Appendix G. Identification of Target Species and Focused Conservation Plans

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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1.0 Introduction

The purpose of the Conservation Strategy of the Central Valley Flood Protection Plan (CVFPP) is to provide direction for the California Department of Water Resources' (DWR's) environmental stewardship activities related to integrated flood management in the Central Valley, and to provide a framework and support for programmatic permitting of flood management activities.

One goal of the Conservation Strategy is to contribute to the recovery and stability of native species populations and overall biotic community diversity. A set of potential target species was identified to support measurable objectives for this goal. For those target species with the greatest need for recovery of their populations, focused conservation planning was conducted. This appendix documents the process used for selecting the target species of the Conservation Strategy, including 17 target species for which focused conservation planning was conducted. The results of this focused planning are also provided in this appendix, in the form of focused conservation plans. This document is scheduled to be updated every 5 years.

Because the conservation needs of species change, in the future, additional species may become suitable targets for the Conservation Strategy. Therefore, during preparation of the 5-year updates to the CVFPP, the preliminary list of species in this appendix will be reevaluated using the same criteria described below. Species meeting these criteria will be added, and focused conservation plans will be developed for them and included in subsequent updates of the Conservation Strategy. During the public comment period, new information regarding the status of the delta smelt (*Hypomesus transpacificus*) and its habitat use in the Systemwide Planning Area (SPA) was made available, and a recovery plan for the species is expected to be released in 2016; therefore, this species will be considered for inclusion in the 2022 CVFPP and Conservation Strategy. Other species that were considered during the initial screening could be reconsidered, and targeted conservation plans may be developed. These species include the western pond turtle (*Actinemys marmorata*), tricolored blackbird (*Agelaius tricolor*), western red bat (*Lasiurus blossevillii*), and western burrowing owl (*Athene cunicularia hypugaea*).

2.0 Selection of Target Species

Potential target species are those sensitive, native species that could most benefit from implementation of the Conservation Strategy to enhance and restore processes and habitats, primarily because of their strong association with river and floodplain ecosystems of the Sacramento and San Joaquin Valleys. A preliminary list of candidate target species was compiled from the lists of sensitive species potentially affected by implementation of the CVFPP (see the CVFPP program environmental impact report [PEIR]; DWR 2012). The preliminary list was also based on additional review of the California Natural Diversity Database (CNDDB; California Department of Fish and Wildlife [CDFW] 2014) and other information sources (California Native Plant Society [CNPS] 2012; CalFish 2012; California Interagency Wildlife

Task Group 2008; Shuford and Gardali 2008; CALFED Bay-Delta Program 2000). To be selected as a potential target, a species had to satisfy all three of the following criteria:

1. **Sensitive or special-status**—The species must be identified as sensitive or special status in local or regional plans, policies, or regulations; or by CDFW, National Marine Fisheries Service (NMFS), or U.S. Fish and Wildlife Service (USFWS). Species included those listed as threatened or endangered under the federal Endangered Species Act (ESA) or California Endangered Species Act (CESA), candidates for listing, species that are Fully Protected under the California Fish and Game Code, California Species of Special Concern, and species on California Rare Plant Ranks 1A, 1B, and 2.
2. **Associated with target habitats**—The species must require riverine aquatic (including shaded riverine aquatic [SRA] cover), riparian, marsh, or periodically inundated floodplain habitats as the primary habitat for one or more life stages or ecological needs (e.g., reproduction or foraging).
3. **Potential CVFPP effect**—Implementation of the CVFPP, including flood projects and operations and maintenance, could temporarily or permanently affect California populations of the species, based on its distribution, habitat associations, and ecology (effects may be adverse or beneficial).

The application of these criteria to the preliminary list of candidates for target species (summarized in Tables 2-1 and 2-2) was reviewed by biologists from DWR, as well as by biologists with expertise in the riverine, riparian, and fresh water emergent marsh systems of the Sacramento and San Joaquin Valleys. It also was reviewed by the Interagency Advisory Committee (see Section 1.3 of the Conservation Strategy for a description of this advisory committee's composition and role). The resulting list of target species, along with their distribution by Conservation Planning Area (CPA; delineated in the Conservation Strategy), is provided in Table 2-3. The habitat requirements of target species then guided development of the Conservation Strategy's objectives and prioritization of future projects.

