and second year (Allen and Cech 2007). Therefore, restoring subtidal freshwater and brackish natural communities can provide important habitats for juvenile green sturgeon. These dendritic channels may also provide greater cover from predators for larval and juvenile green sturgeon (Israel and Klimley 2008).

Objective L2.9 Benefits: Achieving this objective is expected to provide increased food resources for prey species important to green sturgeon (e.g., crustaceans, annelids, mollusks, fish, and midges) and contribute toward increased survival. Foodweb conditions are discussed in greater detail below under Section 3.3.7.8.3, *Species-Specific Goals and Objectives*.

Objective L2.11 Benefits: It is unknown if floodplains were commonly used habitat by juvenile green sturgeon, though floodplains may have served as migration corridors for adults (Israel and Klimley 2008). However, achieving this objective is expected to benefit most life stages of green sturgeon by increasing primary and secondary productivity, which may increase the food available for juvenile and adult green sturgeon in those freshwater and low-salinity regions of the Delta supported by seasonal floodplain inundation.

Objective L2.12 Benefits: Achieving this objective is expected to benefit green sturgeon migration by enhancing and improving the availability and access to shallow-water foraging and predator avoidance habitat. The control of IAV and the restoration of native aquatic plant communities in treated areas are also expected to increase the quantity and quality of habitat suitable for some prey resources important to sturgeon.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.2:** Promote connectivity between low-salinity zone habitats and upstream freshwater habitats, and availability of spawning habitats for native pelagic fish species. • **Objective L3.3:** Provide flows that support the movement of juvenile life stages of native fish species to downstream rearing habitats. • **Objective L3.4:** Provide flows that support the movement of adult life stages of native fish species to natal spawning habitats.

Objectives L3.2 and L3.3 Benefits: Achieving these objectives is intended to provide flexibility in water operations management to allow flows that coincide with the movement of juvenile life stages of native fish. Juvenile sturgeon are able to tolerate brackish conditions downstream. Further, the BDCP will address water quality issues in the Plan Area, such as the low DO levels in the Stockton DWSC and urban stormwater runoff. The BDCP will include funding to the Port of Stockton to continue operation of the aeration facility in the Stockton DWSC, which is intended to directly improve the connectivity between areas downstream of Turner Cut and the San Joaquin River upstream of Stockton by minimizing the low DO condition that persists in this area. The BDCP will also provide funding to urban centers that discharge stormwater to the Plan Area to assist them in reducing their Delta inputs. Reducing the inputs of pollution from urban stormwater is intended to improve water quality and increase the health of the Delta.

Objective L3.4 Benefits: Achieving this objective is intended to provide increased flexibility for water operations of the north Delta diversions and provide flow conditions that coincide with the timing of adult green sturgeon migrations and thus minimize delays and improve spawning success and population recruitment. Reproductively mature green sturgeon migrate into rivers prepared to spawn. They are presumed to migrate directly to upper Sacramento River spawning areas, though they may aggregate temporarily in the upper Delta during the spring or summer to facilitate coordinated migration (Israel and Klimley 2008). Current flow management may inhibit the return of green sturgeon to the Sacramento River and Bay-Delta estuary by restricting the seasonal flow necessary to provide cues for spawning. Once adult green sturgeon have spawned, they appear to reside in rivers for up to 6 months until autumn or winter (Israel and Klimley 2008). Unimpeded connectivity between habitats and safe and timely passage are critical features of the Central Valley rivers' ability to increase spatial distribution of spawning and reduce opportunities for adult mortality.

Goal L4: Increased habitat suitability for covered fish species in the Plan Area.
• **Objective L4.2:** Manage the distribution of covered fish species to minimize movements into areas of high predation risk in the Delta. • **Objective L4.3:** Reduce entrainment losses of covered fish species.

Objective L4.2 Benefits: Achieving this objective is intended to provide alternative migration corridors (e.g., Yolo Bypass) and install features (e.g., weirs and nonphysical fish barriers) to encourage juvenile green sturgeon and other covered fish species to avoid areas that have a high risk for predation or reduced survival.

Objective L4.3 Benefits: Achieving this objective is intended to improve survival of larval and juvenile life stages. While screening criteria for delta smelt (0.1 foot per second) and juvenile salmon (0.33 foot per second) were protective to juvenile green sturgeon (longer than 30 millimeters) in experiments (Swanson et al. 2004), green sturgeon would continue to be vulnerable to impingement or entrainment at screened diversions when they are less than 30 millimeters in length. It is possible that juveniles can also be entrained in water diversions for farmland irrigation, although their benthic behavior may limit this effect.

3.3.7.8.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for green sturgeon are stated below.

Goal TPANC1: Tidal perennial aquatic natural community that supports habitat elements for covered and other native species and that supports improved productivity of covered species.
• **Objective TPANC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create tidal perennial aquatic natural community as necessary when creating tidal emergent wetland natural communities with an emphasis on shallow intertidal areas that provide habitat for covered and other native species.

Objective TPANC1.1 Benefits: Achieving this objective is anticipated to increase food available to juvenile green sturgeon and thus may increase survival. Channelization of the estuary has reduced the amount and quality of subtidal and intertidal habitat available for green sturgeon occupancy and foraging. These habitats have been lost along San Pablo and Suisun Bays, where subadult and adult green sturgeon are commonly found (Israel and Klimley 2008). Once juveniles have the capacity to live in saltwater, they are believed to spend 1 to 3 years in estuaries before making an initial ocean migration.

Goal TPANC2: Tidal perennial aquatic natural community that supports viable populations of native fish.
• **Objective TPANC2.1:** Control invasive aquatic vegetation that adversely affects native fish habitat.

Objective TPANC2.1 Benefits: Achieving this objective is intended to reduce the nonnative plant species that limit the turbidity in the Delta, which have decreased over time (Jassby et al. 2002; Nobriga and Herbold 2009). It is hypothesized that one of the primary causes of the decrease in turbidity is biological filtration by IAV (Brown and Michniuk 2007; Nobriga and Herbold 2009). Controlling IAV, especially SAV, is anticipated to result in some degree of increased turbidity as well as reducing suitable habitat for nonnative predators.

Habitat structure and heterogeneity can affect opportunities for encounter and capture by predators. As discussed above, IAV beds appear to provide habitat that is more favorable to nearshore fishes, such as largemouth bass and sunfish, which also can take advantage of increased water clarity to find prey (Brown 2003; Nobriga et al. 2005; Nobriga and Feyrer 2007). IAV in the estuary has also likely reduced the amount of shallow-water habitat available to coastal migrant and adult green sturgeon (Israel and Klimley 2008). Control of IAV and the restoration of native aquatic plant communities in treated areas are also expected to increase the quantity and quality of habitat suitable for some prey resources (e.g., crustaceans, annelids, mollusks, fish, and midges) important to sturgeon.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them. • **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objectives TBEWNC1.1 and TBEWNC1.2 Benefits: Achieving these objectives is intended to increase primary and secondary productivity and forage fish production, which is expected to increase the quantity and diversity of food items available for green sturgeon occupying affected areas. The substantial reduction in historical tidal wetlands in the Delta is assumed to have reduced nursery and foraging habitats for YOY through spawning adult life stages. As a result, restoring tidal marsh habitat is expected to benefit these same life stages.

Objective TBEWNC1.3 Benefits: Achieving this objective is intended to increase the transport of food and nutrients from tidal marshes (main channel and off-channel) to areas occupied by green sturgeon. This is expected to increase available food to contribute to an increase in the survival of green sturgeon.

Objective TBEWNC1.4 Benefits: Achieving this objective is intended to promote effective exchange throughout the marsh plain to increase the transport of nutrients and food from restored wetlands to habitats in the low-salinity zone typically occupied by older (older than 1 year of age) juvenile green sturgeon. Increasing the transport of food is anticipated to contribute to an increase in the survival of juvenile green sturgeon.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7. • **Objective TFEWNC1.2:** Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.

Objective TFEWNC1.1 Benefits: Achieving this objective is anticipated to result in an increase in primary and secondary productivity and forage fish production, which is expected to increase the quantity and diversity of food items available for green sturgeon occupying affected areas.

Objective TFEWNC1.2 Benefits: Achieving this objective is intended to increase the transport of nutrients and food from restored wetlands to habitats in the low-salinity zone occupied by subadult and adult green sturgeon. Increasing the transport of food is anticipated to contribute to an increase in survival.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian natural community, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objectives VFRNC1.1 and VFRNC1.2 Benefits: Riparian natural community provides important functions to the aquatic system (e.g., large woody debris recruitment, increased bank stability, reduced erosion, flow attenuation during flood events, allochthonous inputs, and shade/insulation) that benefit covered fish species. Achieving these objectives is intended to ensure these riparian communities continue to contribute directly and/or indirectly to the production of food to the aquatic system, important for increased survival of larval and juvenile green sturgeon.

3.3.7.8.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for juvenile and adult green sturgeon within the reserve system. The goals and objectives below are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global recovery goals and objectives are provided here for broader context of green sturgeon recovery (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Ensure green sturgeon utilize all currently occupied areas within the Bay-Delta and its tributaries and are able to take advantage of any unoccupied areas which arise from restoration activities. Maintain stable population size and age structure.
  - **Global Objective 1.1:** Increase abundance and productivity by providing a diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages in estuarine habitats.
  - **Global Objective 1.2:** Increase spatial distribution. Protect and increase life-history and genetic diversity.
  - **Global Objective 1.3:** Provide water quality and other chemical characteristics for optimal behavior, growth, and viability in all life stages.

The biological goals and objectives presented below have been developed to provide for the conservation and management of green sturgeon in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

Goal GRST1: Increased abundance of green sturgeon in the Plan Area.
• **Objective GRST1.1:** Increase juvenile green sturgeon survival (as a proxy for juvenile abundance and population productivity) throughout the BDCP permit term and increase adult green sturgeon survival (as a proxy for adult abundance and productivity) by year 15.
Assumed Stressors: Incubation and rearing conditions, food availability, and illegal harvest. **Stressor Reduction Targets:** • **Rearing.** Document distribution of rearing habitats and their condition and identify opportunities for improvement. Achieve improved rearing conditions in the Bay-Delta and its tributaries by year 15. • **Food availability.** Identify areas with prey resource enhancement opportunities. Determine appropriate rate and schedule for implementation. Increase the quantity and quality of habitats suitable for prey resources important to green sturgeon (crustaceans, annelids, mollusks, fish, and midges) by year 10. • **Entrainment.** Determine the impact of entrainment on the green sturgeon population, and manage entrainment levels to support stable and/or increase population trends. • **Illegal harvest.** Determine an appropriate reduction target, and then reduce illegal harvest of subadult and adult green sturgeon in the Plan Area by the target quantity by year 15.

Objective GRST1.1 Rationale: The underlying principle for this objective is the hypothesis that by increasing juvenile and adult green sturgeon survival under the BDCP, juvenile and adult green sturgeon abundance and population productivity within the Plan Area will also increase. Actions under the BDCP that are focused on stressor reduction targets for green sturgeon within the Plan Area are anticipated to reverse recent green sturgeon population trends and make progress toward meeting Goal GRST1.

- **Rearing.** Improving rearing conditions for juvenile green sturgeon within the Plan Area is expected to increase juvenile green sturgeon survival, and subsequently juvenile production and abundance, within the Plan Area. Increasing juvenile green sturgeon abundance is also expected to contribute to an increase in the abundance of spawning adult green sturgeon over time. Adult green sturgeon are observed in the Sacramento and Feather Rivers between late March and late July (Benson et al. 2007; Heublein 2006), which can be a period of regulated flows in these rivers. Thus, upstream flow management may influence whether conditions are suitable for green sturgeon spawning, embryo incubation, and free embryo, larval, and juvenile survival in areas upstream of the Plan Area.

Green sturgeon critical habitat should have a "flow regime with stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11°C to 19°C [51.5°F to 66.2°F])" (74 FR 52323) (Cech et al. 2000 in Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2004; Mayfield and Cech 2004; Van Eenennaam et al. 2005; Allen et al. 2006b). Water temperatures higher than 20°C are lethal to green sturgeon embryos (Cech et al. 2000). Water releases from SWP/CVP facilities help to maintain water temperatures and flows on the Sacramento and Feather Rivers during the spring and summer for winter-run and spring-run Chinook salmon, respectively. These measures also provide suitable water temperature conditions for a portion of the green sturgeon spawning, incubation, and rearing periods.

Flow characteristics necessary for spawning, incubating eggs, and larval rearing are unknown; however, research occurring under the current NMFS (2009) BiOp is expected to provide information characterizing optimal conditions for these life stages. If linkages between the Sacramento River white sturgeon population and hydraulic processes are similar to those for the green sturgeon, white sturgeon may be a reasonable surrogate for green sturgeon, and measures that enhance white sturgeon populations could benefit green sturgeon as well.

Flow relationships examined by CDFW indicate that greater flows during the late spawning and early life stages between April and July resulted in greater YOY production of white sturgeon (Kohlhorst et al. 1991; Fish 2010). Recruitment was significantly positively correlated with Delta outflow in all months from April to July, but there was no correlation with mean daily volume of diversions. Juvenile green sturgeon develop the critical osmoregulatory capacities between their first and second year that permit them to enter saltwater at a size of 75 centimeters and weight of 1.5 kilograms (Allen and Cech 2007). Restored subtidal freshwater and brackish natural communities can provide important habitats for juvenile green sturgeon. Outflow may indirectly influence juvenile survival by modifying the availability of these freshwater and low-salinity restored habitats in the Delta and Suisun Bay during green sturgeon's first year of life.

Creation, restoration, enhancement, and protection of a diverse range of aquatic habitats are intended to increase the diversity and spatial complexity of available habitats for a wide range of covered fish species, including green sturgeon, and life stages that occur in the Plan Area. For example, enhanced spatial diversity and complexity of habitat types, including variation in water depths, tidal hydrodynamics, water velocities, salinity gradients, seasonal inundation, daily tidal cycles, and permanently inundated subtidal habitats are expected to contribute to an increase in the abundance of juvenile green sturgeon over time. When considered in conjunction with actions to improve food availability and increase survival, the net result is anticipated to be an increase in the abundance of spawning adult green sturgeon over time.

- **Food availability.** Green sturgeon use the lower Sacramento River and Bay-Delta as juveniles, subadults, and adults. In the Delta, YOY green sturgeon sampled in the late summer and fall consumed amphipods, shrimp, and larval and adult midges (Schreiber 1960). When juvenile green sturgeons migrate from the river into the estuary, their diet shifts to larger benthic food items, though they remain generalists and opportunists (Israel et al. 2009). In the Delta, mysid shrimp and amphipods were the primary food items observed in the stomachs of juvenile green sturgeon under 39 centimeters (Radtke 1966). As green sturgeon juveniles grow, they are presumed to become more piscivorous, consuming herring and their eggs, American shad, starry flounder, and goby (Radtke 1966; McKechnie and Fenner 1971). Available benthic food items in the Bay-Delta estuary have changed in the recent past, and invasive invertebrates have replaced native mollusks and shrimps. Kogut (2008) found that the invasive *Potamocorbula* was a major component of the green sturgeon diet. The BDCP is designed to increase growth of juvenile green sturgeon and restore key habitat elements for juvenile green sturgeon by increasing availability, quality, and quantity of habitats within the Plan Area that produce benthic invertebrates and other important food items.

Increasing the timing, frequency and duration of floodplain inundation in Yolo Bypass (*CM2 Yolo Bypass Fisheries Enhancement*); constructing new tidal wetlands (*CM4 Tidal Natural Communities Restoration*); providing for greater floodplain inundation (*CM5 Seasonally Inundated Floodplain Restoration*); and enhancing channel margin habitat quality along up to 20 miles of current levee channel by restoring riparian, marsh, and mudflat habitats along levees (*CM6 Channel Margin Enhancement*) are expected to increase production of periphyton, phytoplankton, macroinvertebrates, insects, and small fish that contribute to the local and regional trophic foodweb associated with each restoration area, thereby contributing to an increase in green sturgeon abundance.

- **Entrainment.** The SWP/CVP facilities, like other diversions in the Study Area, entrain downstream migrating larval, juvenile, and adult green sturgeon in varying degrees that depend on life stage, location, timing, and quantity of water being diverted. There is little documentation of entrainment at most such diversions. No sturgeon entrainment was observed during an agricultural diversion study on the Sacramento River in the north Delta (Nobriga et al. 2004). Larger juvenile sturgeon (longer than 20 centimeters) have been shown to have lower entrainment at diversions with angled bar racks and louvers (Amaral et al. 2002). Reductions in export pumping in the south Delta are expected to have proportional reductions in entrainment of juvenile green sturgeon.

- **Illegal Harvest.** Achieving this objective will increase abundance of all life stages of green sturgeon by reducing the illegal harvest of adults, which are the source of future generations. Green sturgeon males reach a reproductive age (14 years old) earlier and have a shorter lifespan than females. Females may mature as early as 16 years old (Van Eenennaam et al. 2005). Species fecundity peaks at around 24 years old, when all females in this age cohort have matured (Beamesderfer et al. 2007).

  Historically, green sturgeon were harvested as bycatch in commercial fisheries and as a target species in the upper Sacramento River. The states of Washington, Oregon, and California eliminated legal sportfishing and commercial bycatch of green sturgeon between 2006 and 2008. While uncommon, green sturgeon are still captured in Pacific Northwest, San Francisco Bay, and Sacramento River sport fisheries. The retention of green sturgeon is no longer allowed in California or along the Pacific coast, except in tribal fisheries on the Klamath River (Adams et al. 2007). Poaching is an ongoing threat to green and white sturgeon in the Sacramento River, and green sturgeon may be illegally harvested during white sturgeon fisheries in the rivers, Delta, and/or bays.

- The population-level effects of fishing-associated mortality on green sturgeon are not well-documented, and targeted studies and law enforcement are necessary to reduce poaching of subadult and adult green sturgeon. Increased warden activities implemented as part of *CM17 Illegal Harvest Reduction* in the Plan Area are intended to limit illegal harvest of green sturgeon and protect spawning adults. However, uncertainties about sturgeon population size and dynamics as well as the existing extent of mortality from illegal harvest make it difficult to estimate the effectiveness of this measure for this species.

Goal GRST2: Improved connectivity that facilitates timely passage and reduces stranding of adult green sturgeon.
• **Objective GRST2.1:** Eliminate stranding of adult green sturgeon at Fremont Weir, the scour pools directly below Fremont Weir, and the Tule Pool by providing passage at these locations, by year 15, and minimize stranding until this time.
Assumed Stressor: Connectivity. **Stressor Reduction Targets:** • **Connectivity.** Improve connectivity between the Sacramento River and Yolo Bypass for timely passage and decreased stranding of adult green sturgeon between January and May by year 15. • **Passage at Fremont Weir before modification.** Prior to modification of the Fremont Weir, minimize loss from poaching and stranding through increased enforcement and patrols and through fish rescue. • **Passage at Fremont Weir after modification.** Provide adult passage at anthropogenic barriers and impediments in fewer than 36 hours, immediately after modification of the Fremont Weir or by year 15, whichever comes first, through weir operations, continued fish rescue, and continued enforcement. • **Inventory passage barriers and impediments.** Inventory existing human-made migratory impediments and identify opportunities for the BDCP to improve passage/reduce delays within Yolo Bypass. • **Passage at other barriers and impediments in the Plan Area.** As feasible, under the BDCP, limit adult passage delays at human-made barriers and impediments in the Plan Area to fewer than 36 hours by year 15.

Objective GRST2.1 Rationale: Sacramento River flow is diverted through the Yolo and Sutter Bypasses for flood control purposes during periods of high flow associated with winter storms. Diverted river flow through these bypasses may attract green sturgeon adults migrating upstream within the Sacramento River system to spawning grounds further upstream in the Sacramento and Feather Rivers. As waters recede in these bypass systems, upstream passage becomes restricted and sturgeon on their way to spawning grounds can become stranded, leaving them vulnerable to illegal harvest, desiccation, scavenging, and death unless they are rescued (Matica pers. comm.). Therefore, the basis for this objective is that by minimizing stranding within Yolo Bypass (i.e., Fremont Weir, Tule Canal), successful upstream passage of adult green sturgeon to spawning areas within the Sacramento River system will be improved.

Connectivity. Green sturgeon are highly migratory fish, often passing rapidly between freshwater and marine habitats. These individuals quickly ascend northern Central Valley rivers to undertake immediate spawning or emigrate following over-summering to physiologically optimal marine habitats for foraging. Unimpeded connectivity between habitats and safe and timely passage are critical features of the Central Valley rivers that increase spatial distribution of spawning and reduce opportunities for adult mortality. This objective is expected to be met through implementation of seasonal sturgeon passage improvements and operational monitoring programs at gates, barriers, and diversions within Yolo Bypass and the broader Plan Area, that are suspected of limiting connectivity between downstream and upstream areas. Prior to implementation, information on green sturgeon travel times, directionality, and condition will be used to determine measureable outcomes regarding necessary safe and timely passage.

- **Passage at Fremont Weir before and after modification**. The Fremont Weir, a low concrete barrier at the north end of Yolo Bypass is Yolo County, is a documented obstruction to migrating adult green sturgeon. CDFW occasionally has to conduct rescue operations of sturgeon (and other fish) at this structure. Limited stranding and rescue data indicate that appreciable amounts (10% or more) of the green sturgeon spawning population may be negatively affected by the passage impediment caused by the Fremont Weir. Stranding of adult green sturgeon is known to occur in the stilling basin at the base of the Fremont Weir, and it is assumed that the majority of the stranding within the Yolo Bypass occurs in this large pool. Through *CM2 Yolo Bypass Fisheries Enhancement*, the BDCP will focus on eliminating stranding at the large pool at the base of the Fremont Weir while determining whether stranding may be occurring at other areas within Yolo Bypass and working to reduce stranding at those locations as practicable.
- **Inventory of passage barriers and impediments.** It is unknown whether green sturgeon are also stranded or delayed within the Yolo Bypass at locations other than at the Fremont Weir. Therefore, an inventory of other potential human-made barriers and impediments to green sturgeon migration within the Yolo Bypass will be undertaken (CM2), and opportunities to improve passage at these sites and reduce migration delays for or stranding of green sturgeon will be identified. Once other opportunities to improve passage and reduce migration delays are identified, the BDCP will establish priorities for future actions to fix these human-made barriers and impediments. Priorities for fixing passage barriers and impediments will be based on several factors, including the biological benefit for the covered species, cost, and landowner cooperation.
- **Passage at other barriers and impediments in the Yolo Bypass.** Once other passage barriers and impediments to adult green sturgeon spawning migration are identified within the Yolo Bypass, the BDCP will establish procedures and implement appropriate actions, as feasible, to limit adult passage delays to fewer than 36 hours by year 15.

  In addition, spawning adults may be delayed in reaching spawning grounds in the Sacramento River due to misleading water flows through the south and central Delta. Sturgeon immigrating to the San Joaquin River may be confused by Sacramento River flows entering the south Delta via the Delta Cross Channel, which can cause delays and block passage. Delta exports and diversions can also affect Delta flow rates and hydrodynamics, resulting in migration delays (National Marine Fisheries Service 1997). Low DO conditions in the area of the Stockton DWSC can also act as a physical barrier to migration.

Goal GRST3: Increased spatial distribution of young-of-the-year (YOY) and juvenile green sturgeon in the Delta compared to existing conditions.
• **Objective GRST3.1:** Improve water quality parameters and physical habitat characteristics in the Bay-Delta to increase the spatial distribution of green sturgeon in the Plan Area by year 15.
Assumed Stressor: Water quality conditions restrict access to appropriate YOY and juvenile rearing habitat. **Stressor Reduction Target:** • **Water Quality.** Reduce pollutants and improve water quality, with targets to be set by the adaptive management technical team on the basis of developing understanding of sturgeon sensitivity to water quality impairments.

Objective GRST3.1 Rationale: Achieving this objective will increase the spatial distribution and survival of YOY and juvenile green sturgeon by providing water quality conditions that support optimal behavior, growth, and viability of these and subsequent life stages.

- **Water Quality.** Habitat suitability for juvenile sturgeon rearing is primarily dependent on water quality and food availability. Juvenile sturgeon can use a broad range of habitats defined by their temperature, DO, and salinity tolerances; therefore, the distribution of juvenile habitat fluctuates seasonally in freshwater and brackish environments. Sturgeon forage in subtidal and intertidal habitats in the west and south Delta, where low DO can occur seasonally. High water temperatures in the southern portion of the Delta may limit use by sturgeon in some months. Therefore, water quality is likely a limiting factor during early life-history stages of green sturgeon (Israel et al. 2009). However, little is known regarding sensitivity of green sturgeon to water quality impairments.

  Reducing pollutants in the Plan Area will be accomplished by implementing *CM12 Methylmercury Management* and *CM19 Urban Stormwater Treatment*, which will contribute to improving water quality and physical habitat parameters within the Plan Area, thus contributing to an increase in the extent of habitat potentially suitable for green sturgeon. Additionally, green sturgeon and white sturgeon have a high rate of oxygen consumption and require high levels of DO to avoid stress (Gisbert et al. 2001; Lankford et al. 2003; Mayfield and Cech 2004). Therefore, low DO levels in the Plan Area likely result in chronic stress in young green and white sturgeon (Lankford et al. 2003), which forage in subtidal and intertidal Delta habitats and the Stockton DWSC. The BDCP's contribution to increasing DO levels within the Stockton DWSC is expected to improve conditions for rearing and migrating green sturgeon in the San Joaquin River.

3.3.7.9 White Sturgeon

White sturgeon (*Acipenser transmontanus*) spawn primarily in the Sacramento River upstream of the Plan Area, from Colusa downstream to Verona (Kohlhorst 1976), in areas with swift currents and deep pools with gravel substrate. White sturgeon migrate downstream from spawning areas and through the mainstem Sacramento River and Bay-Delta estuary. White sturgeon are most abundant in the Sacramento River and Bay-Delta estuary, and have been reported from the San Joaquin River system, particularly in wet years.

In the Central Valley, white sturgeon populations have declined from an estimated 144,000 adults in 1994 to 10,000 adults in 2005 (Bland 2006). The number of adults fluctuates annually and appears to be the result of highly variable juvenile production; the population is dominated by a few strong year classes associated with high spring outflows (Moyle 2002).

Important threats and stressors to white sturgeon are summarized below. Refer to Appendix 2.A, *Covered Species Accounts,* for a full discussion of these stressors.

- **Harvest.** White sturgeon is a popular game fish in the Bay-Delta estuary and Sacramento River and supports commercial fisheries in Oregon and Washington estuaries. White sturgeon is also vulnerable to illegal harvest. The California Fish and Game Commission has recently adopted more restrictive sportfishing regulations designed to reduce the effects of angler harvest on white sturgeon in the Bay-Delta estuary. However, the effects of legal and illegal harvest on the population dynamics and abundance of white sturgeon within the Bay-Delta estuary are largely unknown.
- **Reduced spawning habitat.** Access to historical spawning habitat has been reduced by construction of barriers to upstream migration. Major dams include Keswick Dam on the Sacramento River and Oroville Dam on the Feather River. Other potential migration barriers include structures such as the Red Bluff Diversion Dam, Sacramento DWSC locks, Sutter Bypass,

Delta Cross Channel gates on the Sacramento River, and Shanghai Bench and Sunset Pumps on the Feather River (Kohlhorst 1976).

- **Exposure to toxins.** Exposure to toxins can lower reproductive success, decrease early life-stage survival, and cause abnormal development in white sturgeon, even at low concentrations. Organic contaminants from agricultural returns, and urban runoff, and high concentrations of trace elements (boron, selenium, and molybdenum) can decrease early life-stage survival, causing abnormal development and high mortality in yolk-sac fry at concentrations of only a few parts per billion. Contaminants that adsorb to sediments, such as pyrethroids, selenium, and mercury, are of particular concern. *Potamocorbula* and Asian clams, the principal components of sturgeon diet in the Delta, are known to bioaccumulate selenium; exposure to these food sources could cause mortality of larval sturgeon.
- **Reduced rearing habitat.** Historical reclamation of wetlands and islands, channelization, and riprapping of levees have reduced and degraded in- and off-channel rearing habitat for white sturgeon.
- **Increased water temperature.** While juvenile and adult white sturgeon are tolerant of higher temperatures, water temperatures greater than 17°C (63°F) have been shown to increase sturgeon egg and larval mortality. Active water management in the Sacramento River has improved conditions in recent years, but temperatures in the lower Feather River may still be unsuitably high for sturgeon spawning and egg incubation. Reduced flow on the San Joaquin River resulting from dam and diversion operations and agricultural return flows contributes to seasonally elevated water temperatures in the mainstem river. Seasonally elevated water temperatures on the San Joaquin River and within the Delta have been identified as a factor affecting habitat quality and availability for sturgeon migration, spawning, and juvenile rearing.
- **Nonnative species.** White sturgeon have been affected both positively and negatively by the introduction of nonnative species into the Bay-Delta estuary. Nonnative species, such as *Potamocorbula* and Asian clam, are now a major component of the white sturgeon diet. However, these benthic filter feeders can accumulate various toxic substances that may adversely affect the health and survival of subadult and adult sturgeon and their reproduction. Nonnative invasive plant species may contribute to raising temperatures, reducing turbidity and DO levels (thereby enhancing habitat for predator species), and inhibiting access to shallow-water habitat by juvenile sturgeon.
- **Dredging.** Hydraulic dredging to maintain vessel access is a common practice in the Sacramento and San Joaquin Rivers, navigation channels within the Delta, and Suisun, San Pablo, and San Francisco Bays. Such dredging operations can affect bottom-oriented fish such as white sturgeon by causing entrainment, reducing benthic prey availability, and resuspending toxins.
- **Reduced turbidity.** Reduced turbidity levels in the Delta could have detrimental effects by increasing the susceptibility of white sturgeon to predation. However, the relationship between turbidity and the vulnerablity of white sturgeon to predation are uncertain.
- **Stranding.** Adult white sturgeon that are attracted by high flows in the Yolo Bypass move on to the floodplain and eventually concentrate behind Fremont Weir where they are blocked from further upstream migration. As flow into Yolo Bypass declines, these sturgeon become stranded behind the flashboards of the weir and can be subjected to illegal fishing.
- **Entrainment at diversions.** There is little evidence that the overall population of white sturgeon is influenced by entrainment. Larval sturgeon are more susceptible to entrainment from water

diversion facilities as a result of their migratory behavior within the water column and reduced swimming capability. The larger SWP/CVP export facilities are located where a low number of juvenile white sturgeon have been recorded.

- **Flow operations.** River flows influence white sturgeon spawning, habitat availability, and prey resources, and have been shown to be related to YOY abundance. Modifications of flow rates have the potential to provide an unnatural cue for spawning, which could result in lowered reproductive success. The dispersal of larval white sturgeon is dependent on high spring river flows, which optimally consist of multiple large flow pulses. Reduced seasonal flows or flows mismatched ecologically with sensitive early life stages may reduce dispersal of these life stages when they are most vulnerable to native and nonnative predation. Flow reductions may serve to reduce or eliminate YOY survival even if spawning was successful. Outflow influences YOY, juvenile, and adult white sturgeon bay and delta habitats by influencing salinity. Tagging data demonstrate white sturgeon move upstream when saline waters encroach eastward in dry years, while white sturgeon expand use of bay habitat when brackish water is pushed westward in wet years (Israel et al. 2009).

White sturgeon is not currently protected under the ESA, and thus no recovery plan has been developed for the species. However, ongoing efforts to conserve the species in the Plan Area include the Anadromous Fish Restoration Program, Central Valley Project Improvement Act, and CALFED programs. The combination of increased law enforcement and new sportfishing regulations adopted over the past several years to protect sturgeon and reduce their harvest is expected to further reduce the effects of illegal and incidental harvest of white sturgeon by recreational anglers throughout the species' range.

The conservation strategy for white sturgeon focuses on life stages occurring within the Plan Area and is intended to benefit those specific life stages when they would be present in the Plan Area. The conservation strategy includes increasing rearing habitat; increasing local production of food; increasing the availability and production of food by exporting organic material from the marsh plain and enhancing phytoplankton, zooplankton, and biological production in tidal channels; minimizing entrainment; improving upstream adult passage conditions; and minimizing illegal harvest. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.9.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for white sturgeon are the same as those identified for green sturgeon, and the associated benefits are the same or similar. See Section 3.3.7.8.1, *Applicable Landscape-Scale Goals and Objectives*.

3.3.7.9.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for white sturgeon are the same as those identified for green sturgeon, and the benefits are the same or similar. See Section 3.3.7.8.2, *Applicable Landscape-Scale Goals and Objectives*.

3.3.7.9.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for white sturgeon within the reserve system. The species-specific goals and objectives for white sturgeon are the same as those discussed above for green sturgeon (Section 3.3.7.8.3) and are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global recovery goals and objectives are provided here for broader context of white sturgeon conservation (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Ensure that white sturgeon use all currently occupied areas within the Bay-Delta and its tributaries and are able to take advantage of any unoccupied areas that become suitable as a result of restoration activities. Maintain stable population size and age structure.
    - **Global Objective 1.1:** Increase abundance. Demonstrate stable or increasing abundance, reproduction, and recruitment.
    - **Global Objective 1.2:** Increase spatial distribution. Protect and increase life-history and genetic diversity.
    - **Global Objective 1.3:** Provide water quality and other chemical characteristics for optimal behavior, growth, and viability in all life stages.

Species-specific biological goals and objectives presented below have been developed to provide for the conservation and management of white sturgeon in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

Goal WTST1: Increased abundance of white sturgeon in the Plan Area.
• **Objective WTST1.1:** Increase juvenile white sturgeon survival (as a proxy for juvenile abundance and population productivity) throughout the BDCP permit term and increase adult white sturgeon survival (as a proxy for adult abundance and productivity) by year 15.
Assumed stressors: Limited rearing conditions, including food availability, entrainment, and illegal harvest. **Stressor reduction targets:** • **Rearing.** Document distribution of rearing habitats and their condition and identify opportunities for improvement. Achieve improved rearing conditions in the Bay-Delta and its tributaries by year 15 • **Food availability.** Identify areas with prey resource enhancement opportunities. Determine appropriate rate and schedule for implementation. Increase the quantity and quality of habitats suitable for prey resources important to white sturgeon (crustaceans, annelids, mollusks, fish, and midges) by year 10. • **Entrainment.** Determine impact of entrainment to the white sturgeon population, and manage entrainment levels to support stable and/or increase population trends. • **Illegal harvest.** Determine an appropriate reduction target, and then reduce illegal harvest of subadult and adult white sturgeon in the Plan Area by the target quantity by year 15.

Objective WTST1.1 Rationale: The underlying principle for this objective is the hypothesis that by increasing juvenile and adult white sturgeon survival through BDCP implementation, juvenile and adult white sturgeon abundance and population productivity within the Plan Area will also increase.

BDCP implementation actions focused on stressor reduction targets for white sturgeon within the Plan Area are anticipated to reverse recent white sturgeon population trends and make progress toward achieving Goal WTST1.

- **Rearing.** The majority of white sturgeon in the San Francisco estuary appear to use the Sacramento River for reproduction. Although they also spawn in the San Joaquin, Feather, and Mokelumne Rivers, little is known about these spawning populations. The Delta and Suisun Bay serve as a migratory corridor, feeding area, and juvenile rearing area for white sturgeon. Larval and juvenile white sturgeon inhabit the lower reaches of the Sacramento and San Joaquin Rivers and the Delta (Stevens and Miller 1970). Water temperatures likely play an important role in the distribution of juvenile white sturgeon in nursery habitat. Water temperatures at shallow depths (1 meter or less) in the Sacramento–San Joaquin estuary averaged 20.5°C during summer, which is the upper limit of the thermal range optimal for white sturgeon (Cech et al. 1984).

  White sturgeon embryos and larvae are intolerant of brackish water, and survival may be limited by saltwater intrusion. Restored subtidal freshwater natural communities can provide important habitats for early life stages of white sturgeon. Salinity is also an important characteristic of juvenile white sturgeon habitat (Israel et al. 2009). Juveniles appear to show preference for fresh water over brackish water (Brannon et al. 1985), although salinity tolerance appears to increase with age. Rearing habitat for larvae and YOY white sturgeon may be lacking currently due to channel and tidal marsh modification.

  As described above for green sturgeon (see Objective GRST1.1), the creation, restoration, enhancement, and protection of a diverse range of aquatic natural communities are intended to increase white sturgeon habitat diversity and complexity. When considered in conjunction with actions to improve food availability and increase survival, the net result is anticipated to be an increase in the abundance of spawning adult white sturgeon over time.

- **Food availability.** See discussion above for green sturgeon (Objective GRST1.1).

- **Entrainment.** See discussion above for green sturgeon (Objective GRST1.1).

- **Illegal Harvest.** Reducing illegal harvest will contribute to an increase in the abundance of adult white sturgeon, which are the source of future generations. Illegal harvest of green sturgeon and illegal harvest of white sturgeon larger than permitted by sportfishing regulations can substantially and rapidly damage those populations, due to small population sizes, less-than-annual spawning periodicity, the ease with which the fish can be captured using readily available illegal means, and the substantial value of sturgeon flesh and eggs in illegal markets (Gingras pers. comm.). While the mortality rates and magnitude of this illegal activity are unquantifiable, they may be quite high. For example, Schaffter and Kohlhorst (1999) postulated that illegal harvest played a role in the decreasing trend in annual survival rates during the 1990s.

  There is a strong financial incentive for poachers to exploit this population, and this incentive has become evident as several organized poaching rings have been exposed and prosecuted since 2000. The BDCP will provide funding to CDFW to increase the number of game wardens in the Delta to reduce illegal poaching. However, uncertainties about sturgeon population sizes and dynamics make it difficult to predict the effectiveness of this measure for this species. Overharvest may be one of the greatest stressors for adult white sturgeon. Maintaining acceptable levels of spawning stock biomass per recruit is critical to sturgeon conservation. It has been suggested that maintaining an adult biomass of at least 20% (Goodyear 1993) to 50% (Boreman et al. 1984) should be targeted for rebuilding the population. *CM17 Illegal Harvest Reduction* will increase enforcement within the Plan Area and reduce illegal harvest, thereby increasing adult white sturgeon abundance.

Goal WTST2: Improved habitat connectivity that facilitates timely passage and reduces stranding of adult white sturgeon.
• **Objective WTST2.1:** Eliminate stranding of adult white sturgeon at Fremont Weir, the scour pool directly below Fremont Weir, and the Tule Pond by providing passage at these locations, by year 15, and minimize stranding until this time.
Assumed Stressor: Connectivity. **Stressor Reduction Targets:** • **Connectivity:** Improve connectivity between the Sacramento River and Yolo Bypass for timely passage and decrease stranding of adult white sturgeon between January and May by year 15. • **Passage at Fremont Weir before modification:** Prior to modification of the Fremont Weir, minimize loss from poaching and stranding through increased enforcement and patrols and through fish rescue. • **Passage at Fremont Weir after modification:** Provide adult passage at human-made barriers and impediments in fewer than 36 hours, immediately after modification of the Fremont Weir or by year 15, whichever comes first, through weir operations, continued fish rescue, and continued enforcement. • **Inventory Passage Barriers and impediments:** Inventory existing human-made migratory impediments and identify opportunities for BDCP to improve passage/reduce delays. • **Passage at other barriers and impediments in the Plan Area:** As feasible as part of BDCP, limit adult passage delays at human-made barriers and impediments in the Plan Area to fewer than 36 hours by year 15.

Objective WTST2.1 Rationale: White sturgeon are highly migratory fish, often passing rapidly between freshwater and marine habitats. Individuals quickly ascend Central Valley rivers to spawn, and unimpeded connectivity between habitats and safe and timely passage are critical to increasing the spatial distribution of spawning adults and reducing adult mortality, passage delays, and stranding.

- **Connectivity.** River flow is diverted through the Yolo Bypass for flood control purposes during periods of high flow in the Sacramento River associated with winter storms and spring runoff. As waters recede in the bypass, passage options become very limited and adult sturgeon migrating upstream within Yolo Bypass can become stranded, leaving them vulnerable to illegal harvest, desiccation, scavenging, and death unless they are rescued (Matica pers. comm.). This objective can be met through implementation of seasonal sturgeon fish passage at Fremont Weir and operational monitoring programs at gates, barriers, and diversions. Prior to implementing these programs, information on white sturgeon travel times, directionality, and disposition should be used to determine measureable outcomes regarding necessary safe and timely passage.

- **Passage at Fremont Weir before and after modification.** The Fremont Weir is a documented barrier to sturgeon, and CDFW occasionally has to conduct rescue operations of sturgeon (and other fishes) at this structure. A recent set of studies provided design and operational criteria for sturgeon passage at Fremont Weir (California Department of Water Resources 2007). These criteria will be incorporated into anticipated modifications to the Fremont Weir to facilitate *CM2 Yolo Bypass Fisheries Enhancement* and improve passage for adult white sturgeon Refer to rationale above for Objective GRST2.1 for more information.

- **Inventory passage barriers and impediments.** As with green sturgeon, it is unknown whether white sturgeon are also stranded or delayed within the Yolo Bypass at locations other than at the Fremont Weir or at locations within the Plan Area other than Yolo Bypass. An inventory of other potential human-made barriers and impediments to white sturgeon migration will be implemented. Refer to rationale above for Objective GRST2.1 for more information.

- **Passage at other barriers and impediments in the Plan Area.** Refer to rational above for Objective GRST2.1.

Goal WTST3: Increased spatial distribution of young-of-the-year (YOY) and juvenile white sturgeon in the Bay-Delta compared to existing condition SWP/CVP regulatory requirements.
• **Objective WTST3.1:** Improve water quality parameters and physical habitat characteristics in the Bay-Delta to increase the spatial distribution of white sturgeon in the Plan Area by year 15.
Assumed Stressors: Water quality conditions restrict access to appropriate YOY and juvenile rearing habitat. **Stressor Reduction Target:** • **Water Quality:** Reduce pollutants and improve water quality, with targets to be set by the adaptive management technical team on the basis of developing understanding of sturgeon sensitivity to water quality impairments.

Objective WTST3.1 Rationale: Achieving this objective will increase the spatial distribution and survival of white sturgeon by providing water quality conditions that support optimal behavior, growth, and viability. Water quality in the Sacramento and San Joaquin Rivers and the Delta is influenced by a variety of point and nonpoint source pollutants from urban, industrial, and agricultural land uses. Runoff from residential, agricultural, and industrial areas introduces pesticides, oil, grease, heavy metals, other organics, and nutrients that contaminate drainage waters and deteriorate the quality of aquatic habitats necessary for white sturgeon survival (National Marine Fisheries Service 1996; Central Valley Regional Water Quality Control Board 1998). Reducing these pollutant sources is expected to improve rearing conditions within the Plan Area and increase the spatial distribution of YOY and juvenile white sturgeon.

Water Quality. Refer to discussion for green sturgeon regarding this stressor reduction target (see Objective GRST3.1).

3.3.7.10 Pacific and River Lamprey

Pacific lamprey (*Entosphenus tridentatus*) and river lamprey (*Lampetra ayresii*) migrating in and out of the Sacramento and San Joaquin River watersheds pass through the Plan Area, but their use of the Plan Area for other purposes is unknown. In the Central Valley, Pacific and river lamprey occur in the lower Sacramento and San Joaquin Rivers and in many of their tributaries, including the Stanislaus, Tuolumne, Merced, and Kings Rivers (Brown and Moyle 1993).

Neither Pacific nor river lamprey is currently listed as either a threatened or endangered species under CESA or ESA, and no recovery plan has been developed for either species. There have been very few efforts to conserve either Pacific or river lamprey in the Central Valley. The CALFED Ecosystem Restoration Program designated the entire lamprey family as “enhance and/or conserve” (CALFED Bay-Delta Program 2000), indicating that the program will undertake actions to conserve and enhance lamprey abundance and distribution and the community diversity in which individuals live for the long-term stability of the species.

Adult Pacific and river lamprey generally migrate upstream to spawning grounds in early March through late June, while adult river lamprey begin their upstream migration in the fall, spawning February through May (Moyle 2002). Pacific lamprey eggs hatch into ammocoetes after approximately 19 days at 15°C, then drift downstream to suitable areas in sand or mud (Moyle 2002) and have been recorded in the Plan Area (H.T. Harvey & Associates with PRBO Conservation Science 2010). The duration of river lamprey egg incubation is likely similar to that of Pacific lamprey. Pacific lamprey begin metamorphosis when they reach 14 to 16 centimeters total length. Downstream migration begins upon completion of this metamorphosis, generally coinciding with high-flow events in winter and spring; river lamprey metamorphosis begins around 12 centimeters total length, with downstream migration during winter and spring similar to Pacific lamprey (Moyle 2002).

The larval form of Pacific lamprey (ammocoete) is common throughout the Plan Area, although there are no abundance estimates from Bay-Delta sampling programs. Few status and trend data are available, and no regular monitoring programs exist with which to assess trends through time. However, anecdotal evidence indicates that populations have been in decline in many California river systems (Moyle 2002).

Ammocoetes live in silty backwaters and eddies with muddy or sandy substrate into which they burrow. Ammocoetes require water temperatures lower than 25°C (76°F) (Moyle et al. 1995). Evaluation of the threats and stressors to Pacific lamprey has been limited. However, the primary threat to the species is thought to be loss or degradation of habitat through dams, diversions, toxins, stream channelization, dredging, and urbanization. Dams have altered flows and water temperatures in channels and limited access to spawning grounds. Toxins may have both lethal and sublethal effects on individuals. Stream channelization, dredging, and diversions have altered flow patterns and rates in channels. Urbanization has degraded habitat by increasing loads of certain toxins, changing runoff patterns, and altering the configuration of some channels. Future climate change is expected to further increase water temperatures and modify the timing of flow-related environmental cues upon which Pacific lamprey depend for life-history events (e.g., outmigration, spawning). Refer to Appendix 2.A, *Covered Species Accounts*, for a full discussion of these stressors.

The Pacific Lamprey Conservation Initiative, led by the USFWS, was initiated in 2007 to "facilitate communication and coordination relative to the conservation of Pacific lampreys throughout their range" (U.S. Fish and Wildlife Service 2007). The goal of the initiative is to restore Pacific lamprey populations and improve their habitat. Anticipated actions from the initiative include development of a Pacific lamprey conservation plan, identification of funding for implementation of the initiative and plan, development of a network of interested parties, funding for immediate conservation actions, and improvements in communication of Pacific lamprey conservation efforts.

No formal evaluations have assessed the threats and stressors to river lamprey. Therefore, threats to river lamprey are assumed to be similar to those described for the co-occurring Pacific lamprey.

The conservation strategy for lamprey focuses on measures to provide passage for larval/juvenile and adult life stages as well as bypass flows and other water operations criteria that will assure continued juvenile outmigration success. The lamprey conservation strategy will include efforts to expand the scientific knowledge base of Pacific and river lamprey in the Plan Area to inform future adaptive management that helps achieve the biological goals and objectives for lamprey. Contributing financial and/or technical resources toward implementing regional monitoring programs focused on Pacific and river lamprey is expected to expand the scientific understanding of both of these species and contribute to identifying measures necessary to maintain self-sustaining populations. Data obtained through cooperation in a regional program could be used to assess population trends, refine knowledge of stressors on key life stages, and complement future adaptive management actions. Relevancy of these data for use in the BDCP will be improved if contributions can be linked to conditions in the Plan Area.

The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM3 through AMM9 in Appendix 3.C, *Avoidance and Minimization Measures*, describe measures that will be implemented to avoid and minimize effects on water bodies and fish.

3.3.7.10.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for Pacific and river lamprey are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA. • **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objective L1.3 Benefits: Achieving this objective is intended to enhance the seasonally inundated floodplains and tidally influenced natural communities that are important for lamprey in terms of primary productivity and food. Providing a gradient of floodplain and tidally influenced natural communities is intended to provide a range of conditions suitable for food production and rearing. The BDCP will restore 65,000 acres of tidal natural communities in the Delta, approximately 10,000 acres of seasonally inundated floodplain, and at least 5,000 acres of riparian natural community, and enhance up to 20 miles of channel margin to benefit covered fish species (in addition to other restoration actions specific to covered terrestrial species). These restoration actions have two principal objectives: to increase the amount of available habitat for covered fish species and to enhance the ecological function of the Delta. Although little is known about lamprey use of channel margin habitat, the species may benefit from enhancement that increases the area of substrate into which ammocoetes can burrow as well as increase primary productivity and thus increase the survival of ammocoetes, which are filter feeders.

Objective L1.4 Benefits: Achieving this objective is intended to make a greater range of habitat conditions, food resources, and habitat complexity available for lamprey. Providing a greater range of potentially suitable habitat conditions for lamprey and the organisms upon which they prey is anticipated to increase the extent of habitats available across a range of conditions (e.g., flow, water temperatures, and turbidity). Close et al. (2003) found that larval Pacific lamprey prefer habitats with soft sediments and low water velocities. Protection and enhancement of suitable larval rearing habitats in the Plan Area are expected to benefit productivity.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.2:** Allow lateral river channel migration. • **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers. • **Objective L2.4:** Support improved ecosystem function in aquatic natural communities by implementing actions to improve water quality, including reducing dissolved oxygen impairments in the Stockton Deep Water Ship Channel, reducing pollutant loading by urban stormwater, and minimizing mobilization of methylmercury from lands in the reserve system. • **Objective L2.5:** Maintain or increase the diversity of spawning, rearing, and migration conditions for native fish species in support of life-history diversity. • **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species. • **Objective L2.8:** Provide refuge habitat for migrating and resident covered fish species. • **Objective L2.11:** Restore 10,000 acres of seasonally inundated floodplain.

Objective L2.2 Benefits: Achieving this objective is intended to restore natural fluvial processes to improve habitat conditions through floodplain inundation, which can increase sediment inputs and thereby maintain suitable substrate conditions for ammocoete settlement and development in the Plan Area.

Objective L2.3 Benefits: Achieving this objective is intended to increase river-floodplain connectivity, which may improve hyporheic processes such as groundwater recharge, improve water quality, provide cool water inputs, and maintain groundwater inputs to surface waters. Increased connectivity may also increase allochthonous inputs, which can contribute to an increase in productivity in aquatic systems.

Objective L2.4 Benefits: Achieving this objective is intended to reduce the amount of pollution in stormwater runoff entering Delta waterways. This will benefit lamprey by reducing pesticides and herbicides. Ammocoetes spend 5 to 7 years living in silty areas that are known to accumulate high levels of toxins. As a result, lamprey are prone to high body burdens of toxins relative to other fish species (Haas and Ichikawa 2007; Bettaso and Goodman 2008). These water quality improvements are intended to contribute to a reduction in the accumulations of toxins in ammocoetes and contribute to increasing available food resources.

Objective L2.5 Benefits: Achieving this objective is intended to provide a range of environmental gradients to ensure that a diversity of suitable rearing conditions exists for lamprey within the Plan Area over the BDCP permit term, thereby increasing the diversity and resiliency of the species.

Objective L2.7 Benefits: Achieving this objective is intended to increase natural dendritic channels in tidal marsh habitats to promote phytoplankton and detrital food production and transport, which may benefit lamprey ammocoetes rearing in and/or migrating through the Plan Area. This may benefit lamprey rearing in the freshwater and low-salinity zones of the Plan Area, as they grow and develop critical osmoregulatory capacities that allow them to enter the ocean.

Objective L2.8 Benefits: Achieving this objective is intended to provide refugia for migrating lamprey, which may reduce potential predation effects.

Objective L2.11 Benefits: Achieving this objective is intended to increase river-floodplain connectivity, which may increase the extent of rearing habitat available to lamprey ammocoetes in the

Plan Area. Restoring seasonally inundated floodplain may contribute to an increase in primary productivity, which will contribute to a more diverse and robust food base for ammocoetes.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.2:** Promote connectivity between low-salinity zone habitats and upstream freshwater habitats, and availability of spawning habitats for native pelagic fish species. • **Objective L3.3:** Provide flows that support the movement of juvenile life stages of native fish species to downstream rearing habitats.

Objective L3.2 Benefits: Achieving this objective is intended to increase connectivity between low-salinity zone habitat and upstream freshwater spawning habitat, which may benefit lamprey adults by improving access to suitable spawning habitats and providing a range of suitable spawning conditions through a variety of habitat conditions. Adult lamprey remain close to the mouths of the rivers from which they came, likely because their prey is most abundant in estuaries and other coastal areas (Moyle 2002).

Objective L3.3 Benefits: Achieving this objective is intended to provide increased flexibility using dual conveyance, and may allow the BDCP to provide flow conditions that can more easily coincide with the timing of juvenile lamprey outmigrations. Enhancing outmigration conditions is expected to reduce predation and improve survival.

Goal L4: Increased habitat suitability for covered fish species in the Plan Area.
• **Objective L4.1:** Manage the distribution and abundance of nonnative predators in the Delta to reduce predation on covered fishes. • **Objective L4.2:** Manage the distribution of covered fish species to minimize movements into areas of high predation risk in the Delta. • **Objective L4.3:** Reduce entrainment losses of covered fish species.

Objective L4.1 Benefits: Achieving this objective is intended to reduce predation on lamprey by nonnative predators. Although predation is a natural part of aquatic community dynamics, excessive predation has been identified as a stressor for covered fish species. Excessive predation is speculative for lamprey, because nothing is known about their population dynamics. Mammals, birds, and other fish species consume lamprey at all life stages (Luzier et al. 2009). The diversity and populations of some predator species, such as largemouth bass and marine mammals, have increased in recent decades, and the targeted harvest, capture, and removal of striped bass and largemouth bass, in particular, may reduce any population-level predation impacts that may be affecting lamprey. Refer to *CM15 Localized Reduction of Predatory Fishes* for a discussion of the management of predators within the Plan Area.

