Appendix B.1
Focused Conservation Plan: Delta Smelt

This page left blank intentionally.

APPENDIX B.1

Focused Conservation Plan: Delta Smelt

Acronym	Description
°F	degree(s) Fahrenheit
CESA	California Endangered Species Act
CPA	Conservation Planning Area
CVFPP	Central Valley Flood Protection Plan
Delta	Sacramento–San Joaquin Delta
ESA	Endangered Species Act
FR	Federal Register
mm	millimeter(s)
SAV	submerged aquatic vegetation
SPA	Systemwide Planning Area
SPFC	State Plan of Flood Control
SRA	shaded riverine aquatic
State	State of California
USFWS	U.S. Fish and Wildlife Service

Conservation Status

As part of the Central Valley Flood Protection Plan (CVFPP) Conservation Strategy Update, this focused conservation plan addresses needs and opportunities to conserve delta smelt (*Hypomesus transpacificus*) in the Systemwide Planning Area (SPA). Within the SPA, delta smelt occupy the Lower Sacramento River Conservation Planning Area (CPA) and the Lower San Joaquin River CPA.

In 1993, delta smelt were State-of-California (State)- and federally listed as threatened under the California Endangered Species Act (CESA) and federal Endangered Species Act (ESA) (58 *Federal Register* [FR] 12854, March 5, 1993). In 2010, the State uplisted the species' CESA status to endangered. That same year, the U.S. Fish and Wildlife Service (USFWS) determined that delta smelt should be reclassified from threatened to endangered under the ESA, but higher-priority actions precluded the promulgation of a formal rulemaking for such a reclassification (75 FR 17667, April 7, 2010).

Recently, USFWS again considered uplisting delta smelt from threatened to endangered status under the ESA. As it had done previously, USFWS determined that delta smelt was warranted for uplisting, but this was precluded by higher-priority actions. The species was assigned a listing priority number of 2, based on the high magnitude and high imminence of threats the species faced rangewide, resulting in mortality or a significant reduction in reproductive capacity (85 FR 73164, Nov. 16, 2020).

Critical habitat for delta smelt was designated in 1994 (59 FR 65256, Dec. 19, 1994). The designated critical habitat includes the following areas:

- The mainstem Sacramento River downstream of Sacramento.
- All of the Yolo Bypass.
- The mainstem San Joaquin River downstream of the San Joaquin County line.
- All river reaches and estuarine areas of the Sacramento–San Joaquin Delta (Delta) (in the Sacramento Delta and San Joaquin Delta hydrologic units).
- All waters of Suisun Bay, including Honker Bay, Grizzly Bay, and connected sloughs.

The following primary constituent elements are considered essential to conserve delta smelt:

- Freshwater or slightly brackish-water spawning sites.
- Larval and juvenile transport from spawning to rearing habitat.
- Rearing habitat.
- Adult migration to spawning habitat.

USFWS developed the *Recovery Plan for Sacramento–San Joaquin Delta Native Fishes* in 1996; however, in its most recent five-year review (2010), USFWS indicated the recovery plan was outdated and was being revised (75 FR 17667, April 7, 2010). The five-year review led to a 12-month finding for a delta smelt uplisting petition. USFWS concluded that changing the status from threatened to endangered was warranted (but precluded), and "that the biological status of this ESU [*sic*] has worsened since the last status review and therefore, we recommend that its status be reassessed in 2–3 years if it does not respond positively to improvements in environmental conditions and management actions" (75 FR 17667, April 7, 2010).

In 2020, USFWS stated the following (85 FR 73164, Nov. 16, 2020):

> *"The primary rationale for reclassifying delta smelt from threatened to endangered was the significant decline in species abundance that have [sic] occurred since 2001, and the continuing downward trend in delta smelt abundance indices supports that finding. Fourteen of the last 15 years have seen fall abundances that have been the lowest ever recorded. 2015 to 2019 results from all four of the surveys analyzed in this review have been the lowest ever recorded for the delta smelt. Delta smelt abundance in fall was exceptionally low between 2004 and 2010, increased during the wet year of 2011, and decreased again to very low levels at present. The latest 2018 and 2019 fall surveys did not detect a single delta smelt, resulting in an abundance index of 0, and the latest 2019 spring survey resulted in an abundance index of 0.4, all of which are the lowest on record."*

Status and Trends

Historical Distribution

Historically, delta smelt were abundant throughout much of their range in San Francisco Bay and the Delta, from San Pablo Bay upstream to Sacramento (on the Sacramento River) and Mossdale (on the San Joaquin River) (75 FR 17667, April 7, 2010).

Current Distribution

Figure B.1-1 the range of delta smelt as determined by the Interagency Ecological Program and Regional Monitoring Program. Delta smelt's extant distribution is mostly restricted to west of the Sacramento and San Joaquin River confluence, although they are found year-round—and sometimes in high numbers—in the North Delta, within the Lower Sacramento River CPA. In particular, the Cache Slough Complex and Liberty Island (downstream portions of the Yolo Bypass) appear to provide important year-round habitat for delta smelt of all life stages (Merz et al. 2011; Sommer et al. 2011; Sommer and Mejia 2013). Delta smelt are found infrequently in the southern and eastern portions of the Delta (i.e., the Lower San Joaquin River CPA) and are largely absent from these areas in summer and fall (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015).

Based on captures of newly hatched larvae and post-spawn adults, the following are known spawning locations in the Lower Sacramento River and Lower San Joaquin River CPAs:

- The Yolo Bypass, Cache and Lindsey sloughs in the lower Sacramento River.
- Between Sherman Island and Venice Island in the lower San Joaquin River.
- The lower Mokelumne River.
- The South Delta.
- The West Delta.

However, in recent years, the densest concentrations of both spawners and larvae have been recorded in the Cache Slough and Sacramento Deep Water Ship Channel complex in the North Delta (U.S. Fish and Wildlife Service 2017).

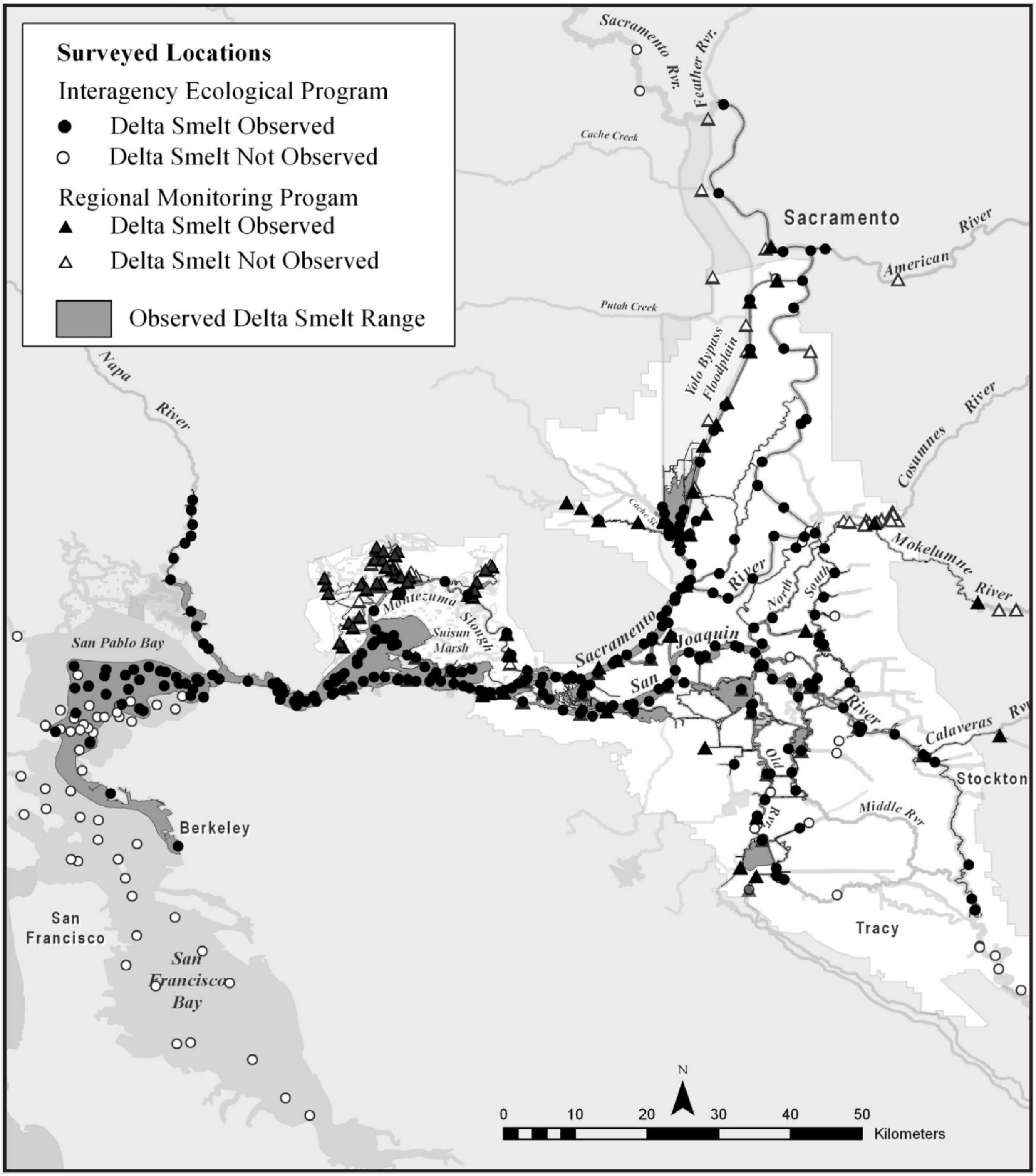
Additional spawning locations occur downstream of these CPAs and include Suisun Bay and Suisun Marsh, and in wet years the Napa River (U.S. Bureau of Reclamation 2007; U.S. Fish and Wildlife Service 2017). The most significant downstream habitat for delta smelt is the lower Napa River (a tributary of San Pablo Bay), although it is typically used only in wet years (Hobbs et al. 2007; Merz et al. 2011; Sommer and Mejia 2013).

Population Trends

Delta smelt were once abundant in San Francisco Bay and the Delta (Moyle 2002; Bennett 2005). Their abundance abruptly decreased in the early 1980s, apparently independent of previous or subsequent changes in abundance trends. A stronger negative trend began in the early 2000s; this abundance trend also was observed in other pelagic fishes of the San Francisco Bay estuary, coinciding with the pelagic organism decline (Nobriga and Herbold 2009; Thomson et al. 2010). Notably, however, catch index values in the Yolo Bypass and Cache Slough Complex portions of the Lower Sacramento River CPA have increased substantially since 2008 while continuing to decrease elsewhere (California Department of Water Resources n.d.).

Much of what is known about abundance and trends in delta smelt populations is based on indices derived from regular sampling conducted by several federal and State agencies (e.g., Bennett 2005; Thomson et al. 2010; Sommer et al. 2011; Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015; and U.S. Fish and Wildlife Service 2017).

Figure B.1-1. Observed Range of Delta Smelt and Species Occurrence at Interagency Ecological Program and Regional Monitoring Survey Stations



Source: Merz et al. 2011; reproduced with permission.

Delta smelt abundance indices for four different life stages (post-larval, juvenile, subadult, and adult) were derived from data collected by the five California Department of Fish and Wildlife fish monitoring programs that differ in terms of their duration, time of year (and thus, life stage sampled), sampling intensity, and net type (Polansky et al. 2019). The surveys include the 20 millimeter (mm), which has the smallest (i.e., 20-mm) mesh size; Summer Townet; Fall Midwater Trawl; Spring Midwater Trawl; and Spring Kodiak Trawl (Polansky et al. 2019) (Figure B.1-2). Figure B.1-2 shows a series of four line graphs depicting indices of delta smelt abundance between 1990 and 2015. In order from first to last, these graphs show the respective abundance indices as determined by the 20-mm survey, Summer Townet survey, Midwater Trawl, and Spring Midwater Trawl and Spring Kodiak Trawl. These surveys reflect conditions in May, July and August, October and November, and February and March, respectively.

The best data on the annual abundance of adult delta smelt began to be collected in 2002 with the initiation of the Spring Kodiak Trawl survey, from which an abundance index has been developed. As the last line graph on Figure B.1-2 shows, the values of this index were highest in 2012 and lowest in 2016.

However, an abundance index for juveniles based on the Fall Midwater Trawl survey indicates abundance levels since 2002 are still well-below the levels that were typical before the declining trend of the early 2000s, and particularly well-below abundance levels before the abrupt decrease in the early 1980s (Figure B.1-2) (Polansky et al. 2019). The recent (2018 and 2019) fall surveys detected no delta smelt, resulting in an abundance index of 0, and the latest 2019 spring survey resulted in an abundance index of 0.4; these abundance indices are the lowest on record (85 FR 73164, Nov. 16, 2020).

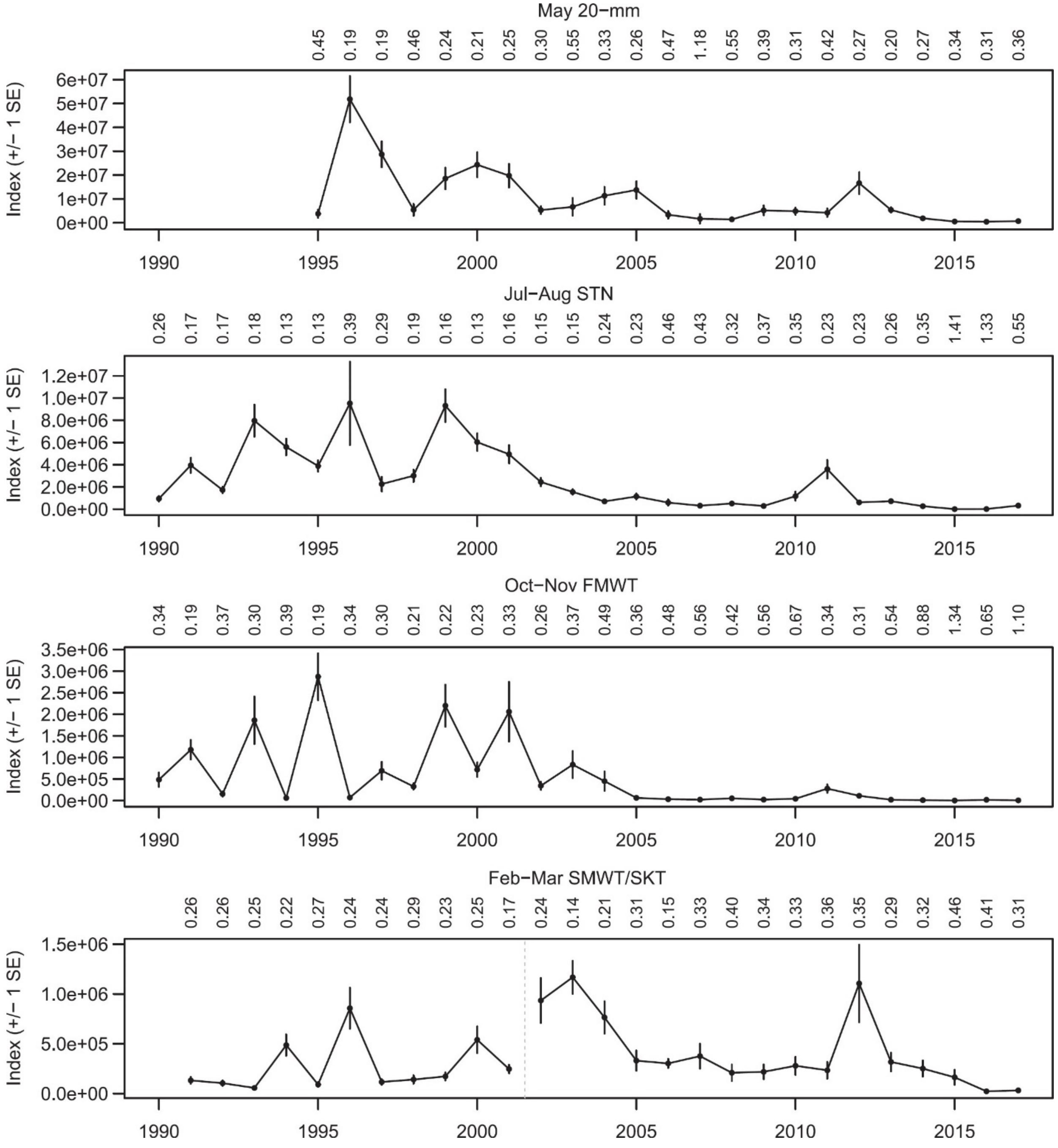
USFWS developed a procedure for estimating delta smelt abundance that is based on Spring Kodiak Trawl data. USFWS's resulting estimates of historical delta smelt abundance in January and February indicate the 2016 population is the lowest between 2002 and 2017, with only 16,000 individuals (95-percent confidence intervals 7,000 to 31,000 individuals) (U.S. Fish and Wildlife Service 2017).

Life History

Delta smelt are an annual estuary-dependent species endemic to San Francisco Bay and the Delta. Adults begin migrating upstream to freshwater spawning grounds with the first flow events in winter. Migration takes one to four weeks, at a rate of approximately 1.1 to 3.9 miles per day, for an average of 2.2 miles per day. Adults appear to hold in the spawning grounds for perhaps one month before initiating spawning (Sommer et al. 2011).

Figure B.1-2. Annual Abundance Indices for Delta Smelt Life Stages

Index of abundance with standard errors are derived for each year from data from five survey types: 20-mm, STN = Summer Townet, FMWT = Fall Midwater Trawl, SMWT = Spring Midwater Trawl, and SKT = Spring Kodiak Trawl.



Source: Polansky et al. 2019.

Most delta smelt spawning occurs in the Lower Sacramento River and Lower San Joaquin River CPAs, in the lower Sacramento River, Yolo Bypass, and San Joaquin River; however, spawning also occurs broadly throughout the Delta, in marsh channels of Suisun Bay, and in wet years in the Napa River (Moyle et al. 1992; Bennett 2005).

Although spawning generally occurs in upstream reaches during dry years, post-spawn adults have been observed in the Sacramento River in at least one wet year (Souza 2002; Bennett 2005). Larval, juvenile, and adult delta smelt have been observed in the Yolo Bypass (California Department of Water Resources n.d.). These observations indicate either some juveniles remain there instead of emigrating to brackish water in the West Delta and Suisun Bay, or fish movement occurs year-round, causing them to be present in the bypass all year (Sommer et al. 2011).

Female delta smelt were thought to spawn only once during their lifetimes; however, recent evidence from laboratory experiments suggests they are capable of spawning multiple clutches within a spawning season, and in the wild they may do so when conditions remain suitable for spawning for a longer period (U.S. Bureau of Reclamation 2007; Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015; USFWS 2017). Although delta smelt are generally considered to be an annual species, a small number of fish may live for two years and either do not spawn in their first year or spawn in both their first and second years (Moyle 2002; Bennett 2005; U.S. Bureau of Reclamation 2007).

Spawning occurs between late February and June, although most occurs from mid-April through May (Bennett 2005). Some evidence exists that delta smelt may spawn primarily below the low-tide level during spring tides, behavior that has been hypothesized to protect eggs from desiccation or to take advantage of enhanced aeration provided by higher tidal velocities.

Spawning during spring tides would also mean that eggs hatch during neap tides when tidal velocities are at a minimum, reducing the chance of larvae displacement (Bennett 2005). Adults mature at 1.97 to 2.76 inches (55 to 70 mm) fork length and rarely grow larger than 3.15 inches (80 mm) fork length. Although fecundity is relatively low, it does increase with size (Bennett 2005).

Eggs have not been collected in the wild; however, laboratory experiments and information from closely related species suggest delta smelt are broadcast spawners that deposit eggs on sandy or gravelly substrate (Bennett 2005; U.S. Bureau of Reclamation 2007; Lindberg et al. 2020). Eggs form a stalk that attaches to substrate, and the eggs hatch in nine days at 59.0 to 69.8 degrees Fahrenheit (°F) (U.S. Bureau of Reclamation 2007; U.S. Fish and Wildlife Service 2017).

Much of the current knowledge about the developmental biology of larval delta smelt comes from observations made under laboratory conditions, although field observations have helped biologists to determine the timing and location of rearing larvae. After hatching, larvae likely drift downstream and quickly settle to the bottom of the river. They begin feeding after five to six days, likely remaining bottom-oriented for up to 65 days before developing into juveniles at approximately 0.8 inch in total length (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015). However, they may quickly move or be displaced from unsuitable habitat before becoming fully developed (Hobbs et al. 2007). Larval delta smelt less than 0.8 inch long are generally found in tidally influenced freshwater habitat, but move downstream toward the low-salinity zone in late spring (Nobriga and Herbold 2009).

Juvenile delta smelt are most associated with the low-salinity zone (less than 3 practical salinity units), and are thus less widely distributed than adults. Nobriga and Herbold (2009) describe a shift in distribution from the Delta in early summer to the Sacramento River and San Joaquin River confluence as the summer progresses, indicating juveniles escape unfavorable temperatures and seek turbid water. This shift is thought to be a response to changes in habitat quality from historical conditions, because historically, juveniles were found throughout the Delta (Nobriga et al. 2008; Nobriga and Herbold 2009). Juvenile delta smelt spend summer and early fall feeding and growing until the first winter storms trigger the upstream spawning migration of maturing adults (Bennett 2005; Nobriga and Herbold 2009; Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015).