3.0 Identification of Target Species for Focused Conservation Planning

For the most part, the Conservation Strategy will achieve benefits for target species through restoration of ecosystem processes and habitats and reduction of stressors related to the flood system. However, a subset of target species have additional, more specialized or localized habitat requirements, or their populations are not primarily restricted by habitat availability. Benefits to these species can be maximized by designing management actions to meet, wherever feasible, the species' specific conservation needs. For example, designing high-water refugia for species sensitive to flood inundation (e.g., riparian brush rabbit) will yield additional benefits at locations identified as critical to a target species. Therefore, to ensure that the Conservation Strategy

Table 2-1. Screening of Animal Species Potentially Affected by CVFPP (including the Conservation Strategy) for Target Species and Focused Conservation Planning

Common Name Scientific Name	Regional Distribution in SPA[a]	Habitats	Status FED/CA[b]	Associated with Target Habitat[c]	Major Potential CVFPP Effect[d]	Potential Target Species[e]	T/E Listed or Potential for T/E Listing[f]	Focused Conservation Needs[g]	Target Species Chosen for Focused Conservation Planning[h]
Invertebrates									
Conservancy fairy shrimp *Branchinecta conservatio*	USR, LSR, LSJR, USJR	Vernal pools, swales, and other ephemeral wetlands	E/-	-	-	No	+	+	No
Lange's metalmark butterfly *Apodemia mormo langei*	LSR	Sand dunes	E/-	-	-	No	+	+	No
Longhorn fairy shrimp *Branchinecta longiantenna*	USJR	Vernal pools, swales, and other ephemeral wetlands	E/-	-	-	No	+	-	No
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	USR, LSR, FR, LSJR,USJR	Elderberries in riparian woodlands or savannas	T/-	+	+	Yes	+	+	Yes
Vernal pool fairy shrimp *Branchinecta lynchi*	USR, LSR, FR, LSJR,USJR	Vernal pools, swales, and other ephemeral wetlands	T/-	-	-	No	+	-	No
Vernal pool tadpole shrimp *Lepidurus packardi*	USR, LSR, LSJR, USJR	Vernal pools, swales, and other ephemeral wetlands	E/-	-	-	No	+	-	No
Fish									
California Central Valley steelhead DPS *Oncorhyncus mykiss*	USR, FR, LSJR, LSJR, USJR	Requires cold, freshwater streams with suitable gravel for spawning; rears seasonally in inundated floodplains, rivers, tributaries, and Delta	T/-	+	+	Yes	+	+	Yes
Central California coast steelhead DPS *Oncorhynchus mykiss*	LSR	Spawn in freshwater streams; adults live and forage in oceanic waters	T/T	+	-	No	+	+	No
Chinook salmon—Central Valley fall-/late-fall-run ESU *Oncorhynchus tshawytscha*	USR, LSR, FR, LSJR,USJR	Requires cold, freshwater streams with suitable gravel for spawning; rears seasonally in inundated floodplains, rivers, tributaries, and Delta	-/CSC	+	+	Yes	-	+	Yes
Chinook salmon—Central Valley spring-run ESU *Oncorhynchus tshawytscha*	USR, LSR, FR, LSJR,USJR	Spawns in freshwater streams and rivers; smolts mature in freshwater streams and later estuarine areas; adults live and forage in oceanic waters and mature in cool, freshwater streams and rivers when not spawning	T/T	+	+	Yes	+	+	Yes
Chinook salmon—Sacramento River winter-run ESU *Oncorhynchus tshawytscha*	LSR, USR	Spawns in freshwater streams and rivers; smolts mature in freshwater streams and later estuarine areas; adults live and forage in oceanic waters and mature in cool, freshwater streams and rivers when not spawning	E/E	+	+	Yes	+	+	Yes
Delta smelt *Hypomesus transpacificus*	LSR, LSJR	Spawns in shallow, fresh, or slightly brackish water upstream of the mixing zone (saltwater-freshwater interface); adults live along the freshwater edge of the mixing zone when not spawning; prior to spawning, adults disperse widely into river channels and tidally influenced backwater sloughs	T/E	+	+	Yes	+	+	No
Green sturgeon—Southern DPS *Acipenser medirostris*	USR, FR, LSR, LSJR,	Spawns in deep pools in large, turbulent, freshwater river mainstems; adults live and forage in oceanic waters, bays, and estuaries when not spawning	T/CSC	+	+	Yes	+	+	Yes
Hardhead *Mylopharodon conocephalus*	USR, LSR FR, LSJR, USJR,	Spawns in pools and side pools of rivers and creeks; juveniles rear in pools of rivers and creeks, and shallow to deeper water of lakes and reservoirs	-/CSC	+	-	No	-	-	No