Objective L4.2 Benefits: Achieving this objective is intended to manage flows to influence the distribution of covered fish species and minimize movements into potential high predation areas of the Delta. Juvenile lamprey may be transported to predator-infested (centrarchid-dominated) tidal and shallow subtidal areas in the Delta where they are vulnerable to predators. Many nonnative species, including striped bass, sturgeon, centrarchids, and catfish, are believed to consume juvenile as well as adult lamprey and may pose a threat to population sizes (Luzier et al. 2009; Baxter et al. 2008). Therefore, managing for higher flows may result in a wider distribution of lamprey and a reduction in predation and mortality rates.

Objective L4.3 Benefits: Achieving this objective is intended to reduce the entrainment of lamprey. Under the BDCP, total exports from combined north and south Delta intakes are expected to increase relative to the existing biological conditions in wet, above-normal, and below-normal water years. Under dry and critical water years, total exports are expected to decrease under the BDCP relative to existing biological conditions. Overall, the BDCP will substantially reduce exports from the south Delta facilities in most months relative to existing biological conditions. Entrainment is expected to be reduced most in wetter years, because a greater percentage of flow will be diverted from the north Delta in wet years than in dry years (Appendix 5.B, *Entrainment*).

3.3.7.10.2 Applicable Natural Community Goals and Objectives

All natural community goals and objectives that provide lamprey habitat (i.e., tidal perennial aquatic, tidal brackish emergent wetland, tidal freshwater emergent wetland and nontidal perennial aquatic) may benefit lamprey. Achieving those objectives that will contribute to an increase in primary productivity and the transport of plant-based food to deepwater habitats (e.g., creation, restoration, and enhancement of aquatic natural communities), which are expected to benefit ammocoetes rearing in the Plan Area and thereby contribute to an increase in their abundance. An increase in the abundance of salmonid fish species in the Plan Area is also expected to provide a greater abundance in the prey available to both Pacific and river lamprey adults. Ammocoetes remain in fresh water for approximately 5 to 7 years, where they burrow into sand, silt and mud and feed on algae, organic material, and microorganisms. Ammocoetes change locations during this stage. Creating, restoring, and enhancing natural communities that will contribute to an increase in primary productivity will also benefit ammocoetes, which are filter feeders for the first 5 to 7 years of their lives, before their metamorphosis into macropthalmia (juveniles), in preparation for their predatory life stage in the ocean and estuary.

3.3.7.10.3 Species-Specific Goals and Objectives

Landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for lamprey within the reserve system. The goals and objectives below are intended to represent specific, quantifiable, biological responses. Species-specific goals and objectives for covered fish also define population performance metrics to be achieved during BDCP implementation.

The following global goal and objective are provided here for broader context of lamprey conservation (Section 3.3.2.2, *Process for Developing Fish Species Biological Goals and Objectives*).

- **Global Goal 1:** Manage estuary to improve habitat. Restore/sustain Pacific and river lamprey populations throughout their historical range
    - **Global Objective 1.1:** Implement actions known to benefit Pacific and river lamprey, minimize threats, and improve scientific understanding.

The biological goals and objectives presented below have been developed to provide for the conservation and management of lamprey in the Plan Area and contribute toward the achievement of the global recovery goals and objectives.

Goal PRL1: Improved habitat connectivity that facilitates timely passage for Pacific and river lamprey within the Plan Area.

- **Objective PRL1.1:** Reduce passage delays for lamprey adults migrating upstream within the Yolo Bypass by year 15.
- **Objective PRL1.2:** Improve downstream passage conditions for lamprey ammocoetes and macropthalmia at the Fremont Weir by year 15.

Assumed stressors: Connectivity and barriers to upstream/downstream migration/passage.

Stressor reduction targets:

- **Adult passage.** Limit passage delays at anthropogenic barriers and impediments in the Yolo Bypass (e.g., Fremont Weir) to fewer than 36 hours by year 15.
- **Larval/juvenile passage.** Improve connectivity between the Sacramento River and Yolo Bypass for improved passage of ammocoetes and macropthalmia by year 15.
- **Inventory passage barriers and impediments.** Inventory existing anthropogenic migratory impediments and identify opportunities for the BDCP to improve passage and reduce delays.
- **Passage at other barriers and impediments in the Plan Area.** As feasible, as part of the BDCP, limit adult passage delays at other anthropogenic barriers and impediments in the Plan Area to fewer than 36 hours by year 15.

Objective PRL1.1 and PRL1.2 Rationale: Improving passage conditions at the Fremont Weir to reduce passage delays for adult lamprey as well as increase the potential for ammocoetes and macropthalmia to enter Yolo Bypass at the Fremont Weir will contribute to improved habitat connectivity for these two life stages. Adult lamprey have been captured during fish rescue operations at the base of the Fremont Weir. In 2011, CDFW documented adult Pacific lamprey during sturgeon rescue operations, although no count was recorded of the number of Pacific lamprey that were captured and released back to the mainstem Sacramento River (California Department of Fish and Game 2011). Collections of Pacific and river lamprey in Yolo Bypass (Sommer et al. 2001b; 2003) suggest the floodplain provides habitat for lamprey ammocoetes during periods of inundation and within the toe drain and other channels that remain watered for extended periods of time. Ammocoetes typically remain burrowed in fine sand and mud from 5 to 7 years, where they live as filter feeders, sucking organic matter and algae off the substrate surface (Moyle 2002). Ammocoetes do not stay in one area for their entire growth period. Most movement occurs at night, and active ammocoetes can be trapped at almost any time of the year (Moyle 2002).

Fluctuations in reservoir and stream water levels, irrigation diversions, and stream dewatering can strand ammocoetes in the substrate (U.S. Fish and Wildlife Service 2009). A single event can have a significant effect on a local lamprey population, affecting multiple generations (U.S. Fish and Wildlife Service 2009; Luzier et al. 2009). However, there is little risk of this occurring in the Plan Area, with the possible exception of Yolo Bypass; the potential risk of stranding of ammocoetes on the Yolo Bypass is unknown.

Downstream movement of juvenile lamprey (macropthalmia) happens year round (Luzier et al. 2009). Due to poor swimming ability (Sutphin and Hueth 2010), movement is probably facilitated by flow conditions and velocities. Juvenile travel time is related to water particle travel time, and increases in freshet flows will likely reduce lamprey travel time (Nez Perce Tribe 2008). Downstream migrating macropthalmia are often impinged on water diversion intake screens, resulting in death (Luzier et al. 2009). While not part of the species-specific goals and objectives, the management of flows and entrainment for other covered species is expected to reduce stranding and entrainment during migration. Likewise, achieving the salmonid biological goals and objectives related to survival and abundance, as well as improved habitat conditions, will likely also benefit lamprey by increasing the abundance of salmonid fishes in the bay and ocean where lamprey feed on them.

Contributing financial and/or technical resources toward implementing regional monitoring programs (e.g., The Pacific Lamprey Conservation Initiative) focused on Pacific and river lamprey is expected to expand the scientific understanding of both species and contribute to the further identification of measures necessary to maintain self-sustaining populations. Data obtained through cooperation in a regional program could be used to assess population trends, refine knowledge of stressors on key life stages (including the quantification of mortality rates among life stages and the factors driving variation in mortality and other vital rates), and complement future adaptive management actions. Relevancy of these data for use in the BDCP will be improved if contributions can be linked to conditions in the Plan Area.

3.3.7.11 Riparian Brush Rabbit

The riparian brush rabbit (*Sylvilagus bachmani riparius*) occupies riparian communities dominated by thickets of willows (*Salix* spp.), wild roses (*Rosa* spp.), blackberries (*Rubus* spp.), and other successional trees and shrubs; and when available, seasonally dense, tall stands of herbaceous plants adjacent to patches of riparian shrubs. In the San Joaquin Valley, these plant communities have been reduced to less than 11% of their historical extent (Katibah 1984). Populations of riparian brush rabbit are known to have occurred historically in riparian forests along the San Joaquin and Stanislaus Rivers and some tributaries to the San Joaquin River (U.S. Fish and Wildlife Service 1998). Population declines are directly associated with the removal of riparian vegetation communities, which is, in large measure, associated with the construction of dams on the major rivers of the Central Valley for irrigation and flood control. Construction of levees along major river systems facilitated the conversion of floodplains to croplands and thus also reduced and fragmented riparian vegetation communities (U.S. Fish and Wildlife Service 1998).

Today, the only known naturally occurring populations of riparian brush rabbits are confined to Caswell Memorial State Park, a 258-acre park supporting riparian oak woodland on the Stanislaus River immediately southeast of the Plan Area, and in the south Delta southwest of Lathrop, which is within the Plan Area (Williams and Basey 1986; Williams et al. 2002) (Figure 2A.12-2). The known distribution of the south Delta population is fragmented into isolated and semi-isolated patches along the San Joaquin River, Paradise Cut, Tom Paine Slough, and railroad rights-of-way in San Joaquin County. The only protected south Delta population segment is in the Oxbow Preserve, a 30-acre riparian forest preserve owned by the Center for Natural Land Management. Paradise Cut is located on private property and the waterway is managed primarily for flood control. Habitat patches are extremely narrow strips—most only a few meters wide—between active farmland and open water (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*). The two extant populations are small, isolated, may not be self-sustaining, and are under proximate threats of extinction (Williams et al. 2002). The population at Caswell Park is vulnerable to threats that include inbreeding (loss of genetic diversity), wildfire, flooding, disease, and predation (chiefly by feral cats) (Williams and Basey 1986; U.S. Fish and Wildlife Service 1998). The south Delta population is vulnerable to stochastic demographic and genetic events, flooding, disease, predation, competition, habitat destruction, and urban edge effects.

Several existing conservation efforts apply to the riparian brush rabbit. The *Recovery Plan for Upland Species of the San Joaquin Valley, California* (Upland Species Recovery Plan) (U.S. Fish and Wildlife Service 1998) focuses brush rabbit conservation on riparian restoration and protection, and population reintroductions. Because the extant populations at Caswell Memorial State Park and the south Delta are isolated from other suitable sites that are uninhabited, reintroductions of individuals from existing populations are required to meet the recovery plan goal of three additional self-sustaining wild populations; to provide a source of animals for reintroduction, a controlled propagation program was undertaken in 1999 by USFWS, CDFW, and Reclamation (Williams et al. 2002). The brush rabbit is a covered species under the *San Joaquin County MSHCP*. In 2011, the Endangered Species Recovery Program developed *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat* (Appendix 3.E) specifically for the purpose of guiding conservation for the BDCP.

The conservation strategy for the riparian brush rabbit, with conservation principles (Appendix 3.E), involves protecting, restoring or creating, and maintaining habitat and corridors near the largest remaining fragments of habitat and extant populations; providing high-water refugia from flooding; and managing feral predators (dogs and cats) in areas occupied by the species. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM25 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.11.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the riparian brush rabbit are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.5:** In restored floodplains, provide a range of elevations that transition from frequently flooded (e.g., every 1 to 2 years) to infrequently flooded (e.g., every 10 years or more) areas to provide a range of habitat conditions, upland habitat values, and refugia from flooding during most flood events.
- **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.5 Benefits: This objective will partially address the need for upland refugia for riparian brush rabbits during flood events. The width of the riparian corridor in otherwise suitable riparian brush rabbit habitat has been greatly reduced as a result of channelization and levee construction, and adjacent uplands have been leveled for agricultural production. These changes have nearly eliminated necessary topography and vegetative cover that provide flood refugia for the riparian brush rabbit. Land between the levees can be entirely submerged during these high-flow events, with few or no high-ground sites with appropriate cover where riparian brush rabbits can seek shelter landward of the levees. In 1995 and 1997, high-flow events in the reduced floodplain resulted in rabbit losses that were catastrophic for the riparian brush rabbit population along the Stanislaus River (River Partners 2008). Floodplain restoration in Conservation Zone 7 will widen the floodplain and provide topographic transitions from frequently flooded to seldom flooded areas, thereby providing potential flood refugia, as described in *CM5 Seasonally Inundated Floodplain Restoration*. Additional provisions for riparian brush rabbit refugia are described under the species-specific objectives (Objectives RBR1.3 and RBR1.5). Provision of upland transitional areas will also provide riparian buffers to reduce the potential for adverse effects from adjacent urban and agricultural lands, such as noise, lighting, and predation from domestic pets.

Objective L1.6 Benefits: Increasing the size and connectivity of the reserve system consistent with this objective will minimize the risk of riparian brush rabbit habitat fragmentation and adverse effects of adjacent land uses. Habitat fragmentation reduces effective population size, increasing the risk of extirpation as a result of population fluctuations or catastrophic events such as flooding. Small reserves are also disproportionately vulnerable to effects from adjacent urban and agricultural lands such as noise, lighting, predation by feral dogs and cats (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*), and disturbance as a result of human encroachment into brush rabbit habitat. A large, interconnected reserve system that builds on existing conservation lands will reduce these effects on riparian brush rabbit.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances.

Objective L2.1 Benefits: Allowing natural flooding regimes consistent with this objective will provide natural vegetation disturbances to encourage establishment of early- to midsuccessional riparian vegetation. In the absence of regular flooding or other similar disturbances, the trees mature and form a dense canopy that creates shade and prevents the establishment of shrubby understory vegetation necessary for riparian brush rabbit. Floodplain restoration, described in *CM5 Seasonally Inundated Floodplain Restoration*, will provide sites for flood-related disturbances to occur. If natural flooding is insufficient to maintain appropriate riparian brush rabbit vegetation structure, the vegetation will be actively managed to provide suitable habitat structure as described in *CM11 Natural Communities Enhancement and Management.*

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: This objective addresses the need to improve riparian connectivity for the riparian brush rabbit. Riparian brush rabbit habitat connectivity is further addressed under Objectives L1.6 and RBR1.1.

Existing brush rabbit populations within the Plan Area appear to be occupying railroad rights-of-way that support suitable riparian shrubs (e.g., the corridor north of the intersection of Interstates 5 and 205). These vegetated railroad rights-of-way can provide a linear corridor to connect patches of habitat across otherwise unsuitable agricultural zones. The reserve system could take advantage of these railroad rights-of-way through strategic protection and restoration of riparian brush rabbit habitat in proximity to such corridors.

3.3.7.11.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the riparian brush rabbit are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objectives VFRNC1.1 and VFRNC1.2 Benefits: Riparian protection and restoration consistent with these objectives will provide additional potential habitat for riparian brush rabbit population expansion. All recorded occurrences of riparian brush rabbit in the Plan Area are in Conservation Zone 7, where riparian protection will occur consistent with Objective VFRNC1.2. Additional restoration and creation in this zone, consistent with Objective VFRNC1.2, will benefit riparian brush rabbit by providing additional habitat potentially available for population expansion (see Goal RBR1, below, for additional objectives related to future growth and expansion of populations). Most or all of the 3,000 acres of riparian restoration within seasonally inundated floodplain are expected to occur in Conservation Zone 7, because this zone has the greatest opportunity for floodplain restoration. However, not all of the protected and restored riparian natural community in Conservation Zone 7 will have suitable structural characteristics necessary for supporting riparian brush rabbit, hence the need for Objective VFRNC2.2 and species-specific goals and objectives described below.

Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.
• **Objective VFRNC2.2:** Maintain 1,000 acres of early- to midsuccessional vegetation with a well-developed understory of dense shrubs on restored seasonally inundated floodplain.

Objective VFRNC2.2 Benefits: Maintaining early- to midsuccessional riparian vegetation consistent with this objective will help to provide habitat for the riparian brush rabbit. As described above for Objective L2.1, riparian brush rabbit requires the dense, shrubby vegetation that is typical of younger riparian stands. *CM5 Seasonally Inundated Floodplain Restoration* is expected to provide sufficiently frequent fluvial disturbance to maintain at least 1,000 acres of early- to midsuccessional riparian vegetation in the Plan Area. However, if fluvial disturbance is not sufficient to meet this objective, additional enhancement and management will be implemented as described in *CM11 Natural Communities Enhancement and Management.* As described in *CM7 Riparian Natural Community Restoration*, the requirement for 1,000 acres of early- to midsuccessional vegetation may overlap with the requirements for protected and restored riparian brush rabbit habitat, if the vegetation and habitat criteria are met for both.

3.3.7.11.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for riparian brush rabbit within the reserve system. The goal and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal RBR1: Suitable habitat available for the future growth and expansion of riparian brush rabbit populations.
• **Objective RBR1.1:** Of the 750 acres of protected valley/foothill riparian natural community protected under Objective VFRNC1.2, protect 200 acres of suitable riparian brush rabbit habitat (defined in *CM7 Riparian Natural Community Restoration*) that is occupied by the species or contiguous with occupied habitat. • **Objective RBR1.2:** Of the 1,000 acres of early- to midsuccessional riparian habitat maintained under VFRNC2.2, maintain at least 800 acres within the range of the riparian brush rabbit (Conservation Zone 7), in areas that are adjacent to or that facilitate connectivity with occupied or potentially occupied habitat. • **Objective RBR1.3:** Of the 5,000 acres of valley/foothill riparian natural community restored under Objective VFRNC1.1, restore/create and maintain 300 acres of early- to midsuccessional riparian habitat that meets the ecological requirements of the riparian brush rabbit and that is within or adjacent to or that facilitates connectivity with existing occupied or potentially occupied habitat. • **Objective RBR1.4:** Create and maintain high-water refugia in the 300 acres of restored riparian brush rabbit habitat and the 200 acres of protected riparian brush rabbit habitat, through the retention, construction and/or restoration of high-ground habitat on mounds, berms, or levees, so that refugia are no further apart than 20 meters. • **Objective RBR1.5:** In protected riparian areas that are occupied by riparian brush rabbit, monitor for and control nonnative predators that are known to prey on riparian brush rabbit. • **Objective RBR1.6:** Of the 8,000 acres of grasslands protected under Objective GNC1.1 and the 2,000 acres of grasslands restored under Objective GNC1.2, protect or restore grasslands on the landward side of levees adjacent to restored floodplain to provide flood refugia and foraging habitat for riparian brush rabbit.

Objective RBR1.1 Rationale: This objective addresses the need to protect habitat occupied by the riparian brush rabbit. The Plan Area supports one of only two existing populations of riparian brush rabbit. Of the approximately 270 acres of known occupied habitat in the Plan Area (Williams et al. 2008), only 30 acres are protected. Protection of habitat occupied by known riparian brush rabbit populations is a guiding conservation principle for this species (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*). As described in *CM11 Natural Communities Enhancement and Management,* the 200 acres will be enhanced and managed as necessary to establish and maintain suitable habitat characteristics for riparian brush rabbit.

Objective RBR1.2 Rationale: This objective ensures that the benefits to riparian brush rabbit assumed to result from riparian natural community restoration are achieved. Approximately 2,909 of the 17,966 acres of mapped riparian natural community in the Plan Area consist of modeled habitat for riparian brush rabbit. Assuming that a similar (16%) proportion of the 5,000 acres of restored riparian natural community consists of riparian brush rabbit habitat, then a total of 800 acres of restored riparian natural community will be suitable for riparian brush rabbit. However, without this objective, there is no commitment that 800 acres be within the range of the riparian brush rabbit. Since riparian brush rabbits occur in early-successional riparian, the objective requires the 800 acres to be a subset of the 1,000 acres of early-successional riparian (Objective VFRNC2.2). All known riparian brush rabbit occurrences in the Plan Area are in Conservation Zone 7, hence the requirement that these 800 acres occur in that zone.

Objective RBR1.3 Rationale: This objective addresses the need to restore or create riparian natural community with the specific characteristics that are suitable for the riparian brush rabbit. Riparian habitat for the brush rabbit includes large patches of dense brush composed of riparian vegetation, ecotonal edges of brushy species to grasses and herbaceous forbs, skeletal scaffolding structure, an open tree overstory, and high-ground refugia. Suitable habitat for this species is extremely limited in the Plan Area and throughout the species' range. The extent of known occupied habitat in the Plan Area is approximately 270 acres (Williams et al. 2008). The occupied sites occur in patches separated by poor quality or unsuitable habitat. Restoring 300 acres of riparian brush rabbit habitat will more than double the extent of riparian brush rabbit habitat in the Plan Area and greatly increase habitat quality by creating larger, better connected patches of habitat. This will facilitate expansion of the distribution and increase in abundance of the species. Riparian habitat will be restored according to the specifications in *CM7 Riparian Natural Community Restoration*, which describes the habitat requirements for this species that will be required elements of restoration plans. These suitable habitat characteristics will be maintained as described in *CM11 Natural Communities Enhancement and Management.*

The 300 acres of riparian brush rabbit habitat will be restored adjacent to areas currently occupied by the south Delta population in Conservation Zone 7 (Figure 2A.12-2). Connectivity with currently occupied or potentially occupied habitat will be a primary factor in the selection of restoration sites. Establishing permanent corridors between patches of occupied habitat will facilitate dispersal of the species and genetic interchange. Focusing restoration efforts on lands adjacent to occupied or potentially occupied sites will increase the extent of available habitat for existing populations and facilitate greater connectivity between them, thereby promoting an expansion of the species' distribution and abundance and contributing to a reduction of the potential extinction threat.

Objective RBR1.4 Rationale: This objective addresses the need to protect the riparian brush rabbit from mortality during flooding. An essential element of riparian brush rabbit habitat is high-water upland refugia, important for survival during flood events. The lack of high-water refugia has been responsible for substantial mortality and population declines during flood events and is considered one of the greatest threats to the Caswell Memorial State Park population (Elsholz 2010). To address this, all riparian brush rabbit restoration projects will be designed to incorporate high-water refugia consisting of protecting, building, or restoring high-ground habitat such as mounds, berms, and levees, no greater than 20 meters apart, and suitable vegetative composition and structure that can provide upland habitat and cover during flood events. Design specifications and vegetation requirements for these refugia are provided in *CM7 Riparian Natural Community Restoration* and Appendix 3.E.

Objective RBR1.5 Rationale: This objective addresses the need to protect the riparian brush rabbit from nonnative feral predators, such as cats and dogs, which can be a threat to the populations, particularly where sufficient cover habitat is not available (Appendix 3.E). Control of feral predators will be particularly important where small populations occur in the vicinity of urban development. Therefore, predation threats by feral predators, particularly cats and dogs, will be monitored and minimized at all sites in the reserve system occupied by the species through predator control (installation of barriers and removal of dogs and cats) or other management actions. Feral predator control is described further in *CM11 Natural Communities Enhancement and Management*.

Objective RBR1.5 Rationale: This objective will partially fulfill the need for upland refugia for riparian brush rabbits during flood events (Objectives L1.1 and RBR1.3 also fulfill this need). Uplands landward of the levees and adjacent to riparian brush rabbit habitat have mostly been converted to agriculture, and thus do not provide refuge habitat during high-flood events. Grassland adjacent to riparian habitat can also provide foraging opportunities for riparian brush rabbit (Appendix 3.E). Provision of uplands adjacent to restored floodplains will also provide riparian buffers to reduce the potential for adverse effects from adjacent urban and agricultural lands, such as noise, lighting, and predation from domestic pets. Criteria for upland areas adjacent to restored riparian are provided in *CM3 Natural Communities Protection and Restoration.*

3.3.7.12 Riparian Woodrat (San Joaquin Valley)

The riparian woodrat (San Joaquin Valley) (*Neotoma fuscipes riparia*) is a subspecies of the dusky-footed woodrat that occurs in riparian woodland with an overstory canopy of trees and a moderate to dense shrub understory, reaching its highest densities in willow thickets growing under a canopy of valley oaks (Williams 1986:1–112; U.S. Fish and Wildlife Service 1998). Before the statewide reduction of riparian communities, the riparian woodrat probably ranged throughout the riparian forests along major streams flowing onto the floor of the northern San Joaquin Valley. There has been a nearly 90% reduction in the extent of riparian communities along these major streams (Katibah 1984). Much of the loss is due to habitat conversion to agricultural lands and the construction of large dams and canals. The riparian woodrat is now confined to lands along the lower portions of the San Joaquin and Stanislaus Rivers in northern San Joaquin County (Williams 1986:1–112, 1993; U.S. Fish and Wildlife Service 1998). Habitat loss and fragmentation are considered the main causes of the riparian woodrat's range contraction (Appendix 2.A, *Covered Species Accounts*).

This species is not known to occur in the Plan Area; the only verified extant population is 2 miles east of the southern end of the Plan Area in Caswell Memorial State Park along the Stanislaus River (Williams 1986:1–112, 1993). Potentially suitable habitat occurs in small patches of valley oak riparian forest within the Plan Area along the San Joaquin River from the southern tip of the Plan Area north to approximately the Interstate 5 overcrossing near Lathrop, and it is possible that this habitat contains undetected riparian woodrats (Figure 2A.13-2).

The riparian woodrat is addressed in the Upland Species Recovery Plan (U.S. Fish and Wildlife Service 1998). Habitat protection and, where appropriate, habitat restoration are the central components of the conservation strategy recommended in the recovery plan (U.S. Fish and Wildlife Service 1998). The recovery plan establishes an overall goal of securing and protecting three riparian woodrat populations by protecting and restoring riparian habitat and reintroducing populations (U.S. Fish and Wildlife Service 1998). In 2011, the Endangered Species Recovery Program developed *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat* (Appendix 3.E) specifically for the purpose of guiding conservation of these species under the BDCP.

The conservation strategy for the riparian woodrat involves providing opportunities for population expansion into the Plan Area from adjacent lands to the south and southeast. The strategy focuses on restoring and maintaining suitable habitat at the southernmost end of Conservation Zone 7, providing connectivity with existing populations to the south and southeast, and creating and maintaining flood refugia. This conservation approach is consistent with the recovery plan (U.S. Fish and Wildlife Service 1998) and conservation principles (Appendix 3.E). The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM25 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.12.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the riparian woodrat are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.5:** In restored floodplains, provide a range of elevations that transition from frequently flooded (e.g., every 1 to 2 years) to infrequently flooded (e.g., every 10 years or more) areas to provide a range of habitat conditions, upland habitat values, and refugia from flooding during most flood events. • **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.5 Benefits: Channelization and levee construction have greatly reduced the width of the riparian corridor in otherwise suitable riparian woodrat habitat,. The result has been a lack of the necessary topography and vegetative cover for woodrat use during high river flows. Land between the levees can be entirely submerged during these high-flow events, leaving few or no high-ground sites where riparian woodrats can seek shelter with appropriate cover landward of the levees. In 1995 and 1997, flood events were catastrophic for the riparian woodrat population along the Stanislaus River (River Partners 2008).

Floodplain restoration in Conservation Zone 7 will widen floodplains, providing opportunities to create higher areas within the floodplain that seldom flood. Additional provisions for woodrat refugia are described under the species-specific objectives. The creation of transitional areas within the floodplain will also provide riparian buffers to reduce the potential for adverse effects from adjacent urban and agricultural lands, such as noise, lighting, and predation from dogs and cats. This objective will be achieved through restoration of wide, topographicaly diverse floodplains, as described in *CM5 Seasonally Inundated Floodplain Restoration*.

Objective L1.6 Benefits: Increasing the size and connectivity of the reserve system consistent with this objective will minimize the risk of riparian woodrat habitat fragmentation and adverse effects of adjacent land uses. Habitat fragmentation results in small population size, increasing the risk of extirpation as a result of population fluctuations and catastrophic events such as flooding. Small reserves are also vulnerable to effects from adjacent urban and agricultural lands uses such as noise, lighting, encroachment of dogs and cats that may prey on riparian woodrats (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*), and disturbance as a result of human encroachment into the habitat. A large, interconnected reserve system that builds on existing conservation lands will reduce these effects on riparian woodrats.

Goal L.3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: Consistent with this objective, riparian restoration within restored floodplain in Conservation Zone 7 will be designed to improve connectivity with the riparian community south of the Plan Area, where the nearest known riparian woodrat population occurs. This will facilitate dispersal of the species and genetic interchange between populations by establishing permanent habitat corridors between known populations (Appendix 3.E). While increased connectivity will not guarantee the northward expansion of riparian woodrats into the Plan Area, it will expand opportunities for riparian woodrat dispersal northward and establishment in the Plan Area. It will also provide continued habitat connectivity between the population to the south and a newly established population, if any, in Conservation Zone 7.

3.3.7.12.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the riparian woodrat are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.

- **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain.
- **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objectives VFRNC1.1 and VFRNC1.2 Benefits: Riparian restoration and protection consistent with these objectives will benefit riparian woodrat by providing habitat for potential population establishment and expansion in the Plan Area. All of the 750 acres of protected riparian and much of the 5,000 acres of restored riparian natural community will occur in Conservation Zone 7, and some of this will have suitable structural characteristics necessary for supporting riparian woodrats; species-specific goals and objectives below address this uncertainty. These objectives will be achieved through riparian restoration and protection as described in *CM3 Natural Communities Protection and Restoration* and *CM7 Riparian Natural Community Restoration.*

Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.

- **Objective VFRNC2.1:** Restore, maintain and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands.

Objective VFRNC2.1 Benefits: Riparian woodrats require a dense shrub understory as well as tall shrubs, small trees or vines to grow above flood levels and provide access to a tree canopy where they forage (Appendix 3.E). Riparian woodrats will therefore benefit from the maintenance and enhancement of structural heterogeneity with adequate vertical overlap among vegetation components. This objective will be achieved through riparian restoration as described in *CM7 Riparian Natural Community Restoration* and vegetation management if necessary, as described in *CM11 Natural Communities Enhancement and Management.*

3.3.7.12.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for riparian woodrat within the reserve system. The goal and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal RW1: A reserve system that includes suitable habitat available for the future growth and expansion of riparian woodrat populations.
• **Objective RW1.1:** Of the 5,000 acres of valley/foothill riparian natural community restored under Objective VFRNC1.1, restore/create and maintain 300 acres riparian habitat in Conservation Zone 7 that meets the ecological requirements of the riparian woodrat (i.e., dense willow understory and oak overstory) and that is adjacent to or facilitates connectivity with existing occupied or potentially occupied habitat. • **Objective RW1.2:** Provide and maintain high-water refugia in the 300 acres of riparian woodrat habitat restored under Objective RW1.1 through the retention, construction, and/or restoration of high-ground habitat on mounds, berms, or levees, so that refugia are no further apart than 20 meters.

Objective RW1.1 Rationale: Restoring or creating and maintaining 300 acres of suitable riparian habitat in an area that is adjacent to or facilitates connectivity with existing or potential habitat will facilitate an expansion of the distribution and increase in abundance of the species. The objective is necessary to meet specific riparian woodrat habitat requirements that would not necessarily be provided through Goal VFRNC1. Riparian habitat will be restored according to provisions in *CM3 Natural Communities Protection and Restoration* and *CM7 Riparian Natural Community Restoration*, which will include site-selection criteria and site-specific restoration guidance to ensure appropriate species composition, density, structure, and other species-specific habitat elements. Management and maintenance of appropriate habitat conditions are further specified in *CM11 Natural Communities Enhancement and Management.* Connectivity with currently occupied or potentially occupied habitat (south of Highway 4) will be the primary factor in the selection of restoration sites to meet this objective.

Objective RW1.2 Rationale: Providing adequate flood refugia will reduce riparian woodrat mortality during flood events (U.S. Fish and Wildlife Service 1998). All riparian woodrat restoration projects will be designed to incorporate high-water refugia, and refugia will be incorporated into protected areas that provide suitable habitat for this species. High-water refugia consist of existing, built, or restored high-ground habitat such as mounds, berms, and levees, and suitable vegetative composition and structure that can provide upland habitat and cover during flood events. Remnants of levees may be retained, and planted and maintained to provide refugia. The specifications for riparian woodrat refugia are provided in *CM7 Riparian Natural Community Restoration*.

3.3.7.13 Salt Marsh Harvest Mouse

The salt marsh harvest mouse (*Reithrodontomys raviventris*) is a small rodent endemic to the salt and brackish marshes of San Francisco, San Pablo, and Suisun Bays (U.S. Fish and Wildlife Service 2001). It depends on salt marshes as its optimal habitat and is primarily found in vegetation dominated by pickleweed. Upland refugia are important during high-tide events so that it can escape flooded low-lying marshlands (Appendix 2.A, *Covered Species Accounts*). Much of the occupied habitat in Suisun Marsh consists of remnant tidal brackish emergent wetlands and artificial nontidal managed and diked wetlands (including adjacent upland grasslands used as refugia during high-tide events) (Figure 2A.14-2). Despite the artificial origin of this habitat, substantial numbers of salt marsh harvest mouse now inhabit nontidal managed and diked wetlands created during the historical reclamation of Suisun Bay tidal marshes.

The historical range of the species likely included most of the marshlands in the San Francisco Bay Area. Tidal marshes have been reduced by nearly 85% since the 1850s. Today, the species potentially occupies an area representing approximately 15% of the historical salt marsh habitat formerly found in the San Francisco Bay Area (Dedrick 1989). Once a vast tidal marsh, much of the remaining habitat is isolated by dikes and landfill, and remaining populations are small and separated by large areas of unsuitable habitat.

Loss and degradation of tidal marsh habitat continues to be the most significant threat to the salt marsh harvest mouse. This loss and fragmentation, initially due to reclamation for farming and later for commercial and industrial development, has isolated populations and reduced dispersal opportunities. The loss of tidal marsh habitat through filling and diking has largely been curtailed. Current factors associated with population decline include conversion of salt marshes to brackish marshes due to freshwater discharges from sewage treatment plants; introduction of nonnative cordgrass, saltgrass, and other plant species; predation by nonnative red foxes and feral cats; and input of runoff, industrial discharges, and sewage effluent (Shellhammer et al. 1982; California Department of Fish and Game 2000; LSA Associates 2007). Probably the most significant long-term threat is the predicted sea level rise of up to 1.2 meters within this century.

The conservation strategy for this species involves restoring and protecting tidal brackish emergent wetland, protecting managed wetland, protecting adjacent upland, and managing and enhancing habitat to provide vegetation structure and composition suitable for sustaining populations of salt marsh harvest mouse, consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Final Tidal Marsh Recovery Plan).[51] It may take several decades to achieve the mature tidal marsh conditions that constitute optimum habitat. To minimize temporal effects, the conservation strategy phases restoration over time, as described in *CM4 Tidal Natural Communities Restoration*. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM26 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.13.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the salt marsh harvest mouse are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.
- **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objective L1.4 Benefits: The salt marsh harvest mouse needs middle to high marsh plain to fulfill vegetation requirements for cover and food, and an adjacent high marsh transition zone to provide refuge during high-tide events (U.S. Fish and Wildlife Service 2010). Providing elevation and

[51] While the conservation strategy is based on the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U.S. Fish and Wildlife Service 2010), vegetation structure and composition will be maintained consistent with the final version of the plan.

hydrological gradients in restored tidal brackish emergent wetland consistent with this objective will address that need.

Objective L1.7 Benefits: Protecting transitional uplands to accommodate sea level rise consistent with this objective will benefit salt marsh harvest mouse by accommodating an upward elevation shift in habitat with sea level rise. Achieving this objective will also provide additional upland areas for salt marsh harvest mice to use as refugia during high-tide events, during the period of time prior to the shift to more tidal influence resulting from sea level rise. Salt marsh harvest mice generally move into the upper brackish marsh fringe during high tide; however, during prolonged periods of winter high tides, mice move into the adjacent upland transition areas. These upland areas are especially important in the winter, because many of the plants on the brackish marsh fringe are annuals that do not provide winter cover, and winter tides are often high enough to inundate these higher wetland zones. As specified in *CM11 Natural Communities Enhancement and Management*, a 200-foot zone from the edge of tidal wetlands within the transitional uplands will be maintained as grassland, riparian, or other natural community types that provide upland cover for salt marsh harvest mouse and other native marsh species.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: This objective will benefit the salt marsh harvest mouse where management efforts reduce invasive nonnative plant species such as perennial pepperweed, which can out-compete the plant species that harvest mice are more dependent upon (e.g., pickleweed). The Implementation Office will also monitor for nonnative predators such as red fox, house cats, and feral hogs, which can destroy habitat, and will implement control measures if needed. Progress toward meeting this objective will be achieved through actions described in *CM11 Natural Communities Enhancement and Management.*

3.3.7.13.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the salt marsh harvest mouse are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25.

Objective TBEWNC1.1 Benefits: Restored tidal brackish emergent wetland will provide habitat for salt marsh harvest mouse, replacing the managed wetland natural community that currently provides habitat. Managed wetland is not a sustainable habitat type because of the potential for catastrophic flooding associated with subsided lands, known levee instability, and projected sea level rise, in addition to the intensive management required to maintain these lands in their managed condition (U.S. Fish and Wildlife 2010). Catastrophic flooding would likely cause mortality of salt marsh harvest mice living within the confines of a failed levee. Tidal brackish emergent wetland, on the other hand, will provide stable and persistent habitat in Suisun Marsh (U.S. Fish and Wildlife Service 2010). As of this writing, the Tidal Marsh Recovery Plan is in draft form; the distribution and composition of restored tidal brackish emergent wetland will be designed to be consistent with the final plan.

The 6,000-acre restoration minimum will ensure a net increase in natural tidal marsh habitat for the salt marsh harvest mouse. This restoration will add 6,000 acres of tidal marsh habitat (primary and secondary) to the existing 6,359 acres in Suisun Marsh, although the existing 6,359 acres may diminish over time as a result of sea level rise. The 6,000 acres of the restored natural community will build off of existing tidal brackish emergent wetlands at elevations that are most likely to persist with sea level rise, to create large, contiguous patches suitable for salt marsh harvest mouse.

Objective TBEWNC1.2 Benefits: Middle and high marsh wetland communities support plant communities that provide high-value habitat for salt marsh harvest mouse. This objective in combination with Objective SMHM1.1 ensures that the middle and high marsh wetland communities will be suitable for the salt marsh harvest mouse. Because most managed wetlands considered for tidal restoration have subsided to elevations characteristic of low marsh, restoration to achieve substantial areas of high or middle tidal marsh is expected to require grading or other active restoration techniques. By ensuring that at least 1,500 acres of the at least 6,000 acres of tidal brackish marsh restoration consist of high and middle marsh, the conservation strategy ensures that the tidal brackish marsh restoration will provide higher-value, primary tidal brackish marsh habitat, rather than predominately low-value low marsh. This objective adds 1,500 acres of primary tidal brackish marsh to the existing 3,641 acres of primary mouse habitat in Suisun Marsh; however, some of the existing acreage may consist of small isolated patches that are not suitable for the species, and the existing acreage is likely to diminish over time as a result of sea level rise. Distributing the restoration of high and middle marsh across three marsh complexes is consistent with the Final Tidal Marsh Recovery Plan goal of supporting populations in areas large enough to persist against rising sea levels. As of this writing, the Tidal Marsh Recovery Plan is in draft form; distribution and composition of restored tidal brackish emergent wetland will be designed to be consistent with the final plan. The restored tidal brackish emergent wetland natural community is expected to have higher long-term conservation value for salt marsh harvest mouse than the existing managed wetlands, because it is sustainable over the long-term, whereas subsided managed wetlands are at high risk of sudden loss as a result of levee failure.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is an invasive forb that forms dense monocultural stands in Suisun Marsh (Trumbo 1994). Pepperweed is a competitor with pickleweed, which the salt marsh harvest mouse depends upon for forage and cover. The California Invasive Plant Council (2012) lists the plant as a severe threat to native vegetation. Meeting this objective will ensure that perennial pepperweed does not impair the functions of the natural community with which the salt marsh harvest mouse has evolved. Limiting perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system is consistent with conservation objectives outlined in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species and native biodiversity.
• **Objective MWNC1.1:** Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.

Objective MWNC1.1 Benefits: Although tidal brackish emergent wetland is believed to have a higher long- term conservation value for salt marsh harvest mouse than managed wetland, as described above, the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010) recognizes that a large proportion of the salt marsh harvest mouse population in Suisun Marsh is in managed wetlands maintained by dikes. Because of this, and because lands in the Grizzly Island Marsh Complex are severely subsided and not readily restorable to tidal conditions, the recovery plan allows managed wetland to be included in the total acreage that must be protected and enhanced to achieve recovery for the salt marsh harvest mouse. Consistent with this objective, at least 1,500 acres of protected managed wetlands in the Grizzly Island Marsh Complex will be enhanced as described in *CM11 Natural Communities Enhancement and Management,* to provide vegetation with structural diversity and food value for native wildlife. Structural diversity will be provided by management and enhancement actions that promote tall stands of pickleweed, which provides cover for the salt marsh harvest mouse and a substrate on which mice climb for refuge during high-tide events.

The additional acreage (at least 6,600 acres) of protected managed wetlands (beyond the 1,500 acres protected for salt marsh harvest mouse) could potentially benefit this species, if the protection occurs in Suisun Marsh. This area will be managed for waterfowl, as described in *CM11 Natural Communities Enhancement and Management*; however, it is expected that salt marsh harvest mouse will be able to occupy portions of the 6,600 acres, because they are known to occur in managed wetlands currently being managed for waterfowl in Suisun Marsh. Although managed wetlands will be managed as described in *CM11 Natural Communities Enhancement and Management* to avoid a net adverse effect on salt marsh harvest mouse within these 6,600 acres, and to benefit salt marsh harvest mouse where such management would not conflict with waterfowl management goals, the primary focus of this 6,600 acres is for waterfowl habitat enhancement and this acreage is not counted toward the overall beneficial effects on the species.

The Draft Tidal Marsh Recovery Plan includes a goal for protecting and enhancing 1,500 acres of managed wetland at Grizzly Island (U.S. Fish and Wildlife Service 2010). Although a portion of this goal has already been met, the 1,500 acres of additional protection and enhancement of managed wetlands under this objective will mitigate habitat loss elsewhere in Suisun Marsh resulting from tidal restoration (i.e., conversion to subtidal natural community).

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.4**: Of the 8,000 acres of grassland protected under Objective GNC1.1 and 2,000 acres of grassland restored under Objective GNC1.2, protect or restore grasslands adjacent to restored tidal brackish emergent wetlands to provide at least 200 feet of adjacent grasslands beyond the sea level rise accommodation area.

Objective GNC1.4 Benefits: Protecting at least 200 feet of grassland beyond the sea level rise accommodation area will benefit salt marsh harvest mouse by providing upland refugia during high-tide events in the long term, after sea level rise has converted the lower elevation grasslands to tidal natural communities. Salt marsh harvest mice generally move into the upper brackish marsh fringe during high tide; however, during prolonged periods of winter high tides, mice move into the adjacent upland transition areas. These upland areas are especially important in the winter because many of the plants on the brackish marsh fringe are annuals that do not provide winter cover, and winter tides are often high enough to inundate these higher wetland zones.

3.3.7.13.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance habitat for salt marsh harvest mouse within the reserve system. The goals and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal SMHM1: Suitable habitat and conditions to sustain a population of salt marsh harvest mouse in the reserve system.

- **Objective SMHM1.1:** Within the at least 1,500 acres of middle and high marsh restored under Objective TBEWNC1.2, provide viable habitat areas for salt marsh harvest mouse, as defined in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Meet population capture efficiency targets described in that plan.
- **Objective SMHM1.2:** Within the 1,500 acres of managed wetland protected and enhanced in the Grizzly Island Marsh Complex under Objective MWNC1.1, provide "Viable Habitat Areas" for salt marsh harvest mouse, as defined in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*, and increase population levels above the current baseline.

Objective SMHM1.1 Rationale: Achieving this objective will provide for the conservation and management of the salt marsh harvest mouse in the Plan Area consistent with the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010). The plan stipulates that high and middle marsh "Viable Habitat Areas" (described in *CM4 Tidal Natural Communities Restoration*) must be 150 acres or more, the minimum acreage thought to sustain a healthy salt marsh harvest mouse population. Actions to be implemented to achieve this objective are described in *CM4 Tidal Natural Communities Restoration.* As of this writing, the Tidal Marsh Recovery Plan is in draft form; the restored Viable Habitat Areas will have appropriate vegetation composition as defined in the Final Tidal Marsh Recovery Plan. This objective also allows restoration to build off of any existing protected habitat to meet the 150-acre minimum size for each patch.

Objective SMHM1.2 Rationale: Achieving this objective will also provide for the conservation and management of the salt marsh harvest mouse in the Plan Area, recognizing that due to subsidence, restoration of tidal brackish marsh in the Grizzly Island Complex may not be feasible. Studies by Sustaita et al. (2011) have shown that salt marsh harvest mouse populations can be relatively high in managed wetlands where they are managed for salt marsh harvest mice. This objective, consistent with the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010), will protect and enhance 1,500 acres of managed wetland habitat on Grizzly Island with the ultimate goals of increasing populations above baseline level and reducing long-term catastrophic risk of levee failure and subsequent loss of habitat through flooding. The managed wetlands will be enhanced and maintained as described in *CM11 Natural Communities Enhancement and Management* to provide Viable Habitat Areas. As of this writing, the Tidal Marsh Recovery Plan is in draft form; the restored Viable Habitat Areas will have appropriate vegetation composition as defined in the final plan. Actions to be implemented to achieve this objective are described in *CM4 Tidal Natural Communities Restoration.*

3.3.7.14 San Joaquin Kit Fox

The San Joaquin kit fox (*Vulpes macrotis mutica*) is closely associated with arid lands that are sparsely vegetated with shrubs or grasses. The species' natural habitats include valley sink scrub, valley saltbrush scrub, and upper Sonoran subshrub natural communities, but these communities do not occur in the Plan Area. In the northern portion of its range, which includes portions of the Plan Area, kit fox is found primarily in annual grassland (Haight et al. 2004). While some types of agriculture such as dry farming and fallow lands can provide marginal habitat value for the San Joaquin kit fox, it is rare in irrigated agricultural lands, particularly near the northern extent of its range (Jensen 1972; Morrell 1972; Cypher pers. comm.).

Historically, the San Joaquin kit fox was reported to occur throughout the semi-arid habitats of the southern Central Valley and adjacent lowland foothills from Kern County to as far north as Tracy (Grinnell et al. 1937). By 1937, San Joaquin kit fox was presumed to have been extirpated from the Tracy area and to extend only as far north as southern Stanislaus County (Grinnell et al. 1937). When the San Joaquin kit fox was added to the federal endangered species list in 1967, there were no known extant occurrences in San Joaquin County or northward. In the 1970s, however, surveys showed that the range of the kit fox extended northward beyond Tracy to eastern Contra Costa County (Jensen 1972; Clark et al. 2002). Relatively few San Joaquin kit foxes have been found in the northern portion of their range within the last few decades, despite a number of surveys (Hall 1983; California Department of Fish and Game 1983; Bell 1994; Smith et al. 2006; Clark et al. 2007a). The northern range of the San Joaquin kit fox (including the Plan Area) was most likely marginal habitat historically and has been further degraded by development pressures, habitat loss, and fragmentation (Clark et al. 2007a). The California Natural Diversity Database (CNDDB) reports eight occurrences of San Joaquin kit fox in the Plan Area, all of which were along the extreme western edge of the Plan Area within Conservation Zone 8, south of Brentwood (California Department of Fish and Game 2009b) (Figure 2A.15-2). However, Clark et al. (2007b) provide evidence that a number of CNDDB occurrences in the northern portion of the species' range may be misidentifications, and may actually be coyote pups. Smith et al. (2006) suggest that the northern range may possibly be an area where the San Joaquin kit fox cannot establish a self-sustaining population (i.e., a population sink).

Habitat loss and fragmentation due to urbanization and agricultural expansion are the principal factors in the decline of the San Joaquin kit fox in the San Joaquin Valley (Laughrin 1970; Jensen 1972; Morrell 1975; Knapp 1978). By 1979, only an estimated 7% of the San Joaquin Valley floor's original native habitat south of Stanislaus County remained untilled and undeveloped (U.S. Fish and Wildlife Service 1983). In its northern range, continued urbanization, primarily in Contra Costa and Alameda Counties, water storage and conveyance projects, road construction, energy development, and other activities continue to reduce and fragment its remaining grassland habitat (U.S. Fish and Wildlife Service 1998). A decline in prey abundance associated with ground squirrel poisoning programs has also been identified as a stressor contributing to reduced kit fox abundance (see habitat model in Appendix 2.A, *Covered Species Accounts*).

The Upland Species Recovery Plan (U.S. Fish and Wildlife Service 1998) provides a recovery strategy for the San Joaquin kit fox that focuses on conserving a number of kit fox populations and connections between these populations to counteract negative consequences of inbreeding, random stochastic events, and demographic factors. The strategy hinges on protecting three geographically distinct core populations: the Carrizo Plain area in San Luis Obispo County, natural lands of western Kern County, and the Ciervo-Panoche area of western Fresno and San Benito Counties. Additionally, the recovery plan calls for protection of several satellite populations[52] (number of populations to be protected dependent on results of research). Nine satellite populations were identified in the recovery plan: the Plan Area includes the northeastern edge of the northernmost kit fox satellite population. A demographic analysis of kit fox populations throughout its range suggested that conservation for the species would be most cost effective farther south in the San Joaquin Valley and Carrizo Plain, outside the Plan Area, where existing populations occur (Haight et al. 2004). The *East Contra Costa County HCP/NCCP* and *San Joaquin County MSHCP* cover San Joaquin kit fox and provide extensive grassland conservation for this species within the Plan Area. The 5-year status review for the kit fox (U.S. Fish and Wildlife Service 2010) indicates that there is currently no known breeding of San Joaquin kit fox in this northernmost extent of the species' range, including the Plan Area.

The conservation strategy for the San Joaquin kit fox involves protecting and enhancing habitat in the northern extent of the species' range to increase the likelihood that kit fox may reside and breed in the Plan Area; and providing connectivity to habitat outside the Plan Area. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM24 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.14.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the San Joaquin kit fox are stated below.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: Consistent with this objective, protecting grasslands in Conservation Zone 8 will contribute to the protection of a San Joaquin kit fox habitat linkage in East Contra Costa County, northeastern Alameda County, and western San Joaquin County, connecting to existing populations farther south in the inner Coast Range. This is further discussed under Objective GNC1.1.

3.3.7.14.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the San Joaquin kit fox are stated below.

[52] Core-satellite metapopulations are those having core populations that are stable over time, and peripheral satellite populations that may experience periodic extirpation with subsequent recolonization from the core populations.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.
• **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex. • **Objective ASWNC1.2:** Restore or create alkali seasonal wetlands in Conservation Zones 1, 8, and/or 11 to achieve no net loss of wetted acres (up to 72 acres of alkali seasonal wetland complex restoration, assuming all anticipated impacts occur).

Goal VPNC1: Vernal pool complexes composed of large, interconnected, or contiguous expanses that represent a range of environmental conditions.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). • **Objective VPNC1.2:** Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools).
Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11. • **Objective GNC1.2:** Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian and tidal and nontidal natural communities for wildlife foraging and upland refugia.

Objectives ASWNC1.1, ASWNC1.2, VPNC1.1, VPNC1.2, and GNC1.1, GNC1.2 Benefits: Because the primary stressor on the kit fox in the northern extent of its range is the loss and fragmentation of grassland habitat through urban and agricultural expansion, protection of grassland habitat is the most effective approach to kit fox conservation. In the Upland Species Recovery Plan (U.S. Fish and Wildlife Service 1998), the recommended conservation strategy for San Joaquin kit fox is centered on conserving three core populations and several satellite populations, and providing connectivity between these populations. The Plan Area includes the northeastern edge of the northernmost satellite population: the strategy focuses on protecting the largest remaining contiguous habitat patches (including grasslands and the grassland component of alkali seasonal wetland and vernal pool complexes) in this area and maintaining connectivity with the remainder of the satellite population in Contra Costa County.

Consistent with Objective GNC1.1, the BDCP will protect 1,000 acres of kit fox grassland breeding, foraging, and dispersal habitat in Conservation Zone 8, adjacent to existing protected habitat. Additional grasslands will be protected consisting of the grassland component of alkali seasonal wetland and vernal pool complex natural communities protected in Conservation Zone 8. Because kit fox home ranges are large (ranging from around 1 to 12 square miles; see Appendix 2.A, *Covered Species Accounts*), habitat connectivity is key to the conservation of the species. For this reason, protected habitat will be acquired in locations that provide connectivity to existing protected breeding habitats in Conservation Zone 8 and to other adjoining kit fox habitat within and adjacent to the Plan Area. Connectivity to occupied habitat adjacent to the Plan Area will help ensure the movement of kit fox to larger habitat patches outside of the Plan Area in Contra Costa County.

Consistent with Objective L3.1 and Goal GNC1, protection will focus in particular on acquiring the largest remaining contiguous patches of unprotected kit fox grassland habitat, which are located south of Highway 4 in Conservation Zone 8 (Appendix 2.A). This area connects to over 620 acres of existing habitat that was protected under the *East Contra Costa County HCP/NCCP*. Conservation Zone 8 supports 74% of the modeled kit fox grassland habitat in the Plan Area, and the remainder consists of fragmented, isolated patches that are unlikely to support this species. Following BDCP implementation, protected modeled kit fox grassland habitat in Conservation Zone 8 will increase by 67% (from 886 acres to 1,481 acres) and from 16% protected to 28% protected. Additional habitat will be restored by meeting Objectives GNC1.2, ASWNC1.2, and VPNC1.2. Conservation lands will be acquired to expand existing protected habitats and provide movement corridors linking kit fox habitats within and adjacent to the Plan Area. These objectives will be met by implementing habitat protection and restoration measures described in *CM3 Natural Communities Protection and Restoration*, *CM8 Grassland Natural Community Restoration*, and *CM9 Vernal Pool and Alkali Seasonal Wetland Natural Community Restoration*.

Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.

- **Objective ASWNC2.3:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase burrow availability for burrow-dependent species.
- **Objective ASWNC2.4:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.