Habitat and Ecological Process Associations

Delta smelt are pelagic (that is, they live near the water surface) and associated with tidally influenced, turbid, low-salinity, and low-velocity water within a moderate temperature range (Swanson et al. [2000], Bennett [2005], Feyrer et al. [2007], Nobriga et al. [2008], Sommer and Mejia [2013], Bennett and Burau [2015], and Bever et al. [2016]).

Turbidity has been hypothesized to play a role in predator avoidance by concealing smelt, and in enhanced feeding opportunities by increasing background contrast and thus improving the visual identification of prey (Sommer and Mejia 2013). Natural sources of turbidity include streambank erosion from channel meander, upslope erosion from rainfall, and primary production. A strong shift toward lower turbidity in the Sacramento River and San Francisco Bay estuary in the late 1990s (Jassby et al. 2002; Glibert 2010; Schoellhamer 2011) has raised concerns regarding effects on habitat conditions for delta smelt (Feyrer et al. 2007; Nobriga et al. 2008).

This species is most often captured when water temperatures are less than 71.6°F, and temperatures above 68°F in spring can increase larval mortality rates (Bennett 2005). The upper temperature threshold is generally considered to be 77°F (Swanson et al. 2000; Nobriga et al. 2008), and capture rates decrease rapidly at temperatures above 75.2°F (Nobriga et al. 2008). Delta smelt are rarely captured when water temperatures are less than 44.6°F, although water temperatures in the Delta seldom become this low (Kimmerer 2004).

Delta smelt have been captured across a range of salinities, from freshwater to brackish water (0 to 18 practical salinity units), and have an upper lethal limit of 19 practical salinity units (Swanson et al. 2000). They are most associated with the low-salinity zone (less than approximately 2 practical salinity units) (Bennett 2005; Feyrer et al. 2007; Nobriga et al. 2008). Thus, the location of the largest fish concentrations in the non-spawning season varies as a function of the water year (Sommer and Mejia 2013). Delta smelt are distributed more downstream at locations such as the Napa River and Suisun Bay in wet years, and farther upstream in dry years. They likely take advantage of tidal movements to migrate (i.e., they “surf the tide”) (Bennett and Burau 2015).

The delta smelt’s upstream migration appears to be triggered by attraction flows, particularly “first-flush” events, resulting in a somewhat coordinated migration strategy (Sommer et al. 2011). Average upstream migration rates are approximately 3.6 kilometers per day, and rates are uncorrelated with Delta flow (Sommer et al. 2011).

Typically, December to March flow pulses trigger upstream migration, but spawning typically peaks from March through May, suggesting adult delta smelt hold for periods of at least a month before spawning (Sommer et al. 2011). Delta smelt have three different distinct life-history phenotypes based on otolith microchemistry: freshwater resident, brackish-water resident, and semi-anadromous fish (Hobbs et al. 2019).

Larval and post-larval delta smelt feed almost exclusively on two species of calanoid copepods (Moyle et al. 1992; Nobriga 2002; Slater and Baxter 2014). As delta smelt grow, they expand their diet to include other copepod species, mysid shrimp, cladocerans, and amphipods (Moyle et al. 1992; Slater 2012; Slater and Baxter 2014). The decreased abundance of copepods and mysids in the upper estuary has caused food limitation to be a major stressor for adult delta smelt (Baxter et al. 2010).

Recent findings have indicated delta smelt may be food-limited, particularly in the spring and summer (Hamilton and Murphy 2018). Smelt collected from areas where the influence of tidal wetlands is greater have much greater stomach fullness than smelt collected from areas with little or no tidal wetland influence, suggesting that food resources for delta smelt are more available when near tidal wetlands (Hammock et al. 2019).

Freshwater-tidal wetlands in the Yolo Bypass may provide a refuge for the delta smelt population during drought conditions, functioning as a critical nursery habitat; particularly when delta smelt are facing serious decline (Mahardja et al. 2019). Delta smelt collected from the Yolo Bypass during the drought were compared to smelt captured elsewhere in the estuary. Smelt from the Yolo Bypass spawned earlier and offspring experienced a higher quality of both feeding conditions and growth rates (Mahardja et al. 2019). During the drought (2012 to 2016), delta smelt abundance in the Yolo Bypass was higher than during the previous 14 years of fish monitoring there, and was at record lows in locations within the estuary where delta smelt were historically found (Mahardja et al. 2019). Delta smelt do not appear to strongly prefer aquatic vegetation or any particular substrate type, although they may avoid concrete structures such as boat ramps (Sommer and Mejia 2013). Even though spawning has not been observed in the wild, many other smelt species are known to use sandy substrate for spawning (Bennett 2005).

Conceptual Models

A conceptual model has been developed to assist in the development of a targeted conservation strategy for delta smelt within the SPA (Figure B.1-3). This model is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species. Rather, as Figure B.1-3 shows, the conceptual model specifically depicts all of the following considerations:

- Habitat conditions required by delta smelt within the SPA: attraction flows, and the quantity and quality of aquatic habitat.

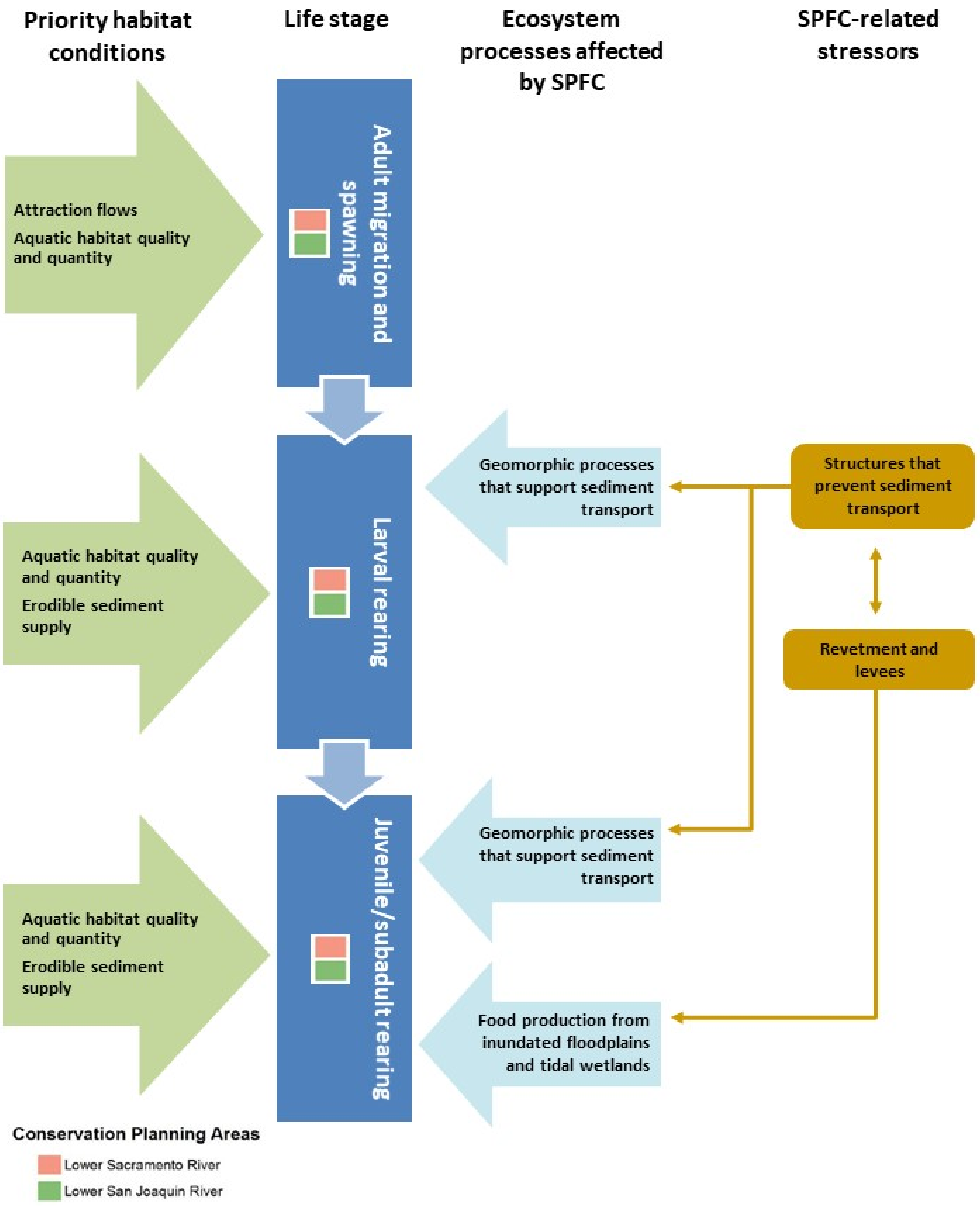
- The specific CPAs within which these habitat conditions occur: the Lower Sacramento River and Lower San Joaquin River CPAs.

- Ecosystem processes that are key for riverine systems within the SPA, and thus may be affected by actions that could be implemented as part of the CVFPP and Conservation Strategy. These include flows that attract upstream migration, flows that improve habitat conditions, geomorphic processes that support sediment transport, floodplain inundation, food production from inundated floodplains and tidal wetlands.

- Stressors related to State Plan of Flood Control (SPFC) facilities and their operations and maintenance. These indirect factors include structures that prevent sediment transport, revetment (lack of shaded riverine aquatic [SRA]), and levees.

- Numerous conceptual models have been developed for delta smelt. These conceptual models focus on the "habitat conditions and ecosystem drivers affecting each delta smelt life stage across seasons and how the seasonal effects contribute to the annual success of the species stressors affecting survival from one life stage to the next." The models were used to generate hypotheses about the factors contributing to changes in delta smelt abundance, and to identify important information gaps (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015).

Figure B.1-3. Conceptual Model for the Delta Smelt within the Systemwide Planning Area



The CVFPP's potential influences on delta smelt and its habitat include:

- Bank protection, which reduces habitat such as SRA; and lack of sediment inputs to the Delta, which affect habitat quality for delta smelt by decreasing turbidity (Feyrer et al. 2007).
- Changes to the Delta's food web that affect delta smelt growth and survival (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015).
- Flood structures that alter shorelines and adjacent bottom substrates, which could affect spawning habitat for delta smelt (Sommer and Mejia 2013).
- Flood structures that decrease mosaics of floodplain tidal slough habitat that can provide a refuge for delta smelt during drought conditions (Mahardja et al. 2019).

Management Issues

Threats and Sensitivities Rangewide

Historically, the following factors, listed in order of importance, were the causes of decline in delta smelt abundance (58 FR 12854, March 5, 1993):

- Reduced river outflows from the Sacramento and San Joaquin rivers and their tributaries.
- Extreme high outflows in years with unusually high rainfall.
- Entrainment mortality at water diversions.
- Perturbations, both human and natural, to the smelt's food web.
- Presence of toxic substances.
- Loss of genetic integrity because of small population size.

The latest findings on delta smelt (85 FR 73164, Nov. 16, 2020) identify the following primary threats to the delta smelt:

- Direct entrainments by federal and State water export facilities.
- Reduction of suitable habitat by summer and fall increases in salinity and water clarity, resulting from decreases in freshwater flow into the estuary.
- Effects of introduced species.

Other potentially significant threats include ammonia in the form of ammonium, which destabilizes cell membranes, resulting in sublethal effects; predation by striped and largemouth bass and inland silversides; contaminants; climate change; and small population size. Changes to the importance of threats to the decline of delta smelt are associated with advancements in the understanding of effects of human activities on the ecosystem supporting delta smelt, as described here.

Water clarity has increased in the Delta since at least 1975 (Jassby et al. 2002). This increase has been identified as a major stressor for delta smelt (Nobriga and Herbold 2009; 75 FR 17667, April 7, 2010). Decreases in turbidity are strongly correlated with decreases in delta smelt distribution (Feyrer et al. 2007; Nobriga et al. 2008; Bever et al. 2016) and abundance (Thomson et al. 2010; Bever et al. 2016). Nobriga and Herbold (2009) summarized the primary hypothesized causes of this increase in water clarity as follows:

- Sediment has been increasingly trapped behind dams and levees (Jassby et al. 2002; Wright and Shoellhamer 2004).
- Sediment was lost from below dams and between levees as a result of high flows during the 1982 to 1983 El Niño event (Jassby et al. 2005), and presumably to a lesser extent, during less extreme high flows in other years.
- More abundant submerged aquatic vegetation (SAV), such as Brazilian waterweed (*Egeria densa*), filters the water (Feyrer et al. 2007).

Levee maintenance and bank protection activities may adversely affect critical habitat for delta smelt (59 FR 65256, Dec. 19, 1994), in part by affecting the natural recruitment of sediments to the stream channel. Channelization within levees has caused a lack of channel meander and associated natural bank, and has converted natural banks with vegetated cover to hardened or revetted banks.

Reduced natural bank erosion in all river reaches upstream of delta smelt habitat likely reduces suspended sediment and turbidity in areas where delta smelt occur. Increases in water clarity may also be attributed to decreases in primary productivity (Jassby et al. 2002), and to a shift from diatoms to cyanobacteria and flagellates in response to increases in ammonium and a shift in the balance of nitrogen and phosphate (Glibert 2010).

Threats from climate change include increases in water temperature and the number of days when mean daily water temperatures exceed 77°F, increased salinity and an eastward shift of the low-salinity zone, and an increase in water clarity (Feyrer et al. 2010; Cloern et al. 2011; Wagner 2012). Greenberg et al. (2012) modeled the influence of riparian habitat on mediating water temperatures in the Lower Sacramento and Lower San Joaquin River CPAs, stressing the importance of maintaining and enhancing riparian habitat on channel banks on a Delta-wide scale to buffer the effects of climate change, especially SRA habitat that may moderate water temperatures.

Delta smelt are vulnerable to entrainment in water diversions, most notably the State Water Project and Central Valley Project diversions; such entrainment has been identified as a major stressor affecting all life stages (Nobriga and Herbold 2009; 75 FR 17667, April 7, 2010). Adults are vulnerable during their winter-spring spawning migrations, and larvae and juveniles are vulnerable from spring to early summer, primarily from March through June (Kimmerer and Nobriga 2008; Nobriga and Herbold 2009). Larvae are most vulnerable in the spring of low-flow years when the low-salinity zone retreats upstream (Kimmerer and Nobriga 2008).

Additional causes of mortality related to human-altered hydrodynamics in the Delta include potential habitat displacement associated with the operation of the Suisun Marsh Salinity Control Gates and entrainment with water used to cool the Mirant power plants (Nobriga and Herbold 2009). However, recently the gates were re-operated to test efficacy of a managed flow pulse into Suisun Marsh, which resulted in benefits to delta smelt and its habitat (Sommer et al. 2020). Also, decreases in abundance index values have been attributed to reduced freshwater outflows associated with statewide water conveyance (Feyrer et al. 2007; Thomson et al. 2010; 75 FR 17667, April 7, 2010).

The introduction of the invasive overbite clam (*Corbula amurensis*) in 1986 substantially reduced phytoplankton biomass throughout the estuary (Jassby et al. 2002; Glibert 2010). The clam affects delta smelt directly by competing with it for food resources (copepods), and indirectly by changing food web dynamics (reduced phytoplankton) (Nobriga and Herbold 2009). The primary food source for larval and juvenile delta smelt, the calanoid copepod (*Eurytemora affinis*), has declined in response to increased predation and competition for food resources (invasive overbite clam), and has been displaced by increasingly abundant non-native copepods of lesser food value (Kimmerer et al. 1994; Bennett 2005; Baxter et al. 2010; Glibert 2010; Winder and Jassby 2011).

The increased occurrence and magnitude of algal blooms (*Microcystis aeruginosa*) have decreased food abundance for delta smelt because the fish’s primary prey, the copepods *Pseudodiaptomus forbesi* and *E. affinis*, are highly sensitive to the toxin produced by *M. aeruginosa* (Microcystin) (Ger et al. 2009; Nobriga and Herbold 2009). Further, Microcystin may be more concentrated in prime habitat for delta smelt because *M. aeruginosa* dies at low salinity. However, *M. aeruginosa* blooms occur in the summer and early fall, and thus poses a threat to delta smelt only during that time (Nobriga and Herbold 2009).

Predation by introduced striped bass has also been identified as a stressor for delta smelt (Nobriga and Herbold 2009); however, predation by invasive fish species in general poses only a low to moderate threat to delta smelt (U.S. Fish and Wildlife Service 2010).

The following stressors are attributable to water toxicity:

- The direct and indirect effects (e.g., zooplankton mortality) of pesticides, particularly because pesticide concentrations and delta smelt occurrence are both positively correlated to turbidity.
- The physiological effects of metal toxicity.
- The effects of wastewater and urban runoff (e.g., ammonia and endocrine-disrupting chemicals).
- The effects of toxic algal blooms (Nobriga and Herbold 2009; Sommer and Mejia 2013).

These stressors likely have not directly caused population declines (Sommer and Mejia 2013).

Ongoing and Future Impacts

Ongoing impacts on delta smelt in the SPA include further reductions of the quality and availability of suitable habitat; the effects of climate change, which will likely include degradation of water quality and habitat suitability; and ongoing water diversions that entrain all life stages and affect habitat quality.

- The availability of suitable habitat will likely continue to be the most critical factor for delta smelt. Changes to the species' historical habitat caused by anthropogenic modification of the landscape, alterations to the natural flow regime and water clarity, the introduction of invasive aquatic species, and several other factors have reduced habitat availability and compromised remaining habitat. Substantial reversals of these negative effects are unlikely in the foreseeable future, so these factors will continue to compromise the ability of delta smelt to survive and thrive.

- Climate change will affect delta smelt habitat in the future, but the rate of climate change is uncertain. Many climate change projections predict increases in water temperature, the eastward migration of the low-salinity zone, and increases in water clarity within the species' habitat. Delta smelt show an abrupt negative response to water temperatures above 77°F, have a narrow tolerance for salinity, and are strongly associated with turbid water, all factors that make them particularly vulnerable to these predicted changes to their habitat.

- Because of their small size and the difficulty of screening large diversions to protect small fish, delta smelt remain vulnerable to entrainment at all life stages. Further, delta smelt are much more vulnerable to mortality than some other fishes, so once entrained, they seldom survive.

Key Information Gaps or Uncertainties

To better understand how current and future CVFPP activities affect the conservation and potential recovery of delta smelt, and to help guide future actions of the CVFPP and Conservation Strategy, the following information is needed:

- A better understanding of the scale of tidal marsh and floodplain restoration and SAV removal needed to improve habitat suitability.

- Data on the effects of invasive aquatic plants on delta smelt survival and habitat.

- Data on the effects of predation on delta smelt populations.

Because CVFPP activities are likely to indirectly affect delta smelt and their habitat, these uncertainties focus largely on “bigger-picture” questions, rather than on specific actions taken under the CVFPP during normal operations and maintenance. The data gaps are discussed here.

- **Scale of restoration efforts.** The scale of restoration efforts, such as reconnecting floodplains and tidal marshes, that is necessary to effect observable changes in delta smelt population parameters (e.g., abundance) is currently unknown. Recent studies have suggested that tidal wetlands do not contribute significantly to adjacent pelagic food webs (Lehman et al. 2010). However, the ratio of tidal wetland area to open-water area in the Delta has decreased approximately 80-fold since historical times, from 14 to 1 historically, to 1 to 6 today (Whipple et al. 2012). It is possible that the massive loss of habitat has reduced or eliminated the capacity of tidal wetlands to support pelagic food webs, rather than some inherent lack of connectivity between tidal wetlands and open water. Lehman et al. (2008) found that water passing through the Yolo Bypass contributed more and higher quality phytoplankton than water passing through the mainstem Sacramento River, indicating that large-scale floodplain inundation can have measurable effects on the pelagic food web. Also, recent research has demonstrated that delta smelt benefit more substantially from freshwater-tidal slough complexes such as the Yolo Bypass than from other parts of the Delta, particularly during drought conditions (Mahardja et al. 2019), suggesting that large-scale connectivity to floodplains or tidal marshes may indeed reconnect these habitats to pelagic food webs. Research that can identify the scale of restoration efforts necessary to affect delta smelt through positive contributions to their food web will help inform long-term planning of mitigation efforts.

- **Invasive aquatic plants.** Invasive aquatic plants, especially SAV (e.g., *Egeria densa*), have been implicated in the decline of delta smelt because of their contribution to increased water clarity (the plants trap sediment) (Hestir et al. 2015) and increased predation risk (the plants provide cover for predators) (Ferrari et al. 2014). However, the extent to which removing these plants will have a population-level effect on smelt abundance is unknown; similarly, it is not known what level of invasive-plant management would be needed to benefit delta smelt.

- **Predation risk.** Predators’ distribution and diet, as well as the amount of overlap between the habitats of predators and delta smelt, are poorly understood (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015). In particular, data are lacking for some life stages of striped bass and largemouth bass. Further studies are needed to identify the life stage–specific spatial and temporal habitat overlap of these predators with all life stages of delta smelt. Placing these overlaps in context with key habitat variables (such as temperature, salinity, and turbidity) would provide a link between environmental drivers and predation risk (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015). Understanding predator and prey interactions would also enable actions that allow the CVFPP to avoid inadvertently enhancing the habitat of any life stage of these predators, which could indirectly affect delta smelt.