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Longfin smelt *Spirinchus thaleichthys*	LSR, LSJR	Typically spawns in freshwater and moves downstream to brackish water to rear.	-/T	+	-	Yes	+	-	No
Sacramento splittail *Pogonichthys macrolepidotus*	FR, USR, LSR, LSJR	Generally lives in areas of low to moderate current; uses floodplain habitat for feeding and spawning	-/-	+	+	Yes	-	-	No
San Joaquin roach *Lavinia symmetricus*	LSJR, USJR	Spawns in pools and side pools of small rivers and creeks; juveniles rear in pools of small rivers and creeks	-/CSC	+	-	No	-	-	No
Amphibians									
California red-legged frog *Rana draytonii*	LSJR	Permanent or ephemeral water sources, including lakes, ponds, reservoirs, slow streams, marshes, bogs, and swamps from sea level to 5,000 feet in woodlands, grasslands, and riparian areas	T/CSC	+	-	No	+	-	No
California tiger salamander *Ambystoma californiense*	LSR, FR, LSJR, USJR	Restricted to vernal pools and seasonal ponds, including many constructed stock ponds, in grassland and oak savannah plant communities, predominantly from sea level to 2,000 feet in elevation	T/T	-	-	No	+	+	No
Foothill yellow-legged frog *Rana boylii*	USR	Streams and rivers with rocky substrate and open, sunny banks, in forests, chaparral, and woodlands from sea level to 6,700 feet; sometimes found in isolated pools, vegetated backwaters, and deep, shaded, spring-fed pools	-/CSC	+	-	No	-	-	No
Northern leopard frog *Lithobates pipiens*	USJR	Grasslands, wet meadows, potholes, forests, woodland, brushlands, springs, canals, bogs, marshes, and reservoirs from sea level to 11,000 feet; generally prefers permanent water with abundant aquatic vegetation	-/CSC	+	-	No	-	-	No
Shasta salamander *Hydromantes shastae*	USR	Mixed conifer, woodland, and chaparral habitats, especially near limestone	-/T	-	-	No	+	-	No
Western spadefoot *Spea hammondii*	USR, LSR, FR, LSJR,USJR	Grasslands, scrub, chaparral, and occasionally oak woodlands in proximity to aquatic habitat such as vernal pools, wetlands, and low-gradient streams.	-/CSC	-	-	No	-	-	No
Reptiles									
Alameda whipsnake *Masticophis lateralis euryxanthus*	LSJR	Chaparral (northern coastal sage scrub and coastal sage), up to 500 feet into adjacent habitats, including grassland, oak savanna, and occasionally oak-bay woodland	T/T	-	-	No	+	-	No
Blunt-nosed leopard lizard *Gambelia sila*	USJR	Semiarid grasslands, alkali flats, and washes of the San Joaquin Valley and foothills	E/E, FP	-	-	No	+	-	No
Coast horned lizard *Phrynosoma blainvillii*	LSR,FR, LSJR, USJR	Grasslands, brushlands, woodlands, and open coniferous forests	-/CSC	-	-	No	-	-	No
Giant garter snake *Thamnophis gigas*	USR, LSR, FR, LSJR, USJR	Marshes, sloughs, drainage canals, and irrigation ditches, especially around rice fields, and occasionally in slow-moving creeks from sea level to 400 feet; prefers locations with vegetation close to the water for basking	T/T	+	+	Yes	+	+	Yes
San Joaquin coachwhip *Masticophis flagellum ruddocki*	USR, LSR,LSJR, USJR	Open, dry vegetation in valley grasslands and saltbush scrub	-/CSC	-	-	No	-	-	No
Silvery legless lizard *Anniella pulchra pulchra*	LSJR, USJR	Moist, warm, loose soil with plant cover in sparsely vegetated areas of beach dunes, chaparral, woodlands, desert scrub, sandy washes, and stream terraces	-/CSC	+	-	No	-	-	No
Western pond turtle *Actinemys marmorata*	USR, LSR, FR,LSJR, USJR	Ponds, lakes, rivers, streams, creeks, marshes, and irrigation ditches with abundant vegetation and either rocky or muddy bottoms, in woodland, forest, and grassland	-/CSC	+	+	Yes	-	-	No