- **Objective VPNC2.4:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase burrow availability for burrow-dependent species.
- **Objective VPNC2.5:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.

- **Objective GNC2.3:** Increase burrow availability for burrow-dependent species.
- **Objective GNC2.4:** Increase prey abundance and accessibility, especially small mammals and insects, for grassland-foraging species.

Objective ASWNC2.3, VPNC2.4 and GNC2.3 Benefits: Increasing burrow availability consistent with these objectives will benefit San Joaquin kit fox by increasing potential den sites on protected grasslands (including the grassland component of alkali seasonal wetland and vernal pool complexes) in Conservation Zone 8. Den sites may be a limiting resource for kit foxes (Clark et al. 2005; Spiegel et al. 1996; Orloff et al. 1986). The San Joaquin kit fox is an obligatory den user: it uses dens for bearing and rearing young, diurnal resting cover, escaping predators, temperature regulation, and avoiding adverse weather conditions (Clark et al. 2005). The kit fox, however, is believed to have weak digging abilities and therefore primarily excavates its dens in loose, sandy soils (Jensen 1972). Kit foxes will also use existing burrows constructed by other animals or human-made structures such as culverts or abandoned pipes (Jensen 1972). Competition from coyotes and other carnivores is believed to be especially intense in the northernmost portion of the species' range, and the kit fox therefore likely requires abundant den sites for escape cover (Orloff et al. 1986). Orloff et al. (1986) hypothesized that availability of denning sites may be the major factor limiting the distribution of San Joaquin kit fox in the northern portion of its range.

The kit fox in the northern portion of its range relies on the use of ground squirrel burrows for dens, and maintenance of ground squirrel populations may therefore be an essential factor in providing suitable habitat for kit fox in this region (Orloff et al. 1986). Therefore, availability of mammal burrows will be increased on protected grasslands consistent with Objectives GNC2.3, ASWNC2.3, and VPNC2.4. Techniques to be implemented to achieve these objectives are described under *CM11 Natural Communities Enhancement and Management.*

Objective ASWNC2.4, VPNC2.5, and GNC2.4 Benefits: Declines in prey abundance have been identified as a factor contributing to reduced kit fox population abundance and distribution (see habitat model in Appendix 2.A, *Covered Species Accounts*). Consequently, consistent with Objectives GNC2.4, ASWNC2.4, and VPNC2.5, protected and restored grassland will be managed to increase the abundance and distribution of San Joaquin kit fox mammalian prey (e.g., discontinued use of pesticides, manipulation of topography, grazing and potentially mowing for increasing ground squirrel densities) in areas that support kit fox. Techniques to be implemented to achieve these objectives are described under *CM11 Natural Communities Enhancement and Management.*

3.3.7.14.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of San Joaquin kit fox within the Plan Area. Grassland protection in Conservation Zone 8 will protect 31% of the San Joaquin kit fox habitat in the Plan Area, and will provide connectivity to the remainder of the northernmost satellite population. Habitat in the Plan Area has marginal value for the kit fox, and this area is not critical to the long-term survival and recovery of the species (Clark et al. 2007a; Smith et al. 2006). Species-specific goals and objectives are not necessary for this species.

3.3.7.15 Suisun Shrew

The Suisun shrew (*Sorex ornatus sinuosus*), one of several subspecies of the ornate shrew, is endemic to the tidal salt and brackish marshes of Solano, Napa, and eastern Sonoma Counties. The species uses a gradient of mature middle and high marsh plain to meet its functional requirements (U.S. Fish and Wildlife Service 2010). High-value habitats support dense, low-lying vegetation of pickleweed (*Sarcocornia pacifica*), cordgrass (*Spartina foliosa*), and gumplant (*Grindelia cuneifolia*), and contain abundant prey of small insects, crustaceans, and other invertebrates. Upland habitats adjacent to tidal marsh also provide cover and sources of food during prolonged flooding of marshes and dikes (Williams 1983). Habitat for Suisun shrew in the Plan Area is represented by tidal brackish emergent wetland in Suisun Marsh and adjacent uplands.

Little information is available on the historical or current abundance of Suisun shrews. Suitable tidal marsh habitat around San Pablo and Suisun Bays that could support the species has declined substantially since early historical times, from about 100,000 acres to around 12,000 acres (Western Ecological Services 1986). The current distribution of the Suisun shrew is limited to isolated remnants of natural tidal and brackish marshes along the northern perimeter of San Pablo Bay and Suisun Marsh, extending as far east as Grizzly Island and as far west as Sonoma Creek and Tubbs Island (Brown and Rudd 1981; Western Ecological Services 1986). All reported occurrences of Suisun shrew in the Plan Area are from the Suisun Marsh in Conservation Zone 11, which contains the largest remaining patches of tidal marsh habitat within the species' range (Figure 2A.16-2).

Degradation of tidal marsh habitats remains the most significant threat to the Suisun shrew. The fragmentation of suitable habitats has isolated Suisun shrew populations, reducing dispersal and gene flow. Small, isolated populations are vulnerable to local extinctions from catastrophic events such as extreme tidal flooding or oil spills. While the loss of tidal marsh habitat from filling and diking has largely ceased, other factors that degrade tidal marsh habitats may still contribute to population declines, including the management of marshes in and around Suisun Marsh (LSA Associates 2007). Contaminants accumulated in the food chain, such as polychlorinated biphenyls, heavy metals, and pesticides, may also degrade habitat and pose a hazard to Suisun shrews (Western Ecological Services 1986).

The conservation strategy for the Suisun shrew involves protecting and restoring brackish tidal marsh wetland natural communities in the Suisun Marsh (Conservation Zone 11). Restoration of large, interconnected patches of tidal brackish wetland will reduce fragmentation, improve habitat functions, and increase opportunities for species dispersal. These efforts should contribute to the growth and expansion of Suisun shrew populations in the Plan Area. However, it may take several decades for the restoration to achieve the mature tidal marsh conditions that constitute high-value habitat for shrews. To minimize this temporal effect, the conservation strategy phases tidal marsh restoration to spread the initial effects of restoration out over time. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM26 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.15.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the Suisun shrew are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.
- **Objective L1.8:** To accommodate sea level rise, provide potential tidal marsh plain within the anticipated future eastward position of the low-salinity zone of the estuary.

Objective L1.7 Benefits: Including upland areas adjacent to restored brackish and freshwater tidal emergent wetland will benefit Suisun shrew both seasonally and over the long term during sea level rise. During high tides, shrews generally move into the halophyte fringe often dominated by the plant fat hen (*Chenopodium album*). However, during prolonged periods of winter high tides, shrews may need to move into the adjacent upland transition areas to avoid drowning (Williams 1983). These upland areas are especially important in the winter as many of the halophyte fringe plants are annuals that do not provide winter cover, and winter tides are often high enough to inundate these higher wetland zones. Upland habitat thus provides cover from predators and inclement winter weather.

Low-gradient upland habitat also provides area for the tidal marsh habitats used by Suisun shrews to migrate in response to rising sea levels. High-gradient transition areas do not allow expansion of shallow waters where emergent wetland habitats important to the shrew can develop. Incorporating low-gradient upland transition zones adjacent to newly created tidal marsh habitat will provide habitat sustainability as sea level continues to rise. Additional grasslands will be protected to provide upland habitat for Suisun shrew beyond the sea level rise accommodation area, as described for Objective GNC1.4, below.

Objective L1.8 Benefits: With sea level rise, the brackish/freshwater boundary will move to the east, potentially expanding Suisun shrews habitat deeper into the Delta. Achieving this objective will provide additional tidal plain habitat in this region of the Delta, which will allow expansion of shrew habitat as it converts over time from freshwater to brackish.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.

- **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: Achieving this objective will benefit the Suisun shrew where management efforts reduce invasive nonnative plant species such as perennial pepperweed and alkali Russian thistle, which can out-compete plant communities that provide Suisun shrew habitat (e.g., pickleweed, cordgrass) and may alter the invertebrate prey community that provides the shrew's forage base. The Implementation Office will also monitor for nonnative predators such as red fox and house cats, and habitat-destroying feral hogs, and will implement control measures if needed. This objective will be met through actions described in *CM11 Natural Communities Enhancement and Management.*

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.

- **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: Tidal marsh restoration design will accommodate the need for movement corridors between large habitat patches, thereby avoiding and minimizing habitat fragmentation for the Suisun shrew. The extent to which habitat fragmentation affects Suisun shrews is unknown, but is probably a concern given that the species uses little, if any, of the managed wetlands that currently separate and isolate patches of tidal marsh habitat.

3.3.7.15.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the Suisun shrew are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.

- **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*.
- **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25.

Objective TBEWNC1.1 Benefits: Restoration of at least 6,000 acres of tidal brackish emergent wetland in the Suisun Marsh will benefit the Suisun shrew by increasing the net extent of habitat available for this species. Approximately 6,000 acres of managed wetlands will be replaced with large expanses of tidal brackish emergent wetland that is functioning naturally. Managed wetlands do not provide suitable habitat for Suisun shrews, as the species is not found in this natural community type.

Objective TBEWNC1.2 Benefits: Compared to low marsh habitats, middle and high marsh wetland communities support plant communities that provide higher value Suisun shrew habitat. Since most of the managed wetlands considered for tidal restoration have subsided to lower elevations, little high or middle tidal marsh is expected to develop post restoration (compared to low marsh) without active management of marsh contours (e.g., grading or tule farming; see *CM4 Tidal Natural Communities Restoration*, Section 3.4.4.3.3, *Methods and Techniques*, for further details). Providing high and middle marsh on at least 1,500 acres of the at least 6,000 acres of restored or created tidal brackish emergent wetland ensures that the tidal brackish marsh restoration will actually benefit Suisun shrew by providing primary habitat (rather than providing predominately low-value low marsh). This objective adds 1,500 acres of modeled primary tidal brackish marsh to the existing 3,171 acres of primary Suisun shrew habitat in Suisun Marsh. Distributing the restoration of high and middle marsh across three marsh complexes ensures the development and expansion of multiple populations, reducing overall species vulnerability to rising sea levels.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
• **Objective TBEWNC2.1:** Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is an invasive forb that out-competes native wetland vegetation, including pickleweed, and forms dense monocultural stands in Suisun Marsh (Trumbo 1994). The California Invasive Plant Council (2012) lists the plant as a severe threat to native vegetation. It is unclear what effect pepperweed invasion could have on the Suisun shrew, although Reynolds and Boyer (2010) found that pepperweed stands altered the local insect and spider community. Meeting this objective will ensure that perennial pepperweed does not impair the functions of the natural community with which the Suisun shrew has evolved. Limiting perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system is consistent with conservation objectives outlined in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.4**: Of the 8,000 acres of grassland protected under Objective GNC1.1 and 2,000 acres of grassland restored under Objective GNC1.2, protect or restore grasslands adjacent to restored tidal brackish emergent wetlands to provide at least 200 feet of adjacent grasslands beyond the sea level rise accommodation area.

Objective GNC1.4 Benefits: Protecting at least 200 feet of grassland beyond the sea level rise accommodation area will benefit Suisun shrew by providing upland habitat for the shrew to use as refugia during high-tide events in the long term, after sea level rise has converted the lower-elevation grasslands to tidal natural communities. During high tides, shrews generally move into the halophyte fringe often dominated by fat hen (a plant). However, during prolonged periods of winter high tides, shrews may need to move into the adjacent upland transition areas to avoid drowning (Williams 1983). These upland areas are especially important in the winter as many of the halophyte fringe plants are annuals that do not provide winter cover, and winter tides are often high enough to inundate these higher wetland zones. Upland habitat thus provides cover from predators and inclement winter weather.

3.3.7.15.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of Suisun shrew within the reserve system. Species-specific goals and objectives are not necessary for this species.

3.3.7.16 California Black Rail

The California black rail (*Laterallus jamaicensis coturniculus*) is a high-marsh species. High-value habitat provides a dense overhead cover of pickleweed and other saline-tolerant plants. In Suisun Marsh, the species has been negatively associated with hardstem and California bulrush (both low marsh species), and saltgrass (a middle and high marsh species that provides little overhead cover and is difficult to traverse), and positively associated with gumplant, which, like pickleweed, is a high marsh plant that provides overhead cover, yet can be traversed and probably provides nesting cover (Spautz et al. 2006). Within the freshwater portion of the Delta, California black rails use the riparian-dominated mid-channel islands of the Sacramento and San Joaquin Rivers, and the cattail marshes of the White Slough Wildlife Area.

The historical range of the California black rail extended from the San Francisco Bay, throughout the Sacramento–San Joaquin Delta, along the coast to northern Baja California, at other southern California locales such as the Salton Sea, and along the lower Colorado River. Loss of tidal marsh habitat since the 1950s has extirpated the species from much of its coastal range, particularly in southern California and much of the San Francisco Bay (Manolis 1978; Garrett and Dunn 1981 in California Department of Water Resources 2001).

Declines in populations of the California black rail in California are a result of habitat loss and degradation along with an increase in exotic predators such as black rats and red foxes (Evens et al. 1991). Evens et al. (1991) examined relative abundance of rails at various locations within the species' range and determined that more than 80% of the remaining population is confined to the northern reaches of the San Francisco Bay estuary. They also determined that the species was subject to continuing and ongoing population decline resulting from habitat loss and/or degradation.

Within the Bay- Delta region, California black rail populations are restricted primarily to the remaining tidal marshlands of the northern San Francisco Bay estuary, the vicinity of Suisun and Napa Marshes, and the mid-channel islands in the Delta. DWR conducted surveys in the Delta in 2009 and 2010. In 2009, researchers located black rails nine times representing two nesting locations: White Slough and at a 25-acre instream island (San Joaquin River) east of Stockton. In 2010, they located rails 31 times—at 12 mid-channel islands and in White Slough—representing 24 nesting pairs.

Overall, habitat availability in the Delta is restricted to remnant wetland sites that are generally unavailable for agricultural uses (Figure 2A.17-2). Insufficient data have been collected to estimate black rail populations within the Plan Area; however, the small populations found in the central Delta portion of the Plan Area likely represent a relatively small proportion of the Bay-Delta region. Regardless, these small populations that persist east of the Suisun Marsh are important relative to the overall range and dispersal capabilities of the species.

The primary conservation approach for California black rail is to restore tidal brackish and freshwater marsh habitat lost to development, and to reduce nonnative predator pressure. The California black rail will also benefit from conservation measures designed to benefit other marsh inhabitants, including the California clapper rail (Section 3.3.7.17). The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM19 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.16.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the California black rail are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objective L1.7 Benefits: Achieving this objective will sustain California black rail habitat by protecting upland transitional areas adjacent to restored brackish and freshwater tidal emergent wetland. This will support the future migration of tidal emergent wetland natural communities in response to sea level rise. As sea level rises and tidal lands are flooded more frequently and with longer duration, there will be a need for freshwater and brackish tidal communities to also shift upward in mean elevation. Without the ability of these habitat types to migrate upward, the existing tidal habitat becomes intertidal and subtidal without being replaced in other, more upland locations.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species. • **Objective L2.7**: Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.

Objective L2.6 Benefits: Consistent with this objective, measures will be implemented as needed to reduce the introduction and proliferation on nonnative wildlife species that threaten California black rail populations. Elsewhere in the San Francisco Bay area, nonnative red foxes, feral cats, and rats have been identified as a threat to nesting populations of rails (Evens and Page 1986; Wood and Nur 2011). As described in *CM11 Natural Communities Enhancement and Management,* monitoring will be conducted to determine whether these or other nonnative animals pose a significant threat to California black rail populations in Suisun Marsh, followed by the implementation of predator control measures, if needed.

Objective L2.7 Benefits: Achieving this objective will benefit the California black rail by promoting the development of additional channel networks and upper marsh habitat. Spautz et al. (2006) found California black rails in Suisun Marsh to be positively correlated with the number of tidal channels less than 1 meter wide. Networks of small channels are generally found in the upper reaches of Suisun Marsh, and often support patches of gumplant nesting cover.

3.3.7.16.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the California black rail are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the least 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
• **Objective TBEWNC2.1:** Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7. • **Objective TFEWNC1.2:** Restore tidal freshwater emergent wetlands in areas that increase connectivity among conservation lands.

Goal TFEWNC2: Biologically diverse tidal freshwater emergent wetland that is enhanced for native species and sustained by natural ecological processes and functions.
• **Objective TFEWNC2.2:** Create topographic heterogeneity in restored tidal freshwater emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objectives TBEWNC1.1, TBEWNC1.2, TFEWNC1.1, and TFEWNC1.2 Benefits: Achieving these objectives will benefit the California black rail by providing additional habitat through restoring at least 16,900 total acres of tidal brackish emergent wetland in Suisun Marsh and tidal freshwater emergent wetland in the Delta region. This will result in a 61% increase in acres of modeled California black rail habitat in the Plan Area: from 27,489 acres to 44,389 acres. Objective TBEWNC1.2 will add 1,500 acres of primary habitat to the existing 4,030 acres of modeled primary California black rail habitat. The restored habitat will consist of large, interconnected patches that will be less vulnerable to habitat edge effects such as encroachment by humans and predators. TFEWNC1.2 will guide the placement of restoration to maximize connectivity among restored and existing habitat to avoid and reduce habitat fragmentation.

Objectives TBEWNC1.4 and TFEWNC2.2 Benefits: Creating topographic heterogeneity in restored tidal brackish and freshwater emergent wetlands will result in a diversity of inundation characteristics and vegetative composition. Elevated areas, especially in the interior portions of the marsh, will provide high marsh supporting suitable plant species that offer overhead cover and suitable nesting habitat for California black rail.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is an invasive forb that out-competes native wetland vegetation, including pickleweed, and forms dense monocultural stands in Suisun Marsh (Trumbo 1994). The California Invasive Plant Council (2012) lists the plant as a severe threat to native vegetation. Although Spautz and Nur (2004) did not find a decline in black rail density as a result of pepperweed presence, they still considered this plant a potential threat if it were to continue to spread. Meeting this objective will ensure that this plant does not impair the functions of the natural community with which the California black rail has evolved. Limiting perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system is consistent with conservation objectives outlined in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species.
• **Objective MWNC1.1:** Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.

Objective MWNC1.1 Benefits: Achieving this objective is expected to benefit the California black rail by enhancing secondary habitat for the species. Portions of the 8,100 acres of protected and enhanced managed wetlands most likely to benefit the species are those in which degraded areas (bare ground or areas infested with invasive species such as monotypic stands of pepperweed) are enhanced and replaced with suitable vegetation such as pickleweed-alkali heath-American bulrush plant associations. Protection and enhancement of managed wetlands to meet this objective will focus on highly degraded areas in order to provide the greatest possible level of enhancement benefit to the managed wetland natural community and associated native species.

3.3.7.16.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for California black rail within the reserve system. The goals and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal CBR1: A reserve system that includes suitable habitat for the future growth and expansion of California black rail populations.
Objective CBR 1.1: At the ecotone that will be created between restored tidal freshwater emergent wetlands and transitional uplands (Objectives L1.3 and TFEW1.1), provide for at least 1,700 acres of California black rail habitat consisting of shallowly inundated emergent vegetation at the upper edge of the marsh (within 50 meters of upland refugia habitat) with adjacent riparian or other shrubs that will provide upland refugia, and other moist soil perennial vegetation.

Objective CBR1.1 Rationale: This objective addresses the need to ensure that a minimum acreage of tidally restored freshwater emergent wetland meets specific habitat requirements for California black rail. The California black rail uses emergent wetland habitats usually within approximately 50 meters of upland habitat with suitable habitat characteristics to provide cover from predators (approximate distance based on a 0.59-hectare circle; Tsao pers. comm.). The mosaic of cover types that occur at the upper edge of the restored tidal marshes includes shallowly inundated emergent vegetation at the upper edge of the marsh; ecotone vegetation composed of moist soil perennials such as rushes (*Juncus* spp.), sedges (*Carex* spp.), swamp smartweed (*Polygonum hydropiperioides*); and higher areas that include shrub and small tree species such as arroyo willow (*Salix lasiolepis*), California rose (*Rosa californica*), and redosier dogwood (*Cornus sericea*) (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*).

3.3.7.17 California Clapper Rail

Typical habitat for the California clapper rail (*Rallus longirostris obsoletus*) consists of dense pickleweed and cordgrass-dominated saline tidal marshes (Zucca 1954; Harvey 1980). The species also uses bulrush and cattail-dominated brackish marshes in the north Bay, including Suisun Marsh (U.S. Fish and Wildlife Service 1998). Suitability of habitat may also depend on other factors, such as patch size, tidal connectivity (within diked marshes), and proximity to other land uses.

The California clapper rail was once very common in the tidal marshes of San Francisco Bay and coastal California. The historical range of this species extended within the coastal California tidal marshes from Humboldt Bay southward to Elkhorn Slough and Morro Bay, and in the estuarine marshes of San Francisco Bay and San Pablo Bay to the Carquinez Strait. Historically, the highest densities of California clapper rails were in south San Francisco Bay (California Department of Water Resources 1994; U.S. Fish and Wildlife Service 1998; LSA Associates 2007).

The California clapper rail was a food source in the 1800s, supporting the gold rush population boom. This dramatically reduced the population, resulting in extirpation from some locations. Development beginning in the 1800s reduced available tidal marsh habitat by 84% (Dedrick 1989). Degradation of tidal marsh habitat continues to be a threat (Williams 1986:1–112; Ohlendorf and Fleming 1988; Ohlendorf et al. 1989; Harvey 1990; Lonzarich et al. 1990; Foerster and Takekawa 1991; Leipsic-Baron 1992; California Department of Fish and Game 2000), primarily as a result of invasive plants such as perennial pepperweed (*Lepidium latifolium*). In the 1980s, predation by red foxes emerged as a population-scale threat, instigating the need for predator control at some locations (Harding et al. 2001). Feral cats and Norway rats have also been identified as potential threats (Schwarzbach et al. 2006).

The current distribution of California clapper rail is limited to San Francisco, San Pablo, and Suisun Bays, and tidal marshes associated with estuarine sloughs draining into these bays (Figure 2A.18-2, and Appendix 2.A, *Covered Species Accounts*) (U.S. Fish and Wildlife Service 1998; Albertson and Evens 2000; California Department of Fish and Game 2000; Liu et al. 2009). USFWS reports that there are populations in all of the larger tidal marshes in south San Francisco Bay. The distribution in the north Bay is patchy and discontinuous, primarily in small, isolated habitat fragments (U.S. Fish and Wildlife Service 1998). Small populations are widely distributed throughout San Pablo Bay and at various locations throughout the Suisun Marsh area (Carquinez Strait to Browns Island, including tidal marshes adjacent to Suisun, Honker, and Grizzly Bays) (U.S. Fish and Wildlife Service 1998). There are 21 occurrence records of this species in Suisun Bay dating from 1978, all within tidal brackish marsh habitats. Liu et al. (2009) found low detection rates in Suisun Marsh during surveys between 2005 and 2008, and found the birds to essentially avoid diked and managed wetlands.

The primary conservation strategy for the California clapper rail is to restore the tidal brackish marsh habitat upon which this species depends. The focus of the Final Tidal Marsh Recovery Plan relative to the California clapper rail is to restore and enhance tidal marsh habitat in Suisun Marsh as a means to increase population numbers and expand the distribution of the species. BDCP implementation will integrate with the existing conservation and enhancement efforts for Suisun Marsh, collectively restoring more extensive patches of suitable habitat that should support larger California clapper rail populations. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM19 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.17.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the California clapper rail are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objective L1.7 Benefits: Achieving this objective will sustain California clapper rail habitat shift by protecting transitional uplands adjacent to brackish communities in the Suisun Marsh. This will support the future migration of brackish and freshwater tidal emergent wetland natural communities in response to sea level rise. As sea level rises and tidal lands are flooded more frequently and with longer duration, there will be a need for freshwater and brackish tidal communities to shift upward in mean elevation. Without the ability of these habitat types to migrate upward, the existing tidal habitat will become intertidal and subtidal without being replaced in other, more upland locations. The Draft Tidal Marsh Recovery Plan recognizes the need to protect upland transition lands (U.S. Fish and Wildlife Service 2010).

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species. • **Objective L2.7**: Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.

Objective L2.6 Benefits: Consistent with this objective, measures will be implemented as needed to reduce the introduction and proliferation of nonnative wildlife species that threaten California clapper rail populations. California clapper rails are subject to heavy predation from nonnative species such as red fox (*Vulpes vulpes*), feral cat (*Felis domesticus*), and Norway rat (*Rattus norvegicus*) as well as various native mammals and raptors (Foerster et al. 1990; Albertson 1995 in LSA Associates 2007; U.S. Fish and Wildlife Service 1998; California Department of Fish and Game 2000). The fragmentation of habitat through the construction of dikes and levees has increased and facilitated predation of clapper rails because terrestrial predators use these features as corridors to access clapper rail habitat (Foerster et al. 1990; Burkett and Lewis 1992). The red fox, the most serious predator on the California clapper rail, has not yet been detected in the Suisun Marsh.

This objective also addresses the threat perennial pepperweed may pose to California clapper rail habitat quality. Perennial pepperweed competes with other native shrubs (e.g., gum plant) that are important winter cover species in the high marsh habitat. The extent to which perennial pepperweed affects the California clapper rail is unknown. Although the areas in Suisun Marsh with the highest level of pepperweed invasion also have the lowest California clapper rail densities, the explanation for this may be that factors making particular areas suitable for pepperweed (relatively low salinity, high elevation, and small tidal prism) also make them less suitable for the California clapper rail (Spautz and Nur 2004). However, in the absence of invasive species control, pepperweed invasions into these currently unsuitable areas may decrease the likelihood of rails colonizing these areas as tidal influence is restored.

Objective L2.7 Benefits: Achieving this objective will benefit the California clapper rail by promoting the development of additional channel networks and upper marsh habitat. The presence of intricate networks of tidal channels in marshes is one of the most important characteristics of high-value rail habitat (Albertson 1996). Muddy channels provide important foraging habitat for California clapper rails during low tides.

3.3.7.17.2 Applicable Natural Communities Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the California clapper rail are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25.

Objectives TBEWNC1.1 and TBEWNC1.2 Benefits: Achieving these objectives will benefit the California clapper rail by providing additional habitat through restoring at least 6,000 total acres of tidal brackish emergent wetland in Suisun Marsh. This will result in a 44% increase in modeled California clapper rail habitat in the Plan Area (from 6,763 acres to 9,763 acres). Objective TBEWNC1.2 will add primary habitat to the existing 306 acres of primary California clapper rail habitat. The restored habitat will consist of large, interconnected patches that will be less vulnerable to habitat edge effects such as encroachment by humans and predators.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is an invasive forb that out-competes native wetland vegetation, including pickleweed, and forms dense monocultural stands in Suisun Marsh (Trumbo 1994). The California Invasive Plant Council (2012) lists the plant as a severe threat to native vegetation. Meeting this objective will ensure that perennial pepperweed does not impair the functions of the natural community with which the California clapper rail has evolved. Limiting perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system is consistent with conservation objectives outlined in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

3.3.7.17.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of California clapper rail within the reserve system. Species-specific goals and objectives are not necessary for this species.

3.3.7.18 Greater Sandhill Crane

Greater sandhill crane (*Grus canadensis tabida*) occurs in the Plan Area during the winter nonbreeding season between October and March. Like many birds, greater sandhill cranes exhibit a high degree of fidelity to their wintering grounds and to specific roosting and foraging habitat areas (Littlefield and Ivey 2000). Wintering habitat for the greater sandhill crane is found almost entirely in cultivated lands, and to a lesser extent in managed wetlands and grasslands, although the most stable winter roost sites are in wetlands. Wintering habitat consists of three primary elements: foraging habitat, loafing habitat, and roosting habitat. Two principal foraging habitat types are used during winter. In the Delta, harvested corn fields are the most commonly used foraging habitat along with winter wheat, alfalfa, pasture, and fallow fields (Pogson and Lindstedt 1988). Use of rice has also been recently documented in the east Delta (Vanklomenpburg pers. comm.). Loafing generally occurs in the middle of the day, when birds loosely congregate along agricultural field borders, levees, rice checks, ditches, managed wetlands, or in alfalfa fields or pastures. During the late afternoon and evening, cranes begin to congregate in large, dense communal groups where they remain until the following morning. Providing protection from predators during the night, roost sites are typically within 2 to 3 miles of foraging and loafing areas (Ivey pers. comm.) and available roosting sites are an essential component of winter habitat. Roosting habitat typically consists of shallowly flooded open fields of variable size (1 to 300 acres) or wetlands interspersed with uplands (Littlefield and Ivey 2000).

Of the estimated total population of 62,600 greater sandhill cranes, an estimated 8,500 (14%) belong to the Central Valley population (Littlefield and Ivey 2000). The Central Valley population breeds from British Columbia to northern California and winters in the Central Valley, arriving in October and reaching maximum densities in December and January. There are two important greater sandhill crane wintering areas in the Central Valley, which have been geographically defined (Pogson and Lindstedt 1988, Littlefield and Ivey 2000, Ivey pers. comm.); they are collectively referred to here as the Greater Sandhill Crane Winter Use Area (Figure 2A.19-2). One is within the Plan Area and the other is in the Butte Basin in Sutter and Glenn Counties. The Greater Sandhill Crane Winter Use Area in the Plan Area includes lands in Conservation Zones 3, 4, 5, and 6, which includes the central Delta and northern Delta east of the Stockton DWSC (Figure 2A.19-2).

Populations of the greater sandhill crane have declined primarily because of effects on their breeding grounds; however, winter habitat in the Central Valley has been reduced because changes in crop patterns have reduced compatible agricultural crop types in traditional wintering areas. The most significant threat to wintering greater sandhill cranes in the Plan Area is the continued loss of traditional winter habitat from urbanization and agricultural conversion (Littlefield and Ivey 2000). While relatively limited urbanization has occurred to date within key crane areas, surrounding development and increased levels of human disturbance may threaten the long-term sustainability of important wintering lands. In the Delta region, the conversion of suitable agricultural foraging and roosting habitats to unsuitable cover types, particularly orchards and vineyards, has removed key habitats and altered the distribution and behavior of wintering greater sandhill cranes. However, the effect of land use changes on the total winter population size is unclear. While portions of the wintering population have been monitored periodically prior to and since the mid-1980s when Littlefield and Ivey (2000) estimated a winter population of 8,500 birds, no other comprehensive survey has been conducted and information has been insufficient to reliably detect trends.

Crane abundance and distribution in the Plan Area is thought to depend on three primary factors: the availability and distribution of suitable cultivated land types, food availability in suitable cultivated lands, and proximity to nighttime roosting habitat. To maintain the population of cranes in the Plan Area, the conservation strategy focuses on maintaining and enhancing suitable foraging habitats on cultivated lands and maintaining and expanding the distribution of managed roosting habitat in the Greater Sandhill Crane Winter Use Area.

The conservation strategy for the greater sandhill crane involves acquiring permanent easements on and fee-title to target lands according to siting and design criteria specified in *CM3 Natural Communities Protection and Restoration* that will then be managed according to the specific guidance in *CM11 Natural Communities Enhancement and Management*. Conservation lands that support greater sandhill crane habitat in the Greater Sandhill Crane Winter Use Area will increase 2 to 3% through implementation of the conservation strategy, and will result in protection of at least 25% of modeled crane habitat. The strategy is expected to help stabilize agricultural patterns in the Greater Sandhill Crane Winter Use Area and provide additional high-value roosting and foraging habitats. The strategy will also focus, to the extent possible, on shifting the crane distribution onto higher elevation lands not subject to the effects of sea level rise and seasonal flood events. The creation of new roosting sites is expected to facilitate use of otherwise underused but suitable foraging and loafing habitats that are currently distant from existing roosting sites. The conservation strategy is expected to further facilitate increased use of currently sparsely used areas in the Greater Sandhill Crane Winter Use Area by coordinating the acquisition of roosting sites with cultivated land conservation easements. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM20 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.18.1 Applicable Landscape-Scale Goals and Objectives

While the landscape goals and objectives will provide broad-based benefits to the ecosystems upon which greater sandhill cranes depend, none are integral to the conservation strategy for this species.

3.3.7.18.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the greater sandhill crane are stated below.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.
• **Objective CLNC1.1:** Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species. • **Objective CLNC1.2**: Target cultivated land conservation to provide connectivity between other conservation lands. • **Objective CLNC1.3**: Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objective CLNC1.1 Benefits: The key to sustaining greater sandhill crane populations in the Plan Area is the sustainability of an economically viable and compatible cultivated landscape. This objective will protect sufficient suitable habitat in the Plan Area for covered species associated with cultivated lands, including the greater sandhill crane. Achieving this objective will offset the loss of cultivated land values from construction actions and the conversion of cultivated lands to tidal restoration. Combined with other conservation lands in the Plan Area and assuming that cultivated land uses will otherwise continue to provide habitat value to covered species in the Plan Area, achieving this objective will address the effects of covered activities on cultivated land values and conserve greater sandhill crane and other covered species associated with cultivated lands.

Objective CLNC1.2 Benefits: Achieving this objective will promote connectivity of suitable cultivated lands to provide for larger parcels of suitable greater sandhill crane wintering habitat. Greater sandhill cranes are highly traditional to roosting sites within the Greater Sandhill Crane Winter Use Area and suitable cultivated land foraging habitat must be in close proximity to these sites to sustain long-term use patterns. Therefore, protecting lands that are adjacent or near traditional crane roosts or foraging habitats will help to sustain and expand these existing use patterns. For example, with the increase in crane use of lands on and surrounding the Stone Lakes National Wildlife Refuge (Appendix 2.A, *Covered Species Accounts*), protecting and managing adjacent lands may help to increase use of this area and expand the cranes' winter distribution within Conservation Zone 4.

Objective CLNC1.3 Benefits: Achieving this objective will retain existing noncultivated habitat elements on protected cultivated lands through the retention of seasonal wetlands and upland edges that sometimes occur in association with cultivated lands.

3.3.7.18.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for greater sandhill crane within the reserve system. The goals and objectives below address additional species-specific needs that will otherwise not be met at the landscape or natural community scale.

Goal GSHC1: Protection and expansion of greater sandhill crane winter range.

- **Objective GSHC1.1**: Within the 48,625 acres of cultivated lands protected under Objective CLNC1.1, protect 7,300 acres of high- to very high-value habitat for greater sandhill crane, with at least 80% maintained in very high-value types in any given year, as defined in *CM3 Natural Communities Protection and Restoration*. This protected habitat will be within 2 miles of known roosting sites in Conservation Zones 3, 4, 5, and/or 6 and will consider sea level rise and local seasonal flood events, greater sandhill crane population levels, and the location of foraging habitat loss. Patch size of protected cultivated lands will be at least 160 acres.
- **Objective GSHC1.2:** To create additional high-value greater sandhill crane winter foraging habitat, at least 10% of the habitat protected under Objective GSHC1.1 will involve acquiring low-value habitat or nonhabitat areas and converting it to high- or very high-value habitat. Created habitat will be within 2 miles of known roosting sites in Conservation Zones 3, 4, 5, and/or 6 and will consider sea level rise and local seasonal flood events, greater sandhill crane population level, and the location of habitat loss.
- **Objective GSHC1.3:** Create 320 acres of managed wetlands consisting of greater sandhill crane roosting habitat in minimum patch sizes of 40 acres within the Greater Sandhill Crane Winter Use Area[53] in Conservation Zones 3, 4, 5, or 6, with consideration of sea level rise and local seasonal flood events. The wetlands will be located within 2 miles of existing permanent roost sites and protected in association with other protected natural community types (excluding nonhabitat cultivated lands) at a ratio of 2:1 upland to wetland to provide buffers around the wetlands.
- **Objective GSHC1.4:** In addition to the 320 acres of created managed wetland greater sandhill crane roosting habitat (Objective GSHC1.3), create two wetland complexes within the Stone Lakes National Wildlife Refuge project boundary[54]. The complexes will be no more than 2 miles apart and will help provide connectivity between the Stone Lakes and Cosumnes greater sandhill crane populations. Each complex will consist of at least three wetlands totaling 90 acres of greater sandhill crane roosting habitat, and will be protected in association with other protected natural community types (excluding nonhabitat cultivated lands) at a ratio of at least 2:1 uplands to wetlands (i.e., two sites with 90 acres of wetlands each). One of the 90-acre wetland complexes may be replaced by 180 acres of cultivated lands (e.g., cornfields) that are flooded following harvest to support roosting cranes and provide highest-value foraging habitat, provided such substitution is consistent with the long-term conservation goals of Stone Lakes National Wildlife Refuge for greater sandhill crane.
- **Objective GSHC1.5:** Create an additional 95 acres of roosting habitat within 2 miles of existing permanent roost sites. The habitat will consist of active cornfields that are flooded following harvest to support roosting cranes and that provide highest-value foraging habitat. Individual fields will be at least 40 acres and can shift locations throughout the Greater Sandhill Crane Winter Use Area, but will be sited with consideration of the location of roosting habitat loss and will be in place prior to roosting habitat loss.

Objective GSHC1.1 Rationale: While Objective CLNC1.1 protects cultivated lands throughout the Plan Area to support covered species associated with these lands, Objective GSHC1.1 establishes the proportion of this overall protection that will be applied to the conservation of the species within the Greater Sandhill Crane Winter Use Area. Because the most important stressor on this species is the conversion of suitable crops in the Winter Use Area to unsuitable crops, the key to long-term conservation of the winter population is sustaining sufficient amounts and types of suitable cultivated lands.

[53] Important geographically defined greater sandhill crane wintering areas in the Central Valley (Pogson and Lindstedt 1988; Littlefield and Ivey 2000; Ivey pers. comm.) (Figure 2A.19-2).

[54] The project boundary delineates the area surrounding the existing refuge for which the refuge has authority to acquire land or easements.

The cultivated land base in the Winter Use Area has remained relatively stable; however, because crop patterns are subject to agricultural economic influences, the extent of the landscape that provides suitable habitat for the crane is less stable and uncertain over time. Additionally, many of the cultivated lands in the Winter Use Area have been converted from crop types that provide habitat for the species to unsuitable vineyards. Therefore, the strategy for the greater sandhill crane is focused on conserving cultivated lands that provide high-value habitat for the crane, to increase the stability and certainty of compatible crops in the Winter Use Area.

The strategy involves targeting lands in Conservation Zones 3, 4, 5, and/or 6 (areas in the Plan Area that are within the Winter Use Area and excluding lands most vulnerable to sea level rise), where they are needed most because of rapid conversion to nonhabitat land cover types, and managing those lands as high-value foraging habitat for cranes. Objective GSHC1.1 requires that conservation lands providing foraging habitat be within 2 miles of known roost sites: This is because the highest levels of use are typically within approximately 2 miles of known roosts, and use (measured as a function of observed crane density) decreases beyond approximately 2 miles of a roost (Ivey pers. comm.). Objective GSHC1.1 also specifies that 80% of this foraging habitat will be managed at the highest habitat value in any given year (Table 3.3-4). Waste corn is the key food item for greater sandhill cranes in the Delta; therefore corn is considered the highest-value crop type. Rice is also a very high-value type, but only a relatively small proportion of the Winter Use Area is capable of supporting rice agriculture. Because crane reserves will represent a relatively small proportion of the available habitat within the Winter Use Area, managing the majority of this area to maximize food value for cranes could be important in sustaining the winter population. Therefore, 80% of the crane reserve acreage will be maintained in the highest-value crop types. The remaining 20% will be managed as at least high-value habitat (Table 3.3-4), which allows for crop rotations and other factors that could influence agricultural productivity. Sea level rise and local seasonal flood events will be considered when siting conservation lands, because crane foraging habitat is likely to become unsuitable at lower elevations with sea level rise as these areas become flooded. Additionally, crane habitat may become unsuitable as a result of large flood events within river floodplains. The minimum patch size is relatively large (160 acres) to minimize the potential effects of human-associated visual and noise disturbances.

Table 3.3-6. Assigned Greater Sandhill Crane Foraging Habitat Value Classes for Agricultural Crop Types

Foraging Habitat Value Class	Agricultural Crop Type
Very high	Corn, rice
High	Alfalfa, irrigated pasture, wheat
Medium	Other grain crops (barley, oats, sorghum)
Low	Other irrigated field and truck crops
None	Orchards, vineyards

This objective will conserve cultivated lands sufficient to address the loss of cultivated land habitat value, and additional enhancement provided through GSHC1.2, as described below, will provide for the conservation and management of greater sandhill crane in the Plan Area.

Objective GSHC1.2 Rationale: Achieving this objective will enhance or create foraging habitat by requiring that 10% of the lands protected under GSHC1.1 be converted from an initial low- or no-value crop type to a high- or very high-value crop type (Table 3.3-4). Requiring that 10% (730 acres) of the crane reserves be created or enhanced by converting unsuitable crops to high-value crops will help to redress the past conversion from high-value to low-value crop types. The strategy involves targeting lands in Conservation Zones 3, 4, 5, and/or 6, which are zones in the Plan Area that are include the Winter Use Area and do not include the lands most vulnerable to sea level rise. Sea level rise and local seasonal flood events will be considered when siting conservation lands because crane foraging habitat is likely to become unsuitable at lower elevations with sea level rise as these areas become flooded. Additionally, crane habitat may become unsuitable as a result of large flood events within river floodplains.

Objective GSHC1.3 Rationale: Managed wetlands provide suitable foraging habitat and potential roosting habitat for greater sandhill cranes. Achieving this objective may increase the number and distribution of crane roost sites in the Greater Sandhill Crane Winter Use Area by creating 320 acres of greater sandhill crane roosting habitat within managed seasonal wetland. Currently, the Plan Area contains 7,340 acres of greater sandhill crane habitat, 86% of which is within existing conservation lands. Creation of at least 320 acres of managed wetland will increase the extent of protected habitat to 91%. The new crane roosts, each at least 40 acres in size, will supplement the existing network of roosts in the Winter Use Area. The rationale for conservation lands in Conservation Zones 3, 4, 5, or 6, with consideration of sea level rise and local flood events, within 2 miles of existing permanent roost sites, is provided in Objective GSHC1.2, above. The managed wetlands will be conserved in association with other natural community types at a ratio of 2:1 upland to wetland to provide buffers around the wetlands that will protect cranes from the types of disturbances that would otherwise result from adjacent roads and developed areas (e.g., roads, noise, visual disturbance, lighting). This is the average upland to wetland ratio for crane roosting habitat on Stone Lakes National Wildlife Refuge (McDermott pers. comm.).

Objective GSHC1.4 Rationale: Objective GSHC1.4 ensures that 180 acres of crane roosting habitat will be constructed within the Stone Lakes National Wildlife Refuge project boundary[55] (Figure 3.3-7). Achieving this objective will promote continued use and expanded use by cranes onto the Stone Lakes National Wildlife Refuge and surrounding lands and will provide additional connectivity between these lands and the Cosumnes River Preserve. Creating roosting habitat near the Greater Sandhill Crane Winter Use Area within the refuge will facilitate use of underused cultivated land foraging habitat in that area and expand the winter distribution. The strategy includes using newly created roosting sites as a management tool to attract cranes out of low-elevation zones that have greater uncertainty to exist in the future, due to the potential for levee failure or flooding.

The area outside the Stone Lakes National Wildlife Refuge but within the refuge project boundary (the area for which the refuge has authority to acquire land or easements) has largely been converted to vineyards, which do not provide habitat for cranes. Additional areas within the project boundary and surrounding lands are threatened by future conversion to vineyards. Past conversion has created an approximately 4-mile gap between wintering cranes in the Stone Lakes and Cosumnes areas. Creating two wetland complexes no more than 2 miles apart in this area will provide improved habitat connectivity between the Stone Lakes and Cosumnes crane populations. It will also ensure that conservation occurs in the vicinity of conveyance facility impacts, to offset losses that might otherwise cause some cranes to leave the area, and in an area where the crane population is constrained by urbanization to the east and sea level rise to the west. Conserved lands within the refuge project

[55] The project boundary delineates the area surrounding the existing refuge for which the refuge has authority to acquire land or easements.

boundary will be transferred to the refuge to ensure management consistent with the rest of the refuge lands, therefore contributing to a regional management strategy for the crane.

Creating several (3 to 5) wetlands in association with each other provides the ability to apply different management regimes to the wetlands, with different depths, timing, and duration of flooding. A diversity of conditions maximizes opportunities for establishing and retaining roosting cranes (McDermott pers. comm.). The wetland blocks provided in this objective are larger than the minimum block size stipulated in Objective GSHC1.3 because of the added need for conservation in this critical area where conversion to vineyards, urbanization to the east, and sea level rise to the west threaten the wintering crane population.

Objective GSHC1.5 Rationale: This objective addresses the loss of winter-flooded corn fields that serve as both roosting habitat and highest-value foraging habitat within the Greater Sandhill Crane Winter Use Area. This type of crane roosting habitat is usually temporary as a result of seasonal changes in farm practices, crop rotational changes, or other management. This habitat type supplements the more static managed wetlands that serve as the primary roosting areas for cranes. These temporary roosting/foraging habitats allow cranes to vary their seasonal movement patterns and spread out into otherwise underused areas of the Delta; it also reduces opportunities for excessively dense roosting concentrations. Objective GSHC1.5 is designed to provide similar function by allowing fields to rotate through the crane use area within protected cultivated lands. This will serve as a secondary source of high-value crane roosting/foraging habitat and provide a dynamic element to the crane conservation program. This objective is intended to offset loss of crane roosting habitat, and the compensatory roosting habitat will be in place prior to loss of roosting habitat as a result of water conveyance facility construction.

3.3.7.19 Least Bell's Vireo

The least Bell's vireo (*Vireo bellii pusillus*) is an obligate riparian breeder that typically inhabits structurally diverse woodlands, including cottonwood-willow woodlands and forests, oak woodlands, and mule fat scrub (U.S. Fish and Wildlife Service 1998). Two features appear to be essential for breeding habitat: the presence of dense cover within 3 to 6 feet (1 to 2 meters) of the ground, where nests are typically sited; and a dense stratified canopy for foraging (Goldwasser 1981; Gray and Greaves 1981; Salata 1981, 1983; Regional Environmental Consultants 1989). Least Bell's vireo territories can range in size from 0.5 to 7.2 acres. Least Bell's vireos exhibit strong site fidelity, sometimes even returning to the same shrub for nesting every year (Riparian Habitat Joint Venture 2004).

A neotropical migrant, the least Bell's vireo breeds entirely in California and northern Baja California. Its historical breeding distribution once extended from coastal southern California through the San Joaquin and Sacramento Valleys as far north as Tehama County near Red Bluff. The Sacramento and San Joaquin Valleys were considered the center of the species' historical breeding range supporting 60 to 80% of the historical population (51 FR 16474). By 1986, USFWS determined that least Bell's vireo had been extirpated from most of its historical range and numbered approximately 300 pairs statewide (51 FR 16474). The population size since increased to an estimated 2,000 pairs in 1998 (Kus 2002), and the breeding range has expanded northwards, with nest sites reported from the San Joaquin River National Wildlife Refuge (Howell et al. 2010) and the Yolo Bypass Wildlife Area (California Department of Fish and Game 2012). The recent documentation of the species in the Yolo Bypass (in the Plan Area) and breeding nearby at the San Joaquin National Wildlife Refuge has heightened awareness of the species' conservation potential in the Plan Area (Figure 2A.20-2).

Habitat loss and fragmentation and cowbird parasitism have been the primary factors leading to the decline of least Bell's vireo (Kus 2002). Flood control and channelization are also stressors on this species; riparian areas are adapted to periodic flooding, and fluvial disturbances promote the development of vegetative structure suitable for least Bell's vireo. Additionally, this species is susceptible to nest abandonment resulting from human disturbance (Kus 2002).

Critical habitat for this state and federally endangered species was designated in 1994, although there is no designated critical habitat in the Plan Area. The *Draft Recovery Plan for the Least Bell's Vireo* emphasizes the need for habitat protection and restoration (U.S. Fish and Wildlife Service 1998). Least Bell's vireo is a focal species of the *Riparian Bird Conservation Plan* (Riparian Habitat Joint Venture 2004), which provides data and recommendations for conservation of riparian birds in California. Riparian habitat creation and restoration are underway throughout California (Riparian Habitat Joint Venture 2004), and the least Bell's vireo is listed as a covered species in at least two northern California HCPs (the *Yolo Natural Heritage Program Plan* and the *Santa Clara Valley HCP/NCCP*, both of which are not yet completed). Actions implemented under those HCPs and the BDCP have the potential to act in synergy toward partial recovery of the least Bell's vireo.

The conservation strategy for least Bell's vireo species involves riparian protection, restoration, and management that promote vegetation structurally suitable for the species, as well as floodplain restoration to reestablish seasonal patterns of fluvial disturbances that promote development of high value riparian habitat. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM22 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.19.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the least Bell's vireo are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.5:** In restored floodplains, provide a range of elevations that transition from frequently flooded (e.g., every 1 to 2 years) to infrequently flooded (e.g., every 10 years or more) areas to provide a range of habitat conditions, upland habitat values, and refugia from flooding during most flood events.
- **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.5 Benefits: Least Bell's vireo will benefit from the transition from seldom flooded to frequently flooded floodplain, consistent with this objective. The elevational transition from low to high ground within the floodplain is expected to provide some relatively dry areas within the floodplain characteristic of uplands (grasslands and scattered shrubs). Least Bell's vireos are among many riparian species that commonly use upland habitat adjacent to riparian nesting sites; these upland areas act as both flood refugia and supplemental foraging areas. Additionally, natural uplands adjacent to restored and protected riparian natural community in the reserve system are important for reducing adverse effects of adjacent land use. Vireos with territories bordering on agricultural land and urban areas are significantly less successful in producing young, compared to vireos in territories bordering undeveloped uplands (Riparian Habitat Joint Venture 2004).

Objective L1.6 Benefits: Increasing the size and connectivity of the reserve system, consistent with this objective, will reduce the risk of riparian natural community fragmentation in the Plan Area. Habitat fragmentation is a primary stressor for this species. The need for large, unfragmented blocks of least Bell's vireo habitat is further described below, for Goal VFRNC1.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances. • **Objective L2.6:** Increase native biodiversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.1 Benefits: Least Bell's vireo will benefit from the restoration of fluvial disturbance regimes that encourage establishment of early- to midsuccessional riparian vegetation, consistent with this objective. Early- to midsuccessional vegetation comprises the dense shrub cover required by least Bell's vireo for nest concealment as well as structurally diverse canopy for foraging (Kus 2002); see also Objective VFRNC2.2, below.

Objective L2.6 Benefits: As described above, least Bell's vireo requires structural diversity in its breeding habitat. Large, monotypic stands of invasive plants can diminish this structural diversity and render habitat unsuitable for the species. Invasive nonnative species that diminish structural diversity and degrade least Bell's vireo habitat conditions include giant reed (*Arundo donax*) and tamarisk (*Tamarix chinensis*) (Riparian Habitat Joint Venture 2004). Invasive plants such as these will be controlled as part of *CM11 Natural Communities Enhancement and Management.* Control of invasive species and maintenance of native vegetation diversity will maintain and enhance vireo habitat.

This objective also addresses the potential need to control nonnative brown-headed cowbird populations. As described in *CM11 Natural Communities Enhancement and Management,* a cowbird control program will be implemented if it is determined through population monitoring that the least Bell's vireo population in the Plan Area is being declining as a result of cowbird parasitism*.*

3.3.7.19.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the least Bell's vireo are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objective VFRNC1.1 Benefits: This objective will increase the likelihood for least Bell's vireo to establish a breeding population in the Plan Area by restoring 5,000 acres of valley/foothill riparian habitat (Figure 2A.20-2), at least 3,000 acres of which will be in wide bands and large, interconnected patches within restored seasonally inundated floodplain. Least Bell's vireos occur in disproportionately high frequencies in wider sections (greater than 250 meters) of riparian habitat, relative to site availability (Kus 2002). The species is also susceptible to nest abandonment as a result of human disturbance, and habitat fragmentation increases the potential for human disturbance. Most riparian corridors in the Plan Area do not currently support sufficiently large wide bands of habitat for least Bell's vireo breeding, so restoration is needed to increase widths to be suitable for breeding habitat. A reserve system with extensive wide bands or large patches of interconnected valley/foothill riparian natural community (Goal VFRNC1) will reduce loss and fragmentation of least Bell's vireo riparian habitat. A large fraction of the 5,000 acres of restored valley/foothill riparian woodland is expected to provide suitable early- to midsuccessional riparian vegetation for this species.

Objective VFRNC1.2 Benefits: This objective will provide least Bell's vireo with some benefit from the protection of 750 acres of existing valley/foothill riparian forest in Conservation Zone 7 in the near- term implementation period. However, the entire 750 acres of protected riparian natural community will not necessarily provide the vegetative structure necessary to support this species (Objective VFRNC2.1).

Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.

- **Objective VFRNC2.1:** Restore, maintain and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands.
- **Objective VFRNC2.2:** Maintain 1,000 acres of early- to midsuccessional vegetation with a well-developed understory of dense shrubs on restored seasonally inundated floodplain.

Objectives VFRNC2.1 and VFRNC2.2 Benefits: Least Bell's vireo will benefit from the maintenance and enhancement of early- to midsuccessional riparian vegetation that is structurally diverse. Least Bell's vireo requires riparian habitat with a relatively open canopy and dense understory. Least Bell's vireos favor early- to midsuccessional riparian vegetation with a well-developed understory of dense shrubs and relatively open canopy. Their nests are typically located in shrubs approximately 1 meter above the ground, and they often forage in taller trees associated with the shrub layer. Riparian stands between 5 and 10 years of age are most suitable for supporting least Bell's vireo (Riparian Habitat Joint Venture 2004), although vegetation structure more than age appears to be the important determinant of site use. Early-successional habitat typically supports the dense shrub cover required for nesting and a structurally diverse canopy for foraging. As stands mature, the tall canopy tends to shade out the shrub layer, making the sites less suitable for nesting; however, least Bell's vireos will continue to use such areas if patches of understory exist (U.S. Fish and Wildlife Service 1998).