Conservation Strategy

Conservation and Recovery Opportunities

The integration of environmental stewardship into all flood management activities (by the California Department of Water Resources and Local Maintaining Agencies) during project planning, design, operations, and maintenance provides an excellent opportunity for the conservation and recovery of sensitive species that are intimately tied to Central Valley riverine ecosystems and the SPFC. The most viable way to support the recovery of delta smelt is to improve habitat for all life stages by encouraging riverine processes that improve natural river morphology and function. Improving the amount and distribution of inundated floodplain and channel-margin restoration would benefit the species. These conservation needs and opportunities are discussed in detail here.

Identified Conservation Needs

1. **Increase the amount and distribution of inundated floodplain habitat throughout the Delta region of the Lower Sacramento River CPA and Lower San Joaquin River CPA:** Inundated off--channel floodplain and tidal slough habitats increase food production rates locally and downstream compared to mainstem channels (Lehman et al. 2008). Such habitats may also contribute to higher growth and survival rates for delta smelt (Mahardja et al. 2019). For delta smelt, inundating the Yolo Bypass more frequently could particularly improve habitat quality in the North Delta. In addition to the more frequent inundation of the Yolo Bypass, floodplain habitat improvements to increase phytoplankton production (Lehman et al. 2008), increase residence time, and improve connectivity through the bypass would benefit delta smelt (Mahardja et al. 2019). Improving the quantity of floodplain and tidal slough habitats would require large-scale restoration actions that include providing connectivity to historical freshwater-tidal habitats that were reclaimed (Mahardja et al. 2019). Increasing the quantity and quality of floodplain and tidal slough habitats in the Lower Sacramento River and Lower San Joaquin River CPAs would improve habitat quality for all life stages of delta smelt.

2. **Improve natural river morphology and function:** Flood control measures downstream of dams, such as bank protection, have affected riparian and instream habitats, particularly in the Lower Sacramento River and Lower San Joaquin River CPAs. Constructed levees that narrow channels have increased flow velocities and channelized rivers so natural geomorphic processes (e.g., channel meander, connectivity to floodplains) are no longer possible. Improving geomorphic processes to support natural bank erosion, sediment deposition, and floodplain inundation is essential for providing habitat for delta smelt.

3. **Decrease the amount of non-native SAV throughout the Delta region of the Lower Sacramento River CPA and Lower San Joaquin River CPA:** SAV affects habitat quality for delta smelt by providing habitat for non-native predators such as largemouth bass and by decreasing turbidity (Hestir et al. 2015). *Egeria densa*, the dominant SAV species, is distributed throughout the Delta; its distribution is affected by light availability, water

depth, substrate type, and water velocity (Hestir et al. 2015). Removing or reducing the extent of SAV would improve habitat conditions for delta smelt.

4. **Improve the distribution and quality of marsh and channel-margin habitat in tidally influenced waterways throughout the Delta region of the Lower Sacramento River CPA and Lower San Joaquin River CPA:** Marsh and channel-margin habitats, including SRA habitat, may provide important food resources for delta smelt and may affect the quality of spawning and larval rearing habitat (Mahardja et al. 2019; Greenberg et al. 2012). The historical reclamation of wetlands and construction of levee systems in the Delta region of the Lower San Joaquin River and Lower Sacramento River CPAs removed most of this habitat. Large-scale restoration of the distribution and amount of tidally influenced channel-margin habitat, particularly in floodplain habitat complexes of the Yolo Bypass, may provide habitat benefits (Herbold et al. 2014; Mahardja et al. 2019).

Integration of Conservation and Restoration in Flood Management

As identified in Table B.1-1, CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the delta smelt. In many cases, the species’ conservation needs can be addressed by implementing management actions that integrate conservation and restoration elements with SPFC operations and maintenance, floodway management, and structural and nonstructural improvements to facilities. The ability to implement some of these actions would depend on operations, maintenance, and floodway management actions and improvements (as described in the following section) to resolve constraints, such as the floodway’s existing capacity to convey flood flows, or revetment removal at a site that may depend on levee relocation to allow bank erosion. Wherever feasible, conservation objectives and indicators will inform management actions for adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Operations, Maintenance, and Floodway Management

Floodwater storage and reservoir forecasting, operations, and coordination: Modifying and coordinating flood operations could include the limited reoperation of reservoirs and weirs.

The reoperation of these facilities could provide flow releases that would improve aquatic habitat conditions by changing the timing and amount of releases and ramping rates from November and early December until the end of April. These modifications could initiate upstream adult migration and generate other environmental benefits, including promoting floodplain connectivity, enhancing meander migration rates, and improving conditions to promote the development of SRA habitat.

Table B.1-1. Summary of the Contributions of CVFPP Management Actions to Identified Conservation Needs of the Delta Smelt

SPFC Activity	Management Actions	Conservation Need 1. Increase Inundated Floodplain	Conservation Need 2. Improve Natural River Function	Conservation Need 3. Decrease Non-native SAV	Conservation Need 4. Increase or Improve Marsh and Channel-margin Habitat
Operations, Maintenance, and Floodway Management	Floodwater storage and reservoir forecasting, operations, and coordination	Positive	Positive	Neutral	Neutral
	Facility maintenance	Neutral	Neutral	Positive	Neutral
	Levee vegetation management	Negative	Neutral	Neutral	Neutral
	Floodway maintenance	Neutral	Neutral	Positive	Neutral
	Floodplain topography modification	Positive	Positive	Positive	Neutral
	Invasive-plant management	Neutral	Positive	Positive	Positive
	Riparian, SRA, and marsh habitat restorations	Neutral	Positive	Positive	Positive
Structural and Nonstructural Improvements	Levee and revetment removal	Positive	Positive	Neutral	Positive
	Levee relocation	Positive	Positive	Positive	Positive
	Bypass expansion and construction	Positive	Neutral	Positive	Positive
	Levee construction and improvement	Neutral	Neutral	Neutral	Neutral
	Flood control structure reconfigurations	Neutral	Neutral	Neutral	Neutral

Notes:
CVFPP management actions are designated as having the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the species.

SAV = submerged aquatic vegetation

Modifying the operation of weirs that spill floodwater into the bypasses is also being evaluated as a CVFPP management action. For example, lowering the crests of overflow weirs and modifying operations so that bypasses carry flows earlier and longer during high river stages would activate the floodplain more frequently and for longer durations. Such floodplain activation could contribute to food web productivity and improve habitat conditions.

Levee vegetation management: The 2012 CVFPP introduced an interim vegetation management strategy, under which levee vegetation in the vegetation management zone is managed for visibility and accessibility, and to reduce threats to levee integrity (Figures 2-1 and 2-2 in Appendix D of the 2012 Conservation Strategy). Consequently, levee riparian vegetation in the vegetation management zone has been significantly trimmed or removed, reducing inputs of terrestrial insects and leaf litter and thereby reducing food availability and nutrient input. Trimming and removal of waterside vegetation also may have detrimental effects on water temperature (Poole and Berman 2001; Greenberg et al. 2012; Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015).

On the whole, levee vegetation management is likely to negatively affect habitat for delta smelt. However, lower waterside vegetation could be retained below the vegetation management zone of levees when it did not present an unacceptable threat to levee integrity. Allowing vegetation to grow on the waterside of levees where levees are adjacent to the river does not compensate for the lack of fully functioning riparian habitat, but does provide some minimal benefits for aquatic species.

In the near term, this approach would also preserve other vegetation within the vegetation management zone that does not impair visibility and accessibility.

Floodway maintenance: Floodway maintenance actions could sustain or improve the existing mosaic of floodplain habitats. At selected locations, maintenance practices could be changed to facilitate the restoration of riparian habitat, or to otherwise provide greater ecological benefits than found under existing conditions. Native vegetation could be planted after sediment is removed, and large woody material that is cleared from levees could be stockpiled and used to enhance habitat (e.g., during levee erosion repairs). For example, fill-placement and rock-repair projects could incorporate SRA elements, where relevant.

Floodplain topography modification: Floodway topography modifications could increase floodway capacity and the frequency and duration of inundation. Floodplain elevations could be lowered to provide more frequent and sustained inundation. Elevations could also be modified to increase topographic and hydrologic diversity (by creating or opening secondary channels or overflow swales). These actions would increase riverine and floodplain habitat values (e.g., potentially increase turbidity and food production in downstream Delta habitats).

Invasive-plant management: Non-native invasive plants that may be removed from lands and facilities operated and maintained by the State could include SAV (e.g., *Egeria* and parrot's feather [*Myriophyllum aquaticum*]) and terrestrial vegetation that affects river geomorphology (e.g., *Arundo* and saltcedar). Aquatic habitats dominated by non-native SAV generally support non-native fishes such as centrarchids (Grimaldo et al. 2012), particularly in the Lower Sacramento and Lower San Joaquin River CPAs; these fish may be predators of delta smelt.

Established non-native terrestrial vegetation in riparian areas displaces important native plants (e.g., willows and cottonwoods) that facilitate river meander and natural geomorphic processes. The removal of non-native invasive plants could therefore benefit delta smelt by improving habitat and reducing predation by non-native fishes.

Riparian, SRA, and marsh habitat restoration: Riparian and marsh habitats could be restored at selected locations in the floodway to benefit delta smelt. Opportunities for riparian restoration would generally be found in non-riparian land cover in the floodway, particularly as part of other management actions to increase floodway capacity. Riparian, SRA, and marsh habitat restoration would be most beneficial in areas where restoration expands or connects existing habitat patches in the Delta. In the bypass system, marsh restoration would generally be beneficial to delta smelt and would be implemented in conjunction with bypass expansion and construction.

Structural and Nonstructural Improvements

Levee and revetment removal: Removing levees and revetment that provide little value to local and systemwide flood management would reduce operations and maintenance costs while improving natural geomorphic and inundation processes in the riverine and floodplain environments. This action would have greater ecological benefits if implemented along or upstream of waterways used by delta smelt, and where removal contributes to a larger zone of active river meander migration.

Levee relocation: Relocating levees farther from rivers (i.e., constructing setback levees) is an important approach to increasing floodway capacity, creating space for river meanders, reconnecting floodplains, allowing the transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. Levee relocation would also provide opportunities to hydraulically connect river systems to mitigation plantings associated with the vegetation management zone, and to improve habitat for delta smelt in the Lower Sacramento River and Lower San Joaquin River CPAs.

Bypass expansion and construction: Bypass expansion could enhance delta smelt habitat (e.g., food resources) by increasing the connectivity of the floodplain to the Delta, thus restoring floodplain ecosystems that contribute to food web productivity. However, bypasses are flooded irregularly. To benefit delta smelt, bypass flooding needs to occur more frequently (e.g., annually), with the appropriate timing and duration to provide suitable habitat. Modifying bypass weirs (e.g., those in the Yolo Bypass and at Paradise Cut) could improve the timing and duration of inundation to benefit fish, especially if coupled with large-scale restoration efforts to increase habitat complexity.

Levee construction and improvement: One levee construction and reconstruction objective that would benefit the delta smelt is restoring geomorphic processes. In addition, new levees could be designed to accommodate hydrologic changes expected to result from climate change.

Flood control structure reconfiguration: A priority action for State-operated and -maintained diversions in the SPA is to reconfigure the Fremont and Sacramento weirs in the Yolo Bypass (in the Lower Sacramento River CPA) and the weir at Paradise Cut (in the Lower San Joaquin River CPA) to increase floodplain inundation (California Department of Water Resources 2012). As discussed, improved floodplain inundation would benefit the delta smelt.

Recovery Plan Alignment

USFWS developed the *Recovery Plan for Sacramento–San Joaquin Delta Native Fishes* in 1996; however, in its most recent five-year review, USFWS indicated the recovery plan is outdated (U.S. Fish and Wildlife Service 2010). The five-year review included actions that could prevent extinction of the species. Table B.1-2 lists examples of specific near- and long-term restoration and conservation actions identified in the five-year review that could be partially implemented through the CVFPP.

Table B.1-2. Examples of Near- and Long-term Restoration and Conservation Actions, by Region, that Could Be Implemented through the CVFPP

CPA	Restoration Action
Lower Sacramento River	• Increase the area of suitable spawning habitat. • Improve freshwater-tidal slough complexes in the Yolo Bypass and Delta. • Improve connectivity in low-flow channels within the Yolo Bypass.
Lower San Joaquin River	• Increase the area of suitable spawning habitat. • Improve freshwater-tidal slough complexes in the Delta.

Source: U.S. Fish and Wildlife Service (2010)

Notes:
CPA = conservation planning area

Measures of Positive Contribution

A primary goal of the Conservation Strategy is to contribute to the recovery and stability of native species populations and overall biotic community diversity. The objective for this goal is a measurable contribution to the conservation of target species, including the delta smelt.

Therefore, building on the preceding discussion, this section of the delta smelt conservation plan provides measures (i.e., metrics or indicators) that will be used to determine how effectively CVFPP management actions contribute to the conservation needs of this species.

Measures for each target threatened or endangered species are organized around indicators of progress toward the Conservation Strategy's process, habitat, and stressor objectives (Table B.1-3 and Table B.1-4). The species-specific measures provide additional detail on geographic location, habitat structure, and other attributes important to conservation of the species.

Table B.1-3. Measures of the Contribution of CVFPP Actions to Conservation of the Delta Smelt

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	Not applicable.
	River Meander Potential—total amount (acres)	Yes	Not applicable.
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	Yes	SRA cover in the Lower Sacramento River and Lower San Joaquin River CPAs may help moderate local temperatures by providing shade; therefore, the more shading of aquatic habitat, the greater benefit is likely to be accrued.
	Total Length and Percentage of Bank Affected by Flood Projects that Incorporate SRA Attributes	Yes	Not applicable.
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	No	Not applicable.
	Habitat Connectivity—median patch size (acres)	No	Not applicable.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Providing marsh habitat that does not include, and minimizes the likelihood of establishment of, non-native SAV is considered an important element for improving growth and survival.
Revetment	Revetment Removed to Increase Meander Potential or Natural Bank—total length (miles)	Yes	Decreasing turbidity in the Delta is considered detrimental to delta smelt. Increasing or restoring erodible banks, particularly in the tidally influenced habitats in the Lower Sacramento River and Lower San Joaquin River CPAs, would provide benefits.

SRA = shaded riverine aquatic

Table B.1-4. Measures of the Contribution of CVFPP Actions to Conservation of the Delta Smelt

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	Improving food production for delta smelt is considered an important element for improving growth and survival. Increasing floodplain connectivity, especially in the Yolo Bypass and in tidally influenced habitats of the Lower Sacramento River and Lower San Joaquin River CPAs, may improve system productivity in the Delta.
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	Not applicable.
Invasive Plants	Invasive-plant-dominated Vegetation—total area reduced (acres)	Yes	Remove or decrease populations of non-native invasive aquatic plants (e.g., *Egeria* sp. and *Myriophyllum aquaticum*) that affect fish habitat, in addition to terrestrial plant species that affect river geomorphology and habitat quality (e.g., *Arundo* and saltcedar).

Notes:
Floodplain inundation potential is the potential of an area to be inundated by a particular flow (e.g., a flow event that occurs about once every two years, or a “50-percent-chance event”). Expected annual habitat units represent the annual average of the area expected to be inundated in general or by flows meeting defined criteria for timing and duration (e.g., sustained spring flows).

Table B.1-3 lists the process, habitat, and stressor targets of the Conservation Strategy; identifies those used to measure the contribution to conservation of delta smelt; and provides additional specificity as necessary to measure this contribution. Management actions intended to benefit delta smelt may simultaneously affect the conservation of other species in the SPA. For this reason, these measures of contribution have been incorporated into each CPA’s objectives for the conservation of target species, which are provided in the Conservation Strategy Update. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

References

Baxter R, Breuer R, Brown L, Conrad L, Feyrer F, Fong S, Gehrts K, Grimaldo L, Herbold B, Hrodey P, Mueller-Solger A, Sommer T, Souza K. 2010. *Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results*. December 2010. Sacramento (CA): Interagency Ecological Program for the San Francisco Estuary.

Bennett WA. 2005. “Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California.” San Francisco Estuary and Watershed Science Volume 3 (Issue 2).

Bennett WA, Burau JR. 2015. “Riders on the Storm: Selective Tidal Movements Facilitate the Spawning Migration of Threatened Delta Smelt in the San Francisco Estuary.” Estuaries and Coasts Volume 38 (Issue 3): Pages 826 to 835.

Bever AJ, MacWilliams ML, Herbold B, Brown LR, Feyrer FV. 2016. “Linking Hydrodynamic Complexity to Delta Smelt (*Hypomesus transpacificus*) Distribution in the San Francisco Estuary, USA.” San Francisco Estuary and Watershed Science Volume 14 (Issue 1).

California Department of Water Resources. n.d. “Guess Who’s Coming to Dinner: Evidence for Increasing Delta Smelt Utilization of the Yolo Bypass” [poster]. Prepared by: Mahardja B, Ikemiyagi N, Schreier B, Aquatic Ecology Section.

California Department of Water Resources. 2012. *Central Valley Flood Management Planning Program: Public Draft Conservation Framework*. Attachment 9C, “Fish Passage Assessment.”

Cloern JE, Knowles N, Brown LR, Cayan D, Dettinger MD, Morgan TL, Shoellhamer DH, Stacey MT, van der Wegen M, Wagner RW, Jassby AD. 2011. “Projected Evolution of California’s San Francisco Bay-Delta-River System in a Century of Climate Change.” PLoS ONE Volume 6 (Issue 9):e24465.

Ferrari MCO, Ranåker L, Weinersmith KL, Young MJ, Sih A, Conrad JL. 2014. “Effects of Turbidity and an Invasive Waterweed on Predation by Introduced Largemouth Bass.” Environmental Biology of Fishes Volume 97: Pages 79t o 90.

Feyrer F, Newman K, Nobriga M, Sommer T. 2010. “Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish.” Estuaries and Coasts Volume 34: Pages 120 to 128.

Feyrer F, Nobriga ML, Sommer TR. 2007. “Multidecadal Trends for Three Declining Fish Species: Habitat Patterns and Mechanisms in the San Francisco Estuary, California, USA.” Canadian Journal of Fisheries and Aquatic Science Volume 64: Pages 723 to 734.

Ger KA, Teh SJ, Goldman CR. 2009. “Microcystin-LR Toxicity on Dominant Copepods *Eurytemora affinis* and *Pseudodiaptomus forbesi* of the Upper San Francisco Estuary.” Science of the Total Environment Volume 407: Pages 4,852 to 4,857.

Glibert PM. 2010. “Long-Term Changes in Nutrient Loading and Stoichiometry and Their Relationships with Changes in Food Web and Dominant Pelagic Fish Species in the

San Francisco Estuary, California." Reviews in Fisheries Science Volume 18 (Issue 2): Pages 211 to 232.

Greenberg JA, Hestir EL, Riano D, Scheer GJ, Ustin SL. 2012. "Using LiDAR Data Analysis to Estimate Changes in Insolation under Large-Scale Riparian Deforestation." Journal of the American Water Resources Association Volume 48: Pages 939 to 948.

Grimaldo L, Miller RE, Peregrin CM, Hymanson Z. 2012. "Fish Assemblages in Reference and Restored Tidal Freshwater Marshes of the San Francisco Estuary." San Francisco Estuary and Watershed Science Volume 10 (Issue 1).

Hamilton SC, Murphy DD. 2018. "Analysis of Limiting Factors across the Life Cycle of Delta Smelt (*Hypomesus transpacificus*)." Environmental Management Volume 62: Pages 365 to 382.

Hammock BG, Hartman R, Slater SB, Hennessy A, Teh SJ. 2019. "Tidal Wetlands Associated with Foraging Success of Delta Smelt." Estuaries and Coasts Volume 42: Pages 857 to 867. Viewed online at: Delta-Smelt. Accessed: July 1, 2020.

Herbold B, Baltz DM, Brown L, Grossinger R, Kimmerer W, Lehman P, Simenstad CS, Wilcox C, Nobriga M. 2014. "The Role of Tidal Marsh Restoration in Fish Management in the San Francisco Estuary." San Francisco Estuary and Watershed Science Volume 12 (Issue 1). Viewed online at: Fish-Management. Accessed: December 23, 2015.

Hestir EL, Schoellhamer DH, Greenberg J, Morgan-King T, Ustin SL. 2015. "The Effect of Submerged Aquatic Vegetation Expansion on a Declining Turbidity Trend in the Sacramento–San Joaquin River Delta." Estuaries and Coasts Volume 39: Pages 1100-1112.

Hobbs JA, Bennett WA, Burton J. 2007. "Classification of Larval and Adult Delta Smelt to Nursery Areas by Use of Trace Elemental Fingerprinting." Transactions of the American Fisheries Society Volume 136: Pages 518 to 527.

Hobbs, JA, Lewis LS, Willmes M, Denny C, Bush E. 2019. "Complex Life Histories Discovered in a Critically Endangered Fish." Scientific Reports Volume 9: Article Number 16772. Viewed online at: Endangered-Fish. Accessed: July 1, 2020.

Interagency Ecological Program, Management, Analysis, and Synthesis Team. 2015. *An Updated Conceptual Model of Delta Smelt Biology: Our Evolving Understanding of an Estuarine Fish.* Technical Report 90. January 2015.

Jassby AD, Cloern JE, Cole BE. 2002. "Annual Primary Production: Patterns and Mechanisms of Change in a Nutrient-Rich Tidal Ecosystem." Limnology and Oceanography Volume 47 (Issue 3): Page 698 to 712.