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Birds									
American peregrine falcon *Falco peregrinus anatum*	USR, LSR, FR, LSJR, USJR	*Nesting:* high rocky cliffs or other high structures *Foraging:* a variety of open habitats, particularly marshes and other wetlands	D/D, FP	+	-	No	-	-	No
Bald eagle *Haliaeetus leucocephalus*	FR	*Foraging:* large bodies of water or free-flowing rivers with abundant fish and adjacent snags or other perches *Nesting:* large, old-growth trees or snags in remote, mixed stands near water	D/E, FP	+	-	No	+	-	No
Bank swallow *Riparia riparia*	USR, LSR, FR	*Foraging:* open riparian areas, grassland, wetlands, water, and cropland *Nesting:* vertical banks and cliffs with fine-textured or sandy friable soils near streams, rivers, ponds, and lakes	-/T	+	+	Yes	+	+	Yes
Black swift *Cypseloides niger*	FR, LSR, LSJR	*Nesting:* canyon walls near water and sheltered by overhanging rock or moss, preferably near waterfalls *Foraging*: over a wide variety of habitats, sometimes far from nests	-/CSC	+	-	No	-	-	No
Black tern *Chlidonias niger*	LSR, LSJR, USJR	*Foraging and nesting:* freshwater emergent wetlands, marshes, lakes, ponds, moist grasslands, and agricultural fields	-/CSC	+	-	No	-	-	No
California black rail *Laterallus jamaicensis coturniculus*	LSR, LSJR	*Foraging and nesting:* tidal emergent wetlands dominated by pickleweed, in the high wetland zones near upper limit of tidal flooding, or in brackish marshes supporting bulrushes and pickleweed; in freshwater, usually found in bulrushes, cattails, and saltgrass adjacent to tidal sloughs	-/T, FP	+	+	Yes	+	+	Yes
Ferruginous hawk (wintering) *Buteo regalis*	USR, LSR, FR, LSJR, USJR	*Foraging:* open grasslands and agricultural fields *Nesting:* does not breed in SPA	-/CSC	-	-	No	-	-	No
Golden eagle *Aquila chrysaetos*	USR, LSR, FR, LSJR, USJR	Inhabits a variety of habitats, including forests, canyons, shrublands, grasslands, and oak woodlands	-/FP	-	-	No	-	-	No
Grasshopper sparrow *Ammodramus savannarum*	USR, LSR, FR, LSJR, USJR	*Nesting and foraging:* short to middle-height, moderately open grasslands with scattered shrubs	-/CSC	-	-	No	-	-	No
Greater sandhill crane *Grus canadensis tabida*	USR, LSR, FR, LSJR, USJR	*Foraging:* open grasslands, grain fields, and open wetlands *Roosting:* in flocks standing in moist fields or in shallow water *Nesting:* does not breed in SPA	-/T, FP	+	+	No	+	+	Yes
Least Bell's vireo *Vireo bellii pusillus*	USR[j], LSR[j], FR[j], LSJR, USJR[j]	*Foraging and nesting:* low, dense riparian growth along water or along dry parts of intermittent streams	E/E	+	-	Yes	+	+	Yes
Least bittern *Ixobrychus exilis*	LSJR, LSR, USJR, USR	*Foraging and nesting:* freshwater and brackish marshes with tall, dense emergent vegetation and clumps of woody plants over deep water	-/CSC	+	+	Yes	-	-	No
Lesser sandhill crane *Grus canadensis*	LSJR, LSR, FR, USJR, USR	*Foraging:* pastures, moist grasslands, alfalfa fields, and shallow wetlands *Nesting:* does not breed in California	-/CSC	+	+	Yes	-	+	No
Little willow flycatcher *Empidonax traillii brewsteri*	FR, USR	*Foraging:* willow thickets and adjacent meadows. *Nesting:* extensive thickets of low, dense willows at edge of wet meadows, ponds, or backwaters	-/E	+	+	Yes	+	-	No