Although maintenance of natural or artificial fluvial disturbance consistent with Objective L2.1 will result in a mosaic of different aged habitat patches (including early- to midsuccessional and late-successional vegetation) and structural habitat diversity, Goals VFRNC2.1 and VFRNC2.2 will further ensure structural diversity and will maintain a representative amount of vegetation at an appropriate successional stage for least Bell's vireo. However, active management, as described in *CM11 Natural Communities Enhancement and Management,* may be necessary to ensure that sufficient structural diversity is present in the reserve system to support least Bell's vireo and other native species that rely on similar habitat structure.

Although least Bell's vireo is not known to presently breed in the Plan Area, three singing males and one female were detected in the Yolo Bypass Wildlife Area during the 2010 breeding season, two singing males were detected in the Yolo Bypass Wildlife Area in 2011, and a single breeding pair recently nested for multiple years immediately south of the Plan Area along the San Joaquin River. This indicates that the species has potential to reestablish itself in suitable habitat in the Plan Area.

Consistent with Objective VFRNC2.2, the reserve system will include suitable habitat for the growth and expansion of a breeding least Bell's vireo population in the Central Valley. Given the relatively small territory size of least Bell's vireo, the large acreage of riparian habitat to be restored, recent breeding records in restored riparian habitat at the nearby San Joaquin River National Wildlife Refuge, and past success in establishing breeding least Bell's vireo pairs in restored habitat (Kus 2002), restoration of riparian natural community under the BDCP have the potential to significantly increase the likelihood of population reestablishment and expansion in the Plan Area.

3.3.7.19.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of least Bell's vireo in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.20 Suisun Song Sparrow

The Suisun song sparrow (*Melospiza melodia maxillaris*) is a nonmigratory songbird endemic to the tidal salt marshes of the Suisun Bay. Suitable habitat for Suisun song sparrow within the Plan Area is primarily represented by tidal brackish emergent wetland and tidal freshwater emergent wetland. The species occupies areas dominated by cordgrass, pickleweed, and gum plant in tidal brackish emergent wetlands, and sedges, cattails, and rushes in tidal freshwater emergent wetlands (Spautz and Nur 2008). Song sparrows also inhabit areas dominated by the invasive perennial pepperweed. Dense vegetation is required for nesting sites, song perches, and refuge from predators (Marshall 1948). Exposed ground such as openings in the tidal marsh and slough margins are important for foraging. Highest densities are found adjacent to upland habitat, and upland transition zones are important refugia during high-tide events and are used by these sparrows at other times as well.

Suisun song sparrow is confined to tidal salt and brackish marshes extending from the Carquinez Strait east to Antioch at the confluence of the San Joaquin and Sacramento Rivers (Grinnell and Miller 1944; Spautz and Nur 2008). The current range of the species remains relatively unchanged since Grinnel and Miller's (1944) description. However, the current distribution is defined by the extent of remaining tidal marsh habitats, which occur primarily along the fringes of the Carquinez Strait and Suisun Bay. Spautz and Nur (2008), citing unpublished data from the Point Reyes Bird Observatory, estimated the total population of Suisun song sparrows to be 43,000 to 66,000 breeding pairs, approximately one-third of the estimated historical population size (Spautz and Nur 2008). Densities in the tidal marsh of Suisun Bay vary widely based on habitat conditions and suitability (Spautz and Nur 2008). Within the Plan Area, most sightings of Suisun song sparrow are from the Suisun Marsh in Conservation Zone 11 (Figure 2A.21-2).

Habitat loss and fragmentation caused by diking, levee construction, channelization, invasive species such as pepperweed, and urbanization remain the primary threats to the Suisun song sparrow (Larsen 1989; Spautz and Nur 2008). Throughout most of the Suisun Marsh, the tidal marsh has been reduced to small fragments that are separated by dispersal barriers or only connected by very narrow strips of vegetation remaining along the banks of tidal sloughs, reducing dispersal, gene flow, and reproduction (Larsen 1989). Small, isolated populations are vulnerable to local extinctions from chance catastrophic events, particularly for highly sedentary species like the Suisun song sparrow. High levels of nest predation may also be a significant threat to the species (Spautz and Nur 2008). Other potential threats include toxins introduced into the system (e.g., oils, sewage) and changes in freshwater outflows that could affect salinity and habitat composition in Suisun Marsh (Larsen 1989).

The conservation strategy for this species involves restoring, protecting, and managing tidal brackish emergent wetlands in the Suisun Marsh. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM22 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.20.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the Suisun song sparrow are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objective L1.7 Benefits: Protecting upland areas adjacent to restored brackish and freshwater tidal emergent wetland, consistent with this objective, will benefit Suisun song sparrow in the short term, and in the long term during anticipated sea level rise. As sea level rises and existing tidal lands are flooded more frequently and with longer duration, there will be a need for freshwater and brackish tidal communities to shift upward in mean elevation. Without the ability of these habitat types to migrate upward, the existing tidal habitat will become intertidal and subtidal without being replaced in other, more upland locations. Protecting transitional areas will provide upland habitat for Suisun song sparrows prior to the point in time when it converts to wetland habitat as a result of sea level rise. Upland habitat in and of itself is a very important component of the suite of habitats used by this bird, especially as refugia during high-tide events. As described for Objective GNC1.4, below, grasslands will also be protected beyond the sea level rise accommodation area.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.

- **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.
- **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels in tidal brackish marsh to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species.

Objective L2.6 Benefits: This objective will address the potential need to control nonnative predators that might be a threat to Suisun song sparrow populations. In at least parts of its range, nonnative red foxes, feral cats, and Norway rats have been identified as a threat to nesting populations of Suisun song sparrows (Spautz and Nur 2008). Suisun Marsh populations, in particular, suffer high rates of nest loss to predators (Greenberg et al. 2006). Under this objective, an assessment will be conducted to determine whether nonnative nest predators pose a significant threat to Suisun song sparrow populations in Suisun Marsh, followed by the implementation of predator control measures if needed. Nonnative smooth cordgrass (*Spartina alterniflora*) and perennial pepperweed have been identified as possible threats to Suisun song sparrows. However, *Spartina* invasion is not yet an issue in Suisun Marsh, and peppergrass appears effects appear to be either positive or neutral (Spautz et al. 2006).

Objective L2.7 Benefits: This objective addresses the need for channel habitat throughout the marsh plain. Suisun song sparrows are associated primarily with tidal channels, especially in marshes where pickleweed dominates and gumplant lines the channels (Spautz and Nur 2008). Promoting the development of additional channel networks will benefit Suisun song sparrows by creating channel margins that support favorable habitat conditions for this species.

3.3.7.20.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the Suisun song sparrow are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* Restore the at least 1,500 acres of middle and high marsh by year 25.

Objective TBEWNC1.1 Benefits: This objective addresses the need for restoring tidal brackish emergent wetland in Suisun Marsh and tidal freshwater emergent wetland in the Delta region. The intended restoration for tidal marshes will benefit Suisun song sparrows by providing additional habitat.

Objective TBEWNC1.2 Benefits: Because of the composition of plant communities most important to Suisun song sparrows, middle and high marsh wetland communities provide higher ecological value than low marsh habitats. Given that most of the managed wetlands considered for tidal restoration have subsided to lower elevations, little high or middle tidal marsh is expected to develop after restoration (compared to low marsh) without active management of marsh contours (e.g., grading). Restoring at least 1,500 acres of the at least 6,000 acres of tidal brackish emergent wetland as high and middle marsh, will ensure that the restoration benefits song sparrows by providing primary habitat (rather than predominately low-value low marsh). This objective adds 1,500 acres of primary tidal brackish marsh to the existing 3,761 acres of primary Suisun song sparrow habitat in Suisun Marsh. Distributing the restoration of high and middle marsh across three marsh complexes promotes the development and expansion of multiple populations, a hedge against rising sea levels.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is an invasive forb that out-competes native wetland vegetation, including pickleweed, and forms dense monocultural stands in Suisun Marsh (Trumbo 1994). The California Invasive Plant Council (2012) lists the plant as a severe threat to native vegetation. Although Spautz and Nur (2004) did find Suisun song sparrow densities to be higher in pepperweed stands, due to greater structure than pickleweed, they did caution that the continued increase of this plant could reach a certain threshold at which it could have a deleterious effect. Meeting this objective will ensure that perennial pepperweed does not impair the functions of the natural community with which the Suisun song sparrow has evolved. Limiting perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system is consistent with conservation objectives outlined in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species.
• **Objective MWNC1.1:** Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.

Objective MWNC1.1 Benefit: Achieving this objective is expected to benefit the Suisun song sparrow by enhancing secondary habitat for the species. Portions of the 8,100 acres of protected and enhanced managed wetlands most likely to benefit the species are those in which degraded areas (bare ground or areas infested with invasive species such as monotypic stands of pepperweed) are enhanced and replaced with dense vegetation required for nesting sites, song perches, and refuge from predators. Protection and enhancement of managed wetlands to meet this objective will focus on highly degraded areas to provide the greatest possible level of enhancement benefit to the managed wetland natural community and associated native species.

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.4**: Of the 8,000 acres of grassland protected under Objective GNC1.1 and 2,000 acres of grassland restored under Objective GNC1.2, protect or restore grasslands adjacent to restored tidal brackish emergent wetlands to provide at least 200 feet of adjacent grasslands beyond the sea level rise accommodation area.

Objective GNC1.4 Benefits: Upland habitat is a very important component of the suite of habitats used by the Suisun song sparrow, especially as refugia during high-tide events. Protecting at least 200 feet of grassland beyond the sea level rise accommodation area will benefit Suisun song sparrow by providing upland habitat for the species to use as refugia during high-tide events in the long term, after sea level rise has converted the lower elevation grasslands to tidal natural communities.

3.3.7.20.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of the Suisun song sparrow in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.21 Swainson's Hawk

Swainson's hawk (*Buteo swainsoni*) nests in the grassland plains and agricultural regions of western North America from southern Canada to northern Mexico. Formerly associated mainly with grassland, desert, and shrub/steppe communities, the conversion of much of the species' range to agriculture has altered the distribution and abundance of the species and changed its key habitat associations throughout much of its range. This species has adapted relatively well to cultivated lands that are compatible with its foraging needs as long as they also provide suitable and secure nesting habitat. Nowhere in the species' range is this exemplified more than in the Central Valley. Almost entirely converted to cultivated lands, the Central Valley currently supports approximately 2,000 nesting pairs of Swainson's hawks (Anderson et al. 2007), and the density of nesting Swainson's hawks in the Yolo, Solano, Sacramento, and San Joaquin County area, considered the core of the Central Valley breeding population, is higher than anywhere else in the species' range. The population in the Plan Area represents an estimated 15 to 20% of the population in the Central Valley, with over 400 nesting records reported since 2000 (Bradbury pers. comm.) (Figure 2A.22-2). At least 300 of these are considered independent nesting territories that are potentially active in any given year and widely distributed in the Plan Area.

The population in the Plan Area is almost entirely dependent on privately owned cultivated lands. Certain crops such as alfalfa, when combined with shrub cover at field edges, provide relatively high densities of small mammal prey for foraging. Isolated trees and stands of trees on cultivated lands provide important nest sites when they are located in close proximity to suitable foraging habitat. The density of Swainson's hawk populations is largely dependent on the abundance and distribution of these crop types and landscape features. Therefore, management of a compatible agricultural matrix and sustaining other essential habitat elements such as nest trees and habitat edges that support refugia for prey populations are essential to the long-term management and sustainability of the Swainson's hawk population in the Plan Area.

The conservation strategy for the Swainson's hawk focuses on maintaining an agricultural landscape throughout the Plan Area that is compatible with the nesting and foraging needs of the Swainson's hawk and that will sustain the existing population. This will be accomplished by protecting and maintaining high foraging values on cultivated lands, protecting and creating nesting habitats, and protecting and creating habitat edges that provide prey refugia. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM18 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.21.1 Applicable Landscape-Scale Goals and Objectives

While the landscape goals and objectives will provide broad-based benefits to the ecosystems upon which Swainson's hawks depend, none are integral to the conservation strategy for this species.

3.3.7.21.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for Swainson's hawk are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objectives VFRNC1.1 and VFRNC1.2 Benefits: Protection and restoration of nesting habitat is key to successful Swainson's hawk conservation in the Plan Area. Nesting Swainson's hawks occur in riparian areas and isolated trees throughout the Plan Area, so protecting valley/foothill riparian forest will provide Swainson's hawk with nesting habitat and likely protect traditional nesting territories. The amount and distribution of existing nesting habitat in the Plan Area is likely sufficient to continue to support a large Swainson's hawk nesting population, but the long-term stability of this habitat is uncertain. Many nest sites occur within or adjacent to working cultivated landscapes where trees are regularly trimmed or removed as part of agricultural operations. In addition, trees that die naturally or from disease may not be replaced. Restoration of valley/foothill riparian forest is necessary to replace this community lost to covered activities, and to ensure sufficient valley/foothill riparian forest remains in the Plan Area to offset continued long-term losses expected in unprotected areas. Since restoration of valley/foothill riparian forest under VFRNC1.1 will occur steadily but gradually during the permit period (see Chapter 6, *Plan Implementation*, for the implementation schedule), it will provide future nesting opportunities for Swainson's hawks to ensure that substantial riparian habitat is maintained in the Plan Area through time.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.
• **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.

Goal VPNC1: Vernal pool complexes composed of large, interconnected, or contiguous expanses that represent a range of environmental conditions.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005).

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11. • **Objective GNC1.2:** Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian and tidal and nontidal natural communities for wildlife foraging and upland refugia.

Objectives ASWNC1.1, VPNC1.1, GNC1.1, and GNC1.2 Benefits: While the Swainson's hawk population is more closely associated with cultivated lands, grasslands provide suitable foraging habitat for the species. Therefore, while the protection of cultivated lands is the primary focus of the conservation strategy to ensure sufficient Swainson's hawk foraging habitat, the protection of 8,000 acres of grasslands and protection of the grassland component of 150 acres of alkali seasonal wetland complex and 600 acres of vernal pool complex will also contribute to the conservation of the species.

Swainson hawk uses grassland remnants in the cultivated lands matrix for foraging early in the season, before cultivated lands provide peak foraging value[56]; the grassland remnants also provide a stable habitat that is accessible during times when the management of cultivated lands results in lower prey abundance and availability.

Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.
• **Objective ASWNC2.4:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.
• **Objective VPNC2.5:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.
• **Objective GNC2.4:** Increase prey abundance and accessibility, especially small mammals and insects, for grassland-foraging species.

Objectives ASWNC2.4, VPNC2.5, and GNC2.4 Benefits: Achieving these objectives will benefit the Swainson's hawk by increasing prey density for this species in protected and managed grasslands, including the grassland component of alkali seasonal wetland and vernal pool complexes. Prey density is directly related to the quality of Swainson's hawk foraging habitat. Techniques that will be implemented to achieve this objective, such as grazing practices and avoiding use of pesticides, are described in *CM11 Natural Communities Enhancement and Management.*

Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species and native biodiversity.
• **Objective MWNC1.1:** Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.

Objective MWNC1.1 Benefits: Achieving this objective will protect and enhance 8,100 acres of managed seasonal wetlands. In addition to supporting wetland elements resulting from seasonal flooding to support wintering waterfowl, this natural community provides Swainson's hawk foraging habitat and is part of the overall foraging landscape. Managed wetlands include upland grassland components and also dry during the spring and become available to foraging Swainson's hawks as prey species recolonize the field. Protection of this natural community will contribute to the conservation of Swainson's hawk habitat.

[56] Swainson hawk also uses alkali seasonal wetland complexes per Objective ASWNC1.1, and vernal pool complexes per Objective VPNC1.1.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.
• **Objective CLNC1.1:** Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species. • **Objective CLNC1.3**: Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objective CLNC1.1 Benefits: The Swainson's hawk is a species of large, open landscapes. In the Central Valley, cultivated lands, and to a lesser extent grasslands, are essential communities required for species persistence. Maintaining high-value cultivated lands is therefore the key underlying element of Swainson's hawk conservation in the Central Valley. The value of cultivated lands and grasslands, in terms of their compatibility with the foraging habitat requirements of Swainson's hawks, as well as the availability of nesting habitat, influences the distribution and abundance of the species. However, certain crop types will need to be maintained within the cultivated landscapes in the Plan Area in order to maintain the high density of Swainson's hawk found in the Plan Area (see *Species-Specific Goals and Objectives* below).

Objective CLNC1.3 Benefits: While cultivated landscapes have become essential for the continued survival of Swainson's hawks in the Central Valley, agricultural practices have also historically removed other important habitats such as riparian forest, woodlands, savannahs, and grasslands that supported nesting and foraging habitat for the species. Today, other than narrow riparian corridors, nesting habitat for Swainson's hawks consists of isolated trees, tree rows along field borders or roads, or small clusters of trees in farmyards or at rural residences. Maintaining these small, isolated nesting habitats is also essential to maintaining the distribution and abundance of the species in the Plan Area. Swainson's hawks also benefit from remnant patches of grassland or other uncultivated areas. These areas provide additional foraging habitat and a source of rodent prey that can recolonize cultivated fields. Swainson's hawks use grassland remnants in the cultivated lands matrix for foraging early in the season, before cultivated lands provide peak foraging value; grasslands also provide a stable habitat that is accessible during times when the management of cultivated lands results in lower prey abundance and availability. This objective is designed in part to provide a means to protect these small but essential habitats that occur within the agricultural matrix. Meeting this objective requires that all cultivated lands protected for Swainson's hawk (i.e., in the reserve system) retain trees, hedgerows, and other edge landscape features that provide habitat for Swainson's hawk and other wildlife.

3.3.7.21.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for Swainson's hawk within the reserve system. The goals and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal SH1: Large, interconnected patches or contiguous expanses of protected Swainson's hawk foraging habitat.
• **Objective SH1.1**: Conserve 1 acre of Swainson's hawk foraging habitat for each acre of lost[57] foraging habitat. • **Objective SH1.2**: Within the 48,625 acres of protected cultivated lands, protect 43,325 acres of Swainson's hawk foraging habitat with at least 50% in very high-value habitat production in Conservation Zones 1, 2, 3, 4, 7, 8, 9, and 11. • **Objective SH1.3:** Of the 43,325 acres of cultivated lands protected as Swainson's hawk foraging habitat under Objective SH1.2, up to 1,500 acres can occur in Conservation Zones 5 and 6, all of which must have land surface elevations greater than −1 foot NAVD88. • **Objective SH1.4:** Within the 138,789 acres of lands protected or restored under Objective L1.1, protect at least 10,750 acres of grassland, vernal pool, and alkali seasonal wetland as Swainson's hawk foraging habitat.

Objective SH1.1 Rationale: This objective establishes the intent for in-kind replacement of foraging habitat removed through covered activities. It will be achieved through protection of cultivated and grassland habitats identified in Objective SH1.2 and Objective SH1.4. Swainson's hawk is a wide-ranging species that requires large unbroken landscapes for successful foraging. Foraging ranges for individual birds in agricultural landscapes are very large, ranging from approximately 1 to 45,405 acres depending on the composition of cover types, which influences prey abundance and availability. With over 300 nesting territories identified in the Plan Area, a substantial portion of the cultivated lands and grasslands in the Plan Area will be required to sustain this population. Therefore, the BDCP will ensure that protection of cultivated lands and grasslands will be equal to losses resulting from covered activities. Protected foraging habitat for the Swainson's hawk will be composed of large landscapes consisting of cover types that are suitable for foraging. Protection of large heterogeneous areas of cultivated lands and grasslands is one of the priorities for conservation of this species. Inclusion of high-value land cover types, such as alfalfa (Table 3.3-5), will increase the value of these reserves. The BDCP will conserve large heterogeneous areas of foraging habitats composed of a matrix of cultivated lands with a large alfalfa component and other natural communities, primarily grasslands, that provide important foraging habitat.

Objective SH1.2 Rationale: This objective addresses the protected cultivated lands that would be designed to maintain Swainson's hawk in the Plan Area. Achieving this objective will protect at least 43,325 acres of cultivated land suitable as Swainson's hawk foraging habitat. At least 50% of this total (21,663 acres) will be maintained in the highest-value foraging class, alfalfa hay. There are no restrictions on the remaining 50% as long as they provide foraging value within one of the foraging value classes listed in Table 3.3-5. This strategy allows for a substantial amount of the highest-value foraging habitat interspersed within a more diverse agricultural matrix. The result is a protected landscape of cultivated lands capable of supporting a high density of Swainson's hawk nests. This also allows for crop rotations (the alfalfa portion can move within the protected landscape as long as the acreage requirement is met) and helps to protect the economic viability of agricultural production in the Plan Area.

Objective SH1.3 Rationale: To avoid the effects of sea level rise and the potential for a reduction in habitat value, protected Swainson's hawk lands will be largely restricted to areas that have low risk of future inundation. However, some high-value habitats in the lower-lying areas of the central Delta

[57] "Lost" is the combination of permanent and long-term temporary habitat loss.

(Conservation Zones 5 and 6) support numerous nesting pairs. This objective addresses the conservation of a relatively small portion of these high-value habitats that are potentially at risk.

Objective SH1.4 Rationale: To contribute to meeting Objective SH1.1, this objective addresses the grassland protection and creation component described under Objectives GNC1.1, GNC1.2, ASWNC1.1, and VPNC1.1. Swainson's hawks rely on grassland foraging habitats, which provided the primary foraging habitat for Swainson's hawks prior to agricultural conversion. While some cultivated types are today regarded as having greater foraging value, grasslands remain an important component of the foraging landscape. All grasslands are expected to provide value as Swainson's hawk foraging habitat. Objectives GNC2.4, ASWNC2.4, and VPNC2.5 will enhance the value of grassland reserves as Swainson hawk foraging habitat.

Table 3.3-7. Foraging Habitat Value Classes for Cultivated Lands for Swainson's Hawk

Foraging Habitat Value Class for Swainson's Hawk	Cultivated Land Type
Very high	Alfalfa hay
Moderate	Irrigated pasture, other hay crops, tomatoes, sugar beets, grain crops (wheat, barley, oats)
Low	Other irrigated field and truck/berry crops
Very low	Safflower, sunflower, corn, grain sorghum
None	Orchards, vineyards, rice

Goal SH2: Cultivated lands that provide conditions suitable for supporting Swainson's hawk.

- **Objective SH2.1:** Increase distribution and abundance of potential Swainson's hawk nest trees in the Plan Area by planting and maintaining native trees along roadsides and field borders within protected cultivated lands at a rate of one tree per 10 acres.
- **Objective SH2.2:** Support the establishment and sustainability of Swainson's hawk prey populations by establishing 20- to 30-foot-wide hedgerows along field borders and roadsides within protected cultivated lands at a minimum rate of 400 linear feet per 100 acres.

Objectives SH2.1 and SH2.2 Rationale: In the absence of a comprehensive effort to maintain habitat diversity, cultivated lands tend to lose diversity over time as trees are lost and not replaced, cultivated fields are extended further into riparian corridors and oak woodlands, wetlands are plowed, and edge habitats are cultivated. Eventually, cultivated lands can become entirely devoid of trees, shrubs, or any uncultivated habitats. As this process continues, nesting opportunities for Swainson's hawks are reduced and the quality of agricultural foraging habitat declines. Where these elements have persisted within the agricultural matrix, Swainson's hawk populations have also persisted. Therefore, to successfully maintain Swainson's hawks in the Plan Area, these essential habitat elements must be maintained on the landscape. These objectives will address this issue by increasing the distribution and abundance of suitable nest trees and creating edge habitat to promote prey populations throughout the protected cultivated lands.

Objective SH2.1 will require planting between approximately 1,500 and 2,700 trees on protected cultivated lands. Trees will be planted according to criteria specified in *CM11 Natural Communities Enhancement and Management*. Trees will be planted in locations that do not interfere with agricultural activities; where they are otherwise limited or in decline; and in numbers and configurations that are appropriate for the location (e.g., linear tree rows, small groves).

Implementing Objective SH2.2 will require a total of approximately 27 to 50 acres of land, or less than 0.1 to 0.2% of the 45,405 acres of protected cultivated lands. Little or no land is expected to be taken out of agricultural production to meet this objective. Hedgerows will also be created based on specific criteria in *CM11 Natural Communities Enhancement and Management*. Hedgerows will be created on the edges of cultivated lands in locations that will not interfere with agricultural operations, where they are limited or in decline, and planted with species that best suit the location and provide the highest value.

3.3.7.22 Tricolored Blackbird

The tricolored blackbird (*Agelaius tricolor*) is a colonial nesting passerine that is largely restricted to California. The species typically nests in areas with open accessible water, a nesting substrate that is protected from ground predators (e.g., vegetation that is flooded, thorny, or spiny), and suitable foraging habitat (e.g., pastures, dry seasonal pools, agricultural fields such as alfalfa and sunflower) that provides abundant insect prey within a few miles of the nesting colony (Hamilton et al. 1995; Beedy and Hamilton 1999; University of California Davis n.d.). Nesting colonies may be located in dense stands of bulrush (*Schoenoplectus* spp.), cattail (*Typha* spp.), Himalayan blackberry (*Rubus armeniacus*), nettle (*Urtica dioica*), willow (*Salix* spp.), silage and grain fields, and weedy stands of thistles (*Circium vulgare*, *Silybum marianum*), mustards (*Brassica* spp.), and mallow (*Malva* spp.) (Neff 1937; Beedy et al. 1991; Hamilton et al. 1995; Hamilton 2000).

Proximity of nesting colonies to suitable foraging habitat appears to be a key factor for high reproductive success by tricolored blackbirds. For purposes of the BDCP, modeled breeding habitat consists of all bulrush, cattail, and blackberry communities, and adjacent high-value foraging areas located within 5 miles of nesting colonies documented in the Plan Area over the last 15 years. Tricolored blackbirds are highly dependent on disturbance events to maintain nesting sites. Older stands of bulrush and cattail with many senescent stems and horizontal dead stems become unattractive to the species for nesting. Breeding season foraging habitat in the Plan Area encompasses grassland, natural seasonal wetlands (e.g., vernal pool complex, alkali seasonal wetland complex), pasturelands (including alfalfa), and sunflower croplands, all habitats known to support abundant insects. During the nonbreeding season, tricolored blackbirds are primarily granivores that forage opportunistically within grasslands, pasturelands, and croplands (University of California Davis nd). Large numbers of tricolored blackbirds are attracted to grains associated with livestock feed lots and dairies. Roosting by nonbreeding tricolored blackbirds occurs in emergent wetlands and shrub stands.

More than 95% of the California breeding population of tricolored blackbird occurs in the Central Valley (Kyle and Kelsey 2011). Breeding also occurs in the foothills of the Sierra Nevada south to Kern County, the coastal slopes from Sonoma County to the Mexican border, and sporadically in the Modoc Plateau. While the overall range of the tricolored blackbirds is largely unchanged since the 1930s (Neff 1937; DeHaven et al. 1975; Beedy et al. 1991; Hamilton 1998), large gaps now exist in the species' former range. Surveys during the 1990s (Hamilton et al. 1995; Beedy and Hamilton 1997; Hamilton 2000) indicated a significant declining trend in California populations since the 1930s, and a particularly dramatic decline since 1994. Statewide surveys conducted during the 2000s indicated some recovery from the recent (1999) population low; however, the population increases have primarily been limited to the San Joaquin Valley and the Tulare Basin (Kyle and Kelsey 2011).

Scattered nesting colonies of tricolored blackbird are reported for the Plan Area. Colonies identified since 1996 have generally been located along the fringe of the Suisun Marsh, in the Yolo Bypass, and along the southwestern perimeter of the Plan Area (Figure 2A.23-2). Tricolored blackbirds may make extensive movements during the breeding season and during winter (Beedy 2008). Wintering tricolored blackbirds often form huge, mixed-species flocks that forage across the landscape. The Delta and central coast are recognized as major wintering areas for tricolored blackbirds (Riparian Habitat Joint Venture 2004; Beedy 2008), with large wintering flocks reported on Sherman Island in the Plan Area.

The most significant historical and ongoing threat to the tricolored blackbird is habitat loss and alteration (Cook 1999; DeHaven 2000; Riparian Habitat Joint Venture 2004; Yolo Natural Heritage Program 2008; University of California Davis nd). The initial conversion of native landscapes in California to agriculture, which removed vast wetland areas that provided nesting habitat, caused initial declines in populations. The more recent conversion of suitable agricultural lands to urban areas has permanently removed historical breeding and foraging habitat for this species. Taken together, these actions have resulted in a decline in productive foraging habitats near nesting colonies that is contributing to low reproductive success. In urbanizing areas, habitat fragmentation and proximity to human disturbances has also led to abandonment of large historical colonies (Beedy and Hamilton 1999). Other threats to the species include predation, poisoning and contamination, and active colony destruction from agricultural practices, primarily in the San Joaquin Valley where grain and silage fields are used for nesting (Beedy and Hayworth 1992; Hamilton et al. 1995; Beedy and Hamilton 1999; Riparian Habitat Joint Venture 2004; Yolo Natural Heritage Program 2008; University of California Davis nd).

The conservation strategy for the tricolored blackbird involves the protection, restoration, and management of wetland nesting habitat and the protection of high-value foraging habitat. These actions are intended to support existing breeding and wintering populations and provide for future population increases in the Plan Area. Since the Plan Area is a major wintering area but supports only a small number of nesting colonies (largely or mainly in the Yolo Bypass; Appendix 2.A, *Covered Species Accounts*), the protection, restoration, and management of wetland nesting habitat near suitable foraging habitat has the potential to provide for future increases in the abundance and distribution of tricolored blackbirds. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM21 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.22.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the tricolored blackbird are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.1:** Protect or restore 142,200 acres of high-value natural communities and covered species habitats. • **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA. • **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objectives L1.1, L1.3, and L1.4 Benefits: Restoration of tidal brackish emergent wetlands, tidal freshwater emergent wetlands, and nontidal perennial emergent wetlands natural communities consistent with this objective will provide suitable nonbreeding roosting habitat for tricolored blackbird, particularly portions that support tall or dense vegetation such as cattails and bulrushes. Restoration sites that incorporate hydrologic and elevation gradients will result in a diversity of inundation characteristics and plant composition in the restored wetlands and provide opportunities for establishment of suitable vegetation to support nonbreeding roosting tricolored blackbirds. Additionally, the restored valley/foothill riparian natural community is expected to provide nonbreeding roosting opportunities for tricolored blackbird where it occurs in early-successional stages. Natural communities that provide nesting habitat for this species are discussed in detail at the natural community level, below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances.

Objective L2.1 Benefits: Because tricolored blackbirds do not tend to nest in older stands of emergent vegetation with many senescent stems and horizontal dead stems, their nesting habitat requires periodic disturbance to regenerate new growth. Under natural conditions, this type of disturbance would normally result from periodic flooding and alluvial scouring; however, the nesting habitat targeted for protection is isolated from the floodplain and unlikely to experience natural disturbances. Therefore, mechanical habitat manipulation, as described in *CM11 Natural Communities Enhancement and Management*, may help to sustain suitable nesting habitat characteristics for tricolored blackbirds in areas targeted to conserve this species.

3.3.7.22.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the tricolored blackbird are stated below.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.
• **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.

Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.
• **Objective ASWNC2.4:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase prey, especially small mammals and insects, for grassland-foraging species

Goal VPNC1: Vernal pool complexes composed of large, interconnected, or contiguous expanses that represent a range of environmental conditions.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005).

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.
• **Objective VPNC2.5:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11. • **Objective GNC1.2:** Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian and tidal and nontidal natural communities for wildlife foraging and upland refugia.

Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.
• **Objective GNC2.4:** Increase prey abundance and accessibility, especially small mammals and insects, for grassland-foraging species.

Objectives ASWNC1.1, ASWNC2.4 VPNC1.1, VPNC2.5, GNC1.1, GNC1.2, and GNC2.4 Benefits: The protection and restoration of grasslands, alkali seasonal wetlands, and vernal pool complexes will provide improved foraging opportunities for tricolored blackbirds during both the breeding and nonbreeding seasons. Proximity of nesting colonies to suitable foraging habitat appears to be a key factor that contributes to high reproductive success in tricolored blackbirds. All of these communities are known to support large insect populations, a vital food resource for successful rearing and fledging of young. Those conservation lands that lie within a few miles of active nesting colonies will provide high-value foraging areas to support breeding tricolored blackbirds. All of these conservation lands will benefit tricolored blackbirds during the nonbreeding season, when large numbers of wintering tricolored blackbirds forage opportunistically across the Plan Area. The management of protected grasslands to increase insect prey through techniques such as grazing practices and avoiding use of pesticides, as described in *CM11 Natural Communities Enhancement and Management*, will provide further benefits to foraging tricolored blackbirds. Protection and restoration of these natural communities will offset losses from covered activities and will contribute to the conservation of tricolored blackbird habitat.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.
• **Objective CLNC1.1:** Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species. • **Objective CLNC1.3:** Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objective CLNC1.1 Benefits: Achieving this objective will provide foraging habitat for nesting and wintering tricolored blackbirds on cultivated lands in the Plan Area. A key to high reproductive success in tricolor nesting colonies is the presence of nearby foraging habitats that support abundant insect populations. Cultivated lands that meet this criterion include pasturelands, alfalfa and other hay crops, and some croplands such as sunflower, especially when use of insecticides is limited. During the nonbreeding season, large numbers of tricolored blackbirds winter in the Plan Area, feeding opportunistically on a wide variety of plant and animal foods, especially grains. Cultivated lands constitute major foraging sites for nonbreeding tricolored blackbirds, with substantial use associated with a variety of croplands, pasturelands, dairies, and livestock feed lots. Achieving this objective is also expected to benefit tricolored blackbirds by reducing any future losses or changes to suitable foraging habitat on cultivated lands and by minimizing adverse effects caused by habitat fragmentation. The quality of cultivated landscapes, in terms of compatibility with the foraging needs of tricolored blackbirds, and the availability of suitable nesting sites influence the distribution and abundance of the species. Consequently, maintaining high-value cultivated lands is an important component of tricolored blackbird conservation in the Plan Area.

Objective CLNC1.3 Benefits: While cultivated landscapes currently provide important foraging habitat for tricolored blackbirds, agricultural practices have removed emergent wetlands, surrounding grasslands, and other natural communities that historically supported nesting tricolored blackbirds in the Plan Area. This objective is designed, in part, to provide a means to protect small but essential habitats for covered species that occur within the agricultural matrix. Meeting this objective requires that cultivated lands protected for tricolored blackbirds retain residual wetlands, grassland patches, shrub stands, and herbaceous edge habitats, which may provide suitable nesting, foraging or roosting habitat for the species. Maintaining these small areas of high-value habitat interspersed within the cultivated landscape will help maintain the distribution and abundance of the species in the Plan Area.

3.3.7.22.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for tricolored blackbirds within the reserve system. The goal and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal TRBL1: Improved nesting, nesting-adjacent foraging, and wintering habitat for tricolored blackbirds in the Plan Area.

- **Objective TRBL1.1:** Protect and manage 50 acres of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat located within 5 miles of high-value foraging habitat in Conservation Zones 1, 2, 8, or 11. Nesting habitat will be managed to provide young, lush stands of bulrush/cattail emergent vegetation and prevent vegetation senescence.
- **Objective TRBL1.2:** Within the 48,625 acres of cultivated lands protected under Objective CLNC1.1, protect at least 26,300 acres of moderate-, high-, or very high-value cultivated lands as nonbreeding foraging habitat, at least 50% of which is of high or very high value.
- **Objective TRBL1.3:** Within the 48,625 acres of protected cultivated lands, protect at least 11,050 acres of high- to very high-value breeding-foraging habitat within 5 miles of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat in Conservation Zones 1, 2, 3, 4, 7, 8, or 11. At least 1,000 acres of will be within 5 miles of the 50 acres of nesting habitat protected under Objective TRBL1.1.

Objective TRBL1.1 Rationale: Although the natural community objectives described above will benefit tricolored blackbirds by protecting or restoring and managing high-value foraging habitat, this species-specific goal is necessary to improve breeding habitat and ensure the species' long-term conservation in the Plan Area. Nesting by tricolored blackbirds in the Plan Area is currently limited by the availability of high-value breeding habitat, which is represented by suitable nesting substrate, such as cattail/bulrush emergent wetland, in close association with highly productive foraging areas that support abundant insect prey, such as grasslands, seasonal wetlands, pasturelands, alfalfa and other hay crops, and some croplands. Proximity to suitable foraging habitat appears to be extremely important in both the establishment of colony sites and overall reproductive success at the colonies (Tricolored Blackbird Working Group 2007; Meese pers. comm.). Most breeding tricolored blackbirds usually forage within 5 miles of their colony sites (Kyle pers. comm.; Meese pers. comm.). Recent banding efforts have demonstrated a strong fidelity to breeding sites by tricolored blackbirds, and a high degree of colony cohesion when birds move to different sites for second breeding attempts (tricolored blackbirds typically nest twice in a breeding season) (University of California Davis nd). Therefore, to successfully manage for tricolored blackbirds and maintain or increase breeding in the Plan Area, 50 acres of occupied or recently occupied tricolored blackbird nesting habitat located in close proximity to high-value foraging habitat will be protected and managed.

Tricolored blackbirds are highly dependent on disturbance events to maintain suitable nesting conditions at nesting colony sites. Ideal nesting substrate is represented by young, actively growing stands of bulrush/cattail emergent vegetation. As stands age and develop an abundance of dead and dying stems and leaves, they become less attractive to the species for nesting. Under natural conditions, periodic disturbance from flooding, alluvial scouring, wildfire, and other landscape altering events serve to rejuvenate aging stands. Since much of the Plan Area is isolated from the floodplain and unlikely to experience natural disturbances, active management is needed to sustain suitable nesting habitat characteristics for tricolored blackbirds. Therefore, mechanical habitat manipulation, prescribed fire or other measures, as described in *CM11 Natural Communities Enhancement and Management*, will be used to sustain nesting substrate for tricolored blackbirds in areas targeted to conserve this species.

Objectives TRBL1.2 and TRBL1.3 Rationale: Because agriculture is expected to remain the primary land use in the Plan Area, the intent of these objectives is to maintain the habitat values of cultivated land that are most essential to tricolored blackbirds. Objective TRBL1.2 will protect 20,500 acres of crop types that are of at least moderate value to foraging tricolored blackbirds during the nonbreeding season, and Objective TRBL1.3 will protect 6,400 acres of high- to very high-value foraging habitat for breeding tricolored blackbirds. These acreages represent the minimum amounts of protected cultivated lands to be provided for tricolored blackbirds, based on estimated habitat losses. It is expected that actual acreages of foraging habitat available to breeding and nonbreeding tricolored blackbirds will be higher. As cultivated land is lost to covered activities, its habitat value for tricolored blackbird will be calculated on a per-acre basis according to Table 3.3-6. The amount of protection of cultivated lands depends on the habitat value of affected lands relative to the value of reserves.

To ensure that cultivated lands supporting large insect populations vital to successful rearing of young are available to nesting tricolored blackbirds, Objective TRBL1.3 also includes the provision that the annual protected cultivated land to be maintained in high or very high-value crop types for breeding foraging habitat be located within 5 miles of occupied or recently occupied tricolored blackbird nesting colonies. At least 1,000 acres of the 11,050 acres will be within 5 miles of the at least 50 acres of nesting habitat protected under Objective TRBL1.1. The remaining protected cultivated lands for tricolored blackbirds will be maintained in moderate or higher-value crop types distributed across the Plan Area. Through this process, cultivated lands will be protected throughout much of the Plan Area to meet the foraging needs of both breeding and wintering tricolored blackbirds. No additional protection of noncultivated lands that provide high-value foraging habitat for tricolored blackbirds (e.g., grasslands, vernal pool complex) is needed, because most of these habitats are protected under the landscape-scale and natural community goals and objectives.

Table 3.3-8. Tricolored Blackbird Foraging Habitat Value Classes

Foraging Habitat Value Class	Agricultural Crop Type/Habitats	
	Breeding Season[a] Foraging Habitat	Nonbreeding Season Foraging Habitat
Very high	Native pasture, nonirrigated native pasture, annual grasslands, vernal pool grasslands, alkali grasslands	Livestock feed lots
High	Sunflower, alfalfa and mixed alfalfa, mixed pasture, induced high water table native pasture, nonirrigated mixed pasture, dairies	Corn, sunflower, millet, alfalfa and mixed alfalfa, mixed pasture, native pasture, induced high water table native pasture, nonirrigated native pasture, rice, dairies, annual grasslands, vernal pool grasslands, alkali grasslands
Medium	Miscellaneous grass pasture, fallow lands cropped within 3 years, new lands prepped for crop production, livestock feed lots	Miscellaneous grass pasture, nonirrigated mixed pasture, fallow lands cropped within 3 years, new lands prepped for crop production
Low	Wheat, mixed grain and hay, farmsteads	Wheat, oats, mixed grain and hay, farmsteads
Marginal	Rice	None
None	All remaining crop types	All remaining crop types

[a] Generally March through August; occasional breeding in fall (September through November).

3.3.7.23 Western Burrowing Owl

Western burrowing owl (*Athene cunicularia hypugaea*) is found in open, well-drained grasslands, agricultural and range lands, and desert habitats often associated with burrowing animals (Klute et al. 2003). The species also occupies golf courses, airports, road and levee embankments, and other disturbed sites where there is sufficient friable soil for burrows (Haug et al. 1993). Because they typically use the burrows created by other species, particularly the California ground squirrel, presence of these species is usually a key indicator of potential occurrence of the western burrowing owl.

The breeding range of the western burrowing owl extends south from southern Canada throughout most of the western half of the United States and south to central Mexico. The winter range extends from central California southeastward through Arizona, New Mexico, and Texas and south into northern and central Mexico and coincides with southern breeding range where the species is resident year-round (Haug et al. 1993). In California, the species is distributed primarily throughout the lowland portions of the state, including the Central Valley, Imperial Valley, the southern desert region, the southern California coast, and the San Francisco Bay Area.

Reported occurrence data indicate that, within the Plan Area, western burrowing owls are concentrated mostly in the grassland and pastureland areas west of the Sacramento DWSC in Yolo and Solano Counties, and in the grasslands along the western edge of the Plan Area between roughly Brentwood/Antioch and Tracy (Figure 2A.24-2). These mostly uncultivated areas support larger and more stable populations of California ground squirrels and are less likely to be disturbed by regular cultivation and other ground disturbances. The species is a year-round resident in the Plan Area; however, local migratory patterns and the extent to which migrants occupy the Plan Area during the nonbreeding season are unclear. Western burrowing owls occur locally in the vicinity of Stockton where they are typically found along levees, canals, field edges, and also in the grasslands in the vicinity of Stone Lakes. Few western burrowing owls have been reported from the central portion of the Delta and the northern Delta east of the Sacramento DWSC. Western burrowing owls persist in low numbers in grassland habitats around the perimeter of Suisun Marsh. Gervais et al. (2008) note that populations in the vicinity of Suisun Marsh and San Pablo Bay are declining.

Conversion of grasslands and pasturelands to incompatible crop types and the destruction of ground squirrel colonies have been the main factors causing the decline of the western burrowing owl population (Zarn 1974). Assimilation of poisons applied to ground squirrel colonies may also affect western burrowing owl populations (James et al. 1990). Although California has a significant western burrowing owl population, development pressures and recent population trends suggest that the species may continue to be extirpated from large portions of its range in California during the next decade (DeSante et al. 2007). While western burrowing owls in the Central Valley have exhibited strong site fidelity even with increasing habitat fragmentation, the species has been extirpated from many historically occupied areas due to increasing urbanization and related causes. Populations in the Plan Area face similar threats from land use changes.

Western burrowing owl is covered by the *East Contra Costa County HCP/NCCP*, *San Joaquin County MSCP*, *Yolo Natural Heritage Program Plan*, and *Solano HCP*, all of which overlap with the Plan Area. The *East Contra Costa County HCP/NCCP* is expected to result in substantial conservation for this species in areas near Conservation Zone 8, and will potentially result in conservation for this species within this zone.

The conservation strategy for the western burrowing owl involves protecting and restoring large areas of grassland natural communities, managing cultivated lands to support foraging habitat, reducing the threat of habitat loss and fragmentation, and managing a landscape that supports ground squirrels, which are critical for creating cover and nesting habitat for western burrowing owls. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM23 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.23.1 Applicable Landscape-Scale Goals and Objectives

While the landscape-scale goals and objectives will provide broad-based benefits to the ecosystems upon which western burrowing owls depend, none are integral to the conservation strategy for this species.

3.3.7.23.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the western burrowing owl are stated below.

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11. • **Objective GNC1.2:** Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian and tidal and nontidal natural communities for wildlife foraging and upland refugia.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.
• **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex. • **Objective ASWNC1.2:** Restore or create alkali seasonal wetlands in Conservation Zones 1, 8, and/or 11 to achieve no net loss of wetted acres (up to 72 acres of alkali seasonal wetland complex restoration, assuming all anticipated impacts occur).

Goal VPNC1: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). • **Objective VPNC1.2:** Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools).

Objectives GNC1.1, ASWNC1.1, and VPNC1.1 Benefits: Urbanization, including residential and commercial development and infrastructure development, and conversion of grasslands to incompatible agricultural lands uses are among the principal causes of habitat loss for western burrowing owls and is a continuing threat to remaining northern California populations (Appendix 2.A, *Covered Species Accounts*). Conservation of western burrowing owl is directed at maintaining a landscape of suitable nesting and foraging habitat across the Plan Area and adjacent lands. However, the protection of grasslands, which occur primarily along the western edge of the Plan Area, are key to protecting high-value burrowing owl habitat and sustaining existing populations in the Plan Area. Objective GNC1.1 will protect a large amount of grassland from any future threats of land conversion and reduce the effects of current levels of habitat fragmentation. Additionally, Objectives ASWNC1.1 and VPNC1.1 will protect alkali seasonal wetland and vernal pool complexes, and the grassland component of these natural communities will provide habitat for western burrowing owl. Grasslands, alkali seasonal wetland complex, and vernal pool complex natural communities will be protected together as contiguous mosaics in Conservation Zones 1, 8, and 11. These objectives will expand the amount of protected high-value habitat in the Plan Area and support existing western burrowing owl populations that occur to the west of Conservation Zone 8 in Contra Costa County and in the areas surrounding Conservation Zones 1 and 11 in Solano County, which would especially benefit declining populations in the vicinity of Suisun Marsh and San Pablo Bay.

Objectives GNC1.2, ASWNC1.2, and VPNC1.2 Benefits: Restoration of grasslands, alkali seasonal wetland complexes, and vernal pool complexes will focus on connecting fragmented patches of other protected grasslands, alkali seasonal wetland complexes, and vernal pool complexes to provide contiguous mosaics of these natural community types, effectively increasing the size of intact grassland landscapes (including the grassland components of the alkali seasonal wetland and vernal pool complexes). This will contribute to reducing the effects of habitat fragmentation that have occurred from development impacts and agricultural conversions, and may facilitate movement of burrowing owls into currently unoccupied areas.

Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.

- **Objective ASWNC2.3:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase burrow availability for burrow-dependent species.
- **Objective ASWNC2.4:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.

- **Objective VPNC2.4:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase burrow availability for burrow-dependent species.
- **Objective VPNC2.5:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal GNC2: Biologically diverse grassland managed to enhance native species and sustained by natural ecological processes.

- **Objective GNC2.3:** Increase burrow availability for burrow-dependent species.
- **Objective GNC2.4:** Increase prey abundance and accessibility, especially small mammals and insects, for grassland-foraging species.

Objectives ASWNC2.3, ASWNC2.4, VPNC2.4, VPNC2.5, GNC2.3, and GNC2.4 Benefits: The distribution of burrowing owls is in part determined by the presence of ground squirrels that initially excavate burrow systems burrowing owls will later inhabit. While grasslands remain relatively abundant along the western edge of the Plan Area and a large amount of grassland will be protected under Objectives GNC1.1, ASWNC1.1, and VPNC1.1 (including the grassland components of alkali seasonal wetland and vernal pool complexes), most of these grasslands are currently not occupied by burrowing owls. This is due in part to burrow availability. To facilitate expansion of the burrowing owl population in the Plan Area, Objectives GNC2.3, ASWNC2.3, and VPNC2.3 will increase burrow availability on protected grasslands by encouraging ground squirrel occupancy and population expansion. This will be done through the creation of berms, mounds, edges, and other features designed to attract and encourage burrowing activity and by prohibiting ground squirrel control programs (i.e., poisoning) in the reserve system, as described in *CM11 Natural Communities Enhancement and Management*. Increasing small mammal and insect prey populations in the reserve system, consistent with GNC2.4, ASWNC2.4, and VPNC2.4, will also contribute to the expansion of the existing burrowing owl population; these objectives will be achieved through management and enhancement as described in *CM11 Natural Communities Enhancement and Management*.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.

- **Objective CLNC1.1:** Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species.
- **Objective CLNC1.3:** Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objective CLNC1.1 Benefits: At least 64% of the Plan Area is cultivated land. While relatively few cultivated cover types are suitable as burrowing owl habitat, certain types, such as irrigated pasture, alfalfa and other hay crops, and even some row and grain crops, can provide foraging habitat for burrowing owls, at least some portion of the year. Burrowing owls occur in agricultural habitats in much lower density than in grassland landscapes and only where suitable edge habitats (e.g., levees, roadside berms, edges of permanent water conveyance canals) are available as burrow habitat. Most cultivated lands are therefore considered low-value habitat, although pasture is considered high-value habitat. Still, these low-value habitats, particularly those supporting low vegetation structure and those that are tilled less frequently (e.g., alfalfa hay) do support breeding and wintering burrowing owls. Cultivated lands can, therefore, contribute to the conservation of burrowing owls under appropriate management regimes. With the extent of cultivated lands protected under Objective CLNC1.1, there are likely to be many opportunities to enhance and manage these reserves to support burrowing owl habitat and encourage burrowing owl occurrence and use. For example, maintaining berms around irrigated pastures, short grasses on levee slopes, and selectively prohibiting ground squirrel control programs can facilitate burrowing owl use of some agricultural lands. An unknown portion of the protected cultivated lands are expected to support burrowing owl habitat that could be further enhanced to expand and support populations in the Plan Area.

Objective CLNC1.3 Benefits: Achieving this objective will support western burrowing owls by maintaining and protecting patches of habitat within cultivated areas that may support western burrowing owl prey species (insects and small mammals) and that may provide suitable burrow habitat, such as berms and other edge habitats. Implementation of this objective may allow western burrowing owls to establish a greater presence in the central portion of the Delta.

3.3.7.23.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for western burrowing owl within the reserve system. The goal and objective below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal WBO1: Contribute to the sustainability of the burrowing owl population by protecting cultivated lands suitable for burrowing owl foraging.

- **Objective WBO1.1:** Of the 48,625 acres of cultivated land protected under Objective CLNC1.1, protect at least 1,000 acres in Conservation Zones 1 and 11 that support high-value burrowing owl habitat and are within 0.5 mile of high-value grassland habitat or occupied low-value habitat.

Objective WBO1.1 Rationale: Western burrowing owls in Conservation Zones 1 and 11 are associated with a landscape that includes a matrix of grasslands and cultivated lands. Much of the cultivated land is high-value burrowing owl habitat consisting of pasture. These lands are used for cattle grazing and for production of hay feed and silage. Burrowing owls that occur in these areas use both the grassland and adjacent cultivated land for foraging and many nesting burrows are in or adjacent to pasturelands, which are uncultivated or infrequently cultivated. In addition to protection of grasslands under Objective GNC1.1, it is important to protect adjacent cultivated lands in this portion of the Plan Area, particularly those that are known to be occupied by nesting and wintering burrowing owls. Protection of 1,000 acres of adjacent cultivated land will substantially increase the extent of connectivity of burrowing owl habitats protected in Conservation Zones 1 and 11, further protect lands that are occupied by burrowing owls, and maintain the matrix of habitats that support this subpopulation. The protection of burrowing owl habitat in Conservation Zones 1 and 11 is also consistent with cultivated land protection for Swainson's hawk, white-tailed kite, and tricolored blackbird.

The western burrowing owl will be conserved in cooperation and in conjunction with neighboring and overlapping HCP/NCCPs to ensure that actions are implemented where they provide the greatest benefit to the regional western burrowing owl population and where they are compatible with conservation of other species associated with grasslands and cultivated lands. The conservation strategy for western burrowing owls is expected to sustain the species' existing population and provide for future increases in its abundance and distribution in and adjacent to the Plan Area.

3.3.7.24 Western Yellow-Billed Cuckoo

The western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) is a neotropical migrant that breeds in North America and winters in South America. The western yellow-billed cuckoo (*C. a. occidentalis*), one of two recognized subspecies, occurs west of the Rocky Mountains. The range of the western subspecies historically extended from southern British Columbia to the Rio Grande River in northern Mexico, and east to the Rocky Mountains (Bent 1940). Based on the historical distribution of the western yellow-billed cuckoo in suitable habitat throughout the Central Valley (Belding 1890), the species presumably nested along the Sacramento, San Joaquin, and Mokelumne Rivers and along smaller tributary drainages such as the Lost Slough, White Slough, and Disappointment Slough. Studies conducted since the 1970s indicate that there may be fewer than 50 breeding pairs of the western yellow-billed cuckoo in California (Gaines 1974; Halterman 1991; Laymon et al. 1997). The only California locations that currently sustain breeding populations include the Colorado River system in southern California, the South Fork Kern River east of Bakersfield, and isolated sites along the Sacramento River in northern California (Laymon and Halterman 1989:272–277; Laymon 1998). There are no recent breeding records of western yellow-billed cuckoos in the Plan Area (Figure 2A.25-2): scattered sightings of this species in the Plan Area over the last 50 years are presumed to be from migrating birds.