Jassby AD, Mueller-Solger AB, Vayssieres M. 2005. "Subregions of the Sacramento–San Joaquin Delta: Identification and Use." Interagency Ecological Program Newsletter Volume 18 (Issue 2): Page 68 to 75.

Kimmerer WJ. 2004. "Open Water Processes of the San Francisco Estuary: From Physical Forcing to Biological Responses." San Francisco Estuary and Watershed Science Volume 2 (Issue 1).

Kimmerer WJ, Gartside E, Orsi JJ. 1994. “Predation by an Introduced Clam as the Likely Cause of Substantial Declines in Zooplankton of San Francisco Bay.” Marine Ecology Progress Series Volume 113: Pages 81 to 93.

Kimmerer WJ, Nobriga ML. 2008. “Investigating Particle Transport and Fate in the Sacramento–San Joaquin Delta Using a Particle Tracking Model.” San Francisco Estuary and Watershed Science Volume 6 (Issue 1).

Lehman PW, Sommer T, Rivard L. 2008. “The Influence of Floodplain Habitat on the Quantity and Quality of Riverine Phytoplankton Carbon Produced during the Food Season in San Francisco Estuary.” Aquatic Ecology Volume 42: Pages 363 to 378.

Lehman PW, Mayr S, Mecum L, Enright C. 2010. “The Freshwater Tidal Wetland Liberty Island, CA Was Both a Source and Sink of Inorganic and Organic Material to the San Francisco Estuary.” Aquatic Ecology Volume 44: Pages 359 to 372.

Lindberg JC, Tsai YJJ, Kammerer BD, Baskerville-Bridges B, Hung TC. 2020. “Spawning Microhabitat Selection in Wild-Caught Delta Smelt *Hypomesus transpacificus* under Laboratory Conditions.” Estuaries and Coasts Volume 43: Pages 174 to 181.

Mahardja B, Hobbs JA, Ikemiyagi N, Benjamin A, Finger AJ. 2019. “Role of Freshwater Floodplain-Tidal Slough Complex in the Persistence of the Endangered Delta Smelt.” PLoS ONE Volume 14 (Issue 1): e0208084. Viewed online at: Freshwater-Floodplain. Accessed: July 1, 2020.

Merz JE, Hamilton S, Bergman PS, Cavallo B. 2011. “Spatial Perspective for Delta Smelt: A Summary of Contemporary Survey Data.” California Department of Fish and Game Volume 97 (Issue 4): Pages 164 to 189.

Moyle PB. 2002. *Inland Fishes of California*. Berkeley (CA): University of California Press.

Moyle PB, Herbold B, Stevens DE, Miller LW. 1992. “Life History and Status of Delta Smelt in the Sacramento–San Joaquin Estuary, California.” Transactions of the American Fisheries Society Volume 121: Pages 67–77.Nobriga M, Herbold B. 2009. T*he Little Fish in California’s Water Supply: A Literature Review and Life-History Conceptual Model for Delta Smelt* (Hypomesus transpacificus) *for the Delta Regional Ecosystem Restoration and Implementation Plan (DRERIP)*. Sacramento–San Joaquin Delta Regional Ecosystem Restoration Implementation Plan.

Nobriga ML. 2002. “Larval Delta Smelt Diet Composition and Feeding Incidence: Environmental and Ontogenetic Influences.” California Fish and Game Volume 88 (Issue 4): Pages 149 to 164.

Nobriga ML, Sommer TR, Feyrer F, Fleming K. 2008. “Long-Term Trends in Summertime Habitat Suitability for Delta Smelt (*Hypomesus transpacificus*).” San Francisco Estuary and Watershed Science Volume 6 (Issue 1).

Polansky L, Mitchell L, Newman KB. 2019. “Using Multistage Design-Based Methods to Construct Abundance Indices and Uncertainty Measures for Delta Smelt.” Transactions of the American Fisheries Society Volume 148: Pages 710 to 724.

Poole GC, Berman CH. 2001. “An Ecological Perspective on In-Stream Temperature: Natural Heat Dynamics and Mechanisms of Human-Caused Thermal Degradation.” Environmental Management Volume 27 (Issue 6): Pages 787 to 802.

Schoellhamer DH. 2011. “Sudden Clearing of Estuarine Waters upon Crossing the Threshold from Transport to Supply Regulation of Sediment Transport as an Erodible Sediment Pool is Depleted: San Francisco Bay, 1999.” Estuaries and Coasts Volume 34: Pages 885 to 899.

Slater SB. 2012. “Delta Smelt Regional Feeding Patterns in Fall 2011.” Interagency Ecological Program for the San Francisco Estuary Newsletter Volume 25 (Issue 2): Pages 36 to 42.

Slater SB, Baxter RD. 2014. “Diet, Prey Selection, and Body Condition of Age-0 Delta Smelt, *Hypomesus transpacificus*, in the Upper San Francisco Estuary.” San Francisco Estuary and Watershed Science Volume 12 (Issue 3).

Sommer, T., R. Hartman, M. Koller, M. Koohafkan, J.L. Conrad, M. MacWilliams, A. Bever, C. Burdi, A. Hennessy, and M. Beakes. 2020. “Evaluation of a large-scale flow manipulation to the upper San Francisco Estuary: Response of habitat conditions for an endangered native fish.” Accessed October 19, 2021. Flow-Manipulation. Accessed October 19, 2021.

Sommer T, Mejia F. 2013. “A Place to Call Home: A Synthesis of Delta Smelt Habitat in the Upper San Francisco Estuary.” San Francisco Estuary and Watershed Science Volume 11 (Issue 2).

Sommer T, Mejia FH, Nobriga ML, Feyrer F, Grimaldo L. 2011. “The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary.” San Francisco Estuary and Watershed Science Volume 9 (Issue 2).

Souza K. 2002. “Revision of California Department of Fish and Game’s Spring Midwater Trawl and Results of the 2002 Spring Kodiak Trawl.” Interagency Ecological Program for the San Francisco Estuary Newsletter Volume 15 (Issue 3): Pages 44 to 47.

Swanson C, Reid T, Young PS, Cech JJ. 2000. “Comparative Environmental Tolerances of Threatened Delta Smelt (*Hypomesus transpacificus*) and Introduced Wakasagi (*H. nipponensis*) in an Altered California Estuary.” Oecologia Volume 123: Pages 384 to 390.

Thomson JR, Kimmerer WJ, Brown LR, Newman KB, MacNally R, Bennett WA, Feyrer F, Fleishman E. 2010. “Bayesian Change Point Analysis of Abundance Trends for Pelagic Fishes in the Upper San Francisco Estuary.” Ecological Applications Volume 20 (Issue 5): Pages 1,431 to 1,448.

U.S. Bureau of Reclamation. 2007. *Spawning, Early Life Stages, and Early Life Histories of the Osmerids Found in the Sacramento–San Joaquin Delta of California*. Mid-Pacific Region, Technical Service Center. Prepared by: Wang JCS, National Environmental Science, Byron (CA). October 2007.

U.S. Fish and Wildlife Service. 2010. *5-Year Review on Delta Smelt (*Hypomesus transpacificus*). Current Classification: Threatened.* Prepared by: Poage V, Bay-Delta Fish and Wildlife Office.

U.S. Fish and Wildlife Service. 2017. Species Assessment and Listing Prioritization Assignment Form: Delta Smelt (*Hypomesus transpacificus*). October 13, 2017.

Wagner RW. 2012. *Temperature and Tidal Dynamics in a Branching Estuarine System.* Dissertation. Berkeley (CA): University of California, Berkeley.

Whipple AA, Grossinger RM, Rankin D, Stanford B, Askevold RA. 2012. *Sacramento–San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process.* Prepared for the California Department of Fish and Game and Ecosystem Restoration Program. A Report of SFEI-ASC's Historical Ecology Program, Publication #672. Richmond (CA): San Francisco Estuary Institute–Aquatic Science Center.

Winder M, Jassby AD. 2011. "Shifts in Zooplankton Community Structure: Implications for Food Web Processes in the Upper San Francisco Estuary." Estuaries and Coasts Volume 34: Pages 675 to 690.

Wright SA, Shoellhamer DH. 2004. "Trends in the Sediment Yield of the Sacramento River, California, 1957–2001." San Francisco Estuary and Watershed Science Volume 2 (Issue 2).

Appendix B.2

Focused Conservation Plan: Tricolored Blackbird

This page left blank intentionally.

APPENDIX B.2

Focused Conservation Plan: Tricolored Blackbird

Acronym	Definition
CESA	California Endangered Species Act
Conservation Strategy	Central Valley Flood Protection Plan Conservation Strategy
CPA	Conservation Planning Area
CVFPP	Central Valley Flood Protection Plan
ESA	Endangered Species Act
SPA	Systemwide Planning Area
SPFC	State Plan of Flood Control
USFWS	U.S. Fish and Wildlife Service

Conservation Status

As part of the Central Valley Flood Protection Plan (CVFPP) Conservation Strategy Update, this focused conservation plan addresses needs and opportunities to conserve the tricolored blackbird (*Agelaius tricolor*) and its habitat in the Systemwide Planning Area (SPA).

Except for small nesting colonies found locally in Oregon, Washington, Nevada, and Baja California, the tricolored blackbird is restricted to California (Beedy 2008). The global population was estimated at approximately 163,000 adults in 2000 (Beedy 2008), with more than 99 percent in California (Hamilton 2000). A recent Tricolored Blackbird Statewide Survey counted a total of 177,656 birds in 37 counties from 44 counties surveyed (Meese 2017).

As indicated in the 2016 CVFPP Conservation Strategy (Conservation Strategy) (California Department of Water Resources 2016), because the conservation needs of species change, additional species may be added to the list of target species during the five-year update process. When the tricolored blackbird was screened as a potential target species in the first iteration of the Conservation Strategy, it was a California Species of Special Concern and was not included as a target species (Appendix G of the 2016 Conservation Strategy). However, on March 18, 2019, the species was subsequently elevated from a Species of Special Concern to a threatened species under the California Endangered Species Act (CESA) due to the precipitous population decline (nearly 90 percent since the 1930s).

In 1991, the U.S. Fish and Wildlife Service (USFWS) included the tricolored blackbird as a candidate (Category 2) for listing as either threatened or endangered (59 *Federal Register* 58990, November 15, 1994) under the federal Endangered Species Act (ESA). USFWS policy changes in 1995 eliminated the Category 2 candidate designation nationwide, and because of this policy change, the species was removed from candidacy.

In 2006, USFWS rejected the petition to list the tricolored blackbird as threatened or endangered. This finding was based on a USFWS 90-day review, which determined that the scientific and commercial information presented in the petition did not warrant listing (Tricolored Blackbird Working Group 2007). On August 15, 2019, USFWS again published a finding that listing the tricolored blackbird under ESA was not warranted, because of "high nesting success in both small and large colonies" and existing regulatory mechanisms, including CESA, that "are currently acting to ameliorate the severity of some existing threats" (Meese 2019).

Thus, the tricolored blackbird is not listed under ESA; however, in addition to its listing under CESA (14 California Code of Regulations Section 670.5), this species is also protected by the federal Migratory Bird Treaty Act and California Fish and Game Code (Sections 3503, 3503.5, and 3513).

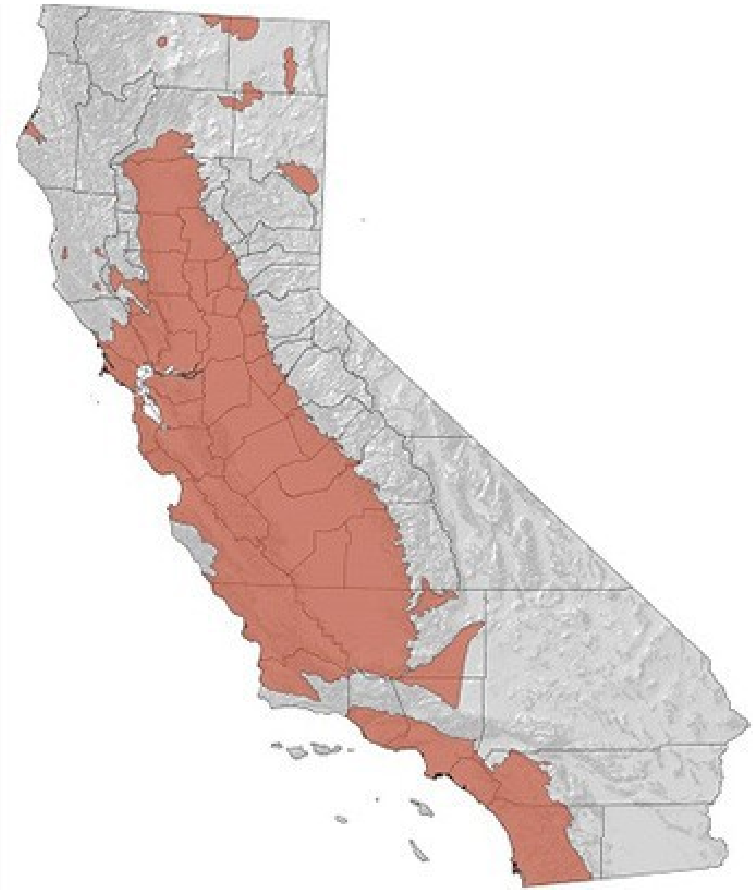
Status and Trends

Distribution

Figure B.2-1 shows the known distribution of tricolored blackbird in California. This species is restricted to California's Central Valley and surrounding foothills and coastal and inland localities in Southern and Central California, with local populations in northeastern California, Oregon, central Washington, western Nevada, and northwestern Baja California (Beedy et al. 2020). The global population was estimated at approximately 163,000 adults in 2000 (Beedy 2008), with more than 99 percent in California and, in most years, 90 percent of the breeding population occurring in the Central Valley (Hamilton 2000). A recent Tricolored Blackbird Statewide Survey counted a total of 177,656 birds in 37 counties from 44 counties surveyed (Meese 2017).

Tricolored blackbirds also breed locally in other lowland areas west of the Sierra and Cascade ranges and in northeastern California. During winter, most of the population remains within California, where they are joined by the birds that breed north of the state (Beedy 2008).

Figure B.2-1. Known Tricolored Blackbird Distribution in California



Source: California Department of Fish and Wildlife 2020

As a species, tricolored blackbirds are resident throughout the year in California, but individual birds migrate and move extensively within the range (Beedy 2008).

Population Trends

Vast flocks of these birds once occurred in California; however, habitat loss, poisonings and shootings of blackbirds to protect crops, pesticide use, and large, persistent, and ongoing annual losses of nests and nesting habitat have contributed to rapid declines of the species in California (Center for Biological Diversity 2015). Virtually all suitable habitats formerly supported foraging and nesting tricolored blackbirds, including marshlands and riparian woodlands in the Central Valley (Beedy et al. 2020). The most common form of destruction of large nesting colonies (more than 50,000 nests) in the San Joaquin Valley, particularly in the early 1990s, was from harvesting grain and discing weeds on fields that supported nesting colonies of tricolored blackbirds (Beedy et al. 2020).

Recent surveys, combined with historical information, indicate the tricolored blackbird has undergone a long-term population decline (Tricolored Blackbird Working Group 2007). In 2014, the population of this species was the smallest number ever recorded, at only 145,000 birds, and the 2017 Tricolored Blackbird Statewide Survey recorded a total of 177,656 birds from 37 counties. By comparison, in 1934, Neff (1937) observed as many as 736,500 from just eight Central Valley counties, and 19th century accounts described flocks of thousands "numbering so many thousands as to darken the sky for some distance by their masses" (Heermann [1859] as conveyed by Beedy 2008). In 1931–1936, Neff (1937) found 252 colonies in 26 California counties, with the largest colony estimated to contain more than 200,000 nests and several others with more than 100,000 (Beedy 2008).

Statewide censuses have revealed steep declines in tricolored blackbird numbers in the Central Valley (Beedy and Hamilton 1997; Hamilton et al. 1999; Hamilton 2000; Green and Edson 2004; Cook and Toft 2005, Meese 2017). Studies conducted in the 1970s revealed that the overall population decreased substantially from the 1930s; more recently, intensive surveys identified a decline of 37 percent between 1994 and 1997 and a 63-percent decline between 2008 and 2014, followed by an increase of 22 percent in 2017 (Beedy et al. 2020).

Life History

The tricolored blackbird diverged from its closest related taxon, the red-winged blackbird (*A. phoeniceus*), more than 3 million years ago (Yasukawa and Searcy 1995). As is the case with red-winged blackbirds, tricolored blackbirds are sexually dimorphic in plumage and size, with males being the larger sex. However, contrary to the variation in California populations of the red-winged blackbird, tricolored blackbirds do not vary in either plumage or body size across the breeding range, and their vocalizations are not regionally distinct (Beedy et al. 2020).

Tricolored blackbirds are colonial breeders, forming the largest colonies of any North American songbird, and breeding colonies have historically consisted of tens to hundreds of thousands of birds (Beedy et al. 2020). Males defend the immediate nesting area and territory size ranges from 6 to 11.5 square feet (Orians 1961). Like red-winged blackbirds, tricolored blackbirds have a polygynous breeding system; one study reported two to three females per territorial male (Collier 1968).

The basic requirements for tricolored blackbird breeding habitat are open, accessible water; a secure nesting substrate; and close foraging habitat with adequate food resources. All of these elements must be present for successful breeding (Beedy and Hamilton 1999; Meese and Beedy 2015). Historically, most colonies were located in freshwater marshes dominated by cattails (*Typha* spp.) or tules (*Schoenoplectus* spp.), with some in nettles (*Urtica* spp.), thistles (*Cirsium* spp.), and willows (*Salix* spp.) (Tricolored Blackbird Working Group 2007). This species also nests in riparian scrub and forests (Beedy and Hamilton 1999); for example, a large colony currently breeds in riparian scrub in the Panoche Valley (Shearwater pers. comm. May 23, 2020). In recent years, large numbers of tricolored blackbirds have also bred in agricultural (e.g., silage) fields.

Nesting tricolored blackbirds prefer large, continuous blocks of cattails and tules (often in the first or second year of growth), and optimal marsh conditions include emergent vegetation at least 4.3 feet high and submerged in shallow water 6 to 18 inches deep (Meese and Beedy 2015). Cattail stands must be at least 50 feet wide to support successful nesting (Meese and Beedy 2015).

With the loss of natural flooding processes and the riparian succession and wetlands sustained by such processes, tricolored blackbirds in the Central Valley forage primarily in managed habitats, including agricultural crops, such as alfalfa, irrigated pastures, grain fields; and in other areas, such as annual grassland, cattle feedlots, and dairies (Tricolored Blackbird Working Group 2007). Tricolored blackbirds continue to forage in remnant native habitats, including riparian scrub, open marshes, and seasonal wetlands.

Typically, tricolored blackbirds forage within approximately 3 to 4 miles of the nesting colony (Orians 1961; Beedy and Hamilton 1997; Tricolored Blackbird Working Group 2007; Beedy et al. 2020). The proximity to suitable foraging habitat appears to be extremely important in establishing breeding colony sites.

The following prey items are important for feeding nestlings (Crase and DeHaven 1977; Tricolored Blackbird Working Group 2007):

- Beetles (Coleopterans).
- Grasshoppers and locusts (Orthopterans).
- True bugs (Hemipterans).
- Spiders (Arachnids).
- Larval insects.

Nest heights typically range from a few inches to about 5 feet above water or ground level in freshwater marshes, and up to 10 feet in the canopies of willows and other riparian trees (Neff 1937; Beedy 2008).

Tricolored blackbirds can attempt to breed more than once per season. Many birds appear to exhibit this behavior by breeding early in the season in the San Joaquin Valley, and then moving to the Sacramento Valley to breed later in the season (Tricolored Blackbird Working Group 2007).

During the non-reproductive season, tricolored blackbirds form huge mixed-species flocks that include red-winged blackbirds, Brewer's blackbirds (*Euphagus cyanocephalus*), European starlings (*Sturnus vulgaris*), and brown-headed cowbirds (*Molothrus ater*). These mixed-species flocks forage in grasslands, in agricultural fields with low-growing vegetation, and at dairies and feedlots (Meese and Beedy 2015). In February, tricolored blackbirds segregate into pure tricolored blackbird flocks before the breeding season (Beedy 2008). Figure B.2-2 shows the *Birds of The World* annual cycle for the tricolored blackbird. As the figure shows, peak molting occurs between the latter part of June and early to mid-September; peak breeding occurs between late March and late June; and peak migration occurs from late March through mid-June.

Habitat and Ecological Process Associations

Conceptual Models

A conceptual model has been designed to assist in the development of a targeted conservation strategy for the tricolored blackbird within the SPA (Figure B.2-3). This model is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species. Rather, as Figure B.2-3 shows, the conceptual model specifically depicts all of the following considerations:

- Habitat conditions required by tricolored blackbirds within the SPA: early successional marsh and riparian habitat, open accessible water, protected nesting substrate (thorny or flooded vegetation), and adequate insect prey within a few kilometers.