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Loggerhead shrike *Lanius ludovidianus*	USR, LSR, FR, LSJR, USJR	*Foraging:* grasslands and agricultural fields *Nesting:* scattered shrubs and trees	-/CSC	-	-	No	-	-	No
Mountain plover *Charadrius montanus*	USR, LSR, USJR	*Foraging*: fallow, grazed or burned fields with short and sparse vegetation cover *Nesting:* does not breed in California	-/CSC	-	-	No	+	-	No
Northern harrier *Circus cyaneus*	USR, LSR, FR, LSJR, USJR	*Foraging and nesting:* tall grasses and forbs in emergent wetland, along rivers or lakes, grasslands, grain fields, or on sagebrush flats several miles from water	-/CSC	+	-	No	-	-	No
Purple martin *Progne subis*	LSJR, LSR	*Foraging:* conifer, woodland, and riparian habitats *Nesting:* snags in old-growth, multilayered, open forests and woodlands	-/CSC	+	-	No	-	-	No
Redhead *Aythya americana*	LSR, LSJR, USJR	*Nesting:* freshwater emergent wetlands where dense stands of cattails and tules are interspersed with areas of deep, open water *Foraging:* large, deep bodies of water	-/CSC	+	+	Yes	-	-	No
Short-eared owl *Asio flammeus*	USR, LSR, FR, LSJR, USJR	*Foraging and nesting:* open prairies, coastal grasslands, marshes, bogs, savanna, and dunes	-/CSC	+	-	No	-	-	No
Suisun song sparrow *Melospiza melodia maxillaries*	LSJR, LSR	*Foraging:* the bare surface of tidally exposed mud among tules and along slough margins in brackish marshes *Nesting:* along edges of sloughs and bays supporting mixed stands of bulrush, cattail, and other emergent vegetation	-/CSC	+	-	No	-	+	No
Swainson's hawk *Buteo swainsoni*	USR, LSR, FR, LSJR, USJR	*Foraging:* open desert, grassland, or cropland containing scattered, large trees or small groves *Nesting:* open riparian habitat, in scattered trees or small groves in sparsely vegetated flatlands; usually found near water in the Central Valley	-/T	+	+	Yes	+	+	Yes
Tricolored blackbird *Agelaius tricolor*	USR, LSR, FR, LSJR, USJR	*Foraging:* on ground in croplands, grassy fields, flooded land, and along edges of ponds *Nesting:* dense cattails, tules, or thickets near freshwater	-/C	+	+	Yes	-	-	No
Western burrowing owl *Athene cunicularia hypugaea*	USR, LSR, LSJR, USJR	*Foraging and nesting*: grasslands and agricultural fields	-/CSC	-	-	No	-	-	No
Western snowy plover *Charadrius alexandrinus nivosus*	LSR, USJR	*Foraging and nesting:* above the high-tide line on coastal beaches, sand spits, dune-backed beaches, sparsely vegetated dunes, beaches at creek and river mouths, and salt pans at lagoons and estuaries	T/CSC	+	-	No	+	-	No
Western yellow-billed cuckoo *Coccyzus americanus occidentalis*	USR, LSR, FR, LSJR[j], USJR[j]	*Foraging and nesting:* extensive deciduous riparian thickets or forests with dense, low-level or understory foliage adjacent to slow-moving watercourses, backwaters, or seeps; willow is almost always a dominant component of the vegetation. In the Sacramento Valley, also rarely uses adjacent walnut orchards; prefers sites with a dominant cottonwood overstory for foraging	T/E	+	+	Yes	+	+	Yes
White-tailed kite *Elanus leucurus*	USR	*Foraging:* undisturbed, open grasslands, meadows, farmlands, and emergent wetlands *Nesting:* large groves of dense, broad-leafed deciduous trees close to foraging areas	-/FP	+	-	No	-	-	No
Yellow-breasted chat *Icteria virens*	USR, LSR[j], FR, LSJR[j], USJR[j]	*Foraging and nesting:* riparian thickets of willow and other brushy thickets near streams or other watercourses	-/CSC	+	+	Yes	-	-	No