The western yellow-billed cuckoo is an obligate riparian species. The primary habitat association for this species is willow-cottonwood riparian forest, but other species such as alder and box elder may be important habitat elements in some areas (Laymon 1998). Nests are primarily constructed in willow (*Salix* spp.) trees, and cottonwood (*Populus fremontii*) trees which provide important foraging habitat for insect prey.

Historical declines of the western yellow-billed cuckoo have been due primarily to the removal of riparian forests for agricultural and urban expansion. Habitat loss and degradation continues to be the most significant threat to remaining populations, a consequence of bank stabilization and flood control projects, urbanization along edges of watercourses, agricultural activities, and river management that alters flow and sediment regimes. The minimum viable habitat patch size for breeding western yellow-billed cuckoo is approximately 41 hectares (Riparian Habitat Joint Venture 2004), and most existing riparian habitat patches that occur in the Plan Area are too small to support breeding pairs. Additionally, predation can be a significant source of nest failures in some areas (Hughes 1999), exacerbated by habitat fragmentation that makes nest sites more accessible and vulnerable to predation. Pesticide use associated with agricultural practices may also pose a long-term threat to cuckoos (Hughes 1999).

A recovery plan has not been prepared for the western yellow-billed cuckoo. Howell et al. (2010) suggest that approximately 71% of riparian habitat in the Sacramento Valley is owned by federal and state agencies and nongovernment organizations, and these acquisitions have been aimed at recovery of the western yellow-billed cuckoo. Significant conservation and research efforts have also occurred at Audubon California's Kern River Preserve, and in association with the Lower Colorado River Multi-Species Conservation Program. The western yellow-billed cuckoo is also a focal species of the *Riparian Bird Conservation Plan* (Riparian Habitat Joint Venture 2004), which provides data and recommendations for conservation of riparian birds in California. Some regional habitat conservation planning efforts may also provide protections, primarily through protection of riparian habitat. The western yellow-billed cuckoo is a covered species under the approved *San Joaquin County MSCP*, and the in-progress *Yolo Natural Heritage Program Plan* and *Butte Regional Conservation Plan*.

The conservation strategy for this species involves riparian protection, restoration, and management that promote vegetation structurally suitable for the western yellow-billed cuckoo, as well as floodplain restoration to reestablish seasonal patterns of fluvial disturbances that promote development of high-value riparian habitat. Because most riparian corridors in the Plan Area do not support sufficiently large riparian patches for cuckoo breeding (Laymon 1998), conservation will be directed toward restoring suitable riparian forest to provide habitat that could allow for the expansion of the existing western yellow-billed cuckoo population back into its historical range in the Plan Area. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM22 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.24.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the western yellow-billed cuckoo are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.5:** In restored floodplains, provide a range of elevations that transition from frequently flooded (e.g., every 1 to 2 years) to infrequently flooded (e.g., every 10 years or more) areas to provide a range of habitat conditions, upland habitat values, and refugia from flooding during most flood events.
- **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.5 Benefits: Including transitions from frequently to seldom flooded areas within the restored floodplains, consistent with this objective, will benefit the western yellow-billed cuckoo where they occur by providing crucial foraging opportunities during flooding events. Because western yellow-billed cuckoo habitat is typically associated with the primary floodplain, floods may regularly reduce the cuckoo's prey base. The western yellow-billed cuckoo prey base, largely katydid and sphinx moth larvae, winters underground. In wet years, cuckoos must forage in upland areas until the prey base in the lower floodplain recovers (Riparian Habitat Joint Venture 2004). Floodplains will be restored to achieve this objective as described in *CM5 Seasonally Inundated Floodplain Restoration.*

Objective L1.6 Benefits: Increasing the size and connectivity of the reserve system, consistent with this objective, will benefit the western yellow-billed cuckoo by reducing the threat of habitat fragmentation in the Plan Area. Habitat fragmentation is a primary stressor for this species. The need for large, unfragmented blocks of western yellow-billed cuckoo habitat is further described below for Goal VFRNC1.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances. • **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.1 Benefits: Achieving this objective will provide conditions suitable for establishing western yellow-billed cuckoo habitat by allowing natural fluvial disturbances that will promote regeneration of riparian structural diversity. Breeding habitat for the cuckoo typically has high structural diversity, with relatively closed primary canopy and a dense shrub layer (Hammond 2011). Continuing habitat succession is identified as important in sustaining breeding populations (Laymon 1998). Riparian systems subject to natural erosional and depositional processes and channel cut-off to create oxbow lakes provide conditions conducive to the establishment of new stands of willow, which create high-value nesting habitat (Laymon 1998; Greco 2012). Habitat along channelized streams or levied systems that restrict these natural processes may become over-mature and less optimal. Floodplains will be restored to advance this objective, as described in *CM5 Seasonally Inundated Floodplain Restoration*, and additional vegetation management may be implemented to mimic natural fluvial processes, as described in *CM11 Natural Communities Enhancement and Management.*

Objective L2.6 Benefits: Increasing native biodiversity and reducing invasive nonnative plant species in the riparian natural community, consistent with this objective, will enhance yellow-billed cuckoo habitat. As described above, this species requires structural diversity in its breeding habitat. Large, monotypic stands of invasive plants can diminish this structural diversity and render habitat unsuitable for the western yellow-billed cuckoo. The nonnative invasive Himalayan blackberry, for example, often invades riparian restoration sites and does not provide the same habitat structural complexity as other riparian plant species: this invasive species may inhibit establishment of other understory species that form important structural components of western yellow-billed cuckoo habitat (Hammond 2011). Reserve management will seek to control invasive plants such as Himalayan blackberry (*CM11 Natural Communities Enhancement and Management*).

3.3.7.24.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the western yellow-billed cuckoo are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objective VFRNC1.1 Benefits: Achieving this objective will increase migratory and breeding opportunities for the western yellow-billed cuckoo in the Plan Area by restoring 5,000 acres of valley/foothill riparian habitat. It is expected that a portion of these 5,000 acres will provide suitable habitat conditions for the western yellow-billed cuckoo because, when combined with existing protected forest stands, most of the restoration will occur as part of large blocks of valley/foothill riparian natural community greater than the minimum required for cuckoo breeding (over 100 acres). The largest contiguous blocks of restored riparian natural community are expected to occur within the restored floodplain, within which this objective requires a minimum 3,000 acres of riparian natural community restoration. The species-specific objectives below will provide additional assurance that riparian vegetation is maintained with suitable habitat conditions for the species.

Objective VFRNC1.2 Benefits: Achieving this objective will provide suitable habitat for the western yellow-billed cuckoo by protecting 750 acres of existing valley/foothill riparian forest in Conservation Zone 7 in the near-term implementation period. By itself, the 750 acres likely does not support suitable habitat for this species because it often occurs in stands smaller than the minimum required for cuckoo breeding. Restoration will be needed to expand existing stands of valley/foothill riparian forest to support the species.

Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.

- **Objective VFRNC2.1:** Restore, maintain and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands.
- **Objective VFRNC2.3:** Maintain at least 500 acres of mature riparian forest in Conservation Zones 4 or 7.
- **Objective VFRNC2.4:** Maintain the at least 500 acres of mature riparian forest (VFRNC2.3) intermixed with a portion of the early- to midsuccessional riparian vegetation (VFRNC2.2) in large blocks with a minimum patch size of 50 acres and minimum width of 330 feet.

Objective VFRNC2.1 Benefits: Achieving this objective will benefit the western yellow-billed cuckoo by increasing structural diversity of riparian vegetation. This will be achieved through restoration and management actions as described in *CM7 Riparian Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management*.

Objectives VFRNC2.3 and VFRNC2.4 Benefits: Achieving these objectives will benefit western yellow-billed cuckoo by providing large structurally diverse blocks of riparian vegetation including a mature riparian component with relatively high, closed canopy. The best habitats for nesting western yellow-billed cuckoos are those with moderately large and tall trees and high canopy cover and foliage volume (Laymon et al. 1997). Nesting habitat patches are a minimum of 50 acres in size and 330 feet wide (Laymon et al. 1997). Additionally, the requirement to maintain at least 500 acres in a single conservation zone is expected to result in habitat patches that are large and closely spaced to maximize habitat value for the species.

3.3.7.24.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of the western yellow-billed cuckoo in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.25 White-Tailed Kite

The white-tailed kite (*Elanus leucurus*) inhabits or uses low elevation, open grasslands, savannah-like habitats, agricultural areas, wetlands, and oak woodlands (Dunk 1995). Most white-tailed kites nest in the Sacramento Valley are found in oak and cottonwood riparian forests, valley oak woodlands, or other groups of trees and are usually associated with compatible foraging habitat consisting of low-growing, herbaceous vegetation in patches of greater than 1,500 square meters (Erichsen et al. 1996). Pasture and hay crops, compatible row and grain crops, and natural vegetation such as seasonal wetlands and annual grasslands provide foraging habitat for this species (Erichsen 1995). The white-tailed kite is excluded from narrow bands of riparian vegetation by Swainson's hawks, and therefore requires wide patches of nesting habitat where its range overlaps with the Swainson's hawk (Hansen pers. comm.). For more detail on white-tailed kite habitat requirements, see Appendix 2.A, *Covered Species Accounts.*

In North America, the white-tailed kite is believed to have historically occurred in the southern portions of the United States and Mexico (Dunk 1995). Currently, the species' distribution includes the east coast and southeast United States, the southwest United States from Texas to California, and north to Washington State, and from Mexico to South America (Dunk 1995). California is currently considered the stronghold of the white-tailed kite's breeding distribution in North America, with nearly all areas up to the western Sierra Nevada foothills and southeastern deserts occupied (Small 1994; Dunk 1995). White-tailed kite is distributed throughout the Plan Area during the breeding and wintering seasons, although relatively few nesting locations have been documented. Most nesting habitat for kites in the Plan Area consists of riparian woodlands and scrub along drainages. Because most of the Plan Area, including grassland, seasonal wetland, and cultivated land natural communities, is potential foraging habitat for kites, the species potentially occurs throughout the Plan Area during winter and in the vicinity of suitable nesting habitat during the breeding season (Figure 2A.26-2).

Urbanization, including residential, commercial, and infrastructure development (roads and oil, water, gas, and electrical conveyance facilities), is one of the principal causes of continuing habitat loss for the white-tailed kite and is a continuing threat to remaining populations, particularly in rapidly urbanizing areas in the Sacramento Valley. While there are examples of kites nesting and roosting in urban areas, in general the species is intolerant of noise and human activities and will abandon nesting areas that are subject to increasing levels of human disturbances. Kites are also sensitive to habitat fragmentation. Low-density urbanization or isolation of habitats also leads to territory abandonment, even if relatively large patches remain undisturbed.

The conservation strategy for the white-tailed kite involves maintaining a landscape of suitable nesting and foraging habitat across the Plan Area. Habitat loss and fragmentation are a primary stressor to white-tailed kite in California. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM18 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.25.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the white-tailed kite are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.1:** Protect or restore 142,200 acres of high-value natural communities and covered species habitats. • **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA. • **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objectives L1.1 and L1.3 Benefits. Many of the natural communities to be protected and restored in the reserve system will provide suitable foraging or nesting habitat for the white-tailed kite. Restored and protected valley/foothill riparian natural community will provide nesting habitat for the species. Restored tidal and nontidal emergent wetlands, restored and protected grasslands and vernal pool complex, protected managed wetlands, and protected alkali seasonal wetlands will provide foraging habitat for the white-tailed kite. Foraging habitat within 5 to 8 miles of nest sites is most likely to be used by white-tailed kites (Hansen pers. comm.), and most of the land in Conservation Zones 1 through 5, 8, and 11, where much of the restoration and protection will take place, are within 8 miles of known white-tailed kite occurrences.

Objective L1.6 Benefits: Increasing the size and connectivity of the reserve system will reduce the risk of habitat fragmentation in the Plan Area. Habitat fragmentation is a primary stressor for this species.

3.3.7.25.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for white-tailed kite are described below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian forest, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objectives VFRNC1.1 and VFRNC1.2 Benefits: These objectives will increase the extent of nesting habitat for the white-tailed kite, and provide for expansion of the species' nesting habitat distribution in the Plan Area. White-tailed kites usually nest in trees within dense canopies, but nest trees can vary from single, isolated trees (although this is rare) to trees in large woodlands. Large patches of riparian habitat provide higher-value nesting habitat than narrow bands of trees, where white-tailed kites are often displaced by Swainson's hawks (Hansen pers. comm.). Achieving these objectives will improve white-tailed kite breeding habitat in the Plan Area in the long term by providing large patches of riparian habitat. Suitable foraging habitat for the white-tailed kite (i.e., low, herbaceous vegetation including marshes, grasslands, and many types of cultivated lands) will be present throughout the Plan Area, and most of the riparian restoration will be within 5 to 8 miles of suitable foraging habitat.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.

- **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.
- **Objective ASWNC1.2**: Restore or create alkali seasonal wetlands in Conservation Zones 1, 8, and/or 11 to achieve no net loss of wetted acres (up to 72 acres of alkali seasonal wetland complex restoration, assuming all anticipated impacts occur).

Goal ASWNC2: Alkali seasonal wetlands that are managed and enhanced to sustain populations of native alkali seasonal wetland species.

- **Objective ASWNC2.4:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal VPNC1: Vernal pool complexes composed of large, interconnected, or contiguous expanses that represent a range of environmental conditions**.**

- **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005).
- **Objective VPNC1.2:** Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools).

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.

- **Objective VPNC2.5:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase prey, especially small mammals and insects, for grassland-foraging species.

Goal GNC1: Extensive grassland composed of large, interconnected patches or contiguous expanses.

- **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11.
- **Objective GNC1.2:** Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian, tidal, and nontidal natural communities for wildlife foraging and upland refugia.

Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes and functions.

- **Objective GNC2.4:** Increase prey abundance and accessibility, especially small mammals and insects, for grassland-foraging species.

Objectives ASWNC1.1, ASWNC1.2, ASWNC2.4, VPNC1.1, VPNC1.2, VPNC2.5, GNC1.1, GNC1.2, and GNC2.4 Benefits: Grasslands, including the grassland natural community and the grasslands surrounded by wetland features in the vernal pool complex and alkali seasonal wetland complex natural communities, protected in Conservation Zones 1, 8, and 11 (Objectives GNC1.1, ASWNC1.1, ASWNC1.2, VPNC1.1, VPNC1.2) will provide suitable foraging habitat for the white-tailed kite, which is known to occur within or adjacent to each of these three conservation zones. Restored grasslands will also provide foraging habitat for white-tailed kite: although this could involve converting cultivated lands that already provide white-tailed kite foraging habitat, the restored grasslands will be protected and managed to sustain habitat value for this species. Achieving Objectives GNC2.4, ASWNC2.4, and VPNC2.5 will benefit the white-tailed kite by increasing the abundance of voles and other small mammals upon which white-tailed kites prey.

Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species and native biodiversity.
• **Objective MWNC1.1:** Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.

Objective MWNC1.1 Benefits: Achieving this objective will protect and enhance 8,100 acres of managed seasonal wetlands. In addition to supporting wetland elements resulting from seasonal flooding to support wintering waterfowl, this natural community provides white-tailed kite foraging habitat and is part of the overall foraging landscape. Managed wetlands include upland grassland components and also dry during the spring and become available to foraging white-tailed kites as prey species recolonize the field. Protection of this natural community will contribute to the conservation of white-tailed kite habitat.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.
• **Objective CLNC1.1:** Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species. • **Objective CLNC1.3:** Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objective CLNC1.1 Benefits: Achieving this objective will provide foraging habitat for white-tailed kites on cultivated lands in the reserve system. High-value habitat for white-tailed kites includes alfalfa and other hay crops, irrigated pastures, and some cultivated habitats, particularly sugar beets and tomatoes, both of which can support relatively large populations of voles (Estep 1989) and which have been highly correlated with kite nest site densities (Erichsen et al. 1994). Kites also forage in dry pastures, rice stubble fields, and occasionally in orchards (Erichsen 1995). Achieving this objective will benefit the white-tailed kite by reducing any future losses of or changes to suitable foraging habitat on cultivated lands and reduce current, as well as the threat of, habitat fragmentation.

Objective CLNC1.3 Benefits: Achieving this objective will protect potential nesting habitat for the white-tailed kite, in addition to the nesting habitat provided through riparian restoration and protection. Although white-tailed kites primarily nest in dense riparian forests, they are also known to use isolated trees, especially where they are associated with compatible agricultural foraging habitat, such as pasture and hay crops, and compatible row and grain crops.

Ongoing cultivated lands within and adjacent to the Plan Area will continue to support foraging habitat for white-tailed kite nesting and wintering in the Plan Area. The white-tailed kite conservation strategy is expected to sustain the existing population of white-tailed kites and provide for future increases in its abundance and distribution within and adjacent to the Plan Area.

3.3.7.25.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of white-tailed kite in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.26 Yellow-Breasted Chat

The yellow-breasted chat (*Icteria virens*) nests and forages in streamside, shrubby thickets of willows, vines, and brush (Small 1994). The species uses early- to midsuccessional riparian habitat, and is dependent on understory and a well-developed shrub layer as well as taller trees with open canopy for singing perches. The species has been classified as an open-canopy obligatory species (i.e., primarily associated with open overstory and brushy understory), with population density directly related to shrub density to a height of 4.5 meters (14.8 feet) (Crawford et al. 1981). The yellow-breasted chat nests near the border of streams, creeks, sloughs, and ponds, in low dense shrubs (willows, with brush and vines).

The yellow-breasted chat is a neotropical migrant that breeds throughout much of North America and winters primarily in Mexico and Central America; a few birds also wintering in California (Small 1994). According to Grinnell and Miller (1944), the species' breeding distribution includes the entire length and breadth of California exclusive of the higher mountains and coastal islands. Within the Plan Area, Grinnel and Wythe (1927) described the chat as a "fairly common summer visitant to the warm interior valleys." The yellow-breasted chat is still present in most of its historical range except in most of the Central Valley (Comrack 2008); however, nesting populations have been extirpated from the San Joaquin and Sacramento Valleys except along foothill tributaries. The yellow-breasted chat occurs in the Plan Area mainly as a spring and fall migrant. During the breeding season, however, it is sparsely distributed across the Plan Area (Figure 2A.27-2) (Appendix 2.A, *Covered Species Accounts*).

Habitat loss is implicated in yellow-breasted chat population declines throughout much of the species' range (Remsen 1978; Rosenberg et al. 1991). In the San Joaquin and Sacramento Valleys, losses and degradation of riparian habitats have resulted from widespread habitat conversion, water diversion, mining, and the introduction of numerous invasive species. Remaining riparian forests are estimated to cover only about 2% of their original area, and are now mostly small, widely spaced remnants (Katibah 1984). Bank stabilization and flood control activities have rendered a relatively stable system and thus reduced the availability of early-successional riparian habitat that chats need for breeding (Ricketts and Kus 2000). Nest parasitism by brown-headed cowbirds has been implicated as a limiting factor in populations outside of California, but research conducted at the Lower Clear Creek Floodway in Shasta County suggest that low nest success is driven by predation rather than nest parasitism and is a likely factor contributing to observed declines (Young and Burnett 2010). Low nest success, especially at restoration sites, may be driven in part by the lack of dense understory, which makes it easier for predators to locate nests.

Species management recommendations include protecting existing, healthy riparian habitat; restoring degraded riparian habitat; maintaining or promoting a dense shrub layer in riparian habitat; and creating a shrub layer in the early stages of restoration projects (Shuford and Gardali 2008). Recommendations for restoration projects include retaining patches of mature riparian habitat with a blackberry understory to provide suitable nesting habitat for this species immediately following restoration, and using supplemental planting of California blackberry (*Rubus ursinus*), wild rose (*Rosa* *californica*), and vines such as California grape (*Vitis californica*) and pipevine (*Aristolochia californica*) to increase nesting success and territory densities at older restoration sites (Young and Burnett 2010). Zeiner et al. (1990) report that yellow-breasted chat territory size ranges from 0.3 to 3.2 acres (0.1 to 1.3 hectares).

A recovery plan has not been prepared for the yellow-breasted chat, but it is a focal species of the *Riparian Bird Conservation Plan* (Riparian Habitat Joint Venture 2004), which provides data and recommendations for conservation of riparian birds in California.

The conservation strategy for this species involves riparian protection, restoration, and management that expands and promotes vegetation structurally suitable for the species, as well as floodplain restoration to reestablish seasonal patterns of fluvial disturbances that promote new development of high-value riparian habitat. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM22 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.26.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the yellow-breasted chat are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.6 Benefits: Increasing the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands will benefit the yellow-breasted chat by reducing the risks of habitat fragmentation and adverse effects from adjacent land uses.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances.

Objective L2.1 Benefits: Regenerating riparian structural diversity through floodplain restoration to ensure natural fluvial disturbances will provide suitable habitat conditions for the yellow-breasted chat. Flood control and river channelization are factors leading to the elimination of suitable early-successional riparian habitat for the yellow-breasted chat (Riparian Habitat Joint Venture 2004). The yellow-breasted chat requires low, dense shrubs for nesting, and early-successional habitat typically supports these shrubs (Riparian Habitat Joint Venture 2004). As stands mature, the tall canopy tends to shade out the shrub layer, making the sites less suitable for the species. Floodplains will be restored as described in *CM5 Seasonally Inundated Floodplain Restoration* to advance this objective, and fluvial disturbance will be mimicked through management as needed to achieve riparian structural diversity, as described in *CM11 Natural Communities Enhancement and Management.*

3.3.7.26.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the yellow-breasted chat are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian forests, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian forest, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objectives VFRNC1.1 and VFRNC1.2 Benefits: Restoration and protection of riparian natural community consistent with this objective will provide nesting habitat for the yellow-breasted chat in the Plan Area, and reverse habitat loss, one of the species' primary stressors. The small territory size for this species (average 1.25 hectares [Thompson and Nolan 1973]) suggests that large-scale restoration and protection of valley/foothill riparian may promote the establishment of sizeable chat populations. Because of their relatively small territories, small habitat patch size is not, by itself, believed to contribute to the decline of this species (Riparian Habitat Joint Venture 2004), but nest predators such as raccoons, foxes, skunks, opossums, and scrub jays are well adapted to fragmented habitats near human habitation. Large-scale riparian restoration and protection resulting in large, contiguous blocks of vegetation buffered from human development can thus reduce predation risk for this species. However, the yellow-breasted chat has specific structural habitat requirements, so only the early- to midsuccessional portions of the 5,750 acres of restored and protected riparian natural community (1,000 acres; see Objective VFRNC2.2) are expected to provide suitable habitat characteristics for the species.

Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.
• **Objective VFRNC2.1:** Restore, maintain and enhance structural heterogeneity with adequate vertical and horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands. • **Objective VFRNC2.2:** Maintain 1,000 acres of early- to midsuccessional vegetation with a well-developed understory of dense shrubs on restored seasonally inundated floodplain.

Objectives VFRNC2.1 and VFRNC2.2 Benefits: These objectives will build on Objective L2.4 to further ensure the structural diversity and maintenance of 1,000 acres of riparian natural community at an appropriate early- to midsuccessional seral stage. This early- to midsuccessional vegetation is essential to yellow-breasted chat habitat. Maintenance of fluvial disturbance consistent with Objective L2.4 is expected to result in a mosaic of different-aged habitat patches and structural habitat diversity of the riparian community in the reserve system. However, if natural fluvial disturbances are not sufficient to maintain 1,000 acres of early- to midsuccessional seral stage riparian vegetation, active vegetation will be implemented to achieve this objective as part of *CM11 Natural Communities Enhancement and Management.*

3.3.7.26.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of yellow-breasted chat in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.27 Giant Garter Snake

The giant garter snake (*Thamnophis gigas*) uses a wide variety of aquatic habitats, including marshes, ponds, sloughs, small lakes, low-gradient streams, and other waterways, including agricultural wetlands such as irrigation and drainage canals, rice fields, and the adjacent uplands. However, in the Plan Area, reclamation projects, which began in the 1860s, have removed most of the marsh habitat and substantially altered the natural flood regime of the Delta (California Department of Water Resources 1995). By the 1940s, nearly all of the marshland had been reclaimed and the Delta had been transformed from a large tidal marsh to the network of channels and leveed islands that exist today. This has resulted in a substantial loss of giant garter snake habitat in the Plan Area and has restricted the species' range to a few isolated sites around the periphery of the Delta.

The giant garter snake is endemic to the wetlands of the Central Valley and was historically distributed from Butte County in the north to Buena Vista Lake in Kern County (U.S. Fish and Wildlife Service 1999). Wetland habitat for giant garter snakes was once abundant throughout the species' historical range, coinciding with the historical distribution of large flood basins, freshwater marshes, and tributary streams of the Central Valley (Hansen and Brode 1980). The species is considered extirpated in the southern San Joaquin Valley and at remnant levels elsewhere in the San Joaquin Valley due to widespread habitat loss and fragmentation (Sloan 2004; Hansen 1988). With the successful adaptation to rice agriculture and associated irrigation channels, populations in the Sacramento Valley are considered more robust. The current range of the giant garter snake extends from near Chico in Butte County south to the Mendota Wildlife Area in Fresno County. However, suitable habitat for the species remains highly fragmented and discontinuous throughout most of its range, resulting in both local and regional isolation of occupied areas.

No occurrences of giant garter snakes are known from the northern portion of the San Joaquin Valley north to the eastern fringe of the Sacramento–San Joaquin River Delta, where the floodplain of the San Joaquin River is limited to a relatively narrow trough (Hansen and Brode 1980; 58 FR 54053). The resulting gap of approximately 100 kilometers (62 miles) separates the southern and northern populations, with no giant garter snakes known from the lowland regions of Stanislaus County (Hansen and Brode 1980; California Department of Fish and Game 2009c).

Occurrence records indicate that giant garter snakes are currently distributed in 13 unique population clusters coinciding with historical flood basins, marshes, wetlands, and tributary streams of the Central Valley (Hansen and Brode 1980; Brode and Hansen 1992; U.S. Fish and Wildlife Service 1999). These populations are isolated, without protected dispersal corridors to other adjacent populations, and are threatened by land use practices and other human activities, including conversion of wetlands and suitable cultivated lands. The Plan Area is in the mid-valley recovery unit identified in the *Draft Recovery Plan for the Giant Garter Snake* (U.S. Fish and Wildlife Service 1999). Three of the 13 giant garter snake populations identified by USFWS occur in the Plan Area in Yolo Basin/Willow Slough, Yolo Basin/Liberty Farms, and Coldani Marsh/White Slough (U.S. Fish and Wildlife Service 1999). While there are several historical occurrences of giant garter snake from elsewhere in the Plan Area, the current distribution is largely limited to the eastern edge of the Plan Area from Coldani Marsh/White Slough northward to approximately Cosumnes River Preserve, and the Yolo Bypass from Fremont Weir to Liberty Farms (Figure 2A.28-2).

Giant garter snake is covered by the *San Joaquin County MSCP*, *Yolo Natural Heritage Program Plan*, *East Contra Costa County HCP/NCCP*, and *Solano HCP*, all of which overlap with the Plan Area. Of these, the *San Joaquin County MSCP* and *Yolo Natural Heritage Program Plan* are likely to include significant conservation for giant garter snake, some of which may take place in the Plan Area. *Natomas Basin HCP* also covers giant garter snake and is adjacent to the Plan Area.

The conservation strategy for the giant garter snake is to protect and restore key habitat and habitat function, expand the species' local range within and adjacent to the Plan Area, and provide increased opportunity for protection and management of the three subpopulations in the Plan Area. The primary stressors on the giant garter snake in the Delta are loss, fragmentation, and degradation of habitat as a result of urban and agricultural expansion. In view of these threats, the focus of this conservation strategy is to provide habitat, provide and enhance connectivity, and enhance habitat function. Implementation actions will provide for the conservation and management of giant garter snake in the Plan Area, particularly in Conservation Zones 2 and 4, which have known populations. Implementation actions outside of these zones will be achieved through restoration of natural communities.

The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM16 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.27.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the giant garter snake are stated below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: While nonnative aquatic plants such as water primrose provide cover for the giant garter snake, they can impede snake movement if they become too dense. Nonnative wildlife species such as bullfrog and largemouth bass prey on young giant garter snakes and may threaten local populations. Consistent with this objective, nonnative invasive plant species that degrade giant garter snake habitat or nonnative wildlife species that prey on the giant garter snake will be controlled if monitoring determines that giant garter snake populations in the reserve system are threatened by these factors.

3.3.7.27.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the giant garter snake are stated below.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.

Objective TFEWNC1.1 Benefits: The restoration of the tidal freshwater emergent wetland natural community in the Plan Area will create or enhance habitat conditions for the giant garter snake and provide potential for dispersal and expansion of populations. Although this natural community type is only expected to be suitable for the giant garter snake where tidal influence is muted, sufficient water is provided during the active season, and adjacent terrestrial refuge is available. Design criteria for restoring tidal wetlands to meet giant garter snake habitat requirements are provided in *CM4 Tidal Natural Communities Restoration*, Section 3.4.4.3.4, *Siting and Design Considerations*. The role of tidal marsh restoration in the giant garter snake conservation strategy is further described under Objective GGS1.4, below.

Goal NFEW/NPANC1: Nontidal marsh consisting of a mosaic of nontidal freshwater emergent perennial wetland and nontidal perennial aquatic natural communities, and providing habitat for covered and other native species.
• **Objective NFEW/NPANC1.1:** Create 1,200 acres of nontidal marsh consisting of a mosaic of nontidal perennial aquatic and nontidal freshwater emergent wetland natural communities, with suitable habitat characteristics for giant garter snake and western pond turtle.

Objectives NFEW/NPANC1.1 Benefits: Creation of nontidal marsh will expand and enhance giant garter snake habitat to allow for increases in giant garter snake abundance and distribution. Nontidal marsh, consisting of a mosaic of nontidal perennial aquatic and nontidal freshwater emergent wetland natural communities, provides the highest-value aquatic habitat for giant garter snake, with opportunities for foraging and cover. Uplands adjacent to these wetlands are also important, and are addressed under the species-specific objectives, below.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.
• **Objective CLNC1.1:** Protect 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species. • **Objective CLNC1.2:** Target cultivated land conservation to provide connectivity between other conservation lands. • **Objective CLNC1.3:** Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objectives CLNC1.1, CLNC1.2, and CLNC1.3 Benefits: Although dependent on the aquatic environment, the giant garter snake occurs within the cultivated landscape where it uses interconnected watercourses (primarily irrigation canals) and associated freshwater emergent wetland habitat and rice lands during the active season and adjacent noncultivated uplands during the inactive season. Maintaining a matrix of cultivated lands that includes suitable interconnected canals with reliable water, associated emergent vegetation, and adjacent upland habitats is essential for conservation of this species.

Cultivated lands protected for Swainson's hawk and greater sandhill crane that occur within the range of the giant garter snake will include water conveyance systems, patches of nontidal marsh, and other aquatic habitats that will be managed to promote use by giant garter snake and other covered species. Protection of cultivated habitats in Zones 2 and 4 for Swainson's hawk and greater sandhill crane conservation is expected to provide opportunities for enhancing connectivity between the Coldani Marsh subpopulation and other historical locations for the species.

3.3.7.27.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for giant garter snake within the reserve system. The goals and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal GGS1: Well-connected high-value upland and aquatic giant garter snake habitat in Conservation Zones 4 and/or 5.
• **Objective GGS1.1:** Of the 1,200 acres of nontidal marsh created under Objective NFEW/NPANC1.1, create at least 600 acres of aquatic habitat for the giant garter snake that is connected to the 1,500 acres of rice land or equivalent-value habitat (Objective GGS1.4). • **Objective GGS1.2:** Of the 8,000 acres of grassland protected under Objective GNC1.1 and 2,000 acres restored under Objective GNC1.2, create or protect 200 acres of high-value upland giant garter snake habitat adjacent to the at least 600 acres of nontidal perennial aquatic habitat being restored and/or created in Conservation Zones 4 and/or 5 (Objective GGS1.1). • **Objective GGS1.3:** Protect giant garter snakes on restored and protected nontidal marsh and adjacent uplands (Objectives GGS1.1 and GGS1.2) from incidental injury or mortality by establishing 200-foot buffers between protected giant garter snake habitat and roads (other than those roads primarily used to support adjacent cultivated lands and levees). Establish giant garter snake reserves at least 2,500 feet from urban areas or areas zoned for urban development. • **Objective GGS1.4:** Create connections from the White Slough population to other areas in the giant garter snake's historical range in the Stone Lakes vicinity by protecting, restoring, and/or creating 1,500 acres of rice land or equivalent-value habitat (e.g., perennial wetland) for the giant garter snake in Conservation Zones 4 and/or 5. Any portion of the 1,500 acres may consist of tidal freshwater emergent wetland and may overlap with the at least 24,000 acres of tidally restored freshwater emergent wetland if it meets specific giant garter snake habitat criteria described in *CM4 Tidal Natural Communities Restoration*. Up to 500 (33%) of the 1,500 acres may consist of suitable uplands adjacent to protected or restored aquatic habitat.

Goal GGS2: Expansive high-value upland and aquatic giant garter snake habitat in Conservation Zone 2 located outside the Yolo Bypass**.**
• **Objective GGS2.1:** Of the 1,200 acres of nontidal marsh created under Objective NFEW/NPANC1.1, create at least 600 acres of connected aquatic giant garter snake habitat outside the Yolo Bypass in Conservation Zone 2. • **Objective GGS2.2:** Of the 8,000 acres of grasslands protected under Objective GNC1.1 and the 2,000 acres restored under Objective GNC1.2, create or protect at least 200 acres of high-value upland habitat adjacent to the at least 600 acres of nontidal marsh habitat created in Conservation Zone 2 outside of Yolo Bypass (Objective GGS2.1). • **Objective GGS2.3:** To expand upon and buffer the newly restored/created nontidal perennial habitat in Conservation Zone 2, protect 700 acres of cultivated lands, with at least 500 acres consisting of rice land and the remainder consisting of compatible cultivated land that can support giant garter snakes. The cultivated lands may be a subset of lands protected for the cultivated lands natural community and other covered species. • **Objective GGS2.4:** Protect giant garter snakes on created nontidal marsh (Objectives GGS2.1) and created or protected adjacent uplands (Objective GGS2.2) from incidental injury or mortality by establishing 200-foot buffers between protected giant garter snake habitat and roads (other than those roads primarily used to support adjacent cultivated lands and levees). Establish giant garter snake reserves at least 2,500 feet from urban areas or areas zoned for urban development.

Objectives GGS1.1, GGS2.1, and GGS2.3 Rationale: Achieving these objectives will provide large blocks of high-value aquatic habitat for giant garter snake within two important subpopulations: the Yolo Basin/Willow Slough subpopulation and the Caldoni Marsh (Delta basin) subpopulation (U.S. Fish and Wildlife Service 1999). Restoration and protection of habitat for the giant garter snake throughout its known historical range, including these two subpopulations, is crucial to the recovery of this species. Restoration/creation and management of wetland habitat in the species' range where little native wetland habitat remains or the habitat is highly fragmented, are needed so that giant garter snake populations are less susceptible to fluctuations in rice production, drought, encroaching urban development, and other factors that may affect the amount and availability of habitat on agricultural lands. Wylie et al. (2009) demonstrated that densities of giant garter snake populations varied by habitat quality and management of the land, buffered natural perennial wetlands having the densest snake population, rice agriculture an intermediate density, and seasonal wetlands managed for waterfowl the lowest density. Large blocks of habitat have several advantages, including reduced edge effects from adjacent incompatible land uses, increased ecosystem function, ability to support larger populations, and economy of scale for costs and implementation of management activities.

Objectives GGS1.2 and GGS2.2 Rationale: Achieving these objectives will provide upland habitat in association with the restored aquatic habitat for giant garter snake. Giant garter snakes require uplands in association with their aquatic habitat for thermoregulation and summer shelter in burrows, and as winter refugia during their dormant period.

Objectives GGS1.3 and GGS2.4 Rationale: Achieving these objectives will ensure that the nontidal marsh and surrounding uplands restored and protected for giant garter snake will be buffered from disturbance related to urban development. A 2,500-foot buffer between giant garter snake habitat and urban areas is expected to substantially reduce the amount of contact and thus potential mortality caused by domestic cats and other effects from urban areas. Domestic cats have been shown to have a significant impact on populations of various native animal species, including giant garter snake. Objectives GGS1.3 and GGS2.4 are consistent with the *Draft Recovery Plan for the Giant Garter Snake* (U.S. Fish and Wildlife Service 1999), which calls for buffering lands that support giant garter snake populations from the effects of urbanization and highway expansion.

Objective GGS1.4 Rationale: While the conservation strategy emphasizes the establishment and management of two giant garter snake reserves designed to protect and enhance existing subpopulations, a broader goal of the strategy is to facilitate movement and dispersal of snakes into otherwise unoccupied portions of the Plan Area and the Delta, and to provide connectivity between populations to facilitate genetic exchange. Increasing the connectivity between populations and within meta-populations is expected to enhance gene flow, increase distribution, and ultimately make the populations more resilient to climate change or catastrophic events.

A giant garter snake corridor is envisioned along the eastern perimeter of the Plan Area connecting the Coldani Marsh/White Slough subpopulation with other portions of the historical range in the Delta. To help achieve this, at least 1,500 acres of rice or giant garter snake habitat with equivalent value will be protected or restored in Conservation Zones 4 and/or 5. Since there is little rice in this area, it is expected that tidal and nontidal marsh restoration will be necessary to meet this objective. Any nontidal marsh restoration applied to this objective would be in addition to the 1,200 acres required under Objective NFEW/NPANC1.1. However, a portion of the at least 24,000 acres of tidal freshwater emergent wetland restoration required under Objective TFEWNC1.1 may contribute toward the 1,500 acres of rice land or equivalent-value habitat, if it meets specific giant garter snake habitat criteria described in *CM4 Tidal Natural Communities Restoration.*

Giant garter snake habitat is composed of a mosaic of emergent wetland, open-water, and upland land cover that collectively supports all the species' life-history requirements. Therefore, upland habitat protection will be a component of the 1,500 acres of rice land or equivalent-value habitat to be protected or restored under GGS1.4.

Goal GGS3: At least 1 acre of giant garter snake habitat conserved for each acre of loss.
• **Objective GGS3.1:** Protect, restore, and/or create at least 2,740 acres of rice land or equivalent-value habitat (e.g., perennial wetland) for the giant garter snake in Conservation Zones 1, 2, 4, or 5. Up to 500 acres may consist of tidal freshwater emergent wetland and may overlap with the at least 5,000 acres of tidally restored freshwater emergent wetland in the Cache Slough ROA if this portion meets giant garter snake habitat criteria specified in *CM4 Tidal Natural Communities Restoration*. Up to 1,700 acres may consist of rice fields in the Yolo Bypass if this portion meets the criteria specified in *CM3 Natural Communities Projection and Restoration*, (Section 3.4.3.3.2, *Siting and Reserve Design*, *Reserve Design Requirements by Species*). Any remaining acreage will consist of rice land or equivalent-value habitat outside the Yolo Bypass. Up to 915 (33%) of the 2,740 acres may consist of suitable uplands adjacent to protected or restored aquatic habitat.

Objectives GGS3.1 Rationale: This objective is based on the intent for in-kind replacement of giant garter snake habitat affected by covered activities, through a combination of direct habitat removal, habitat removal as a result of natural community restoration, loss of rice land in the Yolo bypass as a result of prolonged flooding from *CM2 Yolo Bypass Fisheries Enhancement*, and periodic inundation of giant garter snake upland habitat during the inactive season. An estimated 6,538 acres of giant garter snake habitat will be affected by these activities. Of this, 3,800 acres will be offset by achieving the objectives under Goal GGS1 (for the White Slough population) and GGS2 (for the Willow Slough population). The remaining 2,740 acres needed to conserve 1 acre of habitat for each acre affected may be distributed in Conservation Zones 1, 2, 4, or 5 to benefit either of the two important giant garter snake populations in the Plan Area. This objective provides flexibility as to the type of habitat that may be protected or restored to achieve Goal GGS3. However, a cap is established on the acres of tidal freshwater emergent wetland that may be applied toward the giant garter snake in the Cache Slough ROA; this is because sufficient fully tidal habitat should be restored in the Cache Slough ROA to establish intended benefits for covered fish species, while giant garter snakes require habitat with somewhat muted tidal action. A cap is also established for the acres of rice land that can be protected in the Yolo Bypass; this is because the bypass is not a focal area for giant garter snake recovery due to periodic inundation. However, it is appropriate to offset the loss of 1,700 acres of rice land in the bypass by protecting rice in the bypass in areas that are less susceptible to periodic inundation. Upland habitat protection will be a component of the 1,500 acres of rice land or equivalent-value habitat to be protected or restored under GGS3.1, because upland land cover is a critical element necessary to support the species' life-history requirements (particularly upland basking and cover, and overwintering).

3.3.7.28 Western Pond Turtle

The western pond turtle (*Actinemys marmorata*), although primarily found in natural aquatic habitats, also inhabits impoundments, irrigation ditches, and other artificial and natural water bodies (Ernst et al. 1994). The species is usually found in stagnant or slow-moving freshwater habitats, but brackish habitats are also used (Ernst et al. 1994). Historically, western pond turtles inhabited most water bodies throughout their range, but the series of warm, shallow lakes and extensive slough systems that formerly covered most of the floor of the Central Valley represented their optimal habitat (Jennings et al. 1992). Western pond turtle population declines have been mostly attributed to habitat loss and fragmentation with additional effects from the competition from exotic species (bullfrogs, bass, carp, and exotic turtles), flooding and irrigation, and predation. Habitat quality is often positively correlated with the number of available basking sites (Jennings and Hayes 1994). Turtles seem to avoid areas lacking in significant refugia cut banks and large woody debris (Holland 1994). Upland habitats are also important to western pond turtles for nesting, overwintering, and overland dispersal (Holland 1994). Nesting sites may be as far as 400 meters (1,312 feet) or more from the aquatic habitat, although usually the distance is much less and generally around 100 meters (328 feet) (Jennings and Hayes 1994).

The western pond turtle occurs in the Pacific states of North America from Baja California Norte, north through Washington, and possibly into southernmost British Columbia, Canada (Bury and Germano 2008). In California, this species historically occurred in most Pacific slope drainages between the Oregon and Mexican borders and in only two drainages on the desert slope: the Mojave River (San Bernardino County) and Andreas Canyon (Riverside County) (Jennings and Hayes 1994). Occurrences east of the crest of the Sierra Nevada include Susanville in Lassen County (Stebbins 2003). Most populations throughout the range have exhibited some declines. Bury and Germano (2008) report continued declines in the northern and southernmost portions of the range, but not in the core of the range from central California to southern Oregon. Western pond turtle populations in the Central Valley continue to persist in many areas and appear to have sufficient recruitment to maintain numbers (Germano and Bury 2001).

There are relatively few occurrence records from the Plan Area (Figure 2A.29-2). The CNDDB reports several occurrences spread throughout the Plan Area in Sacramento, San Joaquin, and Contra Costa Counties (California Department of Fish and Game 2011); however, it is likely that this species is underreported and underrepresented in CNDDB. Western pond turtles are common throughout many parts of the Delta, including island interiors, particularly main irrigation and drainage canals or ditches, including toe drains (Patterson pers. comm.). The species has the potential to occur along most of the slower-moving sloughs and other natural watercourses and in artificial channels and other water bodies in the Plan Area where essential habitat elements (streamside cover, logs and other debris for basking, and adjacent upland habitats) are present.

The conservation strategy for western pond turtle involves restoration and protection of aquatic and adjacent upland habitat, and establishment of an interconnected reserve system that provides for western pond turtle dispersal. The habitat protection and restoration needs for this species are addressed at the landscape and natural community levels. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM17 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.28.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the western pond turtle are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.1:** Protect or restore 142,200 acres of high-value natural communities and covered species habitats. • **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA. • **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objectives L1.1 and L1.3 Benefits: Protection and restoration of natural communities consistent with these objectives will benefit western pond turtle by providing an interconnected reserve system with a wide variety of aquatic, nesting and overwintering, and dispersal habitat types. Natural communities that are expected to be used by western pond turtle in some capacity (aquatic foraging and movement, upland nesting and overwintering, or dispersal) include tidal perennial aquatic, tidal brackish emergent wetland, tidal freshwater emergent wetland, valley/foothill riparian, grassland, alkali seasonal wetland complex, vernal pool complex, other natural seasonal wetland, nontidal freshwater emergent wetland, nontidal freshwater aquatic, and cultivated lands. However, western pond turtles use only a small portion of each of these natural community types and are most likely to use specific aquatic features within these communities such as drainage ditches, ponds, and agricultural canals as aquatic habitat and adjacent uplands for nesting and overwintering. Most of the upland natural communities protected will provide suitable dispersal habitat for the western pond turtle because turtles have been known to travel over many different land cover types. Those natural communities most likely to benefit western pond turtle are discussed further under Section 3.3.6, *Natural Community Biological Goals and Objectives*.

Objectives L1.7 Benefits: Protection of transitional uplands, consisting primarily of grasslands, adjacent to tidally restored areas and valley/foothill riparian natural community to accommodate sea level rise, will benefit the western pond turtle by providing opportunities for nesting and overwintering adjacent to tidal areas during the period of sea level rise.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances. • **Objective L2.2:** Allow lateral river channel migration.

Objectives L2.1 and L2.2 Benefits: Floodplain restoration to achieve these objectives will potentially increase the quantity and quality of aquatic habitat for the western pond turtle. Where the floodplain is widened and restored, this will allow oxbows and slow-moving side channels to form, providing suitable aquatic habitat for this species (Bury and Germano 2008; Ernst and Lovich 2009). Where riparian vegetation grows adjacent to slower moving channels, sloughs, and ponds, downed trees can provide important basking habitat and cover habitat for turtles.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: The western pond turtle will benefit from the protection of habitat linkages that allow turtles to disperse over land. Dispersal will allow the species to move between habitat areas and promote gene flow between populations. Fragmentation of western pond turtle populations is thought to be a factor contributing to lack of genetic variability for western pond turtles in Oregon and Washington (Gray 1995). Genetic variability is important for maintaining population stability and resilience.

3.3.7.28.2 Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the western pond turtle are stated below.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.

Objective TFEWNC1.1 Benefits: The restoration of the tidal freshwater emergent wetland natural community in the Plan Area will create or enhance habitat conditions for the western pond turtle, although this natural community type is only expected to be suitable for the western pond turtle where there are sufficient areas with slow moving water and adjacent basking sites. The tidal natural communities designed for giant garter snake, as described in *CM4 Tidal Natural Communities Restoration*, are expected to also provide suitable habitat for western pond turtle.

Goal NFEW/NPANC1: Nontidal marsh consisting of a mosaic of nontidal freshwater emergent wetland and nontidal perennial aquatic natural communities, and providing habitat for covered and other native species.
• **Objective NFEW/NPANC1.1:** Create 1,200 acres of nontidal marsh consisting of a mosaic of nontidal perennial aquatic and nontidal freshwater emergent wetland natural communities, with suitable habitat characteristics for giant garter snake and western pond turtle.

Objective NFEW/NPANC1.1 Benefits: Creation of 1,200 acres of nontidal marsh will benefit the western pond turtle by providing high-value aquatic habitat. As described in *CM10 Nontidal Marsh Restoration*, this community will be restored as a combination of emergent wetland and aquatic habitat, with adjacent upland grasslands for basking, nesting, and overwintering. The western pond turtle is known to be present in Conservation Zone 2 in the Yolo Bypass Wildlife Area (California Department of Fish and Game 2011), and in Conservation Zone 4 in the White Slough Wildlife Area (Germano and Bury 2001); therefore, this species is expected to benefit from restoration in these areas.

Goal MWNC1: Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species.
• **Objective MWNC1.1:** Protect and enhance 8,100 acres of managed wetland, at least 1,500 acres of which are in the Grizzly Island Marsh Complex.

Objective MWNC1.1 Benefit: Achieving this objective is expected to benefit the western pond turtle by enhancing habitat for the species. Portions of the 8,100 acres of protected and enhanced managed wetlands most likely to benefit the species include permanent water areas that are enhanced for breeding waterfowl (primarily on the 6,600 acres protected specifically for waterfowl) and those upland areas where cover is enhanced in areas that support only bare ground or invasive species prior to enhancement. Protection and enhancement of managed wetlands to meet this objective will focus on highly degraded areas to provide the greatest possible level of enhancement benefit to the managed wetland natural community and associated native species.

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11. • **Objective GNC1.3:** Protect stock ponds and other aquatic features within protected grasslands to provide aquatic breeding habitat for native amphibians and aquatic reptiles.

Objectives GNC1.1 and GNC1.3 Benefits: Achieving this objective will provide high-value habitat for the western pond turtle in the reserve system. Grasslands provide the highest-value habitat for western pond turtle nesting and overwintering. Additionally, grasslands in the Plan Area are interspersed with stock ponds and other aquatic features that provide aquatic habitat for this species.

Goal CLNC1: Cultivated lands that provide habitat connectivity and support habitat for covered and other native wildlife species.
• **Objective CLNC1.3:** Maintain and protect the small patches of important wildlife habitats associated with cultivated lands that occur in cultivated lands within the reserve system, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands.

Objective CLNC1.3 Benefits: Achieving these objectives will benefit the western pond turtle through the protection and management of drainage and irrigation ditches associated with cultivated lands, which provide aquatic habitat for this species. Additionally, ponds and upland areas associated with protected cultivated lands will provide aquatic and nesting and overwintering habitat for the pond turtle.

3.3.7.28.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of western pond turtle in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.29 California Red-Legged Frog

Aquatic breeding habitat requirements for the California red-legged frog (*Rana draytonii*) are cold water pond habitats (including intermittent and perennial streams) with emergent and submergent vegetation, providing suitable cover for young and adults and ensuring successful reproduction (Storer 1925; Hayes and Jennings 1988). Optimal habitats are described as deepwater ponds or pools at least 2.3 feet (0.7 meter) deep along low-gradient streams with dense stands of overhanging willows and a fringe of cattails between the willow roots and overhanging willow limbs. The California red-legged frog uses a variety of aquatic habitats that meet these requirements, including permanent and ephemeral ponds, perennial and intermittent streams, seasonal wetlands, springs, seeps, marshes, dune ponds, lagoons, and human-made aquatic features (U.S. Fish and Wildlife Service 2007). In addition to aquatic breeding habitat, the California red-legged frog also requires upland nonbreeding habitat used for cover, aestivation, and dispersal. Nonbreeding cover habitat may include nearly any areas within 1 to 2 miles of a breeding site. Potential cover and aestivation habitat includes all aquatic, riparian, and upland areas that provide cover (61 FR 25813). Dispersal habitat may include annual grasslands, riparian corridors, woodlands, and sometimes active agricultural lands (Fellers and Kleeman 2007). For more detail, see the species account for California red-legged frog in Appendix 2.A, *Covered Species Accounts.*

The historical range of the California red-legged frog is generally characterized as extending south along the coast from the vicinity of Point Reyes National Seashore, Marin County, California, and inland from the vicinity of Redding, Shasta County, California, southward along the interior Coast Ranges and Sierra Nevada foothills to northwestern Baja California, Mexico (U.S. Fish and Wildlife Service 2007) (Appendix 2.A). USFWS (2002) estimates that the species has lost suitable habitat in approximately 70% of its former range, with the most severe declines occurring primarily in the Central Valley and southern California (Jennings and Hayes 1994). There have been recent discoveries at isolated locations in the Sierra Nevada (Placer, Nevada, Yuba, and El Dorado Counties) and two populations in the southern Transverse and Peninsular Ranges. Sizable populations continue to exist only in coastal drainages and associated pond habitats between Point Reyes and Santa Barbara (Jennings and Hayes 1994).

Within the Plan Area the California red-legged frog has been detected only in aquatic habitats within the grassland landscape west and southwest of Clifton Court Forebay, in the vicinity of Byron and Brushy Creek along the west-central edge of the Plan Area, and in some upland sites west of Suisun Marsh (Figure 2A.30-2) (California Department of Fish and Game 2011) (Appendix 2.A). These areas represent the easternmost edge of the current range of California red-legged frog within the Coast Ranges. The occurrences west of Suisun Marsh are separated from the Plan Area by Interstates 80 and 680, which limit movement into the Plan Area. California red-legged frog is not known to occur in the cultivated lands of the Central Valley. Occupied habitats in the Plan Area are characterized by grassland foothills with stock ponds, intermittent drainages, and slow-moving perennial drainages.

The principal factors contributing to the decline of the California red-legged frog are loss of habitat due to urban development, conversion of native habitats to cultivated lands, introduction of nonnative predators such as bullfrogs, and pesticide use (Fisher and Shaffer 1996; Hobbs and Mooney 1998; Davidson et al. 2002). Habitat loss and fragmentation result in small, isolated populations, which reduce individual movements and genetic exchange between populations.

The *Recovery Plan for the California Red-Legged Frog* (U.S. Fish and Wildlife Service 2002) focuses on protection of suitable habitat, *in perpetuity*, within core areas that are defined in the recovery plan, including protection of upstream areas that if adversely affected could make habitat unsuitable. There are two California red-legged frog core recovery areas in the Plan Area, in Conservation Zones 1 and 8 (Figure 2A.30-2).