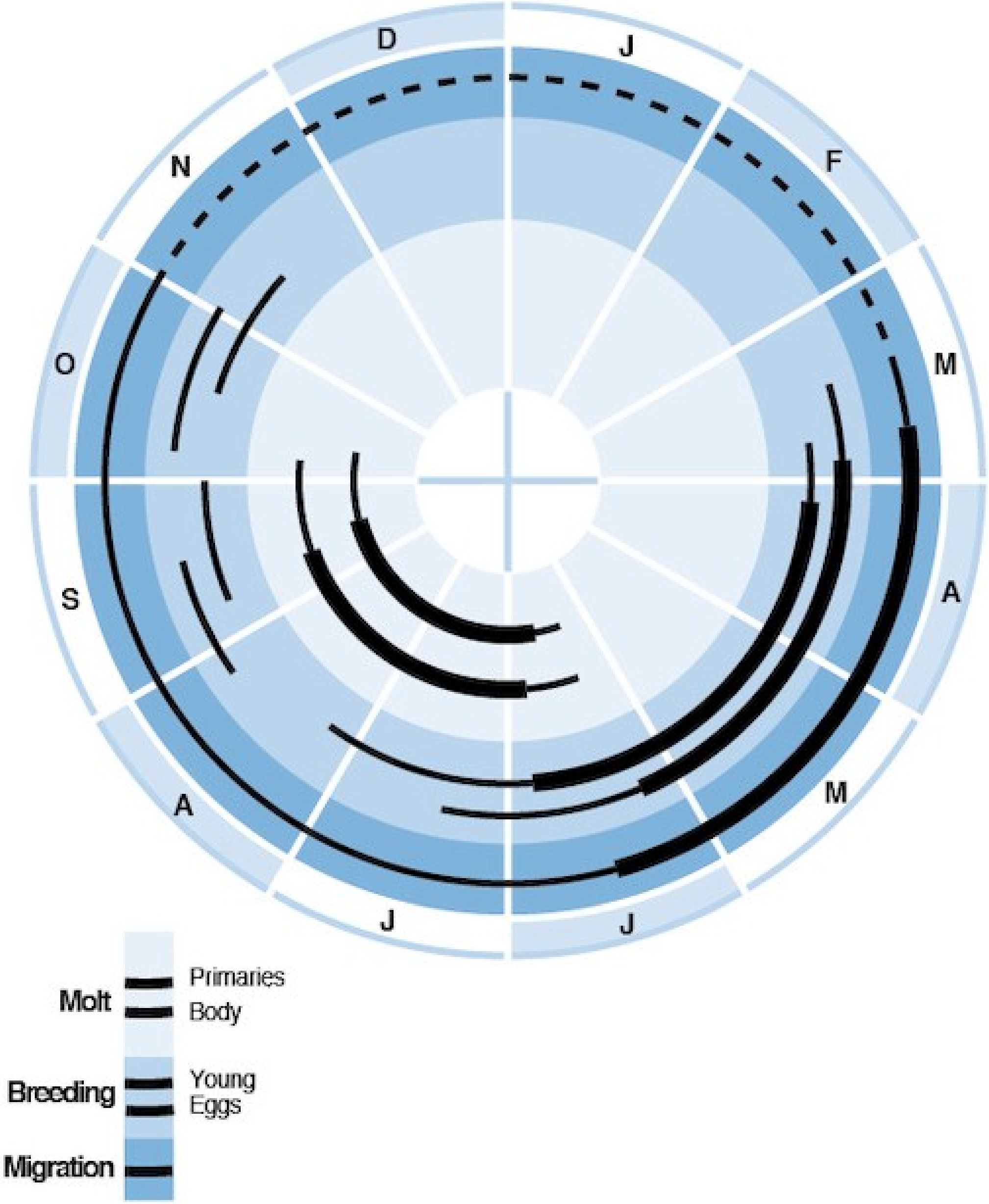
- The specific Conservation Planning Areas (CPAs) within which tricolored blackbirds breed: The Upper and Lower Sacramento and San Joaquin River CPAs and the Feather River CPA.

- Key ecosystem processes of riverine systems within the SPA potentially affected by actions associated with the CVFPP and Conservation Strategy: Riverine geomorphic processes and floodplain inundation that sustains and renews marsh and riparian habitat; loss of the nesting colony or nesting habitat; and herbicide impacts.

- Stressors related to State Plan of Flood Control (SPFC) facilities and their operations and maintenance: Revetment and levees, floodway management and maintenance, and agricultural operations.

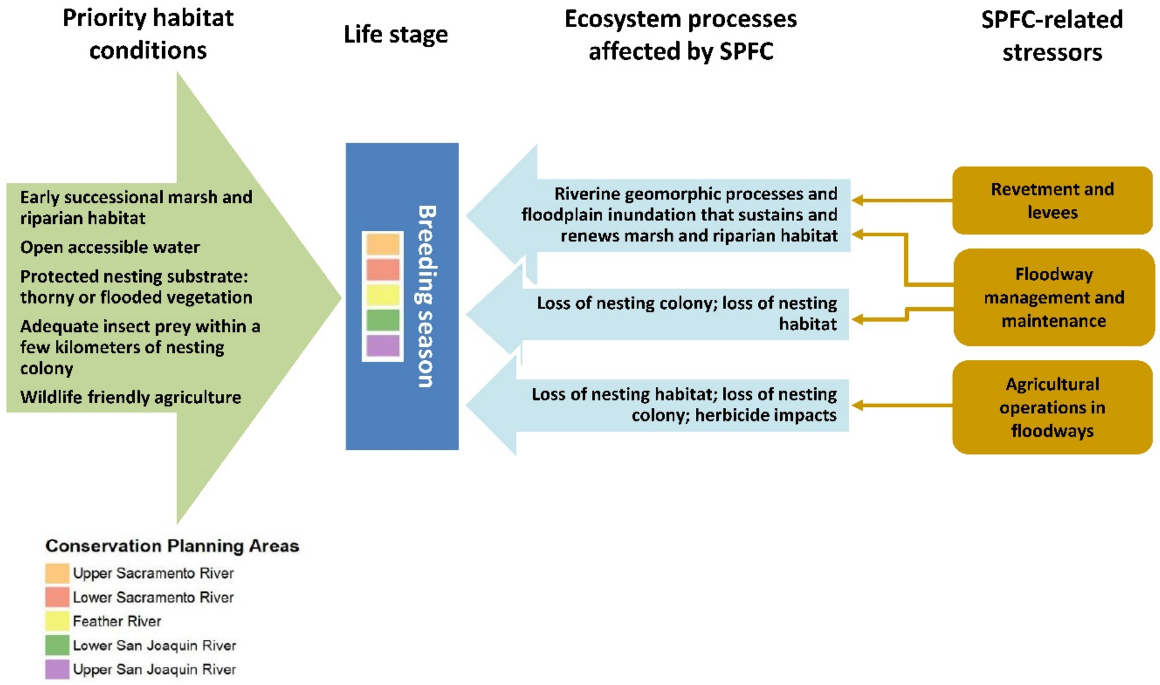
Figure B.2-2. Annual Cycle of the Tricolored Blackbird in California's Central Valley

Thick lines show peak activity; thin lines, off-peak.



Source: Beedy et al. 2020; reproduced with permission.

Figure B.2-3. Conceptual Model for the Tricolored Blackbird within the Systemwide Planning Area



Management Issues

Threats and Sensitivities Rangewide

The greatest effects of anthropogenic activity on tricolored blackbirds are related to habitat loss and the direct disturbance of active nest colonies (Beedy et al. 2020). Suitable habitats in the Central Valley (riparian habitat, marshlands, and perennial grasslands) formerly supported nesting and foraging tricolored blackbirds, but most of the valley has been converted to agriculture and urban development.

The historical—and still preferred—breeding habitat for tricolored blackbirds is freshwater emergent wetland vegetation (Neff 1937; DeHaven et al. 1975; Beedy and Hamilton 1999; Tricolored Blackbird Working Group 2007). In the past, most nesting colonies were in freshwater marshes (Beedy 2008). Water diversions and the loss of natural riverine processes have resulted in the large-scale loss and fragmentation of preferred breeding and foraging habitat for the tricolored blackbird; most researchers consider losses of natural breeding and foraging habitats to be the most important causes of the documented population declines (Tricolored Blackbird Working Group 2007). Before damming, water diversion, and flood control infrastructure and management were implemented, the Central Valley flooded during many years, forming a vast mosaic of riparian forests, freshwater marshes, seasonal wetlands, alkali flats, and upland habitats (including native grasslands and oak savannas) that supported large numbers of tricolored blackbirds (Beedy 2008).

The small percentage of California's original freshwater wetlands remaining in the Central Valley often occurs in small, isolated patches that also support high densities of predators (Tricolored Blackbird Working Group 2007). The shift in the Central Valley during the past century from marsh nesting to silage and rice field nesting is likely related to the loss of freshwater marshes.

Based on the importance of foraging habitat close to potential breeding sites, land uses within 3 to 4 miles of a breeding colony site—which in turn influences the local prey base—determine colony occupation and reproductive success at the particular potential breeding site (Tricolored Blackbird Working Group 2007). Agricultural crops not favorable for foraging tricolored blackbirds (e.g., vineyards and nut trees) have replaced, and continue to replace, grasslands and other more favorable crops (e.g., row and field crops) throughout the Central Valley. This conversion has resulted in decreased foraging opportunities for tricolored blackbirds near otherwise favorable breeding locations, reducing the number of nesting locations and overall foraging area.

Many of the Central Valley's freshwater marshes are managed for waterfowl and other marsh--dependent species. For tricolored blackbirds, water levels need to be deep enough to deter predators, but not deep enough to flood nests—both of which lead to nest loss (Tricolored Blackbird Working Group 2007). Frequent disturbances by predators during nesting may cause mass desertions of breeding colonies at sensitive phases of the breeding cycle; thus, marsh management that does not address the tricolored blackbird's nesting requirements is also a threat.

A major deleterious, rangewide, population-level impact has resulted from agricultural land uses involving grain harvesting and discing in fields occupied by breeding colonies of tricolored blackbirds, causing the loss of some of the largest colonies in California (Beedy et al. 2020).

Because this species nests in large, dense colonies, it is more vulnerable to nest failures that can affect large numbers of nests in a single colony. Large colonies (more than 50,000 nests) in the San Joaquin Valley were destroyed in the 1990s and the first decade of the 2000s. Shooting by farmers attempting to reduce crop damage has been documented in the Sacramento Valley since 2007 (Beedy et al. 2020). Although tricolored blackbirds are listed as threatened under CESA, other blackbird species exempted from protection under federal and state law are often shot in large numbers when depredating rice. During that time of year (autumn), tricolored blackbirds occur in mixed blackbird flocks, and thus, an unknown number of tricolored blackbirds is shot each fall (Meese and Beedy 2015).

Pesticides and other contaminants also affect, or may affect, tricolored blackbirds. For example, selenium contamination is known to decrease hatchability in the closely related red-winged blackbird; and in 1986, nearly complete nesting failure was observed at Kesterson Reservoir in Merced County, which contained water contaminated by high concentrations of selenium from agricultural drainwater (Beedy et al. 2020). Other examples include eggs sprayed with mosquito abatement oil that have failed to hatch and loss of colonies because of the aerial application of herbicides (Beedy et al. 2020).

Concerns have arisen regarding the effects of newly developed water-soluble pesticides targeting insect populations—neonicotinoids and pyrethroids—on the availability of insect food required to raise tricolored blackbird young, and recent declines in tricolored blackbirds breeding in the Sacramento Valley (Beedy et al. 2020).

Ongoing and Future Impacts

- Losses of breeding and foraging habitat related to conversion of agricultural and urban land uses in the Central Valley has resulted in significant negative impacts on the tricolored blackbird population, and continues to do so. This is considered the most significant factor in the long-term reduction of this species' population (Beedy and Hamilton 1997; Hamilton et al. 1999; Hamilton 2000; Tricolored Blackbird Working Group 2007).

- Direct impacts of anthropogenic activities, including harvesting, plowing, burning, and water management, have included the loss of nesting substrate and nests. (In some cases, large numbers of nests have been lost in a single event.) In the SPA, ongoing floodway maintenance, weed eradication, and other ground-disturbing activities can destroy or degrade nesting substrate or result in the loss of active nesting colonies. Ground disturbance can also degrade tricolored blackbird foraging habitat by disrupting soils and reducing prey availability. The use of revetment and other bank protection measures may eliminate the species' habitat.

- Urbanization, agricultural expansion, and other land conversion practices are increasing the abundance of predators by providing anthropogenic food sources and increasing the suitability of habitat for predatory species. Also, the presence of infrastructure such as roadways facilitates predator access into wetland areas.

- The burning and discing of marshes at Central Valley ranches and duck clubs during the spring decreases the number of suitable spring breeding sites for tricolored blackbird, resulting in a temporary loss of breeding habitat in those areas. Water management at freshwater marshes managed for species other than tricolored blackbirds can result in a loss of nests and nesting habitat.

Key Information Gaps or Uncertainties

- **Breeding biology.** Many aspects of tricolored blackbird breeding biology require further study (Beedy et al. 2020). Of these aspects, perhaps most relevant to this focused conservation plan is the need to more precisely determine the factors that lead to nest-site selection, especially the roles of nest-substrate characteristics versus insect abundance in local foraging areas. Another prioritized research area is an assessment of relationships between habitat suitability, foraging ecology, and site philopatry (the tendency of a species to stay in or regularly return to a particular habitat). Further research needs also include assessing the effects of land use characteristics on colony size and reproductive success within colonies, and identifying the ecological factors responsible for multiple breeding attempts in a single breeding season and the relative reproductive success of those attempts.

- **Foraging ecology and pesticides.** Further research is needed on foraging ecology, including quantifying the food supply; identifying the environmental factors that result in an abundance of grasshoppers and other large insect prey in grasslands; and assessing their variability in time and space (Beedy et al. 2020). Also necessary are associated assessments of the relative abundance of insects in organic (unsprayed) versus conventional (sprayed) fields of alfalfa, rice, and sunflowers, and of the potential effects of different pesticides on prey availability.

- **Habitat and predation impacts.** Significant land use changes in the Central Valley have not only led to large-scale losses of breeding and foraging habitats, but also have increased both numbers of tricolored blackbird predators and their access to tricolored blackbird colonies. Research priorities include quantifying recent and projected habitat losses from shifts in agriculture from row crops to orchards and vineyards, or other land uses such as urban (Beedy et al. 2020). Data gaps to close involve prioritizing and managing nesting habitat; assessing the best means to establish alternative freshwater breeding habitat to draw birds away from nesting in silage fields; and comparing differential predation rates by nesting substrate.

- **Distribution and population status.** Monitoring the population trends and distribution of the tricolored blackbird will enable researchers to determine relative contributions of habitat loss and degradation, and to relate changes in population size and locations of tricolored blackbirds to landscape-level changes in habitats. Documenting the effects of restored natural river system dynamics, marshes, and riparian habitats on tricolored blackbirds will further inform ongoing and future implementation and management strategies. Understanding these dynamics is important for identifying and prioritizing sites for conservation and management of this species.

Conservation Strategy

Conservation and Recovery Opportunities

A primary conservation priority for tricolored blackbirds is to create new areas of appropriate habitat and to maintain, enhance, and protect existing habitat suitable for nesting, foraging, and wintering (Tricolored Blackbird Working Group 2007). In the CPAs, the most viable way to increase the population of this species is to create and maintain shallowly inundated emergent wetland habitat and riparian scrub and woodland with native vegetation suitable for foraging and nesting by tricolored blackbirds, and to maintain practices that do not result in nest destruction in agricultural lands in the floodplain.

Nesting colonies can be protected by harvesting crops outside the nesting season or conducting nesting surveys just before harvest to ensure that no nesting tricolored blackbirds are present. The same approach should be applied to vegetation management on levees and within the floodplain. (For example, tricolored blackbirds have nested in thistle on flood control levees in the South Bay region of the San Francisco Bay Area [personal observations by Scott Terrill, principal, wildlife ecology, HT Harvey & Associates, 1990s;] and in mustard, Brassicaceae, stands adjacent to the South Bay Aqueduct [D. Tsao pers. comm. February 10, 2021]). In the CPAs, this species would benefit from management and restoration activities that encourage the expansion of emergent wetlands and riparian habitats, and agricultural practices and maintenance activities (e.g., vegetation clearing) that are modified to avoid the destruction or abandonment of nests.

Like several other target species (e.g., least Bell's vireo and yellow-breasted chat), tricolored blackbirds would benefit from the restoration of natural riverine processes that promote early successional habitat and the implementation of riparian habitat restoration to increase and sustain suitable nesting habitat throughout the SPA.

Identified Conservation Needs

1. **Increase and sustain nesting habitat:** Habitat loss and degradation and nest destruction by anthropogenic activities are the primary threats to the tricolored blackbird (Beedy and Hamilton 1999). Successful nesting requires appropriate water levels and suitable nesting habitat consisting of freshwater marsh with native cattails and tules. To the extent possible, these wetlands should be placed, designed, and managed to minimize predation. In addition, riparian scrub with native willows and other vegetation should be established to provide important nesting habitat.

   Removing non-native, invasive vegetation would also improve opportunities for native vegetation to colonize these areas. However, some introduced plants do provide favorable habitat for breeding and foraging tricolored blackbirds; among these are Himalayan blackberry (*Rubus armeniacus*) and introduced thistles (Beedy 2008). Creating setback levees and facilitating natural processes that lead to relatively continuous, dynamic riparian successional stages within the system would provide opportunities to renew, expand, and sustain nesting habitats. Decommissioning levees should also contribute to geomorphic processes that create diverse riparian ecosystems including early successional habitat and marsh. Creation and expansion of both habitats would be important contributions toward increasing tricolored blackbird populations and the overall recovery of the species.

   Ideal management involves actions that return the marsh to an early stage of dense, rapidly growing stems through effective water management, coupled with the removal of dead stems through burning, grazing, discing, or masticating, or by restoring the natural floodplain conditions that lead to emergent marsh regeneration naturally. Burning is the preferred method of maintaining optimal wetland vegetation: It removes old stems while releasing nutrients supporting the growth of new stems (Meese and Beedy 2015).

   A water management approach of perennial flooding that provides optimal vegetation conditions that may last for four or five years is optimal (Meese and Beedy 2015). Seasonally flooded wetlands, must, however, be managed in an annual or biennial cycle to provide the lush, young cattails preferred by nesting tricolored blackbirds. Management, including seasonal flooding, should be timed so cattails and tules are at least 4 feet tall by

April 1 in the San Joaquin Valley and by May 1 in the Sacramento Valley. This growth requires saturated soils from winter through spring that result from inundation (Meese and Beedy 2015). Management recommendations also include maintaining standing water 6 to 18 inches deep throughout the breeding season to minimize predation by mammals and to cool the microhabitat temperature around nests.

2. **Increase and sustain foraging habitat:** Increasing habitat types that expand the invertebrate prey base—especially grasshoppers, locusts, and other large insects used to raise young—is an important conservation need. Spraying crops that provide a prey base for nesting tricolored blackbirds should be avoided because it negatively affects food availability and could reduce reproductive success.

3. **Minimize nest loss associated with anthropogenic activities:** Nesting colonies could be protected by clearing potential tricolored nesting habitat outside the nesting season or by completing pre-clearing nesting surveys to ensure no nesting tricolored blackbirds are present. Other anthropogenic activities could result in nest loss, such as the inappropriate management of water levels that causes wetlands to drain or floods nests, or construction activities at or near colonies. Wetlands appropriate for breeding should not be drained during the breeding season, and water levels should be managed to avoid causing nest loss in wetlands that support breeding tricolored blackbirds.

Integration of Conservation and Restoration in Flood Management

As Tables B.2-1 and B.2-2 identified, CVFPP management actions have the potential to provide positive, negative, or neutral contributions to the identified conservation needs of the tricolored blackbird. In many cases, the species’ conservation needs could be positively addressed by implementing management actions that integrate conservation and restoration elements with SPFC operation and maintenance, floodway management, and other structural and nonstructural improvements. The ability to implement some of these actions would depend on operations, maintenance, and floodway management actions and other structural and nonstructural improvements (as described in the following section) to resolve constraints, such as the floodway’s existing capacity to convey flood flows, or revetment removal at a site that may depend on levee relocation to allow for bank erosion. Wherever feasible, conservation objectives and indicators will inform management actions for adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Table B.2-1. Summary of the Contributions of CVFPP Management Actions to Identified Conservation Needs of the Tricolored Blackbird

SPFC Conservation Actions – Operations, Maintenance, and Floodway Management	Conservation Need 1. Increase Inundated Floodplain	Conservation Need 2. Improve Natural River Function	Conservation Need 3. Decrease Non-native SAV
Floodwater storage and reservoir forecasting, operations, and coordination	Neutral	Neutral	Neutral
Facility maintenance	Neutral	Neutral	Neutral
Levee vegetation management	Negative	Negative	Negative
Floodway maintenance	Negative	Neutral	Negative
Modification of floodplain topography	Positive	Positive	Neutral
Support of floodplain agriculture	Negative	Negative	Negative
Invasive-plant management	Positive	Positive	Neutral
Restoration of riparian, SRA, and marsh habitats	Positive	Positive	Neutral
Wildlife-friendly agriculture	Positive	Positive	Positive

Notes:
SAV = submerged aquatic vegetation
SPFC = State Plan of Flood Control

Table B.2-2. Summary of the Contributions of CVFPP Management Actions to Identified Conservation Needs of the Tricolored Blackbird

SPFC Conservation Actions – Structural and Nonstructural Improvements	Conservation Need 1. Increase Inundated Floodplain	Conservation Need 2. Improve Natural River Function	Conservation Need 3. Decrease Non-native SAV
Levee and revetment removal	Positive	Positive	Neutral
Levee relocation	Positive	Positive	Neutral
Bypass expansion and construction	Positive	Positive	Neutral
Levee construction and improvement	Positive	Positive	Neutral
Flood control structures	Neutral	Neutral	Neutral

Notes:
CVFPP management actions are designated as having the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the species.