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Yellow-headed blackbird *Xanthocephalus xanthocephalus*	LSR, LSJR, USJR	*Foraging:* freshwater emergent wetland and sometimes along shorelines and in nearby open fields, preferably on moist ground *Nesting:* dense emergent wetland of cattails and tules, often along border of lake or pond	-/CSC	+	+	Yes	-	-	No
Yellow warbler *Dendroica petechia*	USJR, USR, LSR[i] FR, LSJR[i], USJR[i]	*Foraging and nesting*: low to midstory, open-canopy riparian deciduous woodlands with a heavy brush understory; sometimes in montane shrubbery in open conifer forests	-/CSC	+	+	Yes	-	-	No
Mammals									
American badger *Taxidea taxus*	USR, LSR, FR, LSJR, USJR	Drier open states of most scrub, forest, and herbaceous habitats with friable soils	-/CSC	-	-	No	-	-	No
Fresno kangaroo rat *Dipodomys nitratoides exilis*	USJR	Alkali desert scrub habitats between 200 and 300 feet elevation	E/E	-	-	No	+	-	No
Giant kangaroo rat *Dipodomys ingens*	USJR	Annual grasslands and shrub habitats with sparse vegetative cover	E/E	-	-	No	+	-	No
Hoary bat *Lasiurus cinereus*	USR, LSR, FR, LSJR, USJR	*Foraging:* over open areas and lakes *Roosting:* in trees, prefers woodlands and coniferous forests; noncolonial	-/-	+	-	No	-	-	No
Nelson's antelope squirrel *Ammospermophilus nelsoni*	USR	Arid grasslands with loamy soils and moderate shrub cover	-/T	-	-	No	+	-	No
Pallid bat *Antrozous pallidus*	USR, LSR	*Foraging:* over water in mixed conifer forests and conifer woodlands *Roosting:* in rocky outcrops, cliffs, and crevices	-/-	+	-	No	-	-	No
Ringtail *Bassariscus astutus*	FR, USR, LSR	Prefers rocky mountain and canyon areas, but also occurs in desert, woodland, and forest habitats	-/FP	+	-	No	-	-	No
Riparian brush rabbit *Sylvilagus bachmani riparius*	LSJR	Riparian woodlands dominated by oaks with a dense understory of wild roses, grapes, and blackberries	E/E	+	+	Yes	+	+	Yes
Riparian (= San Joaquin Valley) woodrat *Neotoma fuscipes riparia*	LSJR	Riparian habitats with associated evergreen and deciduous oak with dense understories; willow thickets	E/CSC	+	+	Yes	+	+	Yes
Sacramento Valley red fox *Vulpes vulpes patwin*	FR, USR	Grasslands	-/-	-	-	No	+	-	No
San Joaquin kit fox *Vulpes macrotis mutica*	USJR	Saltbush scrub, grasslands, oak savannas, and freshwater scrub	E/T	-	-	No	+	-	No
Salt-marsh harvest mouse *Reithrodontomys raviventris*	LSR, LSJR	Salt marsh dominated by pickleweed and salt grass; generally requires non-submerged, salt-tolerant vegetation for escape during high tides	E/E, FP	+	-	No	+	-	No
Spotted bat *Euderma maculatum*	USR, USJR	*Foraging:* over water and along washes in deserts, grasslands, and mixed conifer forests from below sea level to above 10,000 feet *Roosting:* in rock crevices in cliffs	-/CSC	+	-	No	-	-	No
Townsend's big-eared bat *Plecotus townsendii*	USR, LSR, FR, LSJR, USJR	*Foraging:* along edges of a variety of habitats *Roosting:* in caves, tunnels, mines, trees, and buildings	-/C	+	-	No	-	-	No

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Western mastiff bat *Eumops perotis californicus*	USR, USJR	*Foraging:* over water in broad, open areas of mixed conifer forests and conifer/ woodlands *Roosting:* in crevices in vertical cliffs, usually granite or consolidated sandstone, and in broken terrain with exposed rock faces	-/CSC	+	-	No	-	-	No
Western red bat *Lasiurus blossevilii*	USR, LSR, FR, LSJR, USJR	*Foraging:* over water edges in open areas of mixed conifer and conifer/woodlands *Roosting:* in trees along edges or in habitat mosaics in a variety of habitats	-/CSC	+	-	No	-	-	No

Sources: CDFW 2014; Shuford and Gardali 2008; California Interagency Wildlife Task Group 2008.

Key:
CVFPP = Central Valley Flood Protection Plan
DPS = Distinct Population Segment
ESU= Evolutionarily Significant Unit
SPA = Systemwide Planning Area

Notes:

[a] **Regional Distribution in SPA**
FR = CVFPP Feather River Implementation Region
LSJR = Mid–San Joaquin, Lower San Joaquin, and Delta-South CVFPP Implementation Regions
LSR = Lower Sacramento River and Delta-North CVFPP Implementation Regions
USJR = Upper Sacramento River CVFPP Implementation Region
USR = Upper Sacramento River and Mid-Sacramento River CVFPP Implementation Regions
Distribution in upstream SPA aquatic and floodplain habitats is included in immediately downstream CVFPP Implementation Region.

[b] **Status FED/CA**
Federal
- = No listing
C = Candidate for listing under the federal Endangered Species Act (ESA)
E = listed as endangered under ESA
T = Listed as threatened under ESA
D = Delisted under ESA

California
- = No listing
C = Candidate for listing under the California Endangered Species Act (CESA)
E = Listed as endangered under CESA
T = Listed as threatened under CESA
FP = Fully protected under the California Fish and Game Code
CSC = California Species of Special Concern
D = Delisted under CESA

[c] **Associated with Target Habitat**
+ = Species is associated with riverine aquatic (including shaded riverine aquatic), riparian, perennial wetland, or periodically inundated floodplain habitats.