The conservation strategy for this species is to protect and manage grasslands to sustain and increase habitat values for this species, and to protect and enhance perennial stream channels and stock ponds in grassland natural communities in Conservation Zone 8 through partial livestock exclusion and predator control. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM14 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.29.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the California red-legged frog are stated below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: Consistent with this objective, the introduction and proliferation of nonnative bullfrogs and other nonnative aquatic wildlife that prey on red-legged frogs will be reduced. As described in *CM11 Natural Communities Enhancement and Management*, nonnative aquatic predators that threaten California red-legged frog populations will be removed from ponds and other aquatic habitat, as needed to sustain the red-legged frog population in the reserve system.

3.3.7.29.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the California red-legged frog are stated below.

Goal GNC1: Extensive grasslands composed of large interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11. • **Objective GNC1.3:** Protect stock ponds and other aquatic features within protected grasslands to provide aquatic breeding habitat for native amphibians and aquatic reptiles.

Objectives GNC1.1 and GNC1.3 Benefits: Protection of at least 1,000 acres of grassland in Conservation Zone 8, west of Byron Highway, will benefit California red-legged frog by providing habitat in the portion of the Plan Area with the highest long-term conservation value for the species based on known species occurrences and large, contiguous habitat areas. Consistent with Objective GNC1.3, ponds and other aquatic features within the grasslands will be protected to provide aquatic habitat for this species, and surrounding grassland will provide dispersal and aestivation habitat. Lands protected in Conservation Zone 8 will connect with lands protected under the *East Contra Costa County HCP/NCCP* and the extensive Los Vaqueros Watershed lands, including grassland areas supporting this species. This objective will ensure that California red-legged frog upland and associated aquatic habitats will be protected and enhanced in the largest possible patch sizes adjacent to occupied habitat within and adjacent to the Plan Area.

Approximately 7,823 acres of upland cover and dispersal habitat is present in the Plan Area, of which approximately 1,670 acres (21%) are currently protected. Following BDCP implementation, approximately 35% of modeled California red-legged frog habitat will be protected, including habitat in Conservation Zone 8 that links to occupied habitat outside the Plan Area. Achieving these objectives will preclude potential future fragmentation of the highest-functioning frog habitat in the Plan Area and maintain sufficient habitat area to sustain or increase the existing Plan Area population of

California red-legged frogs and to maintain connectivity with occupied core populations adjacent to the Plan Area that are covered under adjacent and overlapping HCP/NCCPs.

Goal GNC2: Biologically diverse grasslands that are managed to enhance native species and sustained by natural ecological processes.
• **Objective GNC2.3**: Increase burrow availability for burrow-dependent species. • **Objective GNC2.5:** Maintain and enhance aquatic features in grasslands to provide suitable inundation depth and duration and suitable composition of vegetative cover to support breeding for covered amphibian and aquatic reptile species.

Objectives GNC2.3 and GNC2.5 Benefits: Achieving these objectives will benefit the California red-legged frog by maintaining suitable habitat characteristics for this species in the reserve system. Increasing burrow availability consistent with Objective GNC2.3 will provide refugia and cover for aestivating and dispersing California red-legged frogs. Maintaining appropriate depth and duration of aquatic features is important for this species, to ensure that conditions are favorable for supporting the entire aquatic life cycle, from breeding through metamorphosis from larval to adult stages. Furthermore, features that are inundated for a sufficient duration to support the red-legged frog life cycle but are dry in late summer are less likely to support bullfrogs and other aquatic predators. Additionally, livestock exclusion from streams and ponds and other measures will be implemented as described in *CM11 Natural Communities Enhancement and Management* to promote growth of aquatic vegetation with appropriate cover characteristics favorable to California red-legged frogs.

3.3.7.29.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of the California red-legged frog in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.30 California Tiger Salamander, Central Valley Distinct Population Segment

The California tiger salamander (*Ambystoma californiense*) is endemic to California, where its range is limited primarily by the availability of burrows and winter breeding habitat, primarily open grassland landscapes with vernal pools, stock ponds, and playa pools and with burrowing squirrels and pocket gophers (Barry and Shaffer 1994). Extant populations of California tiger salamanders are believed to be declining as a result of habitat loss (Shaffer et al. 1993; Barry and Shaffer 1994; Holland 1998). In particular, an estimated 80% of the species' historical natural aquatic habitat has been lost (Holland 1998), and the species has been eliminated from 55 to 58% of historical breeding sites (Barry and Shaffer 1994).

California tiger salamander has been documented in the past in the Plan Area in Conservations Zones 1, 6, 7, 8, 10, and 11 (Figure 2A.31-2)(California Department of Fish and Game 2011). There are several California tiger salamander occurrences in Conservation Zone 1 that is west of Highway 113 and east of Travis Air Force Base (California Department of Fish and Game 2011), an area designated as critical habitat for California tiger salamander by USFWS. There are also several occurrences along the western edge of Conservation Zone 8, just west of Clifton Court Forebay, and several in the Portero Hills just south of Travis Air Force Base in Conservation Zone 11 (California Department of Fish and Game 2011). Potential habitat exists in vernal pool and alkali wetland natural communities identified in portions of Conservation Zone 1, primarily within its southwestern portion; Conservation Zone 2, on the west half of the Yolo Bypass north of Liberty Island; Conservation Zone 4, off Interstate 5 west of Elk Grove; Conservation Zone 8, in its western half, east and west of Byron Highway; Conservation Zone 9, scattered areas in its southern half; and Conservation Zone 11, along its eastern and northern boundaries.

There is no recovery plan for the California tiger salamander, but this species relies primarily on vernal pool and pond breeding and grassland cover habitat (Appendix 2.A, *Covered Species Accounts*).

The conservation strategy for this species relies primarily on the landscape-scale and natural community goals and objectives for large, interconnected habitat areas, management to promote native vegetation and increase burrows for aestivation, and maintenance of suitable hydrologic conditions. AMM13 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.30.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the California tiger salamander are stated below.

Goal L1: A reserve system with representative natural and seminatural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.6 Benefits: One of the primary causes of the decline of California tiger salamander populations is the fragmentation of habitat resulting from urban and agricultural development. This objective will build on the existing reserve system to protect large, interconnected areas. This objective relates to the California tiger salamander habitat and other areas that may not be used by this species, but may serve to buffer California tiger salamanders and their habitat from the effects of anthropogenic stressors (e.g., hydrologic disturbances, pollutants, nonnative species introductions).

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: Nonnative invasive plant species will be reduced and native plant species encouraged in vernal pools and other aquatic California tiger salamander habitat features, consistent with this objective and as described in *CM11 Natural Communities Enhancement and Management.* Increasing native vegetative cover has been shown to increase vernal pool hydroperiod (Marty 2005), thus making aquatic habitat more suitable for California tiger salamander breeding.

Consistent with this objective, the introduction and proliferation of nonnative bullfrogs and other nonnative aquatic wildlife that prey on California tiger salamanders will be reduced. Bullfrogs and predatory fish are a primary source of mortality for this species (Fisher and Shaffer 1996). As described in *CM11 Natural Communities Enhancement and Management*, nonnative aquatic predators that threaten California tiger salamander populations will be removed from ponds and other aquatic habitat, as needed, to sustain the California tiger salamander population in the reserve system.

Goal L3: Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area.
• **Objective L3.1:** Protect and improve habitat linkages that allow terrestrial covered and other native species to move between protected habitats within and adjacent to the Plan Area.

Objective L3.1 Benefits: Consistent with this objective, measures described in *CM11 Natural Communities Enhancement and Management* such as controlling the height and density of grassland and improvement of culverts will be implemented to facilitate California tiger salamander movement and thus enhance habitat linkages. Increasing opportunities for California tiger salamanders to move through grassland habitats will enhance genetic exchange and the ability to recolonize any areas where the species may have been locally extirpated.

3.3.7.30.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the California tiger salamander are stated below.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex**.**
• **Objective ASWNC1.1**: Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.

Objective ASWNC1.1 Benefits: Alkali seasonal wetlands will be protected within a mosaic of natural communities that will also include grasslands and vernal pool complex as described above, resulting in a large, interconnected reserve system in Conservation Zones 1, 8, and 11. This will benefit the California tiger salamander by providing suitable aquatic and upland habitat in areas known to support this species.

Goal ASWNC2: Alkali seasonal wetland complexes that are managed and enhanced to sustain populations of native alkali seasonal wetland species.
• **Objective ASWNC2.1**: Provide appropriate seasonal flooding characteristics for supporting and sustaining alkali seasonal wetland species. • **Objective ASWNC2.3:** In grasslands surrounding alkali seasonal wetlands within restored and protected alkali seasonal wetland complex, increase burrow availability for burrow-dependent species.

Objective ASWNC2.1 Benefits: Maintaining and enhancing appropriate hydrologic characteristics for alkali seasonal wetlands will benefit California tiger salamander in the same manner that hydrologic maintenance and enhancement of vernal pools will benefit the species, as described for Objective VPNC2.1, above.

The natural community objectives listed above will together protect 11,000 acres of lands—10,000 acres of grassland (GNC1.1 and GNC1.2), 600 acres of vernal pool complex (VPNC1.1 and VPNC2.1), and 400 acres of alkali wetland complex (ASWNC1.1)—that currently, or following enhancement or restoration actions, are expected to provide suitable habitat for California tiger salamander.

Objective ASWNC2.3 Benefits: Increasing burrow availability consistent with this objective is expected to provide refugia and cover for aestivating and dispersing California tiger salamanders within the grassland matrix surrounding alkali seasonal wetlands.

Goal VPNC1: Vernal pool complexes composed of large, interconnected, or contiguous expanses that represent a range of environmental conditions.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). • **Objective VPNC1.2**: Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools). • **Objective VPNC1.3**: Increase the size and connectivity of protected vernal pool complex within the Plan Area and increase connectivity with protected vernal pool complex adjacent to the Plan Area. • **Objective VPNC1.4:** Protect the range of inundation characteristics that are currently represented by vernal pools throughout the Plan Area.

Objectives VPNC1.1, VPNC1.2, and VPNC1.3 Benefits: The protection and restoration of vernal pool complexes within a large, interconnected reserve system in Conservation Zones 1, 8, and 11 will benefit the California tiger salamander by providing suitable aquatic and upland habitat in areas known to support this species. The vernal pool complex natural community will be protected in association with the larger grassland acreage to be protected, as described above, contributing to an extensive interconnected reserve system for this species.

Consistent with Objectives VPNC1.1 and VPNC1.2, vernal pool protection and restoration will occur in Conservation Zones 1, 8, and 11, primarily in areas identified as core recovery areas in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (Vernal Pool Recovery Plan) (U.S. Fish and Wildlife Service 2005). Although California tiger salamander is not included in the Vernal Pool Recovery Plan, habitat and occurrences for this species in Conservation Zones 1, 8, and 11 are concentrated primarily in the core recovery areas.

Objective VPNC1.4 Benefits: Protecting the range of inundation characteristics that are currently represented by vernal pools in the Plan Area will benefit the California tiger salamander by ensuring that a representative proportion of the protected vernal pools are sufficiently large and deep, with long inundation periods, to support the aquatic life cycle for this species. Optimal California tiger salamander breeding habitat consists of large vernal pools, playa pools, or ephemeral ponds that hold water until at least May. In coastal regions such as the Plan Area, California tiger salamander larvae may not metamorphose until late July, and pools holding water through July often have higher reproductive success for this species (Barry and Shaffer 1994).

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.
• **Objective VPNC2.1**: Maintain or enhance vernal pool complexes to provide the appropriate inundation (ponding) characteristics for supporting and sustaining vernal pool species. • **Objective VPNC2.4:** In grasslands surrounding vernal pools within restored and protected vernal pool complex, increase burrow availability for burrow-dependent species.

Objective VPNC2.1 Benefits: Achieving this objective will benefit the California tiger salamander because vernal pools will be maintained and enhanced to ensure that they are inundated for a sufficient period to support the species' entire aquatic life cycle, and will also exhibit seasonal drying to limit the ability of nonnative predators to become established (e.g., bullfrogs and fish).

Objective VPNC2.4 Benefits: Increasing burrow availability consistent with this objective is expected to provide refugia and cover for aestivating and dispersing California tiger salamanders within the grassland matrix surrounding vernal pools.

Goal GNC1: Extensive grasslands composed of large interconnected patches or contiguous expanses.

- **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11.
- **Objective GNC1.2:** Restore 2,000 acres of grasslands to connect fragmented patches of protected grassland and to provide upland habitat adjacent to riparian and tidal and nontidal natural communities for wildlife foraging and upland refugia.
- **Objective GNC1.3**: Protect stock ponds and other aquatic features within protected grasslands to provide aquatic breeding habitat for native amphibians and aquatic reptiles.

Objectives GNC1.1, GNC1.2, and GNC1.3 Benefits: Protection of 8,000 acres of grasslands in Conservation Zones 1, 8, and 11 will benefit the California tiger salamander by providing habitat in the portions of the Plan Area with the highest long-term conservation value for the species based on known species occurrences and large, contiguous habitat areas. Consistent with GNC1.3, ponds and other aquatic features within the grasslands will be protected to provide aquatic habitat for this species, and surrounding grassland will provide dispersal and aestivation habitat. Lands protected in Conservation Zone 8 will connect with the lands protected under the *East Contra Costa County HCP/NCCP*, including grassland areas supporting this species. Lands protected in Conservation Zone 11 will connect with those planned for protection under the *Solano County HCP*, including grassland and vernal pool complex areas supporting this species. Protecting seasonal ponds associated with grasslands, consistent with Objective GNC1.3, will ensure that California tiger salamander aquatic habitat and associated uplands will be protected and enhanced in the largest possible patch sizes adjacent to occupied habitat within and adjacent to the Plan Area.

Grassland restoration will focus specifically on connecting fragmented patches of protected grasslands (GNC1.2), thereby increasing dispersal opportunities for the California tiger salamander. The protection and restoration of these natural communities will increase the extent and connectivity of protected habitat in the Plan Area and region. Protection and restoration will build off existing conservation lands within and adjacent to the Plan Area. Protected and restored vernal pool complex will be managed in conjunction with protected grassland and alkali seasonal wetland complex natural communities to conserve and promote connectivity. The increased habitat extent and connectivity will increase opportunities for genetic exchange and allow for colonization of extirpated populations and restored habitats.

Goal GNC2: Biologically diverse grassland that are managed to enhance native species and sustained by natural ecological processes.

- **Objective GNC2.3**: Increase burrow availability for burrow-dependent species.
- **Objective GNC2.5**: Maintain and enhance aquatic features in grasslands to provide suitable inundation depth and duration and suitable composition of vegetative cover to support breeding for covered amphibian and aquatic reptile species.

Objectives GNC2.3 and GNC2.5 Benefits: Achieving these objectives will benefit the California tiger salamander by maintaining suitable habitat characteristics for this species in the reserve system. Increasing burrow availability consistent with Objective GNC2.5 is expected to provide refugia and cover for aestivating and dispersing California tiger salamanders. Maintaining appropriate depth and duration of aquatic features is important for this species, to ensure that conditions are favorable for supporting the entire aquatic life cycle from breeding through metamorphosis from larval to adult stages. Furthermore, features that are inundated for a sufficient duration to support the California tiger salamander life cycle but are dry in late summer are less likely to support bullfrogs and other aquatic predators (e.g., seasonal ponds and wetlands or stock ponds that can be drained periodically). Additionally, livestock exclusion and other measures will be implemented as described in *CM11 Natural Communities Enhancement and Management* to promote growth of aquatic vegetation with appropriate cover characteristics favorable to the California tiger salamander.

3.3.7.30.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of the California tiger salamander in the Plan Area. Species-specific goals and objectives are not necessary for this species.

3.3.7.31 Valley Elderberry Longhorn Beetle

One of two subspecies of the longhorn beetle, the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is endemic to moist valley/foothill riparian corridors in the lower Sacramento and lower San Joaquin Valleys (U.S. Fish and Wildlife Service 1984). The valley elderberry longhorn beetle has a dependent association with elderberry (*Sambucus* spp.) which is an obligate host plant for valley elderberry longhorn beetle larvae and is necessary for the completion of the beetle's life cycle (Linsley and Chemsak 1972, 1997; Eng 1984; Barr 1991; Collinge et al. 2001).

There is little information regarding range-wide population trends for valley elderberry longhorn beetle. At the time of its listing, the beetle was known from less than 10 locations on the American River, Putah Creek, and the Merced River in the Central Valley. Since the time of its listing, surveys have identified approximately 190 locations of the beetle ranging from Shasta County to Fresno County. Loss of riparian habitat has slowed throughout the Central Valley and efforts specific to this species as of 2006 had resulted in protection of 50,000 acres and restoration of over 5,100 acres of valley elderberry longhorn beetle habitat. Based on the number of sightings throughout the Central Valley and the reduction in primary threats to this species (habitat loss), USFWS recommended in a 5-year status review that the species be delisted (U.S. Fish and Wildlife Service 1984, 2006), and the species was formally proposed for delisting (77 FR 60238–60275).

The current distribution of valley elderberry longhorn beetle through the Plan Area is largely unknown, but current CNDDB occurrence data are concentrated in the northeastern portion of the Plan Area, specifically Conservation Zone 3 near Sacramento. Three occurrences of the valley elderberry longhorn beetle are documented in the Plan Area, including one along Old River north of Tracy and two recent occurrences along small drainages between the Sacramento River and the Sacramento DWSC in the vicinity of West Sacramento (Figure 2A.32-2). (Appendix 2.A, *Covered Species Accounts*) (California Department of Fish and Game 2011). Additional historical occurrences are documented from along the Sacramento River corridor and Putah Creek in Yolo County (Eya 1976; Jones & Stokes 1985, 1986, 1987a, 1987b; U.S. Fish and Wildlife Service 1984; Barr 1991; Collinge et al. 2001). Comprehensive surveys for the species or its host plant, elderberry, have not been conducted and thus the population size and location of the species in the Plan Area is unknown. However, distribution is typically based on the occurrence of elderberry shrubs, which are known to occur along riparian corridors throughout the Plan Area, including the Sacramento River, Stanislaus River, San Joaquin River, and along smaller natural and channelized drainages, as well as in upland habitats. The beetle is considered to potentially occur in all mature elderberry shrubs in the Plan Area with stems at least 1 inch in diameter.

Critical habitat has been designated for the valley elderberry longhorn beetle, but neither of the two sites with critical habitat is located within the boundaries of the Plan Area. Conservation guidelines for the valley elderberry longhorn beetle were established by USFWS in 1999 to mitigate development-related impacts on valley elderberry longhorn beetle habitat (Appendix 3.F, *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*). The valley elderberry longhorn beetle conservation has also been addressed in several regional conservation plans. The valley elderberry longhorn beetle is a covered species under the approved *San Joaquin County MSCP* and the *Natomas Basin HCP*. It is proposed for coverage under the *South Sacramento HCP*, *Solano HCP*, *Yolo Natural Heritage Program Plan*, *Placer County Conservation Plan*, and *Butte Regional Conservation Plan*. Valley elderberry longhorn beetle conservation under the BDCP will therefore tie in with conservation efforts under these other HCPs.

The conservation strategy for valley elderberry longhorn beetle involves floodplain restoration, restoration of 5,000 acres of valley/foothill riparian natural community, and creation of valley elderberry longhorn beetle habitat in the vicinity of existing populations. In all cases, elderberry shrubs would need to be planted or colonize sites naturally in order to provide suitable additional habitat for the species. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM15 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.31.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the valley elderberry longhorn beetle are stated below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.3:** Connect rivers and their floodplains to allow input of large woody debris, leaves, and other organic material to rivers.

Objective L2.3 Benefits: Achieving this objective will benefit valley elderberry longhorn beetle by providing suitable habitat conditions through floodplain restoration. Flood control efforts, and accompanying reduction in the width of the riparian corridor, has contributed to decreased valley elderberry longhorn beetle occupancy in riparian stretches along the Sacramento River (Lang et al. 1989). Floodplain restoration and associated riparian restoration will increase the width of the riparian corridor, and recharging of floodplain groundwater will promote and sustain riparian vegetation.

Most of the floodplain restoration is planned to occur in Conservation Zone 7. There is one current CNDDB occurrence record (#158) for the valley elderberry longhorn beetle in Conservation Zone 7, which reports one adult captured and beetle exit holes observed[58] in elderberry shrubs near Middle River or Old River in 1984. There is another CNDDB occurrence record (#45) for this species

[58] Valley elderberry longhorn beetle larvae develop in the pith of elderberry stems. Before the larvae pupate they burrow out of the stem, creating an exit hole that is characteristic of the species.

immediately south of Conservation Zone 7, outside the Plan Area at Caswell Memorial State Park. This record reports two elderberry plants containing beetle exit holes, observed in 1985. It is unknown whether these two valley elderberry longhorn beetle occurrences in and near Conservation Zone 7 are still extant, but these records indicate that the species is potentially present in Conservation Zone 7. This indicates that floodplain restoration in Conservation Zone 7 will potentially benefit the species by providing additional habitat where elderberries are present in the restored riparian areas, and conditions for population expansion in this zone. This objective will be met through floodplain restoration (*CM5 Seasonally Inundated Floodplain Restoration*).

3.3.7.31.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the valley elderberry longhorn beetle are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian natural community, with locations informed by both existing and historical distribution.

- **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain.
- **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objective VFRNC1.1 Benefits: Achieving this objective will improve conditions for the valley elderberry longhorn beetle by restoring or creating 5,000 acres of valley/foothill riparian in the Plan Area (*CM7 Riparian Natural Community Restoration*), to contribute to the goal of extensive wide bands or large patches of interconnected valley/foothill riparian forests. While the entire 5,000 acres is not expected to provide suitable habitat conditions for the valley elderberry longhorn beetle, some portion of this acreage will benefit the species where restoration occurs in the vicinity of existing populations and where suitable elderberry shrubs are present. Most of the 5,000 acres of riparian restoration will take place within the restored floodplain.

Objective VFRNC1.2 Benefits: Achieving this objective will improve conditions for the valley elderberry longhorn beetle by protecting 750 acres of valley/foothill riparian in the Plan Area (*CM3 Natural Communities Protection and Restoration*), to contribute to the goal of extensive wide bands or large patches of interconnected valley/foothill riparian forests. While the entire 750 acres is not expected to provide suitable habitat conditions for the valley elderberry longhorn beetle, some portion of this acreage will benefit the species where suitable elderberry shrubs are present.

Goal VFRNC3: Maintenance or increase of native biodiversity that is characteristic of the valley/foothill riparian natural community.

- **Objective VFRNC3.1:** Maintain or increase abundance and distribution of valley/foothill riparian natural community vegetation alliances that are rare or uncommon as recognized by California Department of Fish and Game (2010), such as *Cephalanthus occidentalis* (button willow thickets) alliance and *Sambucus nigra* (blue elderberry stands) alliance.

Objective VFRNC3.1 Benefits: Elderberry plantings to establish blue elderberry stands will be incorporated into riparian restoration plans consistent with this objective to contribute to riparian plant species diversity. This is expected to directly benefit the valley elderberry longhorn beetle by increasing the abundance and distribution of the host plant species, thereby potentially providing opportunities to expand the distribution and increase the abundance of valley elderberry longhorn beetle populations in the Plan Area. This objective will be achieved through riparian restoration and enhancement as described in *CM7 Riparian Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management.*

3.3.7.31.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for the valley elderberry longhorn beetle within the reserve system. The goals and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal VELB1: Promote dispersal and expansion of the valley elderberry longhorn beetle where there are known source populations within the American and Sacramento River systems.
• **Objective VELB1.1:** Mitigate impacts on elderberry shrubs by creating valley elderberry longhorn beetle habitat consistent with the U.S. Fish and Wildlife Service valley elderberry longhorn beetle conservation guidelines (Appendix 3.F) and planting elderberry shrubs in high-density clusters. • **Objective VELB1.2:** Site valley elderberry longhorn beetle habitat restoration within drainages immediately adjacent to or in the vicinity of sites confirmed to be occupied by valley elderberry longhorn beetle.

Objective VELB1.1 Rationale: This objective will increase opportunities for colonization by planting elderberry shrubs in high-density clusters to offset their loss to covered activities. The valley elderberry longhorn beetle is more likely to occupy elderberry shrubs that occur in higher densities rather than isolated shrubs, and shrub density is an important factor influencing beetle occupancy (Collinge et al. 2001). To further increase opportunities for colonization by valley elderberry longhorn beetle into restoration sites, any shrubs at impact sites with stems greater than 1 inch in diameter will be transplanted to habitat restoration sites consistent with the USFWS conservation guidelines for the species (Appendix 3.F). Criteria for valley elderberry longhorn beetle habitat restoration are detailed in *CM7 Riparian Natural Community Restoration*.

Because valley elderberry longhorn beetle habitat is patchily and unpredictably distributed within the riparian natural community, the extent to which elderberry shrubs and occupied valley elderberry longhorn beetle habitat will be lost as a result of covered activities cannot be determined at the Plan level. In order to ensure that conservation is roughly proportional to impacts consistent with provisions of the NCCPA, impacts will be determined through site-specific surveys during individual project planning, and mitigated consistent with the USFWS guidelines (Appendix 3.F). These guidelines require transplanting shrubs from the areas of effect to restoration sites, and planting additional elderberry seedlings at ratios ranging from 1:1 to 8:1 (seedling planted to stems affected) for all stems over 1 inch in diameter. As specified in the 1999 guidelines, the mitigation ratio will depend on the diameter of each stem affected, presence or absence of valley elderberry longhorn beetle exit holes in each shrub, and whether or not each affected shrub is in a riparian area. The landscape and natural community level goals and objectives will likely provide benefits to the valley elderberry longhorn beetle beyond mitigation. Furthermore, the habitat restoration for this species will be designed and configured to optimize opportunities for colonization by the valley elderberry longhorn beetle.

Objective VELB1.2 Rationale: This objective will focus restoration on the drainages close to sites occupied by the valley elderberry longhorn beetle. This species has distinct, relatively isolated populations in individual drainages, likely due to the beetle's limited dispersal capability (Collinge et al. 2001). The species is unlikely to colonize unoccupied drainages, even if suitable habitat is present. This necessitates siting habitat restoration within or in the vicinity of occupied drainages, consistent with Objective VELB1.1. Known occupied habitat in the Plan Area occurs in Conservation Zones 2 and 7 in three occurrences, but additional known occurrences are expected to be found as the reserve system is assembled. Some occurrences are known from agricultural ditches and railroad tracks; however, these locations do not provide opportunities to restore dense patches of elderberry shrubs within a riparian matrix directly adjacent to occupied areas. In these cases, restoration would be located within reasonable dispersal distance for the valley elderberry longhorn beetle from known occurrences.

3.3.7.32 Vernal Pool Crustaceans

The covered crustacean species associated with the vernal pool complex are the California linderiella (*Linderiella occidentalis*), conservancy fairy shrimp (*Branchinecta conservatio*), longhorn fairy shrimp (*Branchinecta longiantenna*), midvalley fairy shrimp (*Branchinecta mesovallensis*), vernal pool fairy shrimp (*Branchinecta lynchi*), and vernal pool tadpole shrimp (*Lepidurus packardi*). The historical distributions of the covered vernal pool crustaceans are unknown, but probably coincided with the historical distributions of their habitat (U.S. Fish and Wildlife Service 2005). These species occupy vernal pool complexes, which are described in detail in Section 2.3.4.9, *Vernal Pool Complex*, in Chapter 2, *Existing Ecological Conditions*, and Section 3.3.6.9, *Managed Wetland,* above.

The primary stressors affecting long-term survival and recovery of the covered vernal pool shrimp are habitat loss and fragmentation, and habitat degradation as a result of changes to natural hydrology, erosion, invasive species, incompatible grazing regimes, and recreational activities (U.S. Fish and Wildlife Service 1994). These stressors will be reduced or eliminated on protected and restored lands in the Plan Area consistent with the biological goals and objectives.

The Plan Area contains a total of 11,472 acres of modeled vernal pool crustacean habitat, 2,576 acres of which is degraded vernal pool complex distributed along the margins of the Plan Area, in Conservation Zones 1, 2, 4, 8, 9, and 11.

The current distributions of the covered vernal pool crustacean species occurrences range-wide and in Plan Area are as follows.

- **California linderiella.** This species occurs in the Central Valley from Shasta County south to Fresno County and in the Coast Transverse ranges from Mendocino County south to Ventura County (Eriksen and Belk 1999; Appendix 2.A, *Covered Species Accounts*). Typical habitat for this species includes large, clear pools (Eng et al. 1990), although this species has been found in turbid, tea colored, or small pools (U.S. Fish and Wildlife Service 2005). In the Plan Area, there are records for this species in Conservation Zones 1, 2, 4, 10, and 11 (Figure 2A.33-2 in Appendix 2.A).

- **Conservancy fairy shrimp.** This species is known from a few isolated populations distributed over a large portion of California's Central Valley and in southern California (U.S. Fish and Wildlife Service 2005, p. II-183) (Appendix 2.A). Conservancy fairy shrimp is often found in vernal pools that are relatively large and turbid (U.S. Fish and Wildlife Service 2005:II-183). In the Plan Area, there are recorded occurrences of conservancy fairy shrimp in Conservation Zones 1, 2, and 11 (Figure 2A.34-2 in Appendix 2.A).

- **Longhorn fairy shrimp.** This species is known from only a small number of widely separated populations (Appendix 2.A). The species has been found in small, clear, sandstone outcrop pools in Contra Costa and Alameda Counties; in a matrix of alkali sink and alkali scrub plant communities near Soda Lake in the Carrizo Plain area; in alkaline grassland pools at the Kesterson National Wildlife Refuge; and in a roadside ditch near Los Banos (U.S. Fish and Wildlife Service 2005). There are no recorded occurrences of longhorn fairy shrimp in the Plan Area (Figure 2A.35-2).

- **Midvalley fairy shrimp.** This species is known from a range of vernal pool types, including clear sandstone pools with little alkalinity to turbid vernal pools on clay soils with moderate alkalinity (King et al. 1996; Eriksen and Belk 1999). All known occurrences of midvalley fairy shrimp are in California, between central Sacramento County and northern Fresno County (Appendix 2.A). In the Plan Area, there are recorded occurrences for this species in Conservation Zones 1, 2, 8, and 9, and adjacent to Conservation Zone 4 (Figure 2A.36-2) (Appendix 2.A).
- **Vernal pool fairy shrimp.** This species occupies a variety of vernal pool habitats and is found in 28 counties across the Central Valley and coastal ranges of California, and in Jackson County of southern Oregon (U.S. Fish and Wildlife Service 2005; Appendix 2.A). In the Plan Area, there are recorded occurrences of vernal pool fairy shrimp in Conservation Zones 1, 2, 4, 8, 9, 10, and 11 (Figure 2A.37-2) (Appendix 2.A).
- **Vernal pool tadpole shrimp.** This species occupies a variety of vernal pool habitats across the Central Valley and in the San Francisco Bay area (Appendix 2.A). However, the species is uncommon within its range: Helm (1998) found vernal pool tadpole shrimp in only 17% of vernal pools sampled across 27 counties, and Sugnet (1993 in U.S. Fish and Wildlife Service 2007) found this species at only 11% of 3,092 locations. In the Plan Area, there are recorded vernal pool tadpole shrimp occurrences in Conservation Zones 1, 2, 4, and 11 (Figure 2A.38-2) (Appendix 2.A).

Habitat loss and fragmentation have been identified as the largest threats to the survival and recovery of vernal pool species (U.S. Fish and Wildlife Service 2005, 2007). Habitat loss has generally been the result of urbanization and agricultural conversion, and has also occurred in the form of habitat alteration and degradation as a result of changes to natural hydrology, invasive species, and incompatible grazing regimes.

The conservation strategy for vernal pool crustaceans is guided chiefly by the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005), an ecosystem-level recovery and conservation strategy for vernal pool species developed by USFWS in collaboration with a team of vernal pool species experts. Key elements of the Vernal Pool Recovery Plan include the establishment of reserves throughout the species' ranges to prevent further habitat loss and fragmentation in areas identified as important for the species (core recovery areas) (Figures 2A.33-2, 2A.34-2, 2A.35-2, 2A.36-2, 2A.37-2, and 2A.38-2), the restoration of habitat to achieve no net loss of habitat for vernal pool species, and adaptive habitat management to maintain and enhance habitat values for vernal pool species. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM12 in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to avoid and minimize adverse effects on this species.

3.3.7.32.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the vernal pool crustaceans are stated below.

Goal L1: A large, interconnected reserve system consisting of a landscape-scale mosaic of natural communities.
• **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.6 Benefits: This objective will reduce future habitat loss and fragmentation in the Plan Area. The size and connectivity of reserves, including vernal pool complexes within a matrix of other natural community types, will be increased by building on existing conservation lands and applying the assembly principles described in Section 3.2.4.2.1, *Reserve System Assembly Principles*. Vernal pool complexes will be protected and restored as components of a large, interconnected reserve system, within a mosaic of grasslands and alkali seasonal wetlands. Large, interconnected reserves are less likely to be adversely affected by adjacent disturbances related to urban development, such as urban runoff and human-related habitat degradation (off-road vehicles, trampling) than small, isolated vernal pool complexes.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: This objective will benefit the covered vernal pool crustacean species by reducing threats to the species' biochemical and hydrologic requirements that result from heavy infestations of invasive plant species. This will be achieved by implementing invasive plant control measures, as described in Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*, Section 3.4.11.2.3, *General Enhancement and Management Actions*, and Section 3.4.11.2.6, *Grasslands and Associated Seasonal Wetland Natural Communities.* Invasive plants can increase the production of dense vegetation and thatch that shortens the ponding duration of vernal pools (Marty 2005; Pyke and Marty 2005). Literature also suggests that invasive plants in vernal pools can lead to higher respiratory oxygen consumption relative to photosynthetic oxygen generation (Rogers 1998), and thus low oxygen conditions can stress vernal pool aquatic wildlife.

3.3.7.32.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the vernal pool crustaceans are stated below.

Goal VPNC1: Large, interconnected expanses of vernal pool complex within a reserve system that includes a range of geomorphological, hydrologic, and vegetation characteristics.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). • **Objective VPNC1.2**: Restore vernal pool complex in Conservation Zones 1, 8, and 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools). • **Objective VPNC1.3**: Increase the size and connectivity of protected vernal pool complex within the Plan Area and increase connectivity with protected vernal pool complex adjacent to the Plan Area. • **Objective VPNC1.4**: Protect the range of inundation characteristics that are currently represented by vernal pools throughout the Plan Area.

Objectives VPNC1.1 and VPNC1.2 Benefits: Objective VPNC1.1 will eliminate habitat loss and fragmentation on protected and restored vernal pool complexes on 600 acres in the Plan Area. Objective VPNC1.2 will benefit vernal pool crustaceans by ensuring no net loss of their habitat.

Consistent with Objectives VPNC1.1 and VPNC1.2, vernal pool protection and restoration will occur in Conservation Zones 1, 8, and 11. Although habitat for the vernal pool crustaceans is also present in Conservation Zones 2, 4, and 9, the targeted conservation zones (1, 8, and 11) provide the only opportunities for large-scale conservation of vernal pool crustacean habitat within the Plan Area (Figures 2A.33-2, 2A.34-2, 2A.35-2, 2A.36-2, 2A.37-2, and 2A.38-2). Conservation Zones 2, 4, and 9 are not targeted under the conservation strategy, because the vernal pool complexes in Conservation Zones 2 and 4 are almost entirely under protected status (99%), and in Conservation Zone 9 (approximately 120 acres) they are largely fragmented by development and cultivated lands.

Objectives VPNC1.1 and VPNC1.2 prioritize protection and restoration in core recovery areas (Figures 2A.33-2, 2A.34-2, 2A.35-2, 2A.36-2, 2A.37-2, and 2A.38-2) identified in the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005). These specific sites are considered necessary to recover the federally endangered or threatened vernal pool species or to conserve sites that are necessary to recover those species. For species of concern that are not federally listed, core recovery areas are the specific sites necessary to prevent these species from being federally listed in the future (U.S. Fish and Wildlife Service 2005). The core recovery areas were developed to include viable populations (in some cases, source populations for larger metapopulations) or to contribute to the connectivity of habitat and thus increase dispersal opportunities between populations. Core recovery areas were established to provide for protection throughout the species' ranges, and to prioritize lands with high concentration of species per unit area. Core recovery area boundaries were established for the Vernal Pool Recovery Plan based on the distributions of species occurrence information, data layers for the proposed critical habitat for vernal pools, vernal pool complex mapping (Holland 1998), watershed boundaries, other hydrographic boundaries, topographic features, roads, and land use designations. Establishment of the core recovery areas assumed that the long-term survival and recovery of species are best achieved through two actions.

- Protecting multiple populations so that a single or series of catastrophic events cannot cause the extinction of the whole species.
- Increasing the size of the populations in core areas to a level where threats from genetic, demographic, and normal environmental uncertainties or change are diminished.

Objective VPNC1.3 Benefits: This objective will increase the overall extent and connectivity of the vernal pool reserve system by extending existing protected vernal pool complexes within and adjacent to the Plan Area. Protected and restored vernal pool complex will be incorporated into the reserve system, and protection and management of these lands will prevent habitat degradation that could otherwise result from human activities such as recreation and incompatible grazing regimes. These lands will be enhanced to benefit vernal pool species and managed in conjunction with protected grassland and alkali seasonal wetland complex natural communities to conserve and promote connectivity.

Objective VPNC1.4 Benefits: This objective will ensure that the inundation characteristics of vernal pool habitat for each of the vernal pool crustacean species will be represented in the reserve system. For example, the proportion of pools in the reserve system that are large or deep, thus providing habitat for vernal pool conservancy fairy shrimp, will be representative of the Plan Area. Protected vernal pool complexes will be maintained or enhanced to provide the appropriate hydrological conditions for sustaining vernal pool species. The conservation of 600 acres of large, interconnected tracts of vernal pool complex consistent with Objectives VPNC1.1 and VPNC1.2, and management consistent with VPNC2.1, will also protect intact vernal pool complexes from further alterations to natural hydrology.

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.
• **Objective VPNC2.1**: Maintain or enhance vernal pool complexes to provide the appropriate inundation (ponding) characteristics for supporting and sustaining vernal pool species.

Objective VPNC2.1 Benefits: This objective will provide the appropriate hydrological conditions for sustaining vernal pool species within the reserve system. Altered hydrology of vernal pool complexes can change the timing, frequency, or duration of vernal pool inundation, which can create conditions that render existing vernal pools unsuitable for vernal pool species (U.S. Fish and Wildlife Service 2005, 2007). For example, vernal pool ecosystems have been altered by hydrologic barriers such as roads or canals. Vernal pool hydrology has also been altered by the diversion of urban runoff and agriculture, both of which increase pond timing and duration, converting vernal pools to perennial ponds that are incapable of supporting vernal pool species. The conservation of 600 acres of large, interconnected tracts of vernal pool complex, consistent with Objectives VPNC1.1 and VPNC1.2, and management consistent with VPNC2.1, will protect intact vernal pool complexes from further alterations to natural hydrology.

3.3.7.32.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of vernal pool crustaceans in the Plan Area. Additional species-specific goals and objectives are only deemed necessary for the conservancy fairy shrimp because of this species' relative rarity (fewer than 50 occurrences throughout its range). Although longhorn fairy shrimp is also very rare (10 occurrences range-wide), there are no recorded occurrences of longhorn fairy shrimp in the Plan Area and the species is not expected to be affected by covered activities.

Goal VPC1: Protected occurrences of the rarest covered vernal pool crustacean species.
• **Objective VPC1.1:** Protect one currently unprotected occurrence of conservancy fairy shrimp.

Objective VPC1.1 Rationale: This objective will ensure that the rarest vernal pool crustacean species present in the Plan Area, the conservancy fairy shrimp, will be represented in the reserve system. As shown in Table 3.3-7, only 34 occurrences of this species are recorded range-wide; six of these, 18%, are in the Plan Area (Figure 2A.34-2). Currently 83% of the occurrences in the Plan Area are protected, but because the Plan Area includes a significant proportion of the range-wide occurrences for this rare species, protection of one additional occurrence is warranted. This will result in 100% protection of the known occurrences for conservancy fairy shrimp. Table 3.3-7 depicts the occurrences of the vernal pool crustaceans in the Plan Area.

Table 3.3-9. Covered Vernal Pool Crustacean Species Occurrences and Level of Protection[a]

	Percentage of Range-Wide Occurrences in Plan Area	Percentage of Plan Area Occurrences Currently Protected	Species-Specific Objectives
California linderiella	3% (12/382)	33% (4/12)	None
Conservancy fairy shrimp	18% (6/34)	83% (5/6)	Protect one additional occurrence
Longhorn fairy shrimp	0% (0/10)	0% (0/0)	None
Midvalley fairy shrimp	9% (9/101)	56% (5/9)	None
Vernal pool fairy shrimp	3% (16/608)	38% (6/16)	None
Vernal pool tadpole shrimp	5% (15/274)	80% (12/15)	None

[a] Presumed extant and possibly extirpated occurrences totaled and presented in this table.

Consistency with the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon*

This section addresses consistency of the BDCP with the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005) as it applies to vernal pool crustaceans, because the plan provides very specific guidance for HCPs. The recovery plan addresses all six of the covered vernal pool crustacean species, and lists six elements that an HCP must incorporate to support implementation of the recovery plan for the covered area. Meeting these criteria is also expected to meet NCCPA requirements for these species. The six elements are listed below (in italics), followed by a description of applicable components of the conservation strategy.

1. *Permanently protected vernal pool preserves within the area covered by the Habitat Conservation Plan in large contiguous blocks of suitable habitat.*

   Consistent with Goal VPNC1, the BDCP will result in a large, interconnected vernal pool reserve system in the Plan Area. This will be achieved by building off of the existing reserve system in the Plan Area. The Plan will add 600 acres to the 5,424 acres of modeled vernal pool habitat that are currently protected. A majority of the 600 acres is expected to be protected adjacent to existing conservation lands within the Jepson Prairie core recovery area.

2. *Protection of the entire genetic range of each listed species within the area covered by the Habitat Conservation Plan.*

   As described in the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005: III-5), genetic composition has not been investigated for most of the vernal pool crustacean species; therefore, genetic diversity is assumed to be protected by protecting populations throughout each species' range. The core recovery areas identified in the recovery plan are distinct areas that provide geographic and/or genetic diversity necessary for recovery of the species (U.S. Fish and Wildlife Service 2005: III-18). By focusing 600 acres of vernal pool complex protection within the Jepson Prairie core recovery area, which is ranked as Recovery Zone 1 (highest priority) for conservancy fairy shrimp, vernal pool fairy shrimp, and vernal pool tadpole shrimp, and within the Altamont Hills core recovery areas, which are ranked as Recovery Zone 1 (highest priority) for longhorn fairy shrimp and vernal pool fairy shrimp, the BDCP will protect areas identified in the recovery plan as important for protecting the full range of genetic diversity throughout the range of those species identified in the recovery plan.

The conservation strategy for vernal pool species is based on the assumption that the genetic range of each species in the Plan Area will be protected by protecting lands within different parts of the species' distribution in the Plan Area. The distribution of recorded occurrences for each species, in relation to lands that are already protected and are targeted for protection under the BDCP, is described below and demonstrates that each species' range in the Plan Area will be well represented in the reserve system.

- **California linderiella**. Recorded occurrences for this species are in Conservation Zones 1, 2, 10, and 11 (Figure 2A.33-2). Occurrences and habitat for this species is already protected in Conservation Zones 2, 4, and 11. The occurrence in Conservation Zone 10 is in a small, isolated habitat patch that is not likely to be viable for long-term protection and management, and is outside core recovery areas. Additional vernal pool complex will be protected within the Jepson Prairie core recovery area in Conservation Zones 1 and 11.

- **Conservancy fairy shrimp.** Recorded occurrences for this species are in six locations: one north of Suisun Marsh near the entrance to Portrero Hill landfill, four within the Jepson Prairie core recovery area in Conservation Zones 1 and 11, and one at the Tule Ranch unit of the CDFW Yolo Basin Wildlife Area in Conservation Zone 2 (Figure 2A.34-2). The location for the Tule Ranch occurrence, and the modeled habitat for conservancy fairy shrimp in Conservation Zone 2, are already protected. Approximately 55% of the modeled habitat and three out of four of the conservancy fairy shrimp occurrences within the Jepson Prairie core recovery area in Conservation Zones 1 and 11 are protected, and it is expected that the majority of the 600 acres of vernal pool complex protection will be focused in this area.

- **Longhorn fairy shrimp.** There are no recorded occurrences of longhorn fairy shrimp in the Plan Area, although there are occurrences southwest of the Plan Area near Conservation Zone 8 (Figure 2A.35-2). A portion of the 600 acres of vernal pool protection will occur within Conservation Zone 8.

- **Midvalley fairy shrimp.** There are recorded occurrences for this species in Conservation Zones 1, 2, 8, and 9, and adjacent to Conservation Zone 4 (Figure 2A.36-2). Occurrences and habitat for this species are already protected in Conservation Zone 1 (one occurrence in the Jepson Prairie Preserve), Conservation Zone 2 (two occurrences in the Yolo Bypass Wildlife Area) and Conservation Zone 4 (one occurrence in Stone Lakes National Wildlife Refuge). The occurrence in Conservation Zone 9 is in a small, isolated habitat patch that is not likely to be viable for long-term protection and management, and is outside core recovery areas. Additional vernal pool complex in core recovery areas will be protected in Zones 1 and 8.

- **Vernal pool fairy shrimp.** There are recorded occurrences of vernal pool fairy shrimp in Conservation Zones 1, 2, 4, 8, 9, 10, and 11 (Figure 2A.37-2). Occurrences in Conservation Zones 2 (Tule Ranch) and 4 (Stone Lakes area) are already protected. In addition, occurrences in Conservation Zone 8 (DWR lands and Byron Airport Conservation Easement) and Conservation Zone 11 are protected. The occurrences in Zones 9 and 10 are in small, isolated habitat patches in developed areas that are not likely viable for long-term protection and management, and are outside core recovery areas. Additional vernal pool complex will be protected in Zones 1, 8, and 11.

- **Vernal pool tadpole shrimp.** There are recorded vernal pool tadpole shrimp occurrences in Conservation Zones 1, 2, and 11, and adjacent to Conservation Zone 4 (Figure 2A.38-2). Occurrences and habitat for this species in Conservation Zone 1 (Jepson Prairie Preserve), Conservation Zone 2 (Tule Ranch), Conservation Zone 4 (Stone Lakes National Wildlife

Refuge), and Conservation Zone 11 are already protected, and the conservation strategy will protect additional vernal pool complex in Zones 1 and 11.

3. *Protection of all populations of species with 25 or fewer total occurrences addressed in this plan within the area covered by the Habitat Conservation Plan.*
   - The only covered vernal pool crustacean species with 25 or fewer total occurrences is the longhorn fairy shrimp, and there are no records for this species in the Plan Area.
4. *Connectivity with other preserves within the area covered by the Habitat Conservation Plan.*
   - Reserves will be adjacent to and build on existing conservation lands to support recovery of vernal pool crustaceans in the Plan Area.
5. *Adaptive management of the preserves within the area covered by the Habitat Conservation Plan to support the species addressed in this recovery plan.*
   - See Section 3.6, Adaptive Management and Monitoring Program.
6. *Sufficient funding for management, maintenance, and monitoring of the preserves in perpetuity.*
   - See Chapter 8, Implementation Costs and Funding Sources.

In conclusion, the BDCP addresses all of the six elements listed in the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005) for inclusion in HCPs for each of the covered vernal pool crustaceans.

3.3.7.33 Brittlescale, Heartscale, and San Joaquin Spearscale

Brittlescale (*Atriplex depressa*). This annual plant is a California endemic found in alkaline clay soils in meadows, seeps, and vernal pools (California Native Plant Society 2012a).

Its range extends from Glenn and Colusa Counties in the north, to Merced County in the south. Yolo, Solano, Contra Costa, and Alameda Counties are within its range (California Department of Fish and Wildlife 2013b; California Native Plant Society 2012a). There are eight occurrences[59] of brittlescale in the Plan Area in Conservation Zones 1, 8, and 11 (Figure 2A.45-2). Only one occurrence is within existing conservation lands.

Heartscale (*Atriplex cordulata*). This annual plant is also a California endemic, and is typically found in meadows, seeps, riparian wetlands, chenopod scrub, and valley and foothill grasslands in various soils that are either saline or alkaline (California Department of Fish and Wildlife 2013c; California Native Plant Society 2012b). Heartscale ranges through the Central Valley from Glenn County in the north to Fresno County in the south (California Native Plant Society 2012b). In the Plan Area, there are eight confirmed occurrences of heartscale, all presumed to be extant (California Department of Fish and Wildlife 2013c) (Figure 2A.46-2). Heartscale occurs in Conservation Zones 1, 6, 8, and 11. Two occurrences are within existing conservation lands.

San Joaquin spearscale (*Atriplex joaquiniana*). Also an annual plant endemic to California, San Joaquin spearscale occurs in alkali grasslands and meadows and other seasonal wetlands with alkaline soils (California Department of Fish and Wildlife 2013d). It ranges from Glenn, Colusa, and Yolo

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[59] Rangewide occurrences described for all species include CNDDB occurrences, as well as non-CNDDB occurrences mapped for the BDCP. See Section 2A.0.1.2, *Species Distribution and Status*, of Appendix 2.A, *Covered Species Accounts*, for a description of plant occurrence data sources.

Counties to the north through nine counties in the San Francisco Bay area and Central Valley (California Department of Fish and Wildlife 2013d). In the Plan Area, there are 19 extant occurrences, located primarily along the west side of the Sacramento Valley and Inner Coast Range foothills in Conservation Zones 1, 2, 5, 6, 8, 9, and 11 (Figure 2A.56-2). Two occurrences are within existing conservation lands.

The primary threat to brittlescale is the loss of suitable habitat within the range of the species (California Department of Fish and Wildlife 2013b). Other threats include livestock grazing and trampling (California Department of Fish and Wildlife 2013b), invasive plants, and the periodic inundation of managed wetlands to create habitat for waterfowl (Showers 1996). Reported threats to heartscale include agriculture, development, invasive plants, overgrazing, and trampling (California Department of Fish and Wildlife 2013c; California Native Plant Society 2012c). The primary threats to San Joaquin spearscale are development, agriculture, grazing, waterfowl management, and invasive plants (Showers 1996; California Native Plant Society 2012c). These stressors lead to loss of habitat and degradation of the alkaline soils that provide suitable habitat for the plant.

Because habitat loss and the potential effects of overgrazing are the primary stressors affecting heartscale, brittlescale, and San Joaquin spearscale, the conservation strategy includes protecting and managing existing natural alkaline habitats in the Plan Area. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures,* describes measures that will be implemented to avoid and minimize effects on these species.

3.3.7.33.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for brittlescale, heartscale, and San Joaquin spearscale are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objective L1.4 Benefits: Brittlescale, heartscale, and San Joaquin spearscale are known to occur within the alkaline seasonal wetland natural community. The microhabitat conditions required by heartscale, brittlescale, and San Joaquin spearscale appear to be different. Therefore, protecting and restoring potential habitat with a range of environmental gradients will maximize the potential for conserving the soil, hydrologic, and elevational requirements for each species.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: One of the threats to these three plant species is invasive, nonnative plants. The control and reduction of invasive plants on reserve lands are expected to benefit brittlescale, heartscale, and San Joaquin spearscale by increasing the availability of suitable habitat and reducing competition with invasive, nonnative plants. The control of invasive, nonnative plants on grasslands and associated seasonal wetland natural communities on reserve lands is described in Section 3.4.11.2.6, *Grasslands and Associated Seasonal Wetland Natural Communities*, *Enhancement and Management Actions*.

3.3.7.33.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for brittlescale, heartscale, and San Joaquin spearscale are stated below.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.
• **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.

Goal VPNC1: Vernal pool complexes composed of large, interconnected or contiguous expanses that represent a range of environmental conditions.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). • **Objective VPNC1.2:** Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools).

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11.

Objectives ASWNC1.1, VPNC1.1, VPNC1.2, and GNC1.1 Benefits: Brittlescale, heartscale, and San Joaquin spearscale are primarily associated with the alkali seasonal wetland natural community. In the Plan Area, alkali seasonal wetland is found in small patches within the larger vernal pool/grassland matrix. Vernal pool complexes or grassland targeted for protection have a high potential to also include patches of alkali seasonal wetland and, therefore, suitable habitat for brittlescale, heartscale, and San Joaquin spearscale. Protecting suitable habitat may also include the protection of known or new occurrences. Vernal pool restoration in Conservation Zone 11 also has the potential to protect suitable brittlescale, heartscale, and San Joaquin spearscale habitat, because some of the largest patches of degraded vernal pool habitat (which would be targeted for restoration) occur in Conservation Zone 11 and overlap substantially with brittlescale, heartscale, and San Joaquin spearscale modeled habitat.

3.3.7.33.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for brittlescale, heartscale, and San Joaquin spearscale within the reserve system. The goal and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal BRIT/HART/SJSC1: A reserve system that includes habitat for and occurrences of brittlescale, heartscale, and San Joaquin spearscale.
• **Objective BRIT/HART/SJSC1.1:** Of the 150 acres of alkali seasonal wetland complex protected under Objective ASWNC1.1, 600 acres of vernal pool complex protected under Objective VPNC1.1, and 8,000 acres of grassland natural community protected under Objective GNC1.1, protect at least 75 acres of suitable brittlescale habitat and 75 acres of suitable heartscale habitat in Conservation Zones 1, 8, or 11. • **Objective BRIT/HART/SJSC 1.2:** Protect two currently unprotected occurrences of San Joaquin spearscale in Conservation Zones 1, 8, or 11.