SAV = submerged aquatic vegetation
SPFC = State Plan of Flood Control

Operations, Maintenance, and Floodway Management

Levee vegetation management: Tricolored blackbirds will nest in vegetation on flood control levees, including several types of introduced plants, if the vegetation is attractive for nesting (e.g., Himalayan blackberry, thistle). To avoid direct losses of active nests, any vegetation management of potential breeding habitat on levees should take place outside the tricolored blackbird's nesting season. If this is not possible, pre-clearing nesting surveys should be conducted immediately before the management is scheduled for implementation. If active nests are found, management efforts should be delayed until the colony has fledged.

Floodway maintenance: The floodway supports breeding habitat for tricolored blackbirds, including wetlands with emergent vegetation and riparian scrub and woodlands. Maintenance activities that result in the clearing of nesting habitat (or that otherwise substantially affect such habitat) should occur outside the tricolored blackbird's breeding season. This approach applies not only to vegetation clearing, but also to activities such as demolition or construction, and to other activities near a colony that might disturb the birds to the point of nest abandonment. To avoid direct losses of active nests, vegetation management in potential breeding habitat in the floodplain should occur outside the tricolored blackbird's nesting season. If this is not possible, pre-clearing nesting surveys should be conducted immediately before the management is scheduled for implementation. If active nests are found, management efforts should be delayed until the colony has fledged and then can begin immediately. In addition, preconstruction surveys should be conducted before the start of other types of activities during the breeding season that might result in nest abandonment if appropriate nesting habitat occurs within a given distance of the project (to be determined in consultation with the California Department of Fish and Wildlife).

Modification of floodplain topography: Floodway modifications in strategic locations may provide emergent freshwater marsh habitat and allow for greater topographic and hydrologic diversity, creating habitat conditions that support tricolored blackbirds. Floodplain surfaces could be lowered by excavating benches or swales that allow for more frequent and sustained inundation, which would facilitate marsh formation and may allow additional riparian vegetation to grow along channel margins.

Support of floodplain agriculture: Although tricolored blackbirds do nest and forage in appropriate agricultural crops (i.e., row and field crops), agriculture has replaced vast amounts of native habitat for tricolored blackbirds. However, major nesting colonies have been lost during harvesting, meaning agriculture can represent a significant population sink—and agriculture has replaced much of the historical and preferred habitats occupied by tricolored blackbirds (Beedy 2008). However, some aspects of agriculture that are "friendly" to the species can be applied to agriculture in the CPAs to benefit the species ("Wildlife-friendly agriculture," later in this section, provides more details).

Invasive-plant management: New weed infestations could negatively affect the emergent marsh and early successional riparian habitats, which are the historical and preferred nesting habitats of the tricolored blackbird. Native vegetation provides breeding habitat and is an important food source for tricolored blackbirds because it supports populations of native invertebrates. In general, invasive plants displace native plant species, often over substantial areas. Managing and controlling invasive plants would minimize these impacts. In addition, habitat restoration actions that involve planting native species have been shown to reduce colonization by invasive species in newly planted sites (McClain et al. 2011; Moore et al. 2011; Tjarks 2012). However, after losing preferred native vegetation breeding sites in marshes and riparian areas, tricolored blackbirds have increasingly switched to breeding in some types of non-native-dominated vegetation including Himalayan blackberry and introduced thistle patches, and within row crops (Beedy 2008).

Because tricolored blackbirds will nest in non-native vegetation, an important aspect of the invasive-plant management process is to avoid nest loss by clearing non-native vegetation during the nonbreeding season, or conducting pre-clearing nesting surveys during the breeding season to ensure no active nests are present. If nests are present, clearing should not occur until all nests have fledged.

Restoration of riparian, SRA, and marsh habitats: Restoring emergent marsh and riparian habitat would increase the amount of available breeding habitat for tricolored blackbirds throughout the SPA.

Wildlife-friendly agriculture: Tricolored blackbirds breed and forage in appropriate agricultural fields, such as row and field crops; however, vineyards and orchards do not provide appropriate habitat and are not considered wildlife-friendly for this species. Harvesting should occur outside the tricolored blackbird’s breeding season; or if harvesting is necessary during the breeding season, pre-harvest surveys should be conducted to ensure there are no active nests in the fields. If active nests are found, the harvest should wait until the birds are fledged and could then proceed immediately. Pesticide application should not take place near an active breeding colony.

Structural and Nonstructural Improvements

Levee and revetment removal: Revetment removal would provide an opportunity to improve natural erosional and geomorphic processes important to sustaining and creating habitats along rivers. These processes could help create emergent marsh and riparian scrub habitats if elevations are appropriate for those habitats (e.g., by forming meander bends and cutoffs or new floodplain surfaces). Restoring natural riverine processes may also enhance existing habitat; for instance, scouring could support the regeneration of riparian scrub habitat that provides nesting and foraging habitat for tricolored blackbirds. This approach will reduce habitat fragmentation and increase the extent of early successional habitats, and overall diversity in the floodplain.

Levee relocation: Relocating levees farther from rivers (i.e., constructing setback levees) creates space for rivers to meander, reconnects floodplains, allows the transport and deposition of sediment, supports natural ecosystem disturbance processes, and increases the diversity of riverine and floodplain habitats. These processes would help create new suitable habitat for tricolored blackbirds. In newly reconnected floodplains, emergent wetland and riparian scrub habitat can be restored to provide habitat for this species. In addition, expanding floodways through levee relocation would provide opportunities to improve ecosystem function and increase the extent, quality, and connectivity of habitat.

Bypass expansion and construction: Expanding bypasses would protect large areas of land from development, add agricultural land and natural vegetation to the floodway, and result in the periodic, prolonged inundation of land that was previously isolated from the river system by levees. This agriculture should be limited to row crops favorable to tricolored blackbirds and able to withstand frequent inundation (e.g., rice), as opposed to vineyards and orchards that do not provide suitable habitat and may impede water flows. An expanded, frequently activated floodplain in the bypasses may support the restoration of floodplain ecosystems and may provide suitable habitat for the tricolored blackbird, ideally comprising target areas that are shallowly flooded and dominated by native plant species.

Levee construction and improvement: New or reconstructed levees restrict the floodway. They prevent natural geomorphic processes from creating and sustaining the marsh and early successional riparian habitats the tricolored blackbird relies on for nesting and foraging habitat. Therefore, levees should not be constructed or reconstructed where they would prevent geomorphic processes in areas with the potential to provide substantial amounts of suitable nesting habitat.

Recovery Plan Alignment

There is no ESA recovery plan for tricolored blackbird because it is not federally listed; however, the Tricolored Blackbird Working Group (2007) has developed a conservation plan for this species. The fundamental elements of that plan have been incorporated into this focused conservation plan. Tricolored blackbirds are protected under the CESA and, and, like all native birds in California, are also protected under the federal Migratory Bird Treaty Act and the California Fish and Game Code. The conservation needs of this species in the SPA are addressed in previous sections of this focused conservation plan.

Measures of Positive Contribution

One goal of the Conservation Strategy is to contribute to the recovery and stability of native species populations and overall biotic community diversity. The objective for this goal is a measurable contribution to the conservation of target species, including the tricolored blackbird. Therefore, building on the preceding discussion, this section of the tricolored blackbird conservation plan provides measures (i.e., metrics or indicators) that will be used to determine how effectively CVFPP management actions contribute to the conservation needs of this species.

Measures for each targeted threatened or endangered species are organized around indicators of progress toward the Conservation Strategy’s process, habitat, and stressor objectives. The species-specific measures provide additional detail on geographic location, habitat structure, and other attributes important to conserving the species. For example, the acreages of riparian and marsh restoration are an indicator of progress toward the Conservation Strategy’s habitat objectives. To measure how CVFPP actions contribute to the conservation of tricolored blackbirds, requirements would be added to increase the quantity and quality of emergent wetland and appropriate riparian habitat and minimize environmental stressors, such as nesting habitat and nests from anthropogenic activities.

Tables B.2-3 through B.2-5 list the Conservation Strategy’s process, habitat, and stressor targets; identify those used to measure the contribution to conservation of tricolored blackbirds; and provide additional specificity, as needed, to measure this contribution.

Because management actions intended to benefit the tricolored blackbird may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA’s objectives to conserve target species. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table B.2-3. Measures of the Contribution of CVFPP Actions to Conservation of the Tricolored Blackbird

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain [a]	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50% frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	Saturate soil in winter and spring to achieve the target emergent vegetation height of 4 feet tall by April 1 in the San Joaquin Valley and by May 1 in the Sacramento Valley. Maintain shallow inundation (6 to 18 inches) throughout the breeding season to protect nest colonies from predators and avoid submerging nests.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	Not applicable.
	River Meander Potential—total amount (acres)	Yes	None.
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	Not applicable.

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
SRA Cover	Total Length and Percentage of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	Not applicable.
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Include appropriate riparian breeding habitat.
	Habitat Connectivity—median patch size (acres)	Yes	None.

[a] Floodplain inundation potential is the potential of an area to be inundated by a particular flow (e.g., a flow event that occurs about once every two years, or a “50-percent-chance event”). Expected annual habitat units represent the annual average of the area expected to be inundated in general or by flows meeting defined criteria for timing and duration (e.g., sustained spring flows).

Notes:

EAH = expected annual habitat

SRA = shaded riverine aquatic

Table B.2-4. Measures of the Contribution of CVFPP Actions to Conservation of the Tricolored Blackbird

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	• Maintain emergent wetlands in a state of dense stems with minimal accumulation of dead stems from previous years by restoring natural floodplain processes or by managed disturbances (fire, mastication, discing grazing) at intervals of five years for perennially flooded marshes or every one to two years for seasonal wetlands. For seasonal wetlands, sustain shallow inundation (6 to 18 inches) through April. (San Joaquin Valley) or May (Sacramento Valley) to protect nest colonies from predators while not destroying nests. • Restore patches ofemergent wetland vegetation at least 50 feet wide to support successful nesting.
Floodplain Agriculture	Habitat Amount—total amount of floodplain agriculture providing habitat for target species (acres)	No	Not applicable.
Revetment	Revetment Removed to Increase Meander Potential or Natural Bank—total length (miles)	Yes	None.
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	None.
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	Not applicable.

Table B.2-5. Measures of the Contribution of CVFPP Actions to Conservation of the Tricolored Blackbird

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Invasive Plants	Invasive-plant-dominated Vegetation—total area reduced (acres)	Yes	When removing non-native vegetation in suitable tricolored blackbird nesting habitat (e.g., patches of Himalayan blackberry), replace with native plants that will offset the loss of nesting habitat.

References

Beedy EC. 2008. “Tricolored Blackbird.” In: Shuford WD, Gardali T, editors. *California Bird Species of Special Concern: A Ranked Assessment of Species, Subspecies, and Distinct Populations of Birds of Immediate Conservation Concern in California*. Studies in Western Birds 1. Camarillo and Sacramento (CA): Western Field Ornithologists and California Department of Fish and Game.

Beedy EC, Hamilton WJ III. 1997. *Tricolored Blackbird Status Update and Management Guidelines.* Prepared for: U.S. Fish and Wildlife Service, Migratory Birds and Habitat Program, Portland (OR), and California Department of Fish and Game, Bird and Mammal Conservation Program, Sacramento (CA).

Beedy EC, Hamilton WJ III. 1999. “Tricolored Blackbird (*Agelaius tricolor*).” In: Poole A, Gill F, editors. *The Birds of North America* No. 423. Philadelphia (PA) and Washington, DC: Academy of Natural Sciences and American Ornithologists’ Union.

Beedy EC, Hamilton WJ III, Meese RJ, Airola DA, Pyle P. 2020. “Tricolored Blackbird (Agelaius tricolor),” version 1.0. In: Rodewald PG, editor. Birds of the World. Ithaca (NY): Cornell Lab of Ornithology. Viewed online at: TricoloredBlackbird. Accessed: September 2, 2020

California Department of Fish and Wildlife. 2020. “Drought Stressor Monitoring Case Study: Conserving the Tricolored Blackbird through Monitoring, Breeding Colony Protection, and Habitat Restoration.”Viewed online at: TricoloredBlackbird. Accessed: September 1, 2020.

California Department of Water Resources. 2016. “Central Valley Flood Protection Plan Conservation Strategy.” Sacramento (CA): California Department of Water Resources. Viewed online at: www.CVFPP.org. Accessed: September 2, 2020.

Center for Biological Diversity. 2015. Petition to List the Tricolored Blackbird (Agelaius tricolor) as an Endangered Species and to Designate Critical Habitat Concurrent with Listing. Oakland (CA): Center for Biological Diversity.

Collier G. 1968. Annual Cycle and Behavioral Relationships in the Red-Winged and Tricolored Blackbirds of Southern California. Ph.D. thesis. Los Angeles (CA): University of Southern California. Page 374.

Cook LF, Toft CA. 2005. “Dynamics of Extinction: Population Decline in the Colonially Nesting Tricolored Blackbird *Agelaius tricolor*.” Bird Conservation International Volume 15: Pages 73 to 88.

Crase FT, DeHaven RW. 1977. “Food of Nestling Tricolored Blackbirds.” Condor Volume 79: Page 265.

DeHaven RW, Crase FT, Woronecki PP. 1975. “Breeding Status of the Tricolored Blackbird, 1969–1972.” California Fish and Game Volume 61: Pages 161 to 180.

Green M, Edson L. 2004. “The 2004 Tricolored Blackbird April Survey.” Central Valley Bird Club Bulletin Volume 7: Pages 23 to 31.

Hamilton WJ III. 2000. *Tricolored Blackbird 2000 Breeding Census and Survey—Observations and Recommendations*. Davis (CA): Division of Environmental Studies, University of California, Davis.

Hamilton WJ III, Cook L, Hunting K. 1999. *Tricolored Blackbird 1999 Status Report*. Davis (CA): Division of Environmental Studies, University of California, Davis.

Heermann AL. 1859. “Report upon Birds Collected on the Survey.” Zoological Report No. 2. In In: Williamson RS, editor. Report of Explorations in California for Railroad Routes near the Thirty-fifth and Thirty-second Parallels in 1853: Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi to the Pacific Ocean, 1853–6, Volume 10. Washington, DC: Beverley Tucker, Printer. Pages 29 to 80.

McClain CD, Holl KD, Wood DM. 2011. “Successional Models as Guides for Restoration of Riparian Forest Understory.” Restoration Ecology Volume 19 (Issue 2): Pages 280 to 289.

Meese, R. J. 2017. “Results of the 2017 Tricolored Blackbird Survey.” Calif. Dept. of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program Report 2017-04. Sacramento (CA).

Meese, RJ. 2019. “Tricolored Blackbird Portal.” Viewed online at: Tricolored-Blackbird. Accessed: September 3, 2020.

Meese RJ, Beedy EC. 2015. “Managing Nesting and Foraging Habitats to Benefit Breeding Tricolored Blackbirds.” Central Valley Bird Club Bulletin Volume 17: Pages 79 to 96.

Moore PL, Holl KD, Wood DM. 2011. “Strategies for Restoring Native Understory Plants along the Sacramento River: Timing, Shade, Non-Native Control, and Planning Method.” San Francisco Estuary and Watershed Science Volume 9 (Issue 2).

Neff JA. 1937. “Nesting Distribution of the Tri-colored Red-Wing.” The Condor Volume 39 (Issue 2): Pages 61 to 81.

Orians GH. 1961. The Ecology of Blackbird (Agelaius) Social Systems. Ecological Monographs Volume 31: Pages 285 to 312.

Shearwater D. Owner, Shearwater Journeys, Hollister (CA). May 23, 2020—verbal personal communication with Terrill T, Vice President and Senior Ornithologist, H. T. Harvey & Associates, Los Gatos (CA), regarding tricolored blackbird riparian scrub breeding habitat in the Panoche Valley.

Tjarks H. 2012. “Using a Native Understory to Control Weeds in Riparian Restoration.” California Invasive Plant Council News Volume 20 (Issue 2): Pages 8 to 9.

Tricolored Blackbird Working Group. 2007. *Conservation Plan for the Tricolored Blackbird (*Agelaius tricolor*).* Kester S, editor. San Francisco (CA): Sustainable Conservation.

Yasukawa K, Searcy WA. 1995. “Red-Winged Blackbird (*Agelaius phoeniceus*).” In: Poole A, Gill F, editors. *The Birds of North America*, No. 184. Philadelphia (PA) and Washington, DC: Academy of Natural Sciences and American Ornithologists’ Union.

This page left blank intentionally.

Appendix B.3

Focused Conservation Plan: Yellow-breasted Chat

This page left blank intentionally.

APPENDIX B.3

Focused Conservation Plan: Yellow-breasted Chat

Acronym	Definition
CPA	Conservation Planning Area
CVFPP	Central Valley Flood Protection Plan
SPA	Systemwide Planning Area

Conservation Status

As part of the Central Valley Flood Protection Plan (CVFPP) Conservation Strategy Update, this focused conservation plan addresses needs and opportunities for conserving the yellow-breasted chat (*Icteria virens*) and its habitat in the Systemwide Planning Area (SPA).

The yellow-breasted chat, a California Species of Special Concern, breeds in dense, shrubby, open habitats in North America and winters from northern Mexico to Central America (Billerman 2020). In California, where this species occurs as a migrant and summer resident, it breeds primarily in early successional riparian habitat with a well-developed shrub layer and open tree canopy bordering streams, creeks, sloughs, and rivers (Comrack 2008).

This species has an interesting taxonomic history. It was long considered an aberrant member of the New World warbler family, the Parulidae. Recently, the yellow-breasted chat has been recognized as a quite distinct taxon and placed in a monotypic family, *Icteriidae* (Billerman 2020).

Yellow-breasted chats are widespread, but between 1966 and 2014, their numbers declined throughout the range by an estimated 37 percent (Cornell Lab of Ornithology 2020). Although this species is not listed as threatened or endangered at the federal or state level, it is listed as threatened, endangered, or of special concern in multiple states and Canadian provinces. The yellow-breasted chat is still widely distributed in California but is now rare or absent from much of the Central Valley, with an approximately 35-percent reduction in its breeding range (Comrack 2008). Destruction of riparian habitat is implicated in the decline of this species in the state (Remsen 1978).

Including the yellow-breasted chat as a target species aligns the goals and objectives of the CVFPP Conservation Strategy with those of the Central Valley Joint Venture's Implementation Plan for riparian habitat avian conservation and this species (Central Valley Joint Venture 2006). The yellow-breasted chat was selected as one of seven riparian, breeding focal songbirds for the avian conservation population and habitat objectives in the Central Valley based on the species' ability to meet the following criteria:

- Uses riparian vegetation as principal breeding habitat.
- Warrants special management status or has experienced population declines or reductions in the Central Valley breeding range.
- Is useful for monitoring the effects of management actions in Central Valley riparian ecosystems.

Dybala et al. (2017) added five species to the seven focal species covered by the Central Valley Joint Venture (2006). The yellow-breasted chat was thus included as one of 12 focal species in the *Population and Habitat Objectives for Avian Conservation in California's Central Valley Riparian Ecosystems* (Dybala et al. 2017).

Dybala et al. (2017) established long-term population objectives for each focal species in each region, based on principles of conservation biology; these were intended to meet the goals of establishing genetically robust, self-sustaining, resilient populations. They considered the yellow-breasted chat population in the Sacramento Valley to be small (fewer than 10,000 individuals) and the population in the Yolo-Delta, San Joaquin, and Tulare regions to be very small (fewer than 1,000 individuals). As assessed by Dybala et al. (2017), a "small population" may be below a minimum viable population level and vulnerable to extirpation, and a "very small population" is expected to be well-below a minimum viable population level. The analysis by Dybala et al. (2017) was published after the 2016 Conservation Strategy had been completed.

The restoration of Central Valley riparian habitat is critical to achieving the long-term goal of genetically robust, self-sustaining populations. Dybala et al. (2017) evaluated the current sizes of the Central Valley's yellow-breasted chat populations and the projected population statuses if 10-year and 100-year objectives for riparian habitat and density are reached. Riparian habitat objectives are based on the addition of restored riparian vegetation relative to existing conditions in the four planning regions, and are presented in units of thousands of hectares.