[d] **Major Potential CVFPP Effect**
+ = Implementation of the CVFPP (flood management and conservation actions) could substantially affect California populations of species, based on distribution, habitat associations, and ecology of species. Effects may be adverse or beneficial.

[e] **Target Species**
Yes = Species both associated with a target habitat and could be substantially affected by CVFPP implementation.
No = Species either not associated with a target habitat or not substantially affected by CVFPP implementation.
Target species are species with greatest potential to benefit from or be adversely affected by CVFPP implementation.

[f] **Potential for T/E Listing**
+ = Species is currently State- or federally listed as threatened or endangered, or has high potential of being listed during the next 5–10 years.

[g] **Focused Conservation Needs**
+ = Species has restricted distribution in SPA, requires habitat elements with restricted distribution (e.g., cut banks), or requires large-scale connectivity of habitat features for completion of life cycle.

[h] **Focused Conservation Planning**
Yes = Species is a target species with listing potential and focused conservation needs.
No = Species is not a target species, or does not have listing potential or focused conservation needs.
Focused conservation planning addresses specific conservation needs that otherwise may not be met by restoration of ecological processes and habitats within each region.

[i] Potential distribution based on historic records or poorly known

Table 2-2. Screening of Plant Species Potentially Affected by CVFPP (including the Conservation Strategy) for Target Species and Focused Conservation Planning

Common Name Scientific Name	Regional Distribution in SPA[a]	Habitats	Status FED/CA/CRPR[b]	Associated with Target Habitat[c]	Major Potential CVFPP Effect[d]	Potential Target Species[e]	T/E Listed or Potential for T/E Listing[f]	Focused Conservation Needs[g]	Target Species Chosen for Focused Conservation Planning[h]
Ferris' milk-vetch *Astragalus tener* var. *ferrisiae*	FR, USR, LSR	Meadows and seeps, valley and foothill grassland (subalkaline flats)	-/-/1B.1	+	-	No	-	-	No
Alkali milk-vetch *Astragalus tener* var. *tener*	LSR, LSJR, USJR	Meadows and seeps, mesic valley and foothill grassland; generally alkaline, clay soils	-/-/1B.2	+	-	No	-	-	No
Heartscale *Atriplex cordulata* var. *cordulata*	FR, USR, LSR, LSJR, USJR	Chenopod scrub, meadows and seeps, sandy areas within valley and foothill grassland; saline or alkaline soils	-/-/1B.2	+	-	No	-	-	No
Lost Hills crownscale *Atriplex coronata* var. *vallicola*	USJR	Chenopod scrub, valley and foothill grassland, vernal pools; alkaline soils	-/-/1B.2	+	-	No	-	-	No
Brittlescale *Atriplex depressa*	USR, LSR	Chenopod scrub, meadows and seeps, playas, valley and foothill grassland, vernal pools; alkaline, clay soils	-/-/1B.2	+	-	No	-	-	No
San Joaquin spearscale *Atriplex joaquiniana*	USR, LSR, LSJR	Chenopod scrub, meadows and seeps, playas, valley and foothill grassland; alkaline soils	-/-/1B.2	+	-	No	-	-	No
Lesser saltscale *Atriplex minuscula*	FR, LSJR, USJR	Chenopod scrub, playas, valley and foothill grassland; sandy, alkaline soils	-/-/1B.1	-	-	No	+	-	No
Vernal pool smallscale *Atriplex persistens*	USR, LSR, LSJR, USJR	Vernal pools; alkaline soils	-/-/1B.2	-	-	No	-	-	No
Subtle orache *Atriplex subtilis*	FR, USR, USJR, LSJR	Valley and foothill grassland	-/-/1B.2	-	-	No	+	-	No
Big tarplant *Blepharizonia plumosa*	LSJR	Valley and foothill grassland; generally clay soils	-/-/1B.1	-	-	No	+	-	No
Watershield *Brasenia schreberi*	USR, LSR, LSJR	Marshes	-/-/2.3	+	-	No	-	-	No
Round-leaved filaree *California macrophylla*	USR, LSJR	Cismontane woodland, valley and foothill grassland; often clay soils	-/-/1B.1	-	-	No	+	-	No
Bristly sedge *Carex comosa*	LSR, LSJR	Marshes, valley and foothill grassland, coastal prairie	-/-/2.1	+	-	No	-	-	No
Pink creamsacs *Castilleja rubicundula* ssp. *rubicundula*	USR, FR	Openings in chaparral, cismontane woodland, meadows and seeps; serpentine soils in valley and foothill grassland	-/-/1B.2	+	-	No	-	-	No
Pappose tarplant *Centromadia parryi* ssp. *parryi*	FR	Mesic areas in coastal prairie, meadow, and grassland habitats; often alkaline substrates	-/-/1B.2	-	-	No	-	-	No
Hoover's spurge *Chamaesyce hooveri*	USR	Vernal pools	T/-/1B.2	-	-	No	+	-	No
Hispid bird's-beak *Chloropyron molle* ssp. *hispidum*	USJR	Mesic, alkaline soils in meadows and seeps, playas, and valley and foothill grassland	-/-/1B.1	+	-	No	-	-	No
Soft bird's-beak *Chloropyron molle* ssp. *molle*	LSR	Saline and brackish marshes	E/R/1B.2	+	-	No	+	-	No