Objective BRIT/HART/SJSC1.1 and BRIT/HART/SJSC1.2 Rationale: Brittlescale, heartscale, and San Joaquin spearscale habitat models overlap significantly and are primarily associated with the alkali seasonal wetland natural community; however, the habitat model for the three species also includes vernal pool, alkali seasonal wetland, and grassland natural communities. Because the modeled habitat for brittlescale, heartscale, and San Joaquin spearscale does not overlap completely with any one natural community, the targeted protection of modeled or suitable brittlescale and heartscale habitat and of two San Joaquin spearscale occurrences will ensure protection of the range of habitat requirements that might not be otherwise captured in Objectives AWCNC1.1, VPNC1.1, VPNC1.2, and GNC1.1.

3.3.7.34 Carquinez Goldenbush

Carquinez goldenbush (*Isocoma arguta*) is endemic to California, and is known only from a very limited geographic range north and west of the Montezuma Hills in Solano County (Nesom 1991; California Department of Fish and Wildlife 2013e). It is a small shrub that grows in alluvial soils along seasonal drainages, adjacent to the margins of alkaline playas, and is associated with vegetation that is transitional between the brackish marsh and the grasslands along the eastern border of Suisun Marsh (California Department of Fish and Wildlife 2013b; California Native Plant Society 2012d).

The 10 occurrences in the Plan Area are scattered in small populations in Conservation Zones 1 (Jepson Prairie and Montezuma Hills) and 11 (Suisun Marsh area) (Figure 2A.39-2). Four occurrences are within existing conservation lands.

The continued persistence of the Carquinez goldenbush is threatened by development and agriculture (California Native Plant Society 2012d). The conservation strategy will minimize these threats through the protection of existing or new occurrences of the Carquinez goldenbush and the management of reserve lands to minimize the effects of grazing on ephemeral drainages. The conservation approach for Carquinez goldenbush is to protect grassland, alkali seasonal wetland complex, and vernal pool complex natural communities within the narrow geographic, elevation, and edaphic requirements of this species. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures,* describes measures that will be implemented to avoid and minimize effects on this species.

3.3.7.34.1 Applicable Landscape-Scale Goals and Objectives

While the landscape goals and objectives will provide broad-based benefits to the ecosystems upon which Carquinez goldenbush depends, none are integral to the conservation strategy for this species.

3.3.7.34.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the Carquinez goldenbush are stated below.

Goal ASWNC1: A reserve system including alkali seasonal wetland complex within a mosaic of grasslands and vernal pool complex.
• **Objective ASWNC1.1:** Protect 150 acres of alkali seasonal wetland in Conservation Zones 1, 8, and/or 11 among a mosaic of protected grasslands and vernal pool complex.

Goal VPNC1: Vernal pool complexes composed of large, interconnected, or contiguous expanses that represent a range of environmental conditions.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005).

Goal GNC1: Extensive grasslands composed of large, interconnected patches or contiguous expanses.
• **Objective GNC1.1:** Protect 8,000 acres of grassland with at least 2,000 acres protected in Conservation Zone 1, at least 1,000 acres protected in Conservation Zone 8, at least 2,000 acres protected in Conservation Zone 11, and the remainder distributed among Conservation Zones 1, 2, 4, 5, 7, 8, and 11.

Objectives ASWNC1.1, VPNC1.1, and GNC1.1 Benefits: Carquinez goldenbush modeled habitat (Figure 2A.39-2) and existing, unprotected occurrences are in the grassland, alkali seasonal wetland, and vernal pool complex natural communities along the northern and eastern border of Suisun Marsh in Conservation Zone 11 and in the grassland and vernal pool complex natural communities in Jepson Prairie in Conservation Zone 1. The protection of these natural communities in Conservation Zones 1 and 11 will benefit the Carquinez goldenbush by removing primary threats and protecting existing, unprotected occurrences or lands that may have undiscovered populations. Improved management of these reserves will further remove threats of overgrazing. The consideration of grazing control in ephemeral drainages in the grassland matrix is discussed in *CM11 Natural Communities Enhancement and Management*.

3.3.7.34.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for Carquinez goldenbush within the reserve system. The goal and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal CGB1: A reserve system that includes Carquinez goldenbush occurrences and sustains suitable habitat for this species.
• **Objective CGB1.1:** Protect three unprotected occurrences of the Carquinez goldenbush in Conservation Zones 1 and/or 11. • **Objective CGB1.2**: Maintain and enhance occupied Carquinez goldenbush habitat to slow erosion and reverse degradation from livestock grazing.

Objective CGB1.1 Rationale: Of the 14 known occurrences in this species' small range, 10 are located in the Plan Area, in Conservation Zones 1 and 11. Of these, one is currently protected in Type 1 conservation lands and five in Type 2, 3 or 4 conservation lands. Thus, achieving this objective will contribute substantially to conservation of this narrowly endemic species.

Objective CGB1.2 Rationale: The main stressors on the Carquinez goldenbush are overgrazing and trampling by livestock and the erosion of alkaline soils that are critical to the species. Grasslands, vernal pool complex, and alkali seasonal wetlands in the reserve system will be grazed to maintain their ecological function. While ecologically managed range is correlated with increased densities of most of the covered species dependent on these communities, grazing in and near ephemeral drainages has the potential to degrade habitat for Carquinez goldenbush. Those parts of the reserve system that include Carquinez goldenbush will be managed to maintain and enhance the specific soil and hydrologic characteristics that benefit this species: specifically, alkaline soils around ephemeral drainages. Grazing in the grassland, vernal pool, and alkali seasonal wetland matrix will be managed as described in *CM11 Natural Communities Enhancement and Management*.

3.3.7.35 Delta Button Celery

Delta button celery (*Eryngium racemosum*), a prostrate biennial or short-lived perennial herb, is found in seasonally scoured and inundated swales, depressions, and clay flats in the floodplain of the San Joaquin River (Woolington pers. comm.). The specific locations of occurrences may shift depending on the disturbance and flooding regime. As an early seral species, delta button celery shows no strong fidelity to a particular soil or vegetation type, but reported occurrences are primarily on alkaline clays deposited within bands of coarser-textured soils and willow scrub vegetation.

Delta button celery is endemic to the northern San Joaquin Valley within the historical floodplain of the San Joaquin River (California Department of Fish and Wildlife 2013f). Delta button celery is still found throughout much of its historical range, with the greatest density of occurrences in Merced County.

Delta button celery was formerly known from two occurrences in the Plan Area (one near Discovery Bay and one along the San Joaquin River 3 miles south of Lathrop) (Figure 2A.40-2), but both occurrences are possibly extirpated, because suitable habitat is reported as either gone (Discovery Bay occurrence) or heavily modified by discing (Lathrop occurrence) (California Department of Fish and Wildlife 2013f). The two occurrences are in Conservation Zones 7 and 9; neither is within existing conservation lands.

Historical stressors and ongoing threats to this species include agricultural habitat conversion, flood control activities such as channelization and channel maintenance, overgrazing, dredging, and invasion of habitat by nonnative plant species (California Department of Fish and Game 2008; California Native Plant Society 2012e).

The conservation strategy for delta button celery includes floodplain restoration and active reestablishment of delta button celery occurrences within floodplain restoration areas along the San Joaquin River (Conservation Zone 7). Any populations established in the reserve system will be managed to control invasive, nonnative competitors. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures,* describes measures that will be implemented to avoid and minimize effects on this species.

3.3.7.35.1 Applicable Landscape-Scale Goals and Objectives

The landscape-scale biological goal and objectives integral to the conservation strategy for delta button celery are stated below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances. • **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.1 Benefits: Delta button celery historically relied on overland river flow, and the resulting mesic depressions, to create the necessary wetland hydrology. Floodplain restoration in Conservation Zone 7, as discussed in *CM5 Seasonally Inundated Floodplain Restoration*, will directly benefit this species. As levees are breached and flood flows are allowed to once again connect with clay depressions in the floodplain, suitable habitat for delta button celery is likely to be created. If delta button celery colonizes restored floodplains, it will be important to control invasive, nonnative plants to maintain the species.

Objective L2.6 Benefits: Invasion of habitat by nonnative plant species is a stressor for this species (California Department of Fish and Game 2008). Consistent with this objective, and as described in Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*, delta button celery populations that become established in the Plan Area will be monitored, and invasive species that threaten these populations will be controlled.

3.3.7.35.2 Applicable Natural Community Goals and Objectives

No natural community biological goals and objectives are integral to the delta button celery conservation strategy.

3.3.7.35.3 Species-Specific Goals and Objectives

The landscape-scale biological goal and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for delta button celery in the reserve system. The goal and objective below address species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal DBC1: Expand the distribution and increase the abundance of delta button celery populations.
• **Objective DBC1.1:** Protect and enhance two occurrences of delta button celery. If occurrences are not found in the Plan Area, establish self-sustaining occurrences of delta button celery for a total of two occurrences[60] within the restored floodplain habitat on the mainstem of the San Joaquin River in Conservation Zone 7 between Mossdale and Vernalis.

[60] This objective allows protection of one occurrence and establishment of one occurrence in the reserve system, or establishment of two occurrences in the reserve system.

Objective DBC1.1 Rationale: Although it appears likely that delta button celery may be extirpated from the Plan Area, surveys will be conducted in suitable habitat in and near the recorded occurrences to attempt to find the known occurrences, discover new populations, and/or confirm extirpation. When and if existing occurrences in the Plan Area are identified, the first priority will be to enhance and manage those populations. If occurrences are found or rediscovered, additional floodplain habitat will help to ensure that the species is maintained.

Floodplain restoration along the mainstem of the San Joaquin River provides an opportunity to expand and reestablish suitable habitat for the species. Germination of delta button celery from a persistent seed bank could occur in restored areas. Absent natural recruitment, establishment of new populations through active seeding or outplanting will be necessary to establish new occurrences of the species in the Plan Area. Although active reestablishment of this species has not been tested, it was cultivated successfully from seed in a greenhouse as part of a taxonomic study performed in the 1970s (Sheikh 1978). Thus, seed or container stock can be produced and used to establish new populations in the Plan Area. Occurrence creation for this species is experimental and will only be undertaken in the absence of the ability to manage two known or discovered existing occurrences. Guidelines for collecting and banking seed, propagating nursery stock, and other proven or experimental methods used to promote sustainable plant occurrences are described in Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Enhancement and Management Guidelines and Techniques*. Section 3.4.11.2.5, *Riparian Natural Community, Enhancement and Management Actions* describes how existing or established populations of delta button celery will be managed to control invasive plants. Reestablishment of the species within its historical range will provide for the conservation and management of the species in the Plan Area.

3.3.7.36 Delta Mudwort and Mason's Lilaeopsis

Delta mudwort (*Limosella subulata*). This annual, stoloniferous[61] herb grows on intertidal flats and muddy banks of watercourses in estuarine areas, surrounded by tidal brackish or freshwater marsh and riparian scrub vegetation. Within these communities, it occurs with Mason's lilaeopsis (*Lilaeopsis masonii*) immediately below the tidal elevation where Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*) and Suisun Marsh aster (*Symphyotrichum lentum*) are commonly found (Witham and Kareofelas 1994; May & Associates 2005). Occasionally, it can be found along the edges of tule marshes (Witham and Kareofelas 1994). Salinity of approximately 7 ppt or greater appears to be unsuitable for delta mudwort (Golden and Fiedler 1991).

In California, delta mudwort is found only in the Delta region, from Solano County in the north to San Joaquin County in the south, Contra Costa County in the west, and Sacramento County in the east. All 58 known occurrences of delta mudwort in California are located in the Plan Area, where it is widespread (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013g; California Native Plant Society 2012f) (Figure 2A.42-2).

Delta mudwort occurs in Conservation Zones 1, 2, 4, 5, 6, 8, 10, and 11. Five occurrences are within existing conservation lands.

Mason's lilaeopsis (*Lilaeopsis masonii*). This perennial, rhizomatous herb is all but endemic to the Delta, Suisun Marsh, and eastern San Pablo Bay. It occurs in relatively unvegetated areas in brackish or

[61] Having long stems or runners that can produce new plants.

freshwater habitats that are inundated by waves or tides, such as estuarine wetlands and immediately below the banks of tidal sloughs, rivers, and creeks (Golden and Fiedler 1991; Fiedler and Zebell 1993; California Department of Fish and Game 2000). Within the Delta, Mason's lilaeopsis is not found upstream of the extent of active tidal fluctuation (California Department of Water Resources 2001). It is a colonizing species that primarily establishes on newly deposited or exposed sediments (California Native Plant Society 2012g), but it is occasionally found distributed among riprap-lined levees (Golden and Fiedler 1991). It does not appear to be substrate-specific; it occurs on a range of substrates, including organic mucks, silty clays, and even pure sand (Golden and Fiedler 1991). It has been found in areas with high soil salinity, but those sites might not be optimum habitat (Fiedler and Zebell 1993).

The majority of extant Mason's lilaeopsis occurrences in California (181 out of 196) are located in the Plan Area, where it is widespread (Figure 2A.41-2) (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013h). Mason's lilaeopsis occurs in all conservation zones. Seventeen of the known occurrences are in existing conservation lands. Threats to Mason's lilaeopsis and delta mudwort are varied, but the primary threat is the loss of marsh and floodplain habitat. In addition, erosion, channel stabilization, levee maintenance and construction, flood-control improvements, dredging, dumping spoils, agriculture, recreation, and water quality changes threaten habitat (California Native Plant Society 2012f, 2012g; California Department of Fish and Wildlife 2013g, 2013h). Bank erosion caused by boat wakes removes habitat; yet, measures to limit bank erosion such as placement of riprap prevent the species from recolonizing. Petroleum product spills could have a significant impact on tidal flat biota, and nonbiodegradable litter such as plastics could collect near the tidal drift line, inhibiting plant establishment and growth (Witham and Kareofelas 1994). Other threats include recreational activities (trampling) and invasion by exotic species such as water hyacinth, giant reed (*Arundo donax*), and yellow flag iris (*Iris pseudacorus*) (California Department of Fish and Wildlife 2013g, 2013h). A long-term threat is the stabilization of banks and mudflats resulting from highly regulated water-flow regimes, which can cause floodplain habitat to be less dynamic (Fiedler and Zebell 1993).

Because habitat loss is the primary stressor on Mason's lilaeopsis and delta mudwort, the conservation strategy focuses on restoring and enhancing natural tidal communities. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures*, describes measures that will be implemented to avoid and minimize effects to these species.

3.3.7.36.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for Mason's lilaeopsis and delta mudwort are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA.
- **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.7:** Produce sinuous, high-density, dendritic networks of tidal channels through tidal areas to promote effective exchange throughout the marsh plain and provide foraging habitat for covered fish species. • **Objective L2.10:** Restore or create 20 linear miles of transitional intertidal areas including tidal mudflat natural community and patches of subtidal and lower marsh.

Objectives L1.3, L1.4, and L2.7 Benefits: The primary threat to the Mason's lilaeopsis and delta mudwort is the loss and degradation of tidal marsh and floodplain; in particular, the loss of lower marsh areas at the edge of the vegetated marsh plain, between the marsh and the tidal mudflat. The restoration of tidal wetlands will return natural tidal processes to portions of the Delta that had previously been disconnected from tidal flow by levees and tide gates. By opening levees, and in some cases actively restoring natural communities (e.g., grading, introducing sediment, planting native marsh vegetation), a more natural tidal channel form will be returned to large patches of marsh habitat, within the previously disconnected portions of the marsh and along the existing tidal slough. Tidal restoration will result in a net increase in elevation diversity caused by natural scour and erosion processes, which will increase the quantity and the quality of the lower marsh habitat used by Mason's lilaeopsis and delta mudwort. This increase in habitat availability is expected to increase the number of occurrences and the total population sizes of these species, and provide for the conservation and management of the species in the Plan Area.

Objective L2.10 Benefits: The restoration of intertidal habitat along long, linear stretches of channelized river and stream segments is detailed in *CM6 Channel Margin Enhancement.* Restoration includes seeding and outplanting elevated benches on the outboard (stream) side of the existing levees with riparian and marsh vegetation. This vegetation will likely replace riprap or other hardscape features that while meant to reduce erosion have also removed much of the lower marsh niche habitat used by Mason's lilaeopsis and delta mudwort. The placement of vegetation in the stream channel will increase the natural deposition of sediment, thereby restoring the muddy and sandy banks colonized by these two plant species.

3.3.7.36.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for Mason's lilaeopsis and delta mudwort are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.4:** Create topographic heterogeneity in restored tidal brackish emergent wetland to provide variation in inundation characteristics and vegetative composition.

Objectives TBEWNC1.1, TBEWNC1.2, and TBEWNC1.4 Benefits: While both Mason's lilaeopsis and delta mudwort have known occurrences in or near Suisun Marsh, where the majority of tidal brackish marsh occurs in the Plan Area, Mason's lilaeopsis is by far more common. This is attributed to delta mudwort's suspected low tolerance for salinities greater than 7 ppt. Most of the tidal brackish marsh habitat in Suisun Marsh is behind tidal gates, cut off from the natural tidal cycle. Former slough habitat has been largely replaced by ditches and canals that have little spatial heterogeneity, because the natural sediment scour and depositional process has been lost along with tidal inundation. The restoration of the tidal marsh in Suisun Marsh will reconnect the marsh plain to tidal inundation and restore a more natural tidal slough form. Because of the large number of Mason's lilaeopsis occurrences in this area, the species' propagules and floating seed are expected to quickly colonize restored habitats created by more natural inundation patterns. See *CM4 Tidal Natural Communities Restoration* for more information on the process and expected outcomes of tidal restoration in Suisun Marsh.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is a nonnative, invasive species that, like delta mudwort and Mason's lilaeopsis, is found in the upper margins of tidal marsh communities in the ecotone with upland habitats. The species grows in large, monotypic stands that out-compete and displace native plants. Perennial pepperweed invasion is considered a serious threat to native diversity in Suisun Marsh (U.S. Fish and Wildlife Service 2010) where delta mudwort and Mason's lilaeopsis occur. The reduction in total cover of perennial pepperweed at the upper edges of the tidal brackish emergent wetland community is expected to increase the amount of open areas available for colonization by delta mudwort and Mason's lilaeopsis.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.

Objective TFEWNC1.1 Benefits: Mason's lilaeopsis is more abundant in brackish areas, whereas delta mudwort is more abundant in freshwater areas. Both species occur in the western, central, and eastern portions of the Delta. As in Suisun Marsh, the reestablishment of tidal inundation on large portions of marsh currently isolated behind levees is expected to increase the quantity and quality of tidal slough habitat. Mason's lilaeopsis and delta mudwort colonize the narrow transition zone between the tidal perennial aquatic natural community and the brackish and freshwater tidal emergent wetland natural communities, and the sediment depositional areas along artificial and natural levees in the valley/foothill riparian natural community. These habitats are difficult to model and measure accurately, making it also difficult to predict restoration outcomes with any confidence. However, suitable habitat for these two species is expected to be created at microsites throughout tidal wetland restoration sites, as well as along the margins of restoration sites where remnant levees remain and become islands. This habitat restoration strategy uses multiple restoration types in varied geographic locations throughout the Plan Area to achieve abundant, diverse, and widely distributed pockets of potential habitat for these two species. The rates of plant colonization and succession in these newly restored habitats will depend on the supply of propagules and, therefore, the distance to parent plants; the more proximate a newly created habitat is to existing occurrences, the more likely that it will be colonized.

3.3.7.36.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for Mason's lilaeopsis and Delta mudwort within the reserve system. The goal and objectives below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal DMW/ML1: A reserve system that supports Mason's lilaeopsis and Delta mudwort.
• **Objective DMW/ML1.1:** No net loss of Mason's lilaeopsis and delta mudwort occurrences within restoration sites, or the area of affected tidal range, of restoration projects.

Objective DMW/ML1.1 Rationale: *CM4 Tidal Natural Communities Restoration* and *CM6 Channel Margin Enhancement* will, in the long term, benefit Masons' lilaeopsis and Delta mudwort by increasing the quantity and quality of currently degraded habitat. However, during project implementation, individual plants or entire occurrences may be lost because of the placement of sediment or construction materials atop existing occurrences or because of the desiccation caused by the localized reduction in tidal range back to historical conditions. The no-net-loss standard is appropriate to apply to these species, because, although they are rare, they are widely distributed throughout the Plan Area and have a reproductive strategy conducive to passive restoration. In other words, although they could experience some short-term habitat or occurrence loss, their distribution and abundance are expected to significantly increase with restoration of tidal and nontidal marsh natural communities. This outcome has a high degree of certainty due to the ease of propagation of these species and the already widespread distribution in similar habitats throughout the Plan Area.

3.3.7.37 Delta Tule Pea and Suisun Marsh Aster

Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*). Endemic to Suisun Marsh and the Delta, Delta tule pea is a climbing perennial herb that occurs on the borders of freshwater and brackish marshes below 13 feet in elevation (Grewell et al. 2007; California Native Plant Society 2012h). It has been observed to co-occur with or near other covered plant species such as soft bird's-beak, Mason's lilaeopsis, Suisun Marsh aster, and Delta mudwort (California Department of Fish and Wildlife 2013i).

The range of Delta tule pea includes Sacramento and Solano Counties in the north, Napa and Sonoma Counties in the west, and Contra Costa and San Joaquin Counties in the south. Historically, it was common in Suisun Marsh, but today it is considered occasional to rare. It occurs throughout the legal Delta and along the lower Napa River (California Department of Fish and Wildlife 2013i). The majority of extant occurrences (105 out of 131) are in the Plan Area (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013i) (Figure 2A.43-2). It is found throughout all major tidal slough channels in Suisun Marsh and has been observed at the edges of sloughs and islands throughout the Delta (California Department of Fish and Wildlife 2013i). Delta tule pea occurs in Conservation Zones 1, 6, 8, and 11. In total, 24 occurrences are within existing conservation lands.

Suisun Marsh aster (*Symphyotrichum lentum*). Also endemic to Suisun Marsh and the Delta, Suisun Marsh aster is a rhizomatous perennial herb that grows on the upper margins of tidal brackish and freshwater marshes in the ecotone with terrestrial habitats and above erosional cuts and along the banks of sloughs and watercourses It has been observed in close proximity to Mason's lilaeopsis, Delta tule pea, delta mudwort, and soft bird's-beak (California Native Plant Society 2012i; California Department of Fish and Wildlife 2013j). Suisun Marsh aster is known from 174 extant occurrences, 164 of which are in the Plan Area; it occurs in tidal areas throughout the west and central Delta and Suisun Marsh with scattered occurrences in the north and south Delta (Figure 2A.44-2) (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013j). Suisun Marsh aster occurs in all conservation zones except Conservation Zone 8. A total of 18 occurrences are within existing conservation lands.

The primary threat to Delta tule pea and Suisun Marsh aster is the loss of marsh and floodplain habitat. Historically, habitat for these two species has been lost mostly through development, dredge disposal, agricultural conversion, water diversions, erosion, and diking (California Native Plant Society 2012h, 2012i). Diked marshes generally lack rare tidal marsh species—it is believed that the conditions brought about by dikes favor robust generalist plant species that can better tolerate the extremes of inundation and dryness in diked wetlands (Goals Project 2000). Such habitat losses from human activities still occur, but many of the large marshes are now protected or are zoned to restrict development. Trampling from fishing and hunting access also poses a threat to Delta tule pea (Witham and Kareofelas 1994). Other threats to Suisun Marsh aster include invasive plants, erosion, creek channelizing, levee maintenance and construction, and possibly herbicide applications (California Department of Fish and Wildlife 2013j; California Native Plant Society 2012i).

Because habitat loss and competition from invasive, nonnative plants are the primary stressors on the Delta tule pea and Suisun Marsh aster, the conservation strategy focuses on restoring and enhancing tidal natural communities. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures,* describes measures that will be implemented to avoid and minimize effects on these species.

3.3.7.37.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for Delta tule pea and Suisun Marsh aster are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.3:** Restore and protect 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise. Minimum restoration targets for tidal natural communities in each ROA are 7,000 acres in Suisun Marsh ROA, 5,000 acres in Cache Slough ROA, 1,500 acres in Cosumnes/Mokelumne ROA, 2,100 acres in West Delta ROA, and 5,000 acres in South Delta ROA. • **Objective L1.4:** Include a variety of environmental gradients (e.g., hydrology, elevation, soils, slope, and aspect) within and across a diversity of protected and restored natural communities.

Objectives L1.3 and L1.4 Benefits: Delta tule pea and Suisun Marsh aster are found throughout the tidal regions of the Plan Area. Tidal natural community restoration will include breaching previously leveed marsh habitat and restoring the historical tidal connection. By restoring tidal inundation and increasing the amount of potential habitat, plant propagules and seeds will be carried into newly restored (and previously inaccessible) areas, thus potentially expanding the area of occupied habitat. In addition, restored natural communities will have greater topographic heterogeneity, which will diversify inundation patterns and niche availability for these species. Higher diversity of environmental conditions is expected to increase the quality of habitat within the restored marsh areas and in the tidal slough natural communities outside the restored areas. Expanding available habitat through Objectives L1.3 and L1.4 will increase opportunities for natural colonization by Delta tule pea and Suisun Marsh aster and is expected to increase the number of occurrences in the Plan Area, expand the range of the species, and increase population sizes, thereby contributing substantially to species recovery.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.10:** Restore or create 20 linear miles of transitional intertidal areas including tidal mudflat natural community and patches of subtidal and lower marsh.

Objective L2.10 Benefits: The restoration of intertidal habitat along long, linear stretches of channelized river and stream segments is detailed in *CM6 Channel Margin Enhancement.* Restoration will include seeding and outplanting elevated benches on the outboard (stream) side of the existing levees with riparian and marsh vegetation. This vegetation will likely replace riprap or other hardscape features that have removed much of the lower marsh formerly occupied by Delta tule pea and Suisun marsh aster. The removal of riprap from these benches will increase the area of mudflat and lower and upper marsh areas that constitute suitable habitat for these species. Increasing suitable habitat through Objective L2.10 will increase opportunities for natural colonization of Delta tule pea and Suisun Marsh aster and is expected to increase the number of occurrences in the Plan Area, expand the range of the species, and increase population sizes, thereby contributing substantially to conservation of the species.

3.3.7.37.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the Delta tule pea and Suisun Marsh aster are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them.

Objectives TBEWNC1.1, TBEWNC1.2, and TBEWNC1.3 Benefits: Known occurrences of the Delta tule pea and Suisun Marsh aster are widely distributed throughout Suisun Marsh (California Department of Fish and Wildlife 2013i, 2013j). Most of the tidal brackish marsh habitat in Suisun Marsh is behind tide gates, cut off from the natural tidal cycle. Former slough habitat has been largely replaced by ditches and canals that have low spatial heterogeneity because natural sediment scour and deposition processes have been lost along with tidal inundation. Restoration of tidal brackish emergent wetland natural community will restore tidal inundation to the marsh plain and restore a more natural hydrologic regime to tidal sloughs throughout the marsh. In addition, middle and high marsh habitat types will be restored, which will result in an increase in the total amount of habitat available for occupancy by the species. Because of the abundance of Delta tule pea and Suisun Marsh aster occurrences in Suisun Marsh it is expected that these newly restored areas will be readily colonized by both species. Therefore, the increase in quantity and quality of tidal brackish marsh in Suisun Marsh is expected to increase the number of occurrences, distribution, and rangewide population of these species in Suisun Marsh. See *CM4 Tidal Natural Communities Restoration* for more information on the process and expected outcomes of tidal natural community restoration in Suisun Marsh.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is a nonnative, invasive species that, like Delta tule pea and Suisun Marsh aster, is found in the upper margins of tidal marsh communities in the ecotone with upland habitats. The species grows in large, monotypic stands that out-compete and displace native plants. Perennial pepperweed invasion is considered a serious threat to native diversity in Suisun Marsh (U.S. Fish and Wildlife Service 2010) where Delta tule pea and Suisun Marsh aster occur. The reduction in total cover of perennial pepperweed at the upper edges of the tidal brackish emergent wetland community will increase the amount of open areas available for colonization by Delta tule pea and Suisun Marsh aster.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.

Objective TFEWNC1.1 Benefits: Delta tule pea and Suisun Marsh aster occur in the western, central, eastern, and, to a lesser extent, southern portions of the Delta. Like restoration in Suisun Marsh, the reestablishment of tidal inundation in large areas of marsh formerly isolated behind levees will increase the quantity and quality of tidal slough and marsh habitat for these species. However, while a significant benefit is anticipated, the acreages of beneficial habitat were not calculated, because microhabitats could not be mapped or estimated. The conservation strategy for these plants relies on multiple restoration types in varied geographic locations throughout the Plan Area to achieve diverse and widely distributed pockets of potential habitat. However, the actual rate of plant colonization on these newly restored habitats will depend on the supply of propagules and, therefore, the distance to existing populations; the closer a newly created habitat is to existing occurrences, the more likely it will become colonized.

3.3.7.37.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for Delta tule pea and Suisun Marsh aster within the reserve system. The goal and objective below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal DTP/SMA1: A reserve system that supports the Delta tule pea and Suisun Marsh aster.
• **Objective DTP/SMA1.1:** No net loss of Delta tule pea and Suisun Marsh aster occurrences within restoration sites.

Objective DTP/SMA1.1 Benefits: *CM4 Tidal Natural Communities Restoration* and *CM6 Channel Margin Enhancement* will, in the long term, benefit the Delta tule pea and Suisun Marsh aster by increasing the quantity and quality of their habitat. However, during project implementation, individual plants or entire occurrences may be lost, because of the placement of sediment or construction materials atop existing occurrences or by the desiccation caused by the localized reduction in tidal range associated with restoration of a more natural tidal inundation regime. The no-net-loss standard is appropriate to apply to these species, because, while rare, they are widely distributed throughout the Plan Area and have a reproductive strategy conducive to natural colonization of suitable habitat. In other words, although they may experience some short-term habitat or occurrence loss, the distribution and abundance of these species are expected to recover to prior levels or increase following restoration of tidal and nontidal marsh natural communities. This outcome has a high degree of certainty due to the ease of propagation of these species and the already widespread distribution in similar habitats throughout the Plan Area.

3.3.7.38 Side-Flowering Skullcap

Side-flowering skullcap (*Scutellaria lateriflora*) is a widespread but scattered species inhabiting swamps, marshes, and bogs in the western, central, and eastern United States. It occurs in freshwater tidal areas along channels and sloughs, almost always growing on partially submerged logs or stumps along tidal channels (California Department of Fish and Wildlife 2013k). The known range in

California is limited to a small area of the Delta, and all 12 occurrences are within the Plan Area in Conservation Zones 4 and 5 (Figure 2A.47-2) (California Department of Fish and Wildlife 2013k; California Native Plant Society 2012j). Two occurrences are within existing conservation lands.

Side-flowering skullcap populations are deemed secure globally and there is very little specific information on threats to this species in the Delta, although watercraft recreation is mentioned as a threat to one occurrence (California Department of Fish and Wildlife 2013k). General threats to its wetland habitats in the Delta may include development, erosion, intensive agriculture, and invasive plants; specific threats within California are unknown. In the Delta, side-flowering skullcap grows on logs, stumps, and other large woody material along shoreline that supports primarily riparian and marsh vegetation, and lack of shoreline coarse woody material may be a limiting factor in parts of the Delta.

The conservation strategy for side-flowering skullcap relies on restoration of tidal freshwater emergent wetland and valley/foothill riparian natural communities in Conservation Zones 4, 5, and 6. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures,* describes measures that will be implemented to avoid and minimize effects on this species.

3.3.7.38.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for side-flowering skullcap are stated below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.12:** Enhance 20 miles of channel margin in the Sacramento River and San Joaquin River systems to provide habitat along important migratory routes for anadromous fish and improve wildlife movement.

Objective L2.12 Benefits: One of the results of floodplain loss and degradation in the Plan Area has been a decrease in woody debris upon which this species depends. *CM6 Channel Margin Enhancement* will achieve Objective L2.12 and is expected to result in an increase of woody debris in portions of Conservation Zones 4 and 5 where side-flowering skullcap occurs.

3.3.7.38.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for side-flowering skullcap are stated below.

Goal TFEWNC1: Large, interconnected patches of tidal freshwater emergent wetland natural community.
• **Objective TFEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands to accommodate sea level rise (Objective L1.3), restore or create at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian natural community, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain.

Objectives TFEWNC1.1 and VFRNC1.1 Benefits: Tidal restoration in the Cosumnes-Mokelumne ROA of Conservation Zone 4, which includes the greatest concentrations of side-flowering skullcap in California, will provide additional habitat for this species, and restoration of riparian natural community along the marsh fringes will increase potential sources of woody debris. Tidal restoration will reestablish the inundation and tidal flow patterns that transport woody debris through the wetlands. Because known occurrences of side-flowering skullcap are concentrated in this area, this restoration effort is expected to result in a large increase in the quantity and quality of potential habitat.

3.3.7.38.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to provide for the conservation and management of side-flowering skullcap in the Plan Area. Additional species-specific biological goals and objectives are not necessary.

3.3.7.39 Slough Thistle

Slough thistle (*Cirsium crassicaule*) is endemic to the San Joaquin Valley and has a disjunct distribution; most occurrences are reported in Kings and Kern Counties in the south but a few additional occurrences are located in San Joaquin County (California Department of Fish and Wildlife 2013l; California Native Plant Society 2012k). Slough thistle occurs in freshwater marshes and swamps, and in chenopod scrub and riparian scrub habitats (California Native Plant Society 2012k). It is generally found in the portions of channels that flood at high water and on the banks of floodwater conveyance canals and drains (Griggs pers. comm.; Hansen pers. comm.).

There are 19 slough thistle occurrences in California, two of which were recorded in the southern part of the Plan Area along the San Joaquin River near Lathrop (Figure 2A.48-2) (California Department of Fish and Wildlife 2013l). One occurrence near the San Joaquin River Club has not been seen since 1974 but is still presumed to be extant; the second occurrence northeast of Lathrop Bridge has not been seen since 1933 and is possibly extirpated (California Department of Fish and Wildlife 2013l). These two occurrences of slough thistle are in Conservation Zone 7. Neither occurrence is within existing conservation lands.

Slough thistle populations are declining throughout the San Joaquin Valley (Griggs pers. comm.; Hansen pers. comm.). Conversion of suitable habitat for agricultural uses and competition from invasive, nonnative plants have been reported as the primary threats to slough thistle (California Native Plant Society 2012k). The conservation strategy for slough thistle relies primarily on landscape and natural community level biological goals and objectives to protect and restore floodplain wetland habitat. The strategy also involves reestablishment of occurrences along the San Joaquin River from Mossdale to Vernalis. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and*

Minimization Measures, describes measures that will be implemented to avoid and minimize effects on this species.

3.3.7.39.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for slough thistle are stated below.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.1:** Allow floods to promote fluvial processes, such that bare mineral soils are available for natural recolonization of vegetation, desirable natural community vegetation is regenerated, and structural diversity is promoted, or implement management actions that mimic those natural disturbances.

Objective L2.2 Benefits: Potential slough thistle habitat in the Plan Area has largely been lost to flood control activities such as levee construction, channel straightening, and vegetation control within levees. *CM5 Seasonally Inundated Floodplain Restoration* provides restoration of 10,000 acres of seasonally inundated floodplain, primarily in the Old, Middle, and San Joaquin Rivers in Conservation Zone 7. Floodplain restoration in Conservation Zone 7 will increase the amount of potentially suitable habitat for slough thistle in the Plan Area and provide opportunities for population expansion and introduction of new populations, both of which would contribute to conservation of the species.

3.3.7.39.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for slough thistle are stated below.

Goal VFRNC1: Extensive wide bands or large patches of interconnected valley/foothill riparian natural community, with locations informed by both existing and historical distribution.
• **Objective VFRNC1.1:** Restore or create 5,000 acres of valley/foothill riparian natural community, with at least 3,000 acres occurring on restored seasonally inundated floodplain. • **Objective VFRNC1.2:** Protect 750 acres of existing valley/foothill riparian natural community in Conservation Zone 7 by year 10.

Objectives VFRNC1.1 and VFRNC1.2 Benefits: Two occurrences of slough thistle have been recorded in the Plan Area, both of which are within the footprint of the historical floodplain of the San Joaquin River between Mossdale and Vernalis in Conservation Zone 7. One of these occurrences is listed as "possibly extirpated," and the other is listed "presumed extant" but has not been relocated for nearly 40 years (California Department of Fish and Wildlife 2013l). Protection of 750 acres of existing riparian natural community in Conservation Zone 7 will protect any remaining pockets of suitable slough thistle habitat between the levees and provide sites for artificial reestablishment of slough thistle. The restoration of floodplain on the San Joaquin River between Mossdale and Vernalis will benefit existing, discovered, or newly created occurrences in this locale by significantly increasing the area of suitable riparian scrub habitat exposed to flood flows.

Goal VFRNC2: Increased structural diversity including a mosaic of seral stages, age classes, plant zonation, and plant heights and layers characteristic of valley/foothill riparian natural community.
• **Objective VFRNC2.2:** Maintain 1,000 acres of early- to midsuccessional vegetation with a well-developed understory of dense shrubs on restored seasonally inundated floodplain.

Objective VFRNC2.2 Benefits: Slough thistle grows in openings in riparian vegetation within floodplains. Restoration of riparian natural community will involve establishment of vegetation that is expected to form the matrix within which these openings will occur. The established vegetation would shelter discovered, newly germinated, or established populations from various types of disturbance such as trampling and excessive scouring during flood events.

3.3.7.39.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for slough thistle within the reserve system. The goal and objective below address additional species-specific needs that will not otherwise be met at the landscape or natural community scale.

Goal ST1: Expanded distribution and increased abundance of slough thistle populations.
• **Objective ST1.1:** Protect and enhance two occurrences of slough thistle. If occurrences are not found in the Plan Area, establish self-sustaining occurrences of slough thistle for a total of two occurrences[62] within the 10,000 acres of restored floodplain on the mainstem of the San Joaquin River in Conservation Zone 7 between Mossdale and Vernalis.

Objective ST1.1 Rationale: Slough thistle has two known occurrences in the Plan Area: one possibly extirpated and one presumed extant, although it has not been seen for over 40 years (California Department of Fish and Wildlife 2013l). These two occurrences represent the northern-most extent of the species distribution—the majority of extant occurrences are in Kings and Kern Counties. Although it appears likely that slough thistle may be extirpated from the Plan Area, surveys will be conducted in suitable habitat in and near the recorded occurrences to attempt to find the known occurrences, discover new populations, and/or confirm extirpation. When and if existing occurrences in the Plan Area are identified, the first priority will be to enhance and manage those populations.

Floodplain restoration along the San Joaquin River in Conservation Zone 7 presents an opportunity to expand and reestablish suitable habitat for the species. Germination of slough thistle from a persistent seed bank could occur in restored areas. Absent natural recruitment or discovery of new or formerly known occurrences, establishment of new populations through active seeding or outplanting will be necessary to establish new occurrences of the species in the Plan Area. Active reestablishment of this species is unknown. Occurrence creation is experimental and will only be undertaken in the absence of the ability to manage two known or discovered, existing occurrences. Guidelines for collecting and banking seed to minimize genetic effects, propagating nursery stock, and other proven or experimental methods used to promote sustainable plant occurrences are described in Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Enhancement and Management Guidelines and Techniques*. Section 3.4.11.2.5, *Riparian Natural Community, Enhancement and Management Actions*, describes how existing or established populations of slough thistle will be managed. Reestablishment of this species within its historical range in the Plan Area will provide for the conservation and management of the species in the Plan Area.

[62] This objective allows protection of one occurrence and establishment of one occurrence in the reserve system, or establishment of two occurrences in the reserve system.

3.3.7.40 Soft Bird's-Beak and Suisun Thistle

Within the Plan Area, soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*) and Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) co-occur in Suisun Marsh in similar natural communities and microhabitats.

Soft bird's-beak. Endemic to the Bay-Delta region, soft bird's-beak is an annual root parasite that requires a suitable host plant for survival and reproduction. Pickleweed and saltgrass are known host species, and dodder (*Cuscuta* spp.) may also be a host plant (Grewell et al. 2003). Historically, the range of soft bird's-beak included tidal marshes of Napa and Solano Counties in the north, Contra Costa County in the south, Sonoma and Marin Counties in the west, and Sacramento and San Joaquin Counties in the east. It is now believed to be extirpated from Marin, San Joaquin, Sonoma, and Sacramento Counties (California Department of Fish and Wildlife 2013m). Soft bird's-beak occurs in high salt and brackish tidal marsh of northern San Pablo Bay and the Suisun Marsh area, and in some diked brackish marshes with limited tidal circulation. It occurs primarily on higher well-drained portions of the marsh and the edges of salt pans and in areas of the upper-middle to high marsh zones (Baye et al. 2000; Grewell 2005; Grewell et al. 2007). Soft bird's-beak is known from 26 occurrences, 18 of which are presumed extant (California Department of Fish and Wildlife 2013m). There are 10 extant occurrences of soft bird's-beak in the Plan Area, the majority of which are in and around the northern edge of Suisun Marsh (Figure 2A.49-2) (U.S. Fish and Wildlife Service 2010; California Department of Fish and Wildlife 2013m). Soft bird's-beak occurs in Conservation Zones 5 and 11. Nine occurrences are within existing conservation lands.

Suisun thistle. A tall biennial or short-lived perennial herb, Suisun thistle is endemic to the northern portion of the Suisun Marsh in Solano County, California (U.S. Fish and Wildlife Service 2010). It is found in the upper-middle and high marsh, usually associated with small tidal creek banks that locally drain the marsh peat surface (U.S. Fish and Wildlife Service 2010). It occurs in an area of fewer than 4 miles across in the northern portion of Suisun Bay (Figure 2A.50-2). All four known occurrences are in Conservation Zone 11 in the Plan Area within existing conservation lands (CDFW-owned [Peytonia Slough Ecological Reserve, Hill Slough Wildlife Area, and the Joice Island Unit of the Grizzly Island Wildlife Area] and privately owned [one occurrence in Rush Ranch Open Space]) (California Department of Fish and Wildlife 2013n).

Historically, marsh habitat suitable for Suisun thistle and soft bird's-beak has been lost mostly through development, dredge disposal, agricultural conversion, and diking. Soft bird's-beak is threatened by low population numbers, severely reduced habitat area, and reduced habitat quality, all of which contribute to the species being susceptible to loss by chance events. Invasion by nonnative tidal marsh vegetation and hydrologic alterations to tidal sloughs are also significant stressors (U.S. Fish and Wildlife Service 2010). Threats also include erosion, the elimination or muting of tidal regimes, overgrazing and trampling by livestock, rooting by feral pigs, invasion of habitat by nonnative annual plants that are inappropriate hosts, recent invasion of its habitat by perennial pepperweed (*Lepidium latifolium*), alteration of salinity regimes, mosquito abatement, and oil spills (California Department of Fish and Wildlife 2013m, 2013n; California Native Plant Society 2012l, 2012m; Fiedler et al. 2007; Grewell et al. 2003; Grewell 2005; U.S. Fish and Wildlife Service 2010). Trampling and disturbance by cattle, feral pigs, and human foot traffic can directly damage plants and also damage the fragile root connections between soft bird's-beak and the host plants (U.S. Fish and Wildlife Service 2010). Seed predation by moth larvae is an important factor in population declines at sites in Suisun Marsh (62 FR 61916). The moth larvae spend part of their life cycle buried in sediment; under muted tidal regimes, survival of the moth larvae appeared to be enhanced, in turn increasing seed predation on soft bird's-beak (Grewell et al. 2003). Currently, the major threats to Suisun thistle are competition from the nonnative and highly invasive perennial pepperweed, habitat destruction by feral pigs, and perhaps fire during sensitive periods of the species' life cycle (Fiedler et al. 2007). Other potential but unquantified threats include hybridization with the nonnative bull thistle (*Cirsium vulgare*) and seed predation by the thistle weevil (*Rhinocyllus conicus*) introduced for biocontrol of invasive, nonnative thistles in the genus *Carduus* (Fiedler et al. 2007).

To address these threats, the conservation strategy for soft bird's-beak and Suisun thistle focuses on expanding the number of occurrences by restoring and enhancing suitable habitat and increasing connectivity between suitable habitat patches to promote seed dispersal and colonization of new sites. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures,* describes measures that will be implemented to avoid and minimize effects on these species.

3.3.7.40.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for soft bird's-beak and Suisun thistle are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.

- **Objective L1.7:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), include sufficient transitional uplands along the fringes of restored brackish and freshwater tidal emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of tidal emergent wetland communities that might be needed after the permit term.

Objective L1.7 Benefits: Upland transitional areas adjacent to restored brackish and freshwater tidal emergent wetland are needed to allow tidal emergent wetland natural communities and the species that inhabit them to migrate upland in response to sea level rise. As sea level rises and existing tidal lands are flooded more frequently and for longer duration, freshwater and brackish tidal natural communities also will need to shift upward in mean elevation, which in the flat Delta landscape will necessarily entail substantial lateral shifts in location. For this to occur, adjacent upland habitat needs to transition slowly from low elevations to higher elevations. Adjacent upland areas that transition too quickly from low to high elevations (i.e., have slopes that are too steep) will preclude this gradual conversion to tidal brackish and freshwater marsh. Species' habitat that occurs where transitional elevations are too steep to allow habitat migration will ultimately be "drowned" by sea level rise. Without upward habitat shift for brackish marsh communities in Suisun Marsh, the long-term persistence of upper-middle and high marsh species like Suisun thistle and soft bird's-beak would not be possible. Achieving this objective will protect enough suitable upland to allow tidal emergent wetland natural communities to shift in response to sea level change and, therefore, continue to provide habitat for Suisun thistle and soft bird's-beak. The need for protection of upland transition lands is recognized in the Draft Tidal Marsh Recovery Plan as a prerequisite to delisting both species (U.S. Fish and Wildlife Service 2010).

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species.
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: The aggressively invasive perennial pepperweed poses a serious threat to soft bird's-beak and Suisun thistle. Perennial pepperweed can permanently establish a continuous leaf canopy, eliminating the vegetation gaps that may be essential for seedling establishment and growth, and reproduction of soft bird's-beak and Suisun thistle (U.S. Fish and Wildlife Service 2010). Colonies of Suisun thistle and soft bird's-beak have not been observed to persist in and amongst colonies of perennial pepperweed (U.S. Fish and Wildlife Service 2010). The need for aggressive control of perennial pepperweed is consistent with the Draft Tidal Marsh Recovery Plan for both soft bird's-beak and Suisun thistle (U.S. Fish and Wildlife Service 2010).

In addition to the threat posed by perennial pepperweed, soft bird's-beak is threatened by nonnative, winter annual grass species, especially barbgrass (*Hainardia cylindrica*) and annual beard grass (*Polypogon monspeliensis*). These species are incompatible host plants because they are short-lived annual grasses that do not allow completion of soft bird's-beak's life cycle, unlike the perennial host species. The control of incompatible host plants for soft bird's-beak will be an important strategy for meeting this objective and is discussed in Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Enhancement and Management Guidelines and Techniques, Emergent Wetland Invasive Plant Control*. An increase in native species diversity will benefit native pollinators, such as ground-nesting bees, that are likely to result in the maintenance or enhancement of viable seed production for soft bird's-beak and Suisun thistle (U.S. Fish and Wildlife Service 2010). The increase in native species diversity also has potential to increase the reproductive output of soft bird's-beak by maintaining or increasing populations of wasps that prey on moth larvae, known seed predators on soft bird's-beak (U.S. Fish and Wildlife Service 2010).

3.3.7.40.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for soft bird's-beak and Suisun thistle are stated below.

Goal TBEWNC1: Large expanses and interconnected patches of tidal brackish emergent wetland natural community.
• **Objective TBEWNC1.1:** Within the 65,000 acres of tidal natural communities and transitional uplands (Objective L1.3), restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex to be consistent with the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. • **Objective TBEWNC1.2:** Within the at least 6,000 acres of restored or created tidal brackish emergent wetland (Objective TBEWNC1.1), distribute at least 1,500 acres of middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the final *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*. Restore the at least 1,500 acres of middle and high marsh by year 25. • **Objective TBEWNC1.3:** Restore connectivity to isolated patches of tidal brackish emergent marsh where isolation has reduced effective use of these marshes by the species that depend on them.

Objectives TBEWNC1.1 and TBEWNC1.3 Benefits: The restoration of at least 6,000 acres of tidal brackish emergent wetland will substantially increase the area in Suisun Marsh that is tidally inundated, thereby increasing the area of potential habitat available for colonization by these two species. Because soft bird's-beak and Suisun thistle are high marsh species, the at least 1,500 acres of middle and high marsh restoration are expected to directly benefit the species. Tidal restoration will involve breaching levees and active and passive restoration of previously diked land to achieve inundation patterns and vegetation structure that will resemble a more natural condition. Effective control of invasive plants, including perennial pepperweed, will be required on all reserve system lands. Invasive plant control is expected to improve seed dispersal of Suisun thistle and soft bird's-beak and increase opportunities for germination and colonization of new sites.

Both species occupy specific microhabitats in the upper-middle and high marsh. Restoration will target creation of these and other tidal elevations to support the species. Restored or improved tidal inundation and an increase in tidal inundation diversity will provide the necessary soil salinities to maintain existing occurrences and the disturbance necessary to create unvegetated patches required for germination and colonization of new sites. Soft bird's-beak seeds float, and Suisun thistle seeds are presumed to float (72 FR 18517); thus, improved tidal inundation in occupied areas is expected to increase the potential for successful seed dispersal to expand existing occurrences and create new ones. The restoration of tidal inundation is consistent with the Draft Tidal Marsh Recovery Plan and delisting criteria for both species (U.S. Fish and Wildlife Service 2010).

Objective TBEWNC1.3 Benefits: Connectivity within Suisun Marsh will be restored through protection and enhancement of corridors between marsh and upland habitats and protection and restoration of adjacent upland habitat. These connections with upland habitat will allow for soft bird's-beak and Suisun thistle to shift upward in tidal marsh elevation in response to sea level rise as described above for Objective L1.7. Management of reserve system lands consistent with *CM11 Natural Communities Enhancement and Management* will control invasive plants where they may block or impede seed dispersal by tides or wind. For example, restoration of tidal inundation is expected to convert large stands of cattails (*Typha* spp.) into more heterogeneous marsh communities, reducing the average height of vegetation (and the potential barrier it poses to wind dispersal of seeds) and increasing the occurrence of bare ground important for seed germination. Restoring connectivity within tidal brackish emergent wetland will also promote genetic exchange among the limited number of populations of both species, helping to minimize deleterious genetic effects inherent to small populations.

Goal TBEWNC2: Tidal brackish emergent wetland natural community that is managed to maintain or increase species diversity and habitat value for native species.
Objective TBEWNC2.1: Limit perennial pepperweed to no more than 10% cover in the tidal brackish emergent wetland natural community within the reserve system.

Objective TBEWNC2.1 Benefits: Perennial pepperweed is a nonnative, invasive species that, like soft bird's-beak and Suisun thistle, is found in the upper margins of tidal marsh communities in the ecotone with upland habitats. The species grows in large, monotypic stands that out-compete and displace native plants including soft bird's-beak and Suisun thistle (U.S. Fish and Wildlife Service 2010). Perennial pepperweed invasion is considered a serious threat to soft bird's-beak and Suisun thistle, and the control of perennial pepperweed to less than 10% cover is a delisting requirement of the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010). The reduction in total cover of perennial pepperweed at the upper edges of the tidal brackish emergent wetland community will increase the amount of open areas available for colonization by soft bird's-beak and Suisun thistle.

3.3.7.40.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and associated conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for soft bird's-beak and Suisun thistle within the reserve system. The goal and objective below address additional needs that will not otherwise be met at the landscape or natural community scale.

Goal SBB/SuT1: Protected and expanded soft bird's-beak and Suisun thistle populations.
• **Objective SBB/SuT1.1:** Restore tidal inundation to wetlands in the Hill Slough Ecological Reserve and to the ponded area at Rush Ranch. • **Objective SBB/SuT1.2:** Complete seed banking of all existing Suisun Marsh populations and the representative genetic diversity using accepted seed banking protocols. • **Objective SBB/SuT1.3:** Establish a cultivated population of Suisun thistle from wild seed using accepted seed collection protocols. • **Objective SBB/SuT1.4:** Establish two occurrences of Suisun thistle in Conservation Zone 11.

Objective SBB/SuT1.1 Rationale: Suisun thistle is known to exist as three distinct populations in the following three locations: Peytonia Slough Ecological Reserve, the fully tidal portion of upper Hill Slough, and Rush Ranch and Joice Island (two occurrences considered one population) (U.S. Fish and Wildlife Service 2010). In Suisun Marsh, soft bird's-beak occurs in Hill Slough, Rush Ranch, and Joice Island (Figure 2A.49-2). Although Peytonia Slough and portions of Hill Slough have been restored to the full range of tidal inundation, other portions of Hill Slough and the ponded area at Rush Ranch remain unrestored. The restoration of tidal inundation and the subsequent management and enhancement of Suisun thistle and soft bird's-beak occurrences in these areas are essential to the persistence and conservation of these species and are consistent with delisting criterion for Suisun thistle and soft bird's-beak in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

Objective SBB/SuT1.2 Rationale: Because of the limited number of occurrences and extreme endemism of soft bird's-beak and Suisun thistle, the species are at risk of extinction from random events. Habitat restoration is a long-term objective; in the meantime, the collection and storage of seeds are important short-term actions to ensure that populations could be established if known populations fail and to protect the current range of genetic diversity from catastrophic loss caused by a chance event or unintended effects of restoration actions. Collected and stored seeds can be used to establish new occurrences in suitable protected habitat or to restore an occurrence degraded or lost to restoration. Conservation seed banking of "all existing populations and representative genetic diversity" is a delisting requirement in the Draft Tidal Marsh Recovery Plan for both soft bird's-beak and Suisun thistle (U.S. Fish and Wildlife Service 2010). In addition, banked wild seed for these two species could be used to support experimental conservation efforts to establish new occurrences or enhance existing occurrences. Guidelines for collecting and banking seed to minimize population or genetic effects, propagating nursery stock, and other proven or experimental methods used to establish sustainable plant occurrences are described in Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Enhancement and Management Guidelines and Techniques*.