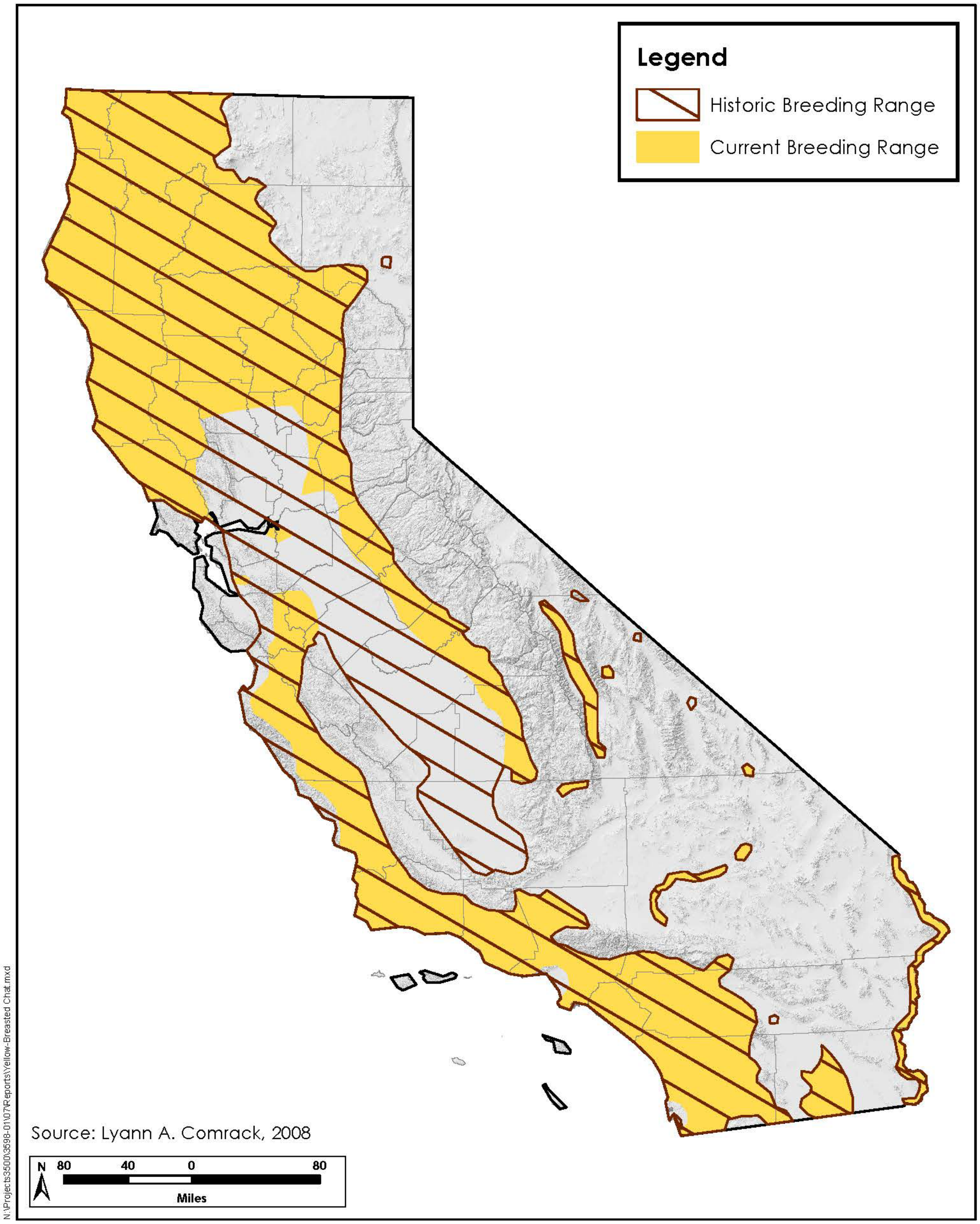
Status and Trends

Distribution

Figure B.3-1 shows the current and historical distributions in California, as well as breeding records, for the yellow-breasted chat. The yellow-breasted chat has two subspecies. The nominate subspecies, *I. v. virens*, breeds in the eastern portion of the range from the eastern Great Plains (and locally north to extreme southeastern Canada) and central Texas eastward. The western subspecies, *I. v. auricollis* (also known as the "long-tailed chat"), breeds in the western portion of the range from the western portion of the Great Plains (locally north to southwestern

Canada) south through the western United States to west Texas (Eckerle and Thompson 2020); thus, this subspecies represents the taxon that breeds in California's Central Valley. Both subspecies winter primarily from Mexico south to Central America.

Figure B.3-1. Recent and Historic Distributions in California and Locations of Breeding Records for Yellow-breasted Chat



Source: Lyann A. Comrack, 2008

In California, the yellow-breasted chat is a migrant and summer visitor from late March to late September, with a breeding period from late April through early August (Garrett and Dunn 1981; Eckerle and Thompson 2001; Unitt 2004). Breeding bird survey data indicate that northwestern rivers, including the Klamath, Trinity, and Eel, support the highest breeding densities in the state (Sauer et al. 2005). The yellow-breasted chat population has declined over much of the California breeding range (the following section, “Population Trends,” provides more details). Winter records are quite rare in the state (eBird 2020), with the closest “normal” wintering area in central Baja California and coastal west Mexico (Dunn and Alderfer 2011).

Population Trends

The yellow-breasted chat was formerly a fairly common to common species that bred throughout the state below elevations of approximately 5,000 feet (Grinnell and Miller 1944). Although still widely distributed in California, the yellow-breasted chat has declined significantly throughout much of the state, particularly the Central Valley and much of Southern California (Remsen 1978; Garrett and Dunn 1981; Comrack 2008). The yellow-breasted chat is now rare or absent from much of the Central Valley, with an approximately 35-percent reduction in its breeding range (Comrack 2008). The destruction of riparian habitat has been implicated in the decline of this species in the state (Remsen 1978). Most of the remaining Central Valley birds currently breed in the northern Sacramento Valley. The species is still considered to be breeding in a few locations in the San Joaquin Valley, and also breeds in the Sacramento–San Joaquin Delta (Comrack 2008; Dybala et al. 2017).

In addition to experiencing habitat loss, chats are frequent hosts to brood parasitism by the brown-headed cowbird (*Molothrus ater)* (Ehrlich et al. 1988; Comrack 2008). This is likely to have contributed to the overall reduction in California’s chat population, although the actual impact of cowbirds is less well-established than for some other riparian species (e.g., least Bell’s vireo). Indirect evidence of the negative relationship between cowbirds and chats includes a lack of chats in apparently suitable habitat (Comrack 2008). Chats have become quite numerous at Camp Pendleton, in San Diego County, where cowbird management has been conducted for years (Comrack 2008), indicating that cowbird management is likely to aid in increasing chat reproductive success. Cowbird management has been successfully implemented as a management strategy to reduce brood parasitism rates (Griffith and Griffith 2000; Famolaro 2006), although cowbird management can be labor-intensive and expensive (Robinson et al. 1993). However, restoring and maintaining suitable habitat and the riverine processes that renew early successional habitat may be a more sustainable method of maximizing breeding opportunities, because the yellow-breasted chat’s preferred dense habitat (like the least Bell’s vireo) provides a buffer from brown-headed cowbirds (Sharp and Kus 2006).

Another factor contributing to the decline in the chat population is impacts on understory and shrubby riparian habitat, caused by vegetation clearing for flood control maintenance and by urban development, agriculture, and livestock grazing (Comrack 2008).

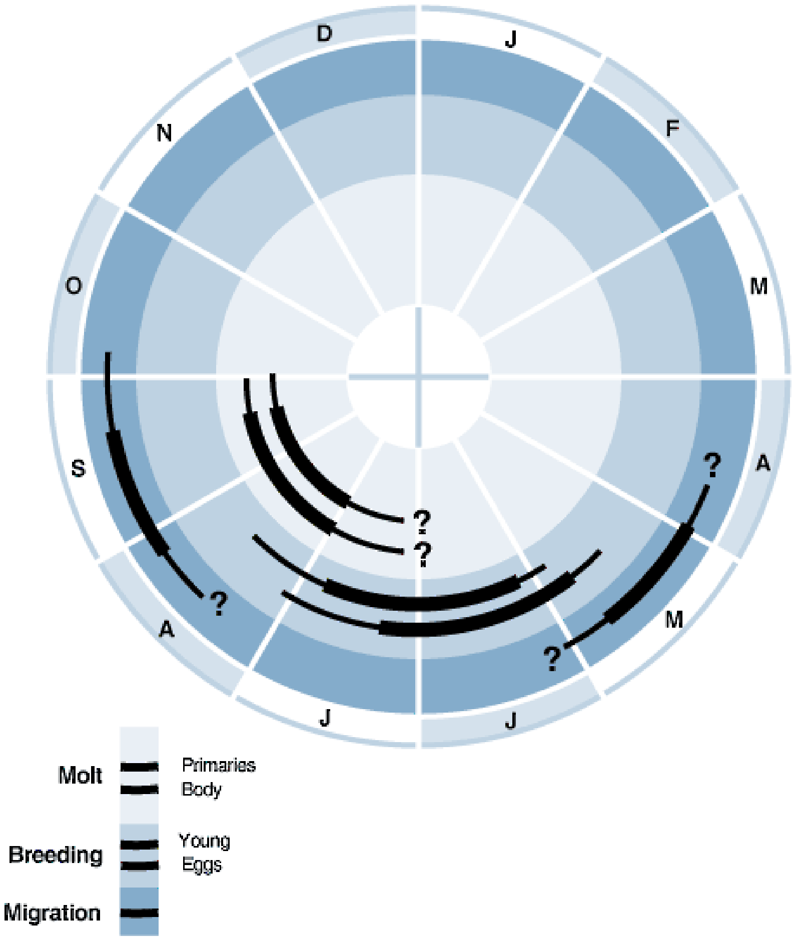
Life History

The yellow-breasted chat is an entirely migratory species, with no resident populations. The species breeds from central Mexico north throughout much of North America, reaching southwestern and extreme southeastern Canada, and winters from coastal Mexico south into Central America (Eckerle and Thompson 2020).

Yellow-breasted chats are known for their extremely shy, retiring, and skulking nature, except when males sing from exposed perches or when giving display flight songs (Dunn and Garrett 1997). Foraging takes place in dense thickets and consists primarily of gleaning insects from foliage. Figure B.3-2 shows the *Birds of North America* annual cycle for the yellow-breasted chat. As the figure shows, peak molting occurs from August through mid-September; peak breeding occurs between late May and late July; and peak migration occurs in early to mid-May and late August to mid-September.

Figure B.3-2. Annual Cycle of Breeding, Molt, and Migration in the Yellow-breasted Chat

Thick lines show peak activity; thin lines, off-peak.



Source: Eckerle and Thompson 2020; reproduced with permission.

Nests are constructed 1 to 8 feet above ground level and are well concealed in dense shrubs or tangled vines. They are built of an outer base of dead leaves and weeds, with an inner cup of tightly woven vine bark, lined with fine stems and grass (Kaufman 1996). This species typically lays three or four (but up to six) creamy white eggs with brown spots. Yellow-breasted chats lay one or two broods per season, with an incubation period of 1 to 12 days and a nestling period of seven to 10 days.

Habitat and Ecological Process Associations

Yellow-breasted chats occupy early successional riparian habitats with a well-developed shrub layer and an open canopy (Comrack 2008). In the western portion of the range, nesting habitat typically include riparian areas associated with the narrow borders of waterways. Early successional riparian habitats are ephemeral, productive communities and require periodic disturbance to renew and maintain the vegetative structural components and species composition used by the yellow-breasted chat. Plants typical of yellow-breasted chat habitat include blackberry, wild grape, willows, and cottonwood. A dense understory is an essential habitat requirement for the species, but as early successional habitat matures, the understory thins and does not provide adequate cover for this species. Active riverine processes, such as periodic inundation, erosion and deposition, lateral channel migration, and avulsion (i.e., channel cutoff), promote the establishment and growth of the early successional plant communities required by yellow-breasted chats. As these natural processes continue, they generate new floodplain surfaces and create a mosaic of vegetation that supports suitable nesting habitat for the species.

Yellow-breasted chats forage primarily on invertebrates, especially during the breeding season, to provide amino acids for egg formation and the growth and development of nestlings, as is the case with most birds (Eckerle and Thompson 2020). For yellow-breasted chats, these invertebrates include beetles, ants, bees, mayflies, cicadas, moths, and caterpillars (Cornell Lab of Ornithology 2020). Nestlings are fed insects, primarily; particularly, orthopterans and larval lepidopterans (Eckerle and Thompson 2020).

However, like many migrants, this species feeds largely on fruit in late summer and fall. In California, these late-summer and fall-ripening fruits include native elderberries, wild grape, honeysuckle, wild strawberry, blackberry, and chokecherry (Dunn and Garrett 1997; Cornell Lab of Ornithology 2020). Wild fruits are an important food source for many north temperate breeding birds during late-summer and fall migration. This consumption is critical for migratory birds that rely on the energy provided by fruit to store fat and fuel for migration, such as yellow-breasted chats (Gallinat et al. 2020). In turn, birds disperse seeds for the plants by consuming the fruits. Thus, the availability and synchronization of native plant species to provide fruit during the appropriate periods is critical to support local populations of migratory birds.

Many non-native invasive plant species are from different families or genera than native species and differ in many of their biochemical and structural traits. Although some non-native invasive plant species have small, fleshy fruits, they may not be as suitable as a food source as native species. In one study, Gallinat et al. (2020) found that although invasive shrubs fruited later than native plants on average, and they produced a large proportion of the total fruits available in late autumn, birds primarily consumed the fruits of native species throughout the autumn. These results and the importance of late-summer and fall fruits as a food source support the incorporation of native species with small, fleshy fruits (such as elderberry and native blackberry) into riparian habitat restoration projects in the Central Valley.

In addition, landscapes dominated by non-native plants are unlikely to support the same diversity and biomass of insect herbivores as landscapes dominated by native host plants; as such, it follows that populations of insectivores, such as birds, will be compromised (Burghardt et al. 2009).

Conceptual Models

A conceptual model has been designed to assist in the development of a targeted conservation strategy for the yellow-breasted chat within the SPA (Figure B.3-3). This model is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species. Rather, as Figure B.3-3 shows, the conceptual model specifically depicts the following considerations:

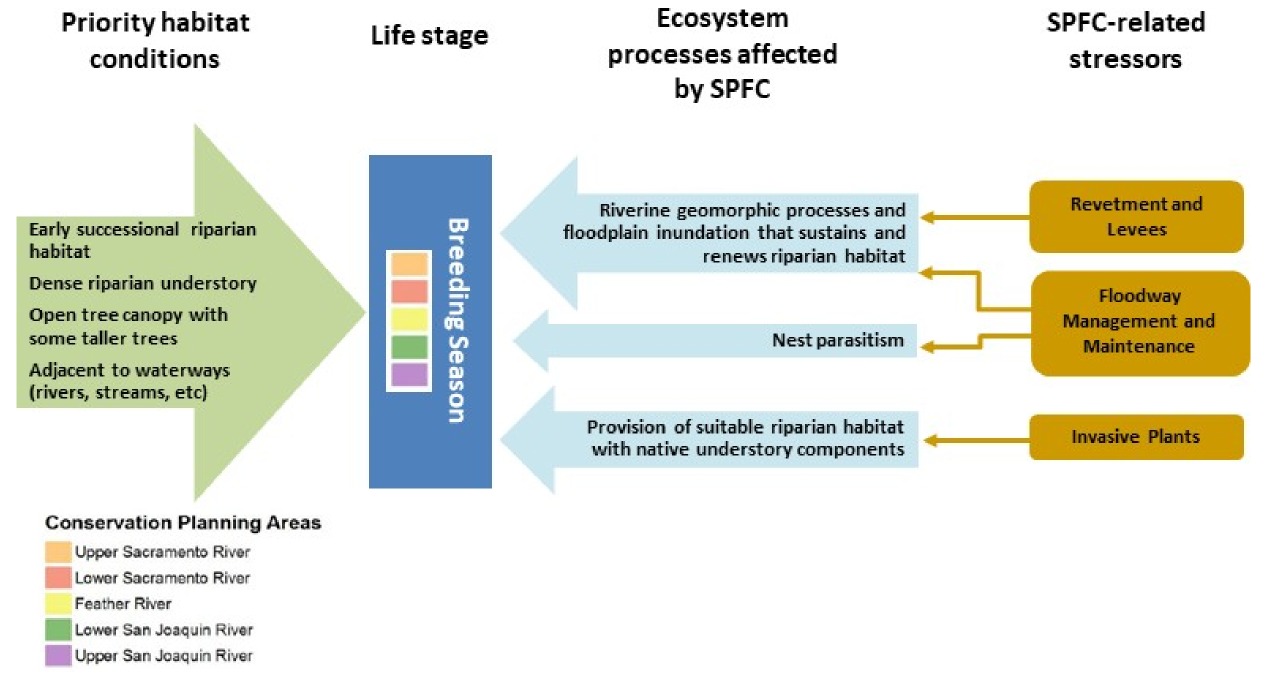
- Habitat conditions required by yellow-breasted chat within the SPA: Early successional riparian habitat, a dense riparian understory, an open tree canopy with some taller trees, and a location adjacent to a waterway. (Nesting habitat is usually restricted to the borders of streams, creeks, and rivers.) “Early successional riparian habitat” refers to a well-developed shrub layer and open canopy with taller trees such as cottonwoods for singing perches. Food includes invertebrates, especially terrestrial insects and fruit produced by native plants in the late-summer and fall.

- The specific Conservation Planning Areas (CPAs) the yellow-breasted chat may breed in, under suitable habitat conditions: The Upper and Lower Sacramento Rivers and San Joaquin River CPAs and the Feather River CPA.

- Key ecosystem processes of riverine systems within the SPA potentially affected by actions associated with the CVFPP, including the Conservation Strategy: Riverine geomorphic processes and floodplain inundation that sustains and renews riparian habitat; nest parasitism; and the provision of suitable riparian habitats with native understory components.

- Stressors related to State Plan of Flood Control facilities and their operations and maintenance: Revetment and levees, floodway management and maintenance, and invasive plants.

Figure B.3-3. Conceptual Model for the Yellow-breasted Chat within the Systemwide Planning Area



Management Issues

Threats and Sensitivities Rangewide

The population decline of yellow-breasted chats in the Central Valley and elsewhere in California is largely a function of the following factors:

- Loss and degradation of early successional riparian habitat
- Alteration and loss of river processes that renew and maintain these habitats
- Brood parasitism by brown-headed cowbirds
- Habitat effects caused by invasive, exotic vegetation

Riparian habitat is estimated to have declined in California by up to 95 percent since European contact (The Bay Institute 1998).

Dams, water diversions, levees, and other flood control structures reduce channel migration and natural disturbances, which initiate the development of early successional vegetation that provides suitable habitat. Instead, these structures lead to a predominance of mature riparian forests with dense canopies and open understories, which represent unsuitable breeding habitat for this species.

The yellow-breasted chats' dependence on understory and shrubby riparian vegetation for nesting makes them vulnerable to habitat loss from vegetation removal along river channels during flood control maintenance, which often occurs during the breeding season (Comrack 2008). In addition to direct impacts during the breeding season, on the whole, levee and floodplain vegetation management may negatively affect habitat for chats through the direct loss of suitable riparian habitat and by fragmenting existing patches of habitat. Because early successional habitat is already greatly reduced within the SPA, maintenance activities contribute to the overall decline of this habitat-dependent bird species, such as the chat.

The conversion of riparian habitat to agriculture also contributes to habitat loss and fragmentation. In addition, riparian habitat fragmentation and the establishment of agricultural lands adjacent to yellow-breasted chat breeding sites may increase nest parasitism by brown-headed cowbirds. If agricultural land or developed areas surround suitable nesting habitat, brown-headed cowbirds can become more abundant and, consequently, lower the breeding success of riparian-breeding avian species, including the yellow-breasted chat. Another tool to reduce parasitism rates could include minimizing the availability of food sources for the brown-headed cowbird (e.g., grass seeds, crop grains, insects disturbed by domestic ungulates), especially near suitable habitat for the yellow-breasted chat, which could also serve as the primary method of controlling cowbirds. Yellow-breasted chats are also affected by grazing. Ohmart (1994) found that chat densities increased fourfold in six years in response to the removal of livestock along the San Pedro River in Arizona.

In addition to threats to their breeding grounds, migratory birds experience threats during migration and on their wintering grounds (Kirby et al. 2008). Reductions in migratory stopover habitat and habitat on the wintering grounds can contribute substantially to reductions in migratory bird populations (Bairlein 2016).

Ongoing and Future Impacts

The most important ongoing and likely future issues for sustaining viable breeding populations of yellow-breasted chats in the Central Valley are the current low availability of suitable breeding habitat and continued loss of suitable habitat, the lack of river processes that sustain early successional habitat, and nest parasitism by brown-headed cowbirds.

Key Information Gaps or Uncertainties

To better understand factors affecting the Central Valley's yellow-breasted chat population, more information is needed regarding the local population trends, migratory routes, and wintering areas of Central Valley breeding chats; pesticide effects; patch sizes required for breeding; and brown-headed cowbird parasitism.

- **Regional population trends.** Monitoring population trends for the yellow-breasted chat at a regional level will enable researchers to identify the sites of population increases or declines, and help determine the relative contributions of habitat loss and degradation, cowbird parasitism, and other factors that influence the population. In addition, monitoring the effects of the Conservation Strategy on yellow-breasted chats in the Central Valley related to the restoration and management of riparian habitat and the increased incorporation of natural river system dynamics will further inform ongoing and future implementation and management strategies. Understanding these dynamics will be the key to identifying and prioritizing sites for conservation and management of this species.

- **Migration and wintering grounds.** Very little information exists regarding the wintering range and migratory routes of chats that breed in California. Observations of wintering yellow-breasted chats have been recorded from Baja California Sur, Mexico, and Central America. Understanding conditions in the wintering grounds and identifying key stopover locations will help identify the habitats and threats this species may encounter during migration and on the wintering grounds, and could help determine the relative importance of management actions on the breeding grounds versus the migratory and wintering areas.

- **Pesticides**. Pesticides may affect yellow-breasted chat behavior or cause fatalities, either through direct contact or by reducing or contaminating prey populations, but the extent to which pesticides affect chat populations is unknown. Pesticide and herbicide use on agricultural lands adjacent to habitat may also reduce insect abundance in chat foraging areas.

- **West Nile virus.** West Nile virus–positive dead birds have been found in the CPAs (Wheeler et al. 2009). The yellow-breasted chat was shown to have a significant negative population interaction between the presence of West Nile virus and human land use (agricultural or urban and suburban lands near Monitoring Avian Productivity and Survivorship Program stations throughout the United States), but not a significant direct negative effect from only the presence of the virus (George et al. 2015). The authors concluded a negative interaction between land use and West Nile virus suggests the virus's effects may be amplified with increased agriculture and urban development around the habitat of species showing this negative relationship. The degree to which West Nile virus may affect yellow-breasted chats in the Central Valley is currently unknown.

- **Breeding habitat patch size**. More data on the relationship between (appropriate) habitat patch size and shape and the chats' reproductive success and breeding densities in Central Valley riparian habitat would help inform habitat restoration and management for chats.

- **Brood parasitism by brown-headed cowbirds.** Further and more detailed information regarding the impacts of brown-headed cowbirds on the reproductive success of yellow-breasted chats would help to inform the degree to which cowbird control benefits chats.

Conservation Strategy

Conservation and Recovery Opportunities

The most viable ways to support the recovery of the yellow-breasted chat are to encourage natural riverine processes that promote early native successional riparian habitat, and to restore native riparian habitat to increase and sustain suitable nesting habitat throughout the SPA, while reducing occurrences of brood parasitism by the brown-headed cowbird. Creating patches of suitable breeding habitat and connecting those patches to existing or new suitable habitat will increase opportunities for the yellow-breasted chat breeding populations to recover along waterway margins in the SPA. Connecting riparian habitat and increasing cottonwood-willow habitat between riparian forest patches may also benefit many other bird species, including special-status species (e.g., western yellow-billed cuckoo and least Bell’s vireo) (Kleinschmidt Associates 2008).

Improving ecosystem function and restoring natural riverine geomorphology through the implementation of appropriate management actions would create the disturbance regimes necessary to create and maintain this suitable habitat. Incorporating early successional plant species with a dense understory into riparian restoration efforts and restoring river processes throughout the Central Valley may be the key to maximizing opportunities for the valley’s yellow-breasted chat population to recover. Cowbird management could also be used as a tool to prevent nest parasitism in areas where yellow-breasted chat populations are monitored and low productivity is documented. All such conservation and restoration initiatives could incorporate the vegetative and structural components identified in the “Conceptual Models” section.

Identified Conservation Needs

1. **Increase and sustain nesting habitat:** The yellow-breasted chat is a riparian obligate, dependent on early successional to mid-seral riparian habitat with a dense understory and the natural hydrologic and geomorphic processes that create and sustain it. Creating setback levees and facilitating natural flood processes that lead to relatively continuous, dynamic riparian successional stages within the system will provide opportunities to renew, expand, and sustain nesting habitat. Decommissioning levees may also contribute to geomorphic processes that create diverse riparian ecosystems, including early successional habitat. Restoring riparian habitat in core population areas would provide habitat connectivity that is important to increasing the species’ numbers and facilitating colonization in the SPA. Removing exotic vegetation would also improve opportunities for native vegetation to colonize these areas, limiting the spread of undesirable species in the SPA and enhancing the outcomes of riparian restoration efforts.

2. **Reduce nest parasitism:** Brood parasitism by brown-headed cowbirds lowers the breeding success of the yellow-breasted chat. Sustaining dense, early successional habitat with a dense understory may naturally minimize rates of nest parasitism (Siegle and Ahlers 2004). Reducing cowbird food sources by reducing row-crop waste grain and reducing domestic ungulate presence, especially feedlots and dairies, near chat breeding habitat may reduce local cowbird

populations, which may lower parasitism rates (Robinson et al. 1993). Conducting surveys for brown-headed cowbirds in areas where breeding populations of yellow-breasted chats occur would inform targeted conservation efforts. To ensure yellow-breasted chats have the opportunity to successfully breed and disperse, brown-headed cowbirds may need to be removed, but this should not be the primary management method. This approach to cowbird management would also significantly benefit other riparian avian species, many of which are heavily exploited by cowbird brood parasitism—especially another target species, the least Bell’s vireo.

Integration of Conservation and Restoration in Flood Management

As identified in Table B.3-1, CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the yellow- breasted chat. In many cases, the species’ conservation needs can be positively addressed by implementing management actions that integrate conservation and restoration elements with State Plan of Flood Control operations and maintenance, floodway management, and structural and nonstructural improvements. The ability to implement some of these actions would depend on operations, maintenance, and floodway management actions and improvements (as described in the following section) to resolve constraints, such as the floodway’s existing capacity to convey flood flows, or revetment removal at a site that may depend on levee relocation to allow bank erosion. Wherever feasible, conservation objectives and indicators will inform management actions for adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Table B.3-1. Summary of the Contributions of CVFPP Management Actions to Identified Conservation Needs of the Yellow-breasted Chat

SPFC Activity	Management Actions	Conservation Need 1. Increase and Sustain Nesting Habitat	Conservation Need 2. Reduce Nest Parasitism
Operations, Maintenance, and Floodway Management	Floodwater storage and reservoir forecasting, operations, and coordination	Neutral	Neutral
	Facility maintenance	Neutral	Neutral
	Levee vegetation management	Neutral	Neutral
	Floodway maintenance	Neutral	Neutral
	Modification of floodplain topography	Positive	Neutral
	Support of floodplain agriculture	Neutral	Negative

SPFC Activity	Management Actions	Conservation Need 1. Increase and Sustain Nesting Habitat	Conservation Need 2. Reduce Nest Parasitism
Operations, Maintenance, and Floodway Management	Invasive-plant management	Positive	Positive
	Restoration of riparian, SRA, and marsh habitats	Positive	Positive
	Wildlife-friendly agriculture	Neutral	Negative
Structural and Nonstructural Improvements	Levee and revetment removal	Positive	Neutral
	Levee relocation	Positive	Neutral
	Bypass expansion and construction	Positive	Negative
	Levee construction and improvement	Negative	Neutral
	Flood control structures	Neutral	Neutral

Notes:
CVFPP management actions are designated as having the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the species.

SRA = shaded riverine aquatic

Operations, Maintenance, and Floodway Management

Modification of floodplain topography: Lowering floodplain elevations would provide more frequent and sustained inundation, which may promote the growth of additional riparian vegetation (i.e., more suitable yellow-breasted chat habitat) along channel margins.

Support of floodplain agriculture: Agricultural lands provide habitat for the brown-headed cowbird. Providing scrub habitat or other vegetative buffers between agricultural lands and riparian breeding habitat for yellow-breasted chat would be important to protect and conceal nests from brown-headed cowbirds.

Invasive-plant management: New or expanded weed infestations could negatively affect the early successional riparian habitat on which the yellow-breasted chat relies during the breeding season. Native vegetation provides an important food source for yellow-breasted chats, both by supporting native invertebrate populations and by providing fruit during key periods. In general, invasive plants have been shown to significantly displace native plant species.

Managing and controlling invasive plants would minimize these impacts. In addition, habitat restoration actions that involve planting native species have been shown to reduce colonization by invasive species in newly planted sites (McClain et al. 2011; Moore et al. 2011; Tjarks 2012).

Restoration of riparian, SRA, and marsh habitats: Riparian restoration would increase the amount of riparian habitat available for yellow-breasted chats, and would be fundamental to bringing Central Valley chat populations to viable population levels throughout the SPA (Dybala et al. 2017). Providing corridors of suitable habitat throughout the SPA would maximize opportunities for this species to expand. Dense, contiguous early successional habitat would also protect nests from the brown-headed cowbird.

Incorporating a planting palette that includes Great Valley willow-scrub, cottonwood forest, and mixed riparian forest vegetation, including native fruiting riparian vegetation, would create nesting and foraging habitat for the yellow-breasted chat (U.S. Fish and Wildlife Service 2005); this diversified habitat would also provide corridors that accommodate other riparian-obligate species. Dybala et al. (2017) demonstrated the critical importance of increasing riparian habitat over existing conditions to increasing and maintaining a viable yellow-breasted chat population in the Central Valley. Further, because this species is adapted to exploiting successional habitats, it rapidly colonizes newly created habitat areas. This bodes well for positive population-level responses to management actions that create additional areas of suitable habitat (Eckerle et al. 2020).

Wildlife-friendly agriculture: Wildlife-friendly agriculture is an important conservation tool that can benefit many target species, but the brown-headed cowbird prefers expanses of open habitat. Establishing agricultural lands next to known or potential yellow-breasted chat breeding locations may inadvertently lead to nest parasitism by cowbirds.

Structural and Nonstructural Improvements

Levee and revetment removal: Removing levees and revetment would create opportunities to improve the riverine geomorphic and floodplain inundation processes that are important to sustaining habitats along rivers. Encouraging river meander and natural erosional processes that deposit soils and facilitate the establishment of early successional riparian habitat would benefit the yellow-breasted chat by providing and maintaining suitable nesting and foraging habitats. This approach will reduce the fragmentation of riverine habitat and increase habitat succession, native plant populations, and overall diversity in the floodplain.

Levee relocation: As discussed, improving ecosystem function and restoring natural riverine geomorphology by relocating levees would create opportunities to establish and sustain early successional riparian habitat. Specifically, an expanded floodway that is reconnected to the river channel would allow for river meander, sediment erosion and deposition, and natural ecosystem disturbance processes. Each of these processes could help create new suitable habitat and renew early successional habitat that is important for sustaining populations of the yellow-breasted chat. In addition, floodways that are expanded through the relocation of levees would provide opportunities to improve ecosystem function and increase the extent, quality, and connectivity of habitat.

Bypass expansion and construction: Expanding bypasses would add agricultural land and natural vegetation to the floodway and would result in the periodic, prolonged inundation of land that was previously isolated from the river system by levees. An expanded, frequently activated floodplain in the bypasses may support some restoration of floodplain ecosystems, and may provide suitable nesting habitat for the yellow-breasted chat. However, expanding bypasses would also add agricultural land, potentially providing habitat for the brown-headed cowbird.

Agricultural land should be sited away from areas that could support nesting habitat for the yellow-breasted chat.

Levee construction and improvement: New or improved levees could restrict the floodway, preventing natural geomorphic processes from creating and sustaining the early successional riparian habitat upon which the yellow-breasted chat relies as nesting habitat. New levees should not be constructed adjacent to rivers and near areas that have the potential to support suitable nesting habitat.

Measures of Positive Contribution

One goal of the Conservation Strategy is to contribute to the recovery and stability of native species populations and overall biotic community diversity. The objective for this goal is a measurable contribution to the conservation of target species, including the yellow-breasted chat. Therefore, building on the preceding discussion, this section of the yellow-breasted chat conservation plan provides measures (i.e., metrics or indicators) that will be used to determine how effectively CVFPP management actions contribute to the conservation needs of this species.

Measures for each target species are organized around indicators of progress toward the Conservation Strategy's process, habitat, and stressor objectives (Table B.3-2). The species-specific measures provide additional detail on geographic location, habitat structure, and other attributes important to conservation of the species. For example, the acreage of riparian restoration is an indicator of progress toward the Conservation Strategy's riparian habitat objective. To measure the contribution of CVFPP actions to the conservation of the yellow-breasted chat, requirements would be added to increase acreage that makes a positive contribution to the early successional riparian habitat required by the species for nesting.

Table B.3-2 lists the process, habitat, and stressor targets of the Conservation Strategy; identifies those used to measure the contribution to conservation of yellow-breasted chat; and provides additional specificity as necessary to measure this contribution. Table B.3-3 provides the target, indicator, and selected measure of contribution.

Table B.3-2. Measures of the Contribution of CVFPP Actions to Conservation of the Yellow-breasted Chat

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50% frequently activated floodplain, and total amount of expected annual inundated floodplain habitat [a]	Yes	None.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	None.
	River Meander Potential—total amount (acres)	Yes	Nesting habitat requires adjacency to water.
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	Yes	Nesting and foraging habitats require adjacency to natural rivers or streams.
SRA Cover	Total Length and Percentage of Bank Affected by Flood Projects that Incorporate SRA Attributes	Yes	None.
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Nesting and foraging habitats require dense thickets of early successional riparian habitat (willows and other low shrubs), with a dense shrub layer, including native fruiting vegetation, and an open tree canopy with scattered tall trees, and presence of a water edge.
	Habitat Connectivity—median patch size (acres)	Yes	Nesting and foraging habitats require a tree and water edge or shrub and water edge.
Marsh	Habitat Amount—total amount and total amount on active floodplain area (acres)	No	Not applicable.

[a] Floodplain inundation potential is the potential of an area to be inundated by a particular flow (e.g., a flow event that occurs about once every two years, or a "50-percent-chance event"). Expected annual habitat units represent the annual average of the area expected to be inundated in general or by flows meeting defined criteria for timing and duration (e.g., sustained spring flows).

Notes:

EAH = expected annual habitat

SRA = shaded riverine aquatic

Table B.3-3. Target, Indicator, and Selected Measure of Contribution for the Yellow-breasted Chat

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	Yes	Breeding success would be increased by reducing cowbird food sources by reducing non-native grass and row-crop seeds and reducing domestic ungulate presence, especially feedlots and dairies near chat breeding habitat.
Revetment	Revetment Removed to Increase Meander Potential or Natural Bank—total length (miles)	Yes	None.
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	None.
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	Not applicable.
Invasive Plants	Invasive-plant-dominated Vegetation—total area reduced (acres)	Yes	None.

Because management actions intended to benefit the yellow-breasted chat may simultaneously affect the conservation of other species in the SPA (e.g., least Bell's vireo), these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in the Conservation Strategy Update. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

References

Bairlein F. 2016. "Migratory Birds under Threat." Science Volume 354: Pages 547 ro 548.

Billerman SM. 2020. "Yellow-breasted Chat (*Icteriidae*)," version 1.0. In: Billerman SM, Keemey BK, Rodewald PG, Schulenberg TS, editors, *Birds of the World*. Ithaca (NY): Cornell Lab of Ornithology.

Burghardt KT, Tallamy DW, Shriver WG. 2009. "Impact of Native Plants on Bird and Butterfly Biodiversity in Suburban Landscapes." Conservation Biology Volume 23: Pages 219 to 224.

Central Valley Joint Venture. 2006. "Central Valley Joint Venture Implementation Plan: Conserving Bird Habitat." Sacramento (CA): U.S. Fish and Wildlife Service: Viewed online at: http://centralvalley.org. Accessed: August 26, 2020.

Comrack LA. 2008. Yellow-breasted Chat. In: Shuford WD, Gardali T, editors, California Bird Species of Special Concern: A Ranked Assessment of Species, Subspecies, and Distinct Populations of Birds of Immediate Conservation Concern in California. Studies in Western Birds 1. Camarillo and Sacramento (CA): Western Field Ornithologists and California Department of Fish and Game.

Cornell Lab of Ornithology. 2020. "All About Birds." Viewed online at: Yellow-Breasted-Chat. Accessed: October 19, 2021.

Dunn J, Alderfer J. 2011. *Field Guide to the Birds of North America*. Washington, DC: National Geographic Society.

Dunn JL, Garrett KL. 1997. *A Field Guide to the Birds of North America.* New York (NY): Houghton Mifflin.

Dybala KE, Clipperton N, Gardali T, Golet GH, Kelsey R, Lorenzato S, Melcer R Jr., Seavy NE, Silveira JG, Yarris GS. 2017. "Population and Habitat Objectives for Avian Conservation in California's Central Valley Riparian Ecosystems." San Francisco Estuary and Watershed Science Volume 15 (Issue 1), Article 5. California Digital Library, University of California.

eBird 2020. "Bird Observations." Viewed online at: BirdObservations. Accessed: August 27, 2020.

Eckerle PK, Thompson CF. 2001. "Yellow-breasted Chat (*Icteria virens*)." In: Poole A, Gill F, editors, *The Birds of North America*, No. 575. Philadelphia (PA): Birds of North America.

Eckerle PK, Thompson CF. 2020. "Yellow-breasted Chat *Icteria virens.*" In: Birds of the World Online. Ithaca (NY): Cornell Lab of Ornithology. Viewed online at: www.birds.org. Accessed: August 24, 2020.

Ehrlich PR, Dobkin DS, Wheye D. 1988. The Birder's Handbook: A Field Guide to the Natural History of North American Birds. New York: Simon and Schuster.

Famolaro P. 2006. *2005 Threatened and Endangered Species Survey Report.* Unpublished report. Prepared by: Sweetwater Authority. Prepared for: U.S. Fish and Wildlife Service, Carlsbad Field Office, Carlsbad (CA).

Gallinat AS, Primack RB, Lloyd-Evans TL. 2020. "Can Invasive Species Replace Native Species as a Resource for Birds under Climate Change? A Case Study on Bird-Fruit Interactions." Biological Conservation Volume 241 (108268): Pages 1 to 10.

Garrett K, Dunn J. 1981. *Birds of Southern California: Status and Distribution*. Los Angeles (CA): Los Angeles Audubon Society.

George TL, Harrigan RJ, LaManna JA, DeSante DF, Saracco JF, Smith TB. 2015. “Persistent Impacts of West Nile Virus on North American Bird Populations.” Proceedings of the National Academy of Sciences Volume 112: Pages 14,290 to 14,294.

Griffith J, Griffith J. 2000. “Cowbird Control and the Endangered Least Bell’s Vireo: A Management Success Story.” In: Smith J, Cook T, Rothstein S, Robinson S, Sealy S, editors, *Ecology and Management of Cowbirds and their Hosts*. Austin (TX): University of Texas Press. Pages 342 to 356.

Grinnell J, Miller AH. 1944. *The Distribution of the Birds of California.* Cooper Ornithological Club, Pacific Coast Avifauna Number 27. Berkeley (CA).

Kaufman K. 1996. *Lives of North American Birds.* New York (NY): Houghton Mifflin Company.

Kirby JS, Stattersfield AJ, Butchart SHM, Evens MI. 2008. “Key Conservation Issues for Migratory Land and Waterbird Species on the World’s Major Flyways.” Bird Conservation International Volume 18 (S1): Pages 49 to 73.

Kleinschmidt Associates. 2008. *Cosumnes River Preserve Management Plan*. Grass Valley (CA). March 2008.

McClain CD, Holl KD, Wood DM. 2011. “Successional Models as Guides for Restoration of Riparian Forest Understory.” Restoration Ecology Volume 19 (Issue 2): Pages 280 to 289.

Moore PL, Holl KD, Wood DM. 2011. “Strategies for Restoring Native Understory Plants along the Sacramento River: Timing, Shade, Non-native Control, and Planting Method.” San Francisco Estuary and Watershed Science Volume 9 (Issue 2), Article 1.

Ohmart RD. 1994. “The Effects of Human-Induced Changes on the Avifauna of Western Riparian Habitats.” Studies in Avian Biology Volume 15: Pages 273 to 285.

Remsen JV Jr. 1978. *Bird Species of Special Concern in California: An Annotated List of Declining or Vulnerable Bird Species*. Nongame Wildlife Investigations, Wildlife Management Branch. Administrative Report 78-1. Sacramento (CA): California Department of Fish and Game.

Robinson, S. K., J. A. Grzybowski, S. I Rothstein, M. C. Brittingham, L. J. Petit, F. R. Thompson. 1993. “Management Implications of Cowbird Parasitism on Neotropical Migrant Songbirds.” *Status and Management of Neotropical Migratory Birds*. U. S. Dept. of Agriculture, Forest Service 93-102 General Technical Report. Fort Collins (CO). September 1993.

Sauer JR, Hines JE, Fallon J. 2005. *The North American Breeding Bird Survey: Results and Analysis 1966–2004*, version 2005.2. Laurel (MD): U.S. Geological Survey Patuxent Wildlife Research Center. Viewed online at: www.mbr-pwrc.usgs.gov/bbs/bbs/html. Accessed: August 26, 2020.

Sharp BL, Kus BE. 2006. “Factors Influencing the Incidence of Cowbird Parasitism of Least Bell's Vireos.” Journal of Wildlife Management Volume 70 (Issue 3): Pages 682 to 690.

Siegle, R. and D. Ahlers. 2004. “Brown-headed Cowbird Management Techniques Manual.” U.S. Department of the Interior Bureau of Reclamation Technical Service Center Ecological Planning and Assessment Group. Denver (Co).

Tjarks H. 2012. “Using a Native Understory to Control Weeds in Riparian Restoration.” California Invasive Plant Council News Volume 20 (Issue 2): Pages 8 to 9.

The Bay Institute. 1998. From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed. Novato (CA). July 1998.

Unitt P. 2004. *The Birds of San Diego County*. San Diego Society of Natural History Memoir 13.

U.S. Fish and Wildlife Service. 2005. *Sacramento River National Wildlife Refuge Final Comprehensive Conservation Plan*. Sacramento (CA): California/Nevada Refuge Planning Office. June 2005.

Wheeler SS, Barker CM, Fang Y, Armijos MV, Carroll BD, Husted S, Johnson WO, Reisen WK. 2009. “Differential Impact of West Nile Virus on California Birds.” Condor Volume 111: Pages 1 to20.