Objective SBB/SuT1.3 Rationale: The creation of a cultivated population of Suisun thistle is an important, short-term action intended to reduce the risk of extinction through catastrophic extirpation of populations (U.S. Fish and Wildlife Service 2010). A cultivated population grown from locally sourced, wild seed can be used to answer basic biological, management, and propagation research questions. Seed or nursery stock sourced from a cultivated population can be used to test the efficacy of restoration methods (e.g., seed dispersal versus the outplanting of nursery stock) or to establish new populations in restored or recently disturbed soils when the collection of wild seed might pose unnecessary risk to the remaining population(s) (U.S. Fish and Wildlife Service 2010). Seed used to found a cultivated population will be collected in consideration of both preserving genetic diversity and sampling the range of genetic diversity for the source population(s) using approved seed collection protocols. Guidelines for collecting and banking seed to minimize population or genetic effects, propagating nursery stock, and other proven or experimental methods used to establish sustainable plant occurrences are described in Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Enhancement and Management Guidelines and Techniques*.

Objective SBB/SuT1.4 Rationale: The establishment of four occurrences of Suisun thistle will contribute toward meeting delisting requirements of the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010). Additional occurrences established in existing or newly restored tidal marsh will expand the distribution and increase the total population of Suisun thistle, thereby decreasing the potential for extirpation. The two newly established occurrences will be added to the two existing protected occurrences to equal four total occurrences protected, thus meeting the delisting criteria for this species in the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010).

Occurrences will be established using wild or cultivated seed (founded from wild-collected seed) collected using approved seed banking protocols (U.S. Fish and Wildlife Service 2010). Guidelines for collecting and banking seed to minimize population or genetic effects, propagating nursery stock, and other proven or experimental methods used to establish sustainable plant occurrences are described in Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Enhancement and Management Guidelines and Techniques*.

3.3.7.41 Vernal Pool Plants

The covered plant species associated with vernal pool complex are alkali milk-vetch (*Astragalus tener* var*. tener*), Boggs Lake hedge-hyssop (*Gratiola heterosepala*), dwarf downingia (*Downingia pusilla*), Heckard's peppergrass (*Lepidium latipes* var. *heckardii*), and legenere (*Legenere limosa*). The historical distributions of these covered vernal pool plants are unknown, but probably coincided with the historical distributions of their habitat (U.S. Fish and Wildlife Service 2005). These species occupy vernal pool complexes, which are described in detail in Section 2.3.4.9, *Vernal Pool Complex*, and Section 3.3.6.8, *Vernal Pool Complex*, above (alkali milk-vetch and Heckard's peppergrass also occupy alkali seasonal wetlands). Vernal pool complexes in the western United States are distributed from eastern Washington to northern Baja California, Mexico (Moran 1984); and within this range, the remaining vernal pool acreage represents less than 10% of that prior to anthropogenic alteration of these landscapes since the 1800s (Keeley and Zedler 1998).

The primary stressors affecting long-term survival and recovery of the covered vernal pool plants include habitat loss and fragmentation, altered hydrology, and invasive plants (U.S. Fish and Wildlife Service 2005). These stressors will be reduced or eliminated in the reserve system consistent with the biological goals and objectives.

The Plan Area contains 8,896 acres of modeled vernal pool plant habitat and 2,576 acres of modeled, degraded vernal pool habitat distributed along the margins of the Plan Area, in Conservation Zones 1, 2, 4, 8, 9, and 11 (Figure 3.2-9). The rangewide and Plan Area–wide distributions for each covered plant species are described below, as are the known historical extent and decline of each species.

Alkali milk-vetch. Historically, this endemic annual was widely distributed around the San Francisco Bay region and in the Sacramento and northern San Joaquin Valleys as far south as Monterey and San Benito Counties (Barneby 1964), but by 1989 only a few populations remained (Liston 1992).

There are 67 total occurrences reported, of which 39 are presumed extant (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013o). The current range of alkali milk-vetch encompasses the Southern Sacramento Valley, northern San Joaquin Valley, and east San Francisco Bay Area, extending from Napa, Solano, and Yolo Counties in the north, to Merced County in the south, to Alameda County in the west. There are 19 occurrences in the Plan Area, three of which are possibly extirpated and one of which is extirpated (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013o). Occurrences are widely distributed throughout the vernal pool natural community in Conservation Zones 1, 2, 6, 8, and 11, but most dense in the Jepson Prairie core recovery area (Conservation Zones 1 and 11) and in the Putah Creek area (Conservation Zone 2) (Figure 2A.51-2).

Boggs Lake hedge-hyssop. Boggs Lake hedge-hyssop is a semi-aquatic annual herb that has been reported from various habitats, including the edges of marshes and natural lakes, stock ponds, swales, and vernal pools (Witham 2006; Barbour et al. 2007; California Department of Fish and Wildlife 2013p). It has been observed in several types of vernal pools, including basalt flow, hardpan, claypan, and alkaline playa pools, and is not endemic to California. There are presently 89 known occurrences of Boggs Lake hedge-hyssop in the state, of which 86 are extant, and only one of which occurs in the Plan Area (Figure 2A.52-2) (California Department of Fish and Wildlife 2013p). This occurrence is at the very western edge of Conservation Zone 1 within the Jepson Prairie Preserve, an existing conservation land (several occurrences are immediately outside the Plan Area).

Dwarf downingia. This small aquatic annual occurs in vernal pools, vernal swales, pools in seasonal streambeds, vernal marshes, tire ruts, hydrologically altered sloughs, and irrigation ponds (California Department of Fish and Wildlife 2013q). In California, dwarf downingia is known from 122 occurrences of which 114 are presumed extant. Its range extends from southern Tehama County to Fresno County and from Sonoma County to Placer County (California Department of Fish and Wildlife 2013q). There are 12 occurrences in the Plan Area, all extant, mostly in the Jepson Prairie core recovery area (Conservation Zones 1 and 11), with three occurrences near the eastern edge of Suisun Marsh (Conservation Zone 11) and one occurrence near Elk Grove (Conservation Zone 4) (Figure 2A.53-2).

Heckard's peppergrass. Heckard's peppergrass is endemic to California and extremely rare, and is presumed to be declining due to a loss of suitable habitat. (California Department of Fish and Wildlife 2013r). There are 15 occurrences in California, all of them extant, and limited to Glenn, Solano, and Yolo Counties in California (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013r). There are 5 occurrences in the Plan Area, two occurrences in the vernal pool complex areas of Stone Lakes National Wildlife Refuge in Conservation Zone 4, two occurrences just south of Putah Creek (Tule Ranch) in Conservation Zone 2, and one east of the Jepson Prairie core recovery area in Cache Slough (Wilcox and Gridley Ranches) in Conservation Zone 1 (Figure 2A.54-2).

Legenere. This small aquatic annual plant, endemic to California, is found in vernal pools, vernal swales, and alkaline flats in vernal pool grasslands primarily in the lower Sacramento Valley, and also in the north Coast Range, northern San Joaquin Valley, and Santa Cruz Mountains (California Department of Fish and Wildlife 2013s). There are 78 occurrences of legenere in the state, 69 of which are extant (California Department of Fish and Wildlife 2013s).There are 8 occurrences in the Plan Area, one of which has been extirpated; most of these occurrences are within the Jepson Prairie core recovery area (Figure 2A.55-2) (California Department of Fish and Wildlife 2013s).

The conservation strategy for vernal pool plants is guided chiefly by the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005), an ecosystem-level recovery and conservation strategy for vernal pool species. Key goals of the Vernal Pool Recovery Plan include the establishment of reserves throughout the species' ranges to prevent further habitat loss and fragmentation in areas identified as important for the species (called "core recovery areas"); restoration of vernal pools to achieve no net loss of habitat for vernal pool species (assuming reintroduction into restored areas); and adaptive habitat management to maintain and enhance habitat values for vernal pool species. While only three of five covered vernal pool plant species are included in the Vernal Pool Recovery Plan (alkali milk-vetch, Boggs Lake hedge-hyssop, and legenere), the plan's ecosystem approach can appropriately be applied to all five covered vernal pool plant species. However, species-specific objectives are also necessary for some of the species. The conservation measures that will be implemented to achieve the biological goals and objectives discussed below are described in Section 3.4, *Conservation Measures*. Table 3.3-1 lists the conservation measures that support each objective. AMM11 in Appendix 3.C, *Avoidance and Minimization Measures,* describes measures that will be implemented to avoid and minimize effects on these species.

3.3.7.41.1 Applicable Landscape-Scale Goals and Objectives

Landscape-scale biological goals and objectives integral to the conservation strategy for the vernal pool plant species are stated below.

Goal L1: A reserve system with representative natural and semi-natural landscapes consisting of a mosaic of natural communities that is adaptable to changing conditions to sustain populations of covered species and maintain or increase native biodiversity.
• **Objective L1.6:** Increase the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands.

Objective L1.6 Benefits: This objective will reduce future habitat loss and fragmentation in the Plan Area by protecting lands *in perpetuity* and reducing threats to vernal pools. The size and connectivity of conservation lands, including vernal pool complexes within a matrix of other natural community types, will be increased by building on the existing conservation lands and applying the reserve system assembly principles described in Section 3.2.4.2.1, *Reserve System Assembly Principles*. Vernal pool complexes will be protected and restored as components of a large, interconnected network, within a mosaic of grasslands and alkali seasonal wetlands. The large size and the connectivity of reserves, including vernal pool complex and other associated natural communities, will provide sufficient upland habitat to protect plant pollinators and to sustain important predators of herbivores such as rodents and rabbits (U.S. Fish and Wildlife Service 2005). Large, interconnected reserves are also less likely to be adversely affected by adjacent disturbances related to urban development, such as urban runoff or the invasion of exotic plant species.

Goal L2: Ecological processes and conditions that sustain and reestablish natural communities and native species
• **Objective L2.6:** Increase native species diversity and relative cover of native plant species, and reduce the introduction and proliferation of nonnative species.

Objective L2.6 Benefits: This objective will benefit the covered vernal pool plant species by reducing threats to the species' habitat requirements that result from heavy infestations of invasive, nonnative plant species. Invasive, nonnative plant species threaten the abundance and diversity of vernal pool plants. They have contributed to the decline of native vernal pool plant populations, in general, but disproportionately affect a number of covered plant species including alkali milk-vetch (U.S. Fish and Wildlife Service 2005). Consistent with Objective L2.6, all vernal pool natural community acquired as reserves will be monitored and adaptively managed for potential effects of invasive, nonnative plant species on covered and other native plant abundance and distribution, as described in Section 3.4.11.2.6, *Grasslands and Associated Seasonal Wetland Natural Communities*, *Enhancement and Management Actions.*

3.3.7.41.2 Applicable Natural Community Goals and Objectives

Natural community biological goals and objectives integral to the conservation strategy for the vernal pool plant species are stated below.

Goal VPNC1: Large, interconnected expanses of vernal pool complex within a reserve system that includes a range of geomorphological, hydrologic, and vegetation characteristics.
• **Objective VPNC1.1:** Protect 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11, primarily in core vernal pool recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). • **Objective VPNC1.2:** Restore vernal pool complex in Conservation Zones 1, 8, and/or 11 to achieve no net loss of vernal pool acreage (up to 67 acres of vernal pool complex restoration, assuming that all anticipated impacts [10 wetted acres] occur and that the restored vernal pool complex has 15% density of vernal pools). • **Objective VPNC1.3:** Increase the size and connectivity of protected vernal pool complex in the Plan Area and increase connectivity with protected vernal pool complex adjacent to the Plan Area.

Objectives VPNC1.1, VPNC1.2, and VPNC1.3 Benefits: Protection of 600 acres of vernal pool complex (Objective VPNC1.1) will prevent habitat loss and fragmentation of this natural community in the Plan Area. Restoration of vernal pool complex (Objective VPNC1.2) will offset inadvertent loss of vernal pool habitat and ensure no net loss of habitat for vernal pool plant species. Finally, Objective VPNC1.3 will build on existing protected vernal pool complexes in and adjacent to the Plan Area to increase the overall extent and connectivity of vernal pools in the reserve system. The permanent protection of existing vernal pool complexes from further habitat loss and fragmentation is the best strategy for ensuring continued survival of plant species dependent on vernal pools (U.S. Fish and Wildlife Service 2005).

The vernal pool natural community supports vernal pool plant species habitat in Conservation Zones 1, 2, 4, 8, 9, and 11 along the margins of the Delta. Conservation Zones 1, 8, and 11 include core recovery areas for these species, as described in the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005). Conservation Zones 1, 8, and 11 also provide the greatest opportunities for large-scale conservation of vernal pool plant species in the Plan Area. The vernal pool natural community in Conservation Zones 2 and 4 is almost entirely under protected status (99%). The vernal pool natural community in Conservation Zone 9 (approximately 120 acres), located in the vicinity of Discovery Bay, is largely fragmented by development and cultivated lands.

The 600 acres of vernal pool protection will occur in Conservation Zones 1, 8, and 11. Consistent with objectives VPNC1.1, VPNC1.2, and VPNC1.3, and as described in Section 2.3.4.9, *Vernal Pool Complex,* in Chapter 2, *Existing Ecological Conditions,* protected areas will capture the diversity of vernal pool types in the Plan Area and conserve the largest possible contiguous areas of vernal pool complex. Protected and restored vernal pool complex will be enhanced to benefit vernal pool species and managed in conjunction with protected grassland and alkali seasonal wetland complex natural communities to conserve and promote connectivity within vernal pool complexes as well as with other natural communities*. CM3 Natural Communities Protection and Restoration* and *CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration* detail the specific methods necessary to successfully achieve the vernal pool natural community objectives.

Objectives VPNC1.1 and VPNC1.2 prioritize protection and restoration in core recovery areas identified in the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005). These 11 specific sites are considered necessary to recover the federally endangered or threatened vernal pool species or to conserve sites that are necessary to recover those species. For species of concern that are not federally listed, core recovery areas are the specific sites necessary to prevent these species from being federally listed in the future (U.S. Fish and Wildlife Service 2005). The core recovery areas were developed to include viable populations (in some cases, source populations for larger metapopulations) or to contribute to the connectivity of habitat and thus increase dispersal opportunities between populations. Core recovery areas were established to provide for protection throughout the species' ranges, and to prioritize lands with a high concentration of species per unit area. Core recovery area boundaries were established for the Vernal Pool Recovery Plan based on data from distributions of species occurrence information, data layers for the proposed critical habitat for vernal pools, vernal pool complex mapping (Holland 1998), watershed boundaries, other hydrographic boundaries, topographic features, roads, and land use designations. Establishment of the core recovery areas assumed that the long-term survival and recovery of species are best achieved through two actions.

- Protect multiple populations so that a single or series of catastrophic events cannot cause the extinction of the species.
- Increase the size of the populations in core areas to a level where threats from genetic, demographic, and normal environmental uncertainties or change are diminished.

Objectives VPNC1.1, VPNC1.2, and VPNC1.3 will be advanced through prioritization, selection, acquisition, and protection of lands under *CM3 Natural Communities Protection and Restoration*. Objective VPNC1.2 will be further advanced through restoration activities under *CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration.*

Assembling a large, interconnected reserve system consistent with Goal VPNC1, including optimization of connectivity between upland and lower portions of the watersheds within vernal pool complexes, will contribute to native pollinator conservation by preventing fragmentation effects. This large system of vernal pool reserves will be assembled using the acquisition criteria described in *CM3 Natural Communities Protection and Restoration*, and vernal pool complexes will be managed and enhanced as described in *CM11 Natural Communities Enhancement and Management*.

Goal VPNC2: Vernal pool complexes that are managed and enhanced to sustain populations of native vernal pool species.
• **Objective VPNC2.1:** Maintain or enhance vernal pool complexes to provide the appropriate inundation (ponding) characteristics for supporting and sustaining vernal pool species. • **Objective VPNC2.2:** Maintain and enhance pollination service in the vernal pool complex, especially by native invertebrates including native solitary bees.

Objective VPNC2.1 Benefits: This objective will provide the appropriate hydrologic conditions for sustaining vernal pool species. Altered hydrology of vernal pool complexes can change the timing, frequency, or duration of vernal pool inundation, which can create conditions that render existing vernal pools unsuitable for vernal pool species (U.S. Fish and Wildlife Service 2005). For example, vernal pool ecosystems have been altered by hydrologic barriers such as roads or canals. Vernal pool hydrology has also been altered by the diversion of urban runoff and agriculture, both of which increase pond timing and duration, converting vernal pools to perennial ponds that are incapable of supporting vernal pool plant species. The conservation of 600 acres of large, interconnected tracts of vernal pool complex consistent with Objectives VPNC1.1 and VPNC1.2, and management consistent with VPNC2.1, will protect intact vernal pool complexes from alterations to natural hydrology that could reduce their suitability for vernal pool species.

Objective VPNC2.2 Benefits: Many rare and endemic vernal pool plant species depend on native insects for pollination (Eaton 2001). Legenere is pollinated by native bees (Buchman et al. 2010), while alkali milk-vetch is likely pollinated by butterflies (Liston 1992). Pollination mechanisms for Heckard's peppergrass are unknown (Hoffman Black et al. 2010). Vernal pool complexes will be managed as described in Section 3.4.11.2.6, *Grasslands and Associated Seasonal Wetland Natural Communities, Enhancement and Management Guidelines and Techniques, Vernal Pool Pollinators*.

3.3.7.41.3 Species-Specific Goals and Objectives

The landscape-scale and natural community biological goals and objectives, and conservation measures, discussed above, are expected to protect, restore, and enhance suitable habitat for the covered vernal pool plant species in the reserve system. Boggs Lake hedge-hyssop, dwarf downingia, and legenere are sufficiently conserved by the landscape-scale and natural community biological goals and objectives as described above. Alkali milk-vetch and Heckard's peppergrass have additional species-specific occurrence requirements, as described below.

Goal VPP1: A reserve system that protects vernal pool plant populations.
• **Objective VPP1.1:** Protect two currently unprotected occurrences of alkali milk-vetch in the Altamont Hills or Jepson Prairie core recovery areas (Conservation Zones 1, 8, or 11). • **Objective VPP1.2:** Maintain no net loss of Heckard's peppergrass in Conservation Zones 1, 8, or 11 within restoration sites or the associated area of affected tidal range.

Objective VPP1.1 Rationale: This objective will ensure that alkali milk-vetch will be represented in the reserve system. In addition, protecting two additional occurrences within the core recovery areas will provide for the conservation and management of the species in the Plan Area.

Objective VPP1.2 Rationale. Heckard's peppergrass will benefit from vernal pool protection and enhancement and management by increasing the quantity and quality of habitat for the species as well as the potential to discover unknown occurrences. However, during implementation, the loss of individual plants or an occurrence is possible due to tidal restoration. The occurrence that has potential to be affected (CNDDB Element Occurrence number 7) is an 1891 collection that has not been field-verified since; although CNDDB lists it as "presumed extant" (California Department of Fish and Wildlife 2013r), it is considered likely to be extirpated (Preston pers. comm.). In addition, the exact location is unknown and it is mapped by CNDDB as a best guess along Haas Slough. Because this occurrence is very unlikely to exist, and protection and management of habitat are expected to yield the discovery of additional occurrences that will allow conservation of the species, the no-net-loss standard is appropriate to apply to this plant. Table 3.3-8 depicts the occurrence of the covered vernal pool plants in the Plan Area.

Table 3.3-10. Covered Vernal Pool Plant Species Occurrences and Level of Protection[a]

Species	Percentage of Range-Wide Occurrences in Plan Area	Percentage of Plan Area Occurrences Currently Protected	Number of Occurrences that Overlap with Hypothetical Tidal Restoration Footprints[b]	Species-Specific Objectives
Alkali milk-vetch	32% (18/57)	60% (9/15)	0	Protect two additional occurrences
Boggs Lake hedge-hyssop	1% (1/87)	100% (1/1)	0	None (landscape and natural community objectives are sufficient)
Dwarf downingia	10% (12/116)	100% (12/12)	0	None (landscape and natural community objectives are sufficient)
Heckard's peppergrass	33% (5/15)	80% (4/5)	1	Maintain no net loss
Legenere	10% (7/71)	86% (6/7)	0	None (landscape and natural community objectives are sufficient)

[a] Presumed extant and possibly extirpated occurrences totaled and presented in this table.

[b] Tidal restoration impacts on natural communities and species modeled habitat, as well as on species occurrences, were determined by choosing "hypothetical" restoration footprints. Although impacts on these vernal pool plant species might occur, the potential is very low and full avoidance of species occurrences is expected.

Consistency with *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon*`

The Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005) lists six elements that an HCP must incorporate to implement the recovery plan for its plan area. These six elements are listed below (in *italics*) and described as they relate to the BDCP and the three covered plant species addressed in the recovery plan (alkali milk-vetch, Boggs Lake hedge-hyssop, and legenere).

1. *Permanently protected vernal pool preserves within the area covered by the Habitat Conservation Plan in large contiguous blocks of suitable habitat.*

   Consistent with Goal VPNC1, the BDCP will result in a large, interconnected network of vernal pools in the reserve system. This will be achieved by building on the existing conservation lands in and adjacent to the Plan Area. The BDCP will add 600 acres to the 6,311 acres of modeled vernal pool plant habitat on existing conservation lands. A majority of the 600 acres is expected to be protected adjacent to existing conservation lands within the Jepson Prairie core recovery area.

2. *Protection of the entire genetic range of each listed species within the area covered by the Habitat Conservation Plan.*

   As described in the Vernal Pool Recovery Plan (U.S. Fish and Wildlife Service 2005:III-5), genetic composition has not been investigated for most of the vernal pool plant species; therefore, genetic diversity is assumed to be protected by protecting populations throughout each species' range. The core recovery areas identified in the Vernal Pool Recovery Plan are distinct areas that provide geographic and/or genetic diversity necessary for recovery of the species (U.S. Fish and Wildlife Service 2005:III-18). By focusing 600 acres of vernal pool complex protection within the Jepson Prairie core recovery area, which is ranked as Recovery Zone 1 (highest priority) for all three vernal pool plants, and within the Altamont Hills core recovery area, in Recovery Zone 1 for alkali milk-vetch, the BDCP will protect areas identified in the recovery plan as important for protecting the full range of genetic diversity throughout the range of those species identified in the recovery plan.

   The conservation strategy for vernal pool species is based on the assumption that the genetic range of each species in the Plan Area is protected by protecting lands that represent the species' distribution throughout the Plan Area. The distribution of occurrences for each of the three species in the recovery plan, in relation to existing conservation lands and lands targeted for protection under the BDCP, is described below.

   - **Alkali milk-vetch.** Extant occurrences of this species are in Conservation Zones 1, 2, 8, and 11 (Figure 2A.51-2) (Appendix 2.A, *Covered Species Accounts*). Eleven extant and possibly extirpated occurrences are within existing conservation lands, including the three extant occurrences in Conservation Zone 2 (Tule Ranch) the three occurrences in Conservation Zone 1 in the Jepson Prairie Preserve, and one occurrence in Conservation Zone 11 in the Suisun Resource Conservation District. Additional vernal pool complex will be protected in Conservation Zones 1, 8, and 11; therefore, this plant's range within the Plan Area will be well represented in the reserve system.

   - **Boggs Lake hedge-hyssop.** There is one occurrence of this species in the Plan Area, located in Conservation Zone 1 on existing conservation lands in the Jepson Prairie Preserve (Figure 2A.52-2). A majority of the 600 acres of vernal pool protection is expected to occur in Conservation Zone 1, where additional occurrences of the species are most likely to be found based on its distribution in and near the Plan Area (Figure 2A.52-2).

   - **Legenere.** Extant occurrences of this species are in Conservation Zones 1 and 4 (Figure 2A.55-2). Six of the seven extant occurrences in the Plan Area are on existing conservation lands. Additional vernal pool complex will be protected in Zone 1; therefore, the species' range within the Plan Area will be well represented in the reserve system.

3. *Protection of all populations of species with 25 or fewer total occurrences addressed in this plan within the area covered by the Habitat Conservation Plan.*

   All three covered species addressed in the Vernal Pool Recovery Plan have more than 25 occurrences in the state; therefore, this element does not apply to the covered species.

4. *Connectivity with other preserves within the area covered by the Habitat Conservation Plan.*

   The reserve system will be adjacent to existing conservation lands and will build on the network of existing conservation lands to conserve vernal pool plants in the Plan Area.

5. *Adaptive management of the preserves within the area covered by the Habitat Conservation Plan to support the species addressed in this recovery plan.*

   See Section 3.6, Adaptive Management and Monitoring Program.

6. *Sufficient funding for management, maintenance, and monitoring of the preserves in perpetuity.*

   See Chapter 8, Implementation Costs and Funding Sources.

Of the three covered species included in the Vernal Pool Recovery Plan, alkali milk-vetch is the only species that has several unprotected occurrences in the Plan Area. The protection of two unprotected occurrences of alkali milk-vetch will contribute to achieving the overall 80% occurrence protection goal (of all known, extant occurrences throughout the species' range) for alkali milk-vetch in the recovery plan (U.S. Fish and Wildlife Service 2005). In conclusion, with respect to the covered vernal pool plants, the BDCP includes five of the six elements listed in the recovery plan (U.S. Fish and Wildlife Service 2005) for an HCP to be deemed equivalent to recovery.

3.3.8 References Cited

3.3.8.1 Literature Cited

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Cypher, Brian. Associate Director and Research Ecologist. Endangered Species Recovery Program. Stanislaus, CA. June 2007—telephone conversation regarding San Joaquin kit fox habitat.

Bradbury, Michael. Environmental Resource Coordinator. California Department of Water Resources, West Sacramento, CA.—email to Ellen Berryman, ICF International, containing swainson hawks counts, unpublished data.

Gingras, M. BDR-IEP Program Manager. California Department of Fish and Game, Bay Delta Region. December 19, 2012—email to Chris Soncarty, ICF International.

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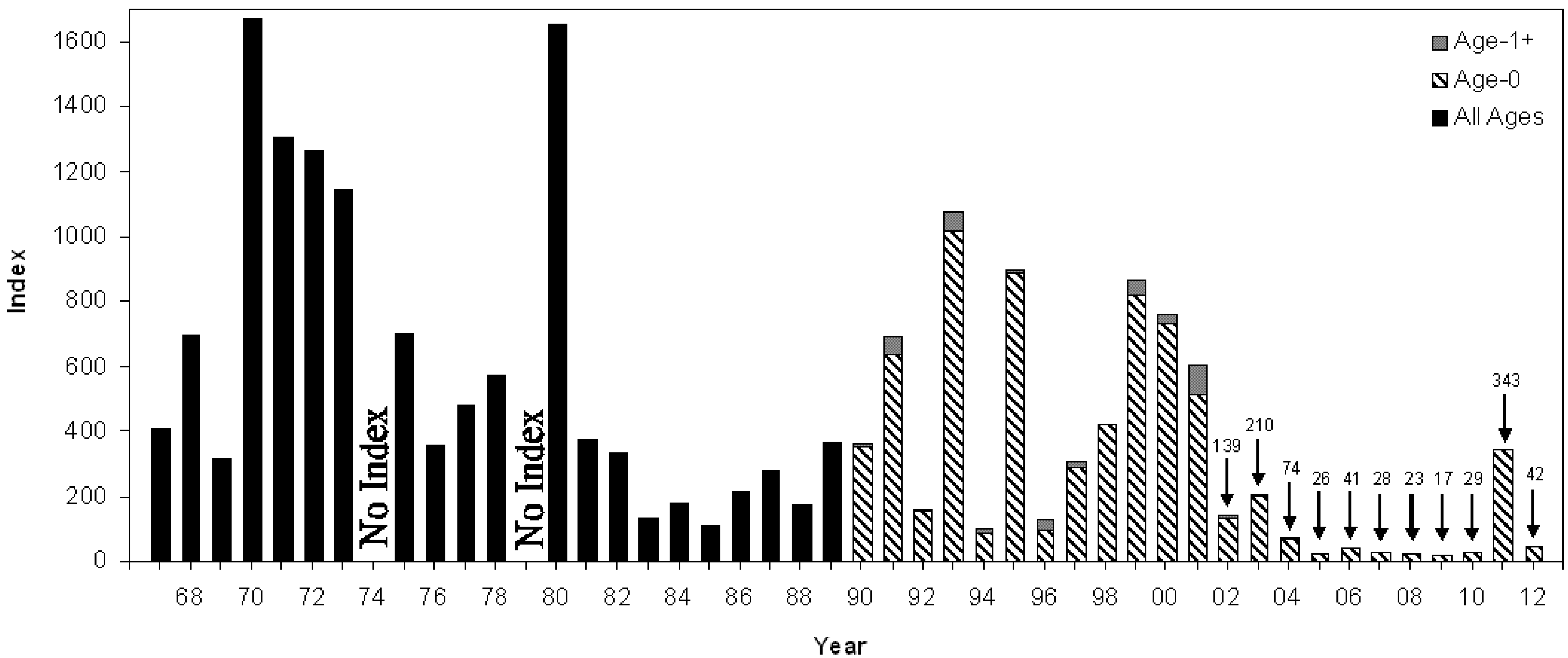

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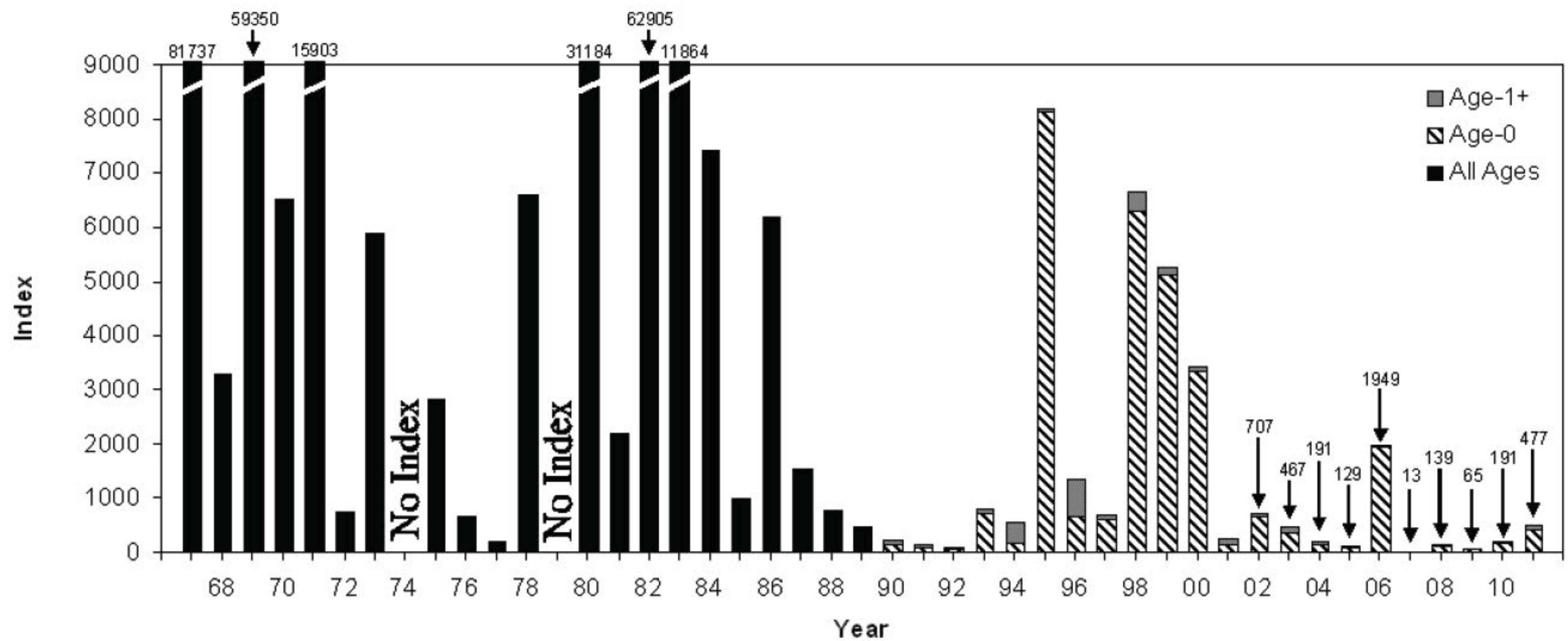
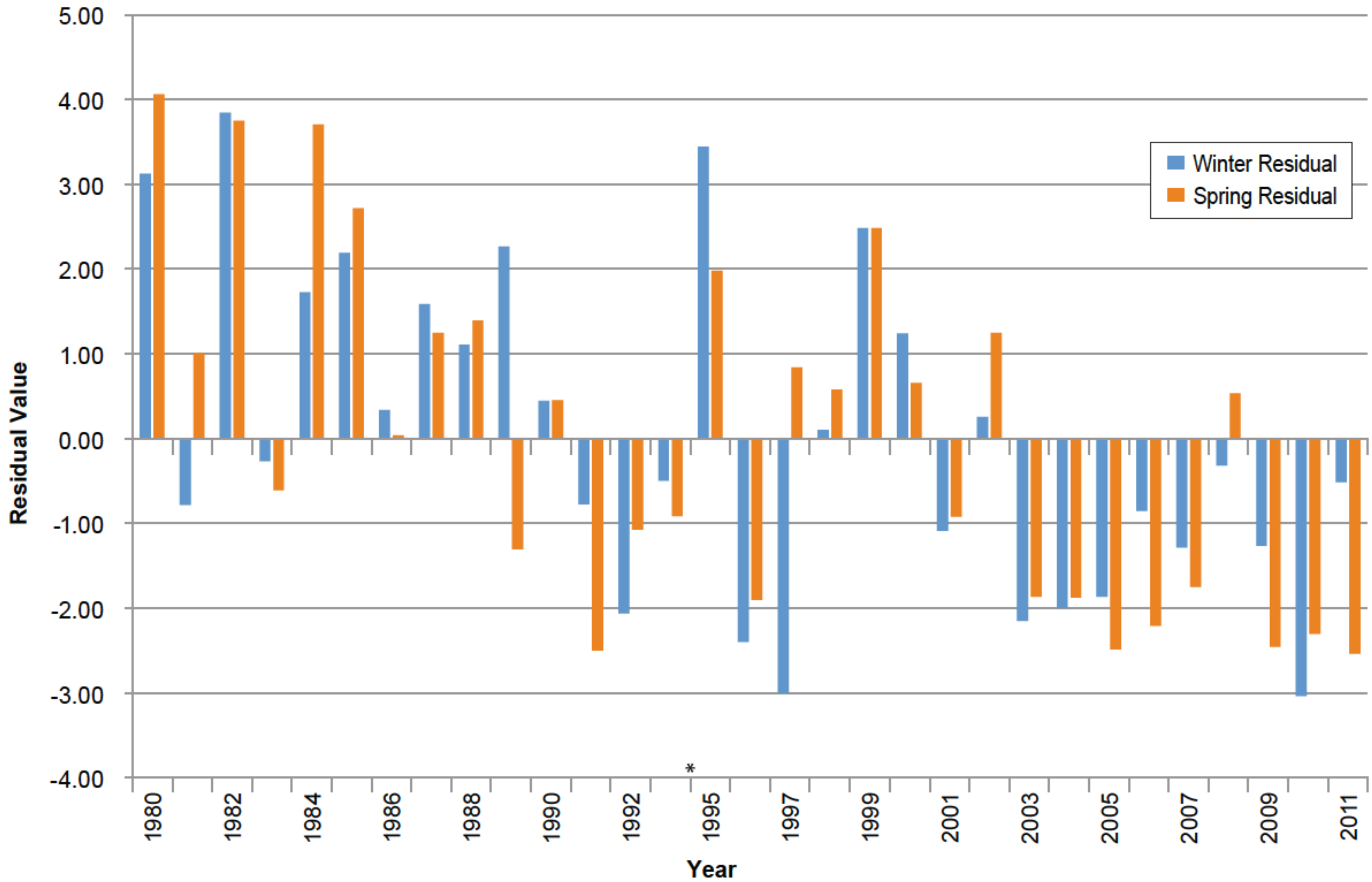
Graphics ... BDCP HCP (Rev. 9-6-13 TM)

Figure 3.3-1
Fall Midwater Trawl Annual Abundance Indices for Delta Smelt, 1967–2012



Source: California Department of Fish and Game. 2012. *Fall Midwater Trawl Abundance Indices for Longfin Smelt (*Spirinchum thaleichtys*), 1967-2011.* Available: <http://www.dfg.ca.gov/delta/data/fmwt/Indices/sld003.asp>. Accessed: May 31, 2012.

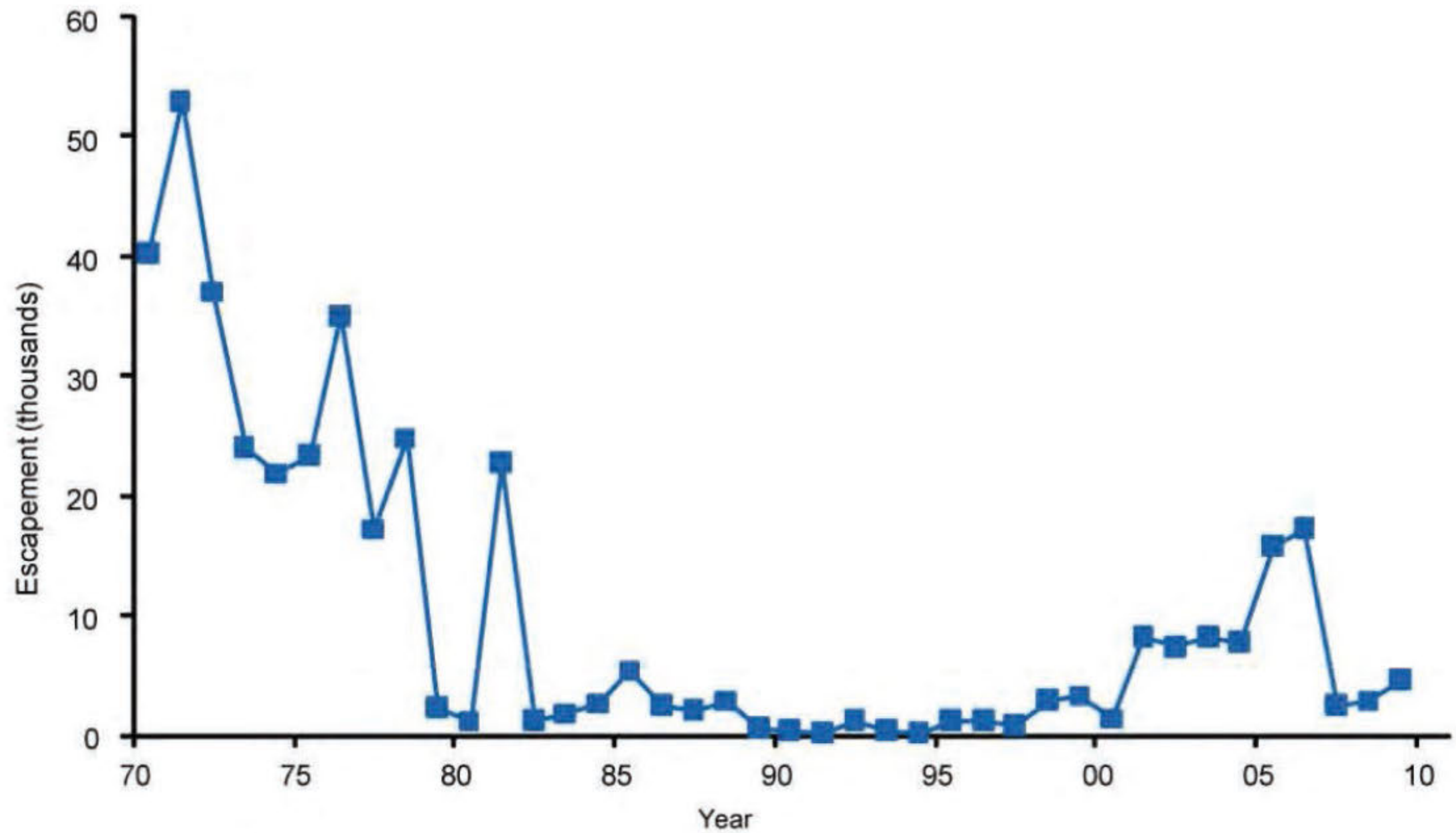
Figure 3.3-2
Fall Midwater Trawl Annual Abundance Indices of Longfin Smelt, 1967–2011



Predicted values are based on the regression of observed index values against preceding December through February (winter) and March through May (spring) Log10-transformed average Delta outflow levels. The composite index is the sum of individually log10-transformed and z-scored Fall Midwater Trawl, SF Bay Study Otter Trawl and SF Bay Study Midwater Trawl Longfin Smelt annual abundance indices. Fall Midwater Trawl annual abundance is based on all ages collected, whereas SF Bay Study indices for both trawls are based on age-0 catches only.

* 1994 was excluded as one of the Bay Study indices was not available for that year.

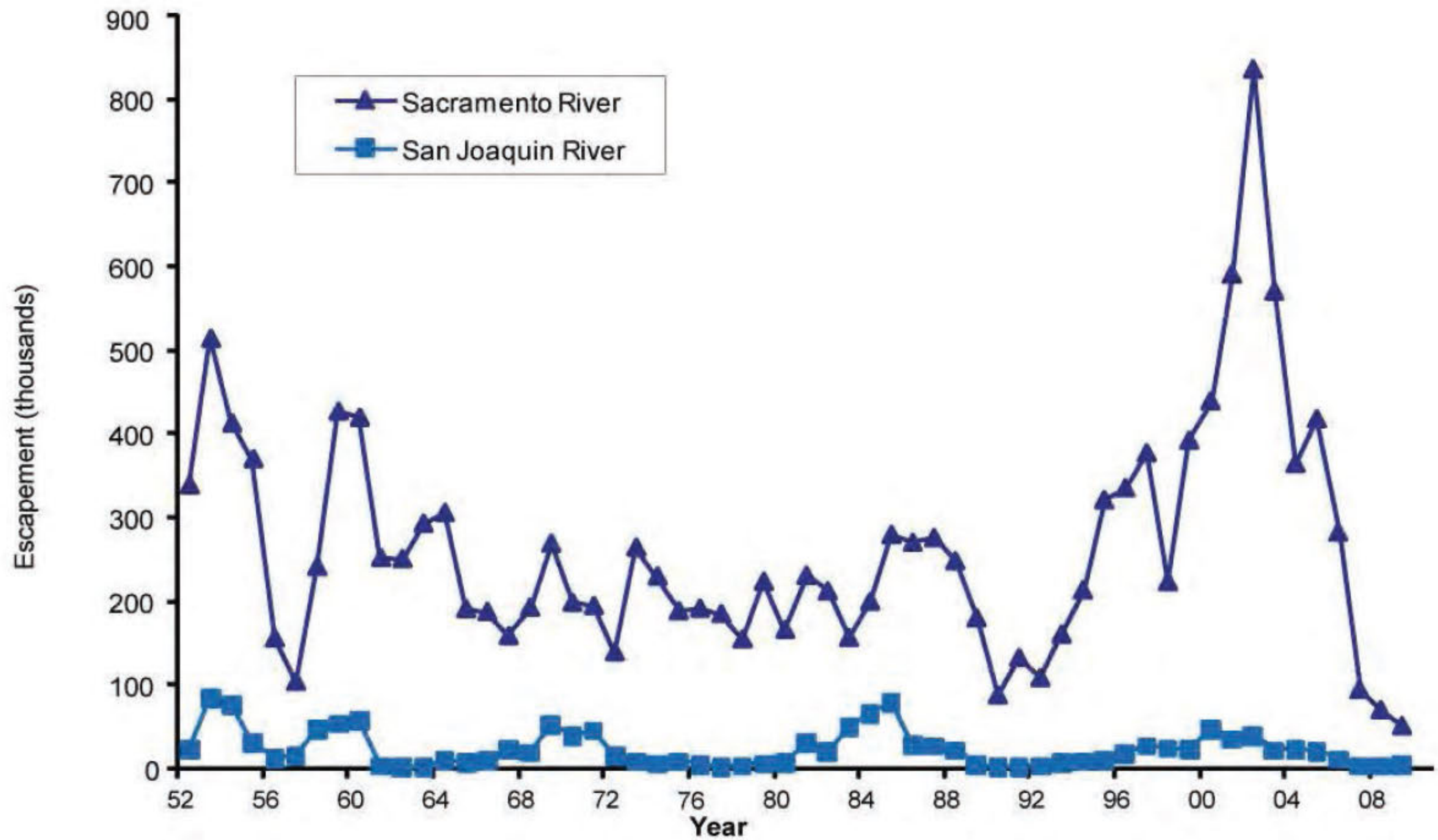
Figure 3.3-3
Annual Residual Values between Observed Composite Index of Longfin Smelt Abundance and Predicted Index Values (1980–2011)



Source: California Department of Fish and Game. 2010. Historical Spawner Escapement Estimates for Sacramento River Fall-Run/Late Fall–Run and San Joaquin River Fall-Run Chinook Salmon. GrandTab. September. Available: <www.calfish.org>.

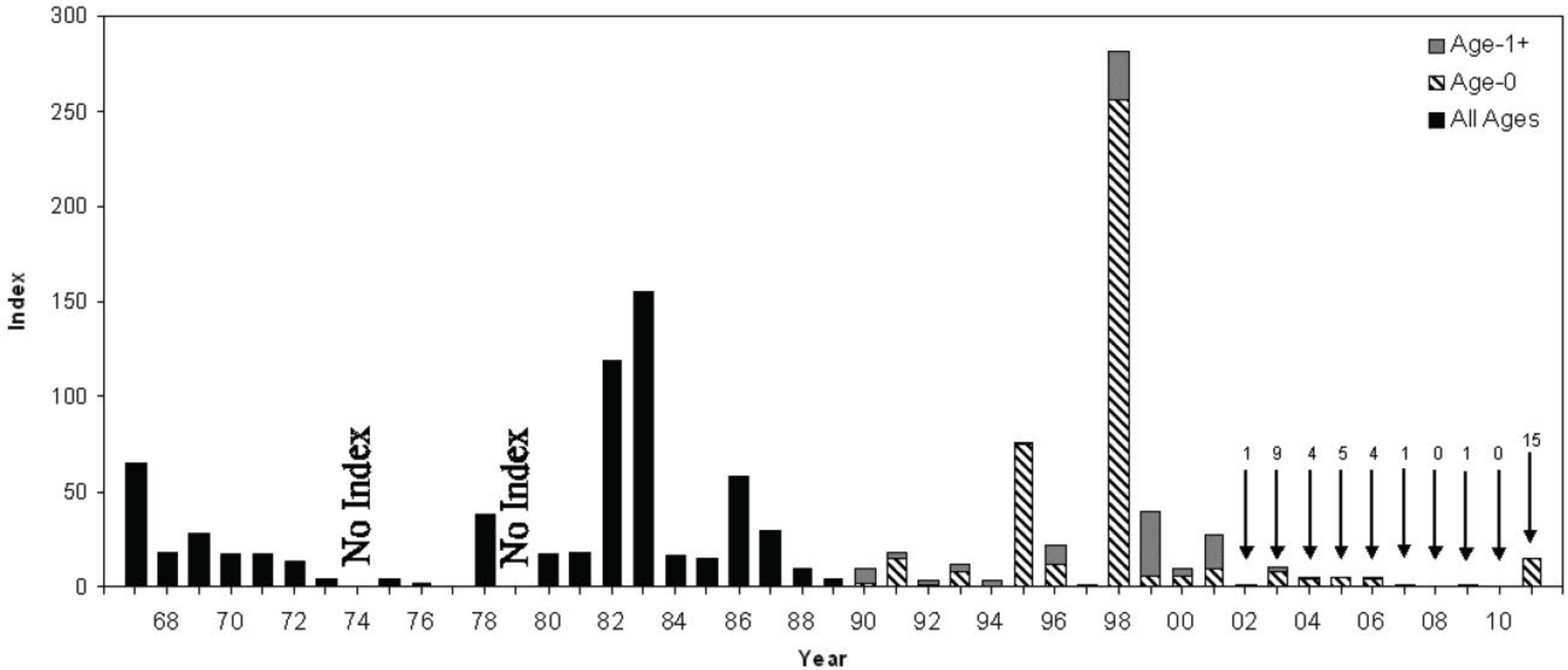
Graphics ... BDCP Other Chapters (Rev. 2-25-13 TM)

Figure 3.3-4
Estimated Historical Spawner Escapement of Sacramento River Winter-Run Chinook Salmon (1970–2009)



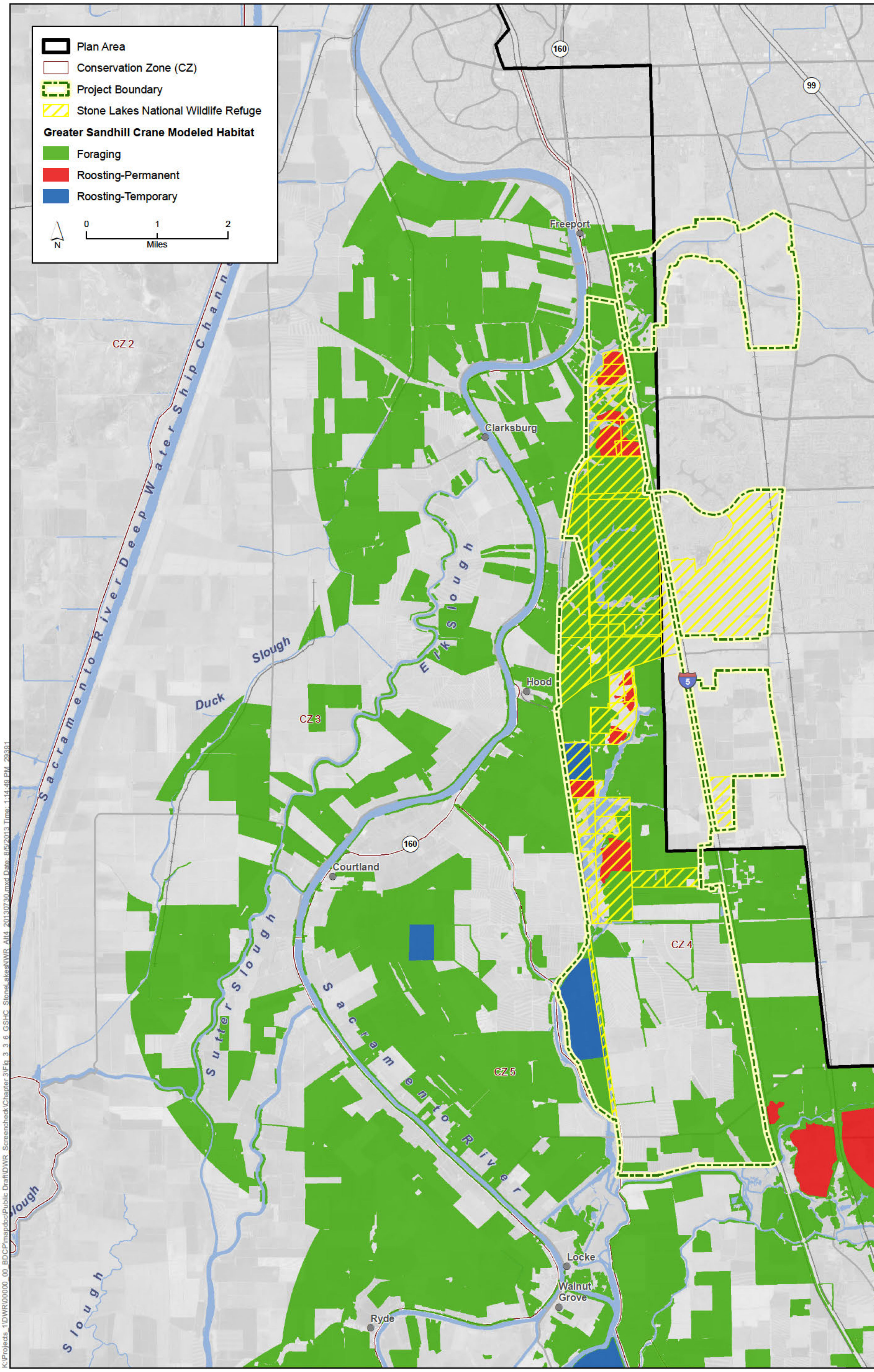
Source: California Department of Fish and Game. 2010. Historical Spawner Escapement Estimates for Sacramento River Winter-Run Chinook Salmon. GrandTab. September. Available: <www.calfish.org>.

Figure 3.3-5
Estimated Historical Spawner Escapement of Central Valley Fall-Run Chinook Salmon (1952–2009)



Source: California Department of Fish and Game. 2012. Fall Midwater Trawl Abundance Indices for Sacramento Splittail (Pogonichthys macrolepidotus), 1967-2011. Available: <http://www.dfg.ca.gov/delta/data/fmwt/Indices/sld005.asp>. Accessed: May 31, 2012.

Figure 3.3-6
Fall Midwater Trawl Annual Abundance Indices for Sacramento Splittail, 1967–2011



GIS Data Source: Constructability (Rev 2b), DHCCP DWR 2012;
Stone Lakes NWR, Stone Lakes 2013.

Figure 3.3-7
Stone Lakes National Wildlife Refuge and Greater Sandhill Crane Habitat

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