Table 2-2. Screening of Plant Species Potentially Affected by CVFPP (including the Conservation Strategy) for Target Species and Focused Conservation Planning

Common Name Scientific Name	Regional Distribution in SPA[a]	Habitats	Status FED/CA/CRPR[b]	Associated with Target Habitat[c]	Major Potential CVFPP Effect[d]	Potential Target Species[e]	T/E Listed or Potential for T/E Listing[f]	Focused Conservation Needs[g]	Target Species Chosen for Focused Conservation Planning[h]
Palmate-bracted bird's-beak *Chloropyron palmatum*	USR, LSR, LSJR, USJR	Chenopod scrub, valley and foothill grassland; generally alkaline soils	E/E/1B.1	-	-	No	+	-	No
Bolander's water-hemlock *Cicuta maculata* var. *bolanderi*	LSR	Marshes, margins of water bodies, and valley and foothill grassland	-/-/2.1	+	-	No	-	-	No
Slough thistle *Cirsium crassicaule*	LSJR, USJR[i]	Chenopod scrub, riparian scrub, and marshes within sloughs	-/-/1B.1	+	+	Yes	+	+	Yes
Silky cryptantha *Cryptantha crinita*	USR	Gravelly streambeds in cismontane woodland, lower montane coniferous forest, riparian forest, riparian woodland, and valley and foothill grassland	-/-/1B.2	+	-	No	-	-	No
Hoover's cryptantha *Cryptantha hooveri*	USJR	Valley and foothill grassland, inland dunes; sandy soils	-/-/1A	-	-	No	-	-	No
Peruvian dodder *Cuscuta obtusifloraolia* var. *glandulosa*	USR, LSR	Fresh and brackish marshes	-/-/2.21	+	-	No	-	-	No
Recurved larkspur *Delphinium recurvatum*	FR, USR, LSJR, USJR	Chenopod scrub, cismontane woodland, valley and foothill grassland; generally alkaline substrates	-/-/1B.2	-	-	No	-	-	No
Dwarf downingia *Downingia humilis*	USR, LSR, USJR	Vernal pools, mesic valley and foothill grassland	-/-/2.2	-	-	No	-	-	No
Delta button-celery *Eryngium racemosum*	LSJR, USJR	Vernally mesic clay depressions in riparian scrub	-/E/1B.1	+	+	Yes	+	+	Yes
Adobe-lily *Fritillaria pluriflora*	USR	Chaparral, cismontane woodland, valley and foothill grassland; often “adobe” clay soils	-/-/1B.2	-	-	No	-	-	No
Bogg’s Lake hedge-hyssop *Gratiola heterosepala*	USR, LSR	Marshes along lake margins, vernal pools on clay soils	-/E/1B.2	+	-	No	+	-	No
Woolly rose-mallow *Hibiscus lasiocarpos* var. *occidentalis*	FR, USR, LSR, LSJR	Freshwater marshes	-/-/1B.2	+	+	Yes	-	-	No
California satintail *Imperata brevifolia*	USJR	Chaparral, coastal scrub, Mojave desert scrub, meadows and seeps (often alkali), and riparian scrub	-/-/2.1	+	-	No	-	-	No
Carquinez goldenbush *Isocoma arguta*	LSR	Valley and foothill grassland; generally alkaline soils	-/-/1B.1	-	-	No	-	-	No
Northern California black walnut *Juglans hindsii*	LSR	Riparian forest and woodland	-/-/1B.1	+	-	No	-	+	No
Coulter's goldfields *Lasthenia glabrata* ssp. *coulteri*	USR, USJR	Coastal salt marshes, playas, vernal pools	-/-/1B.1	-	-	No	+	-	No
Delta tule pea *Lathyrus jepsonii* var. *jepsonii*	LSR, LSJR[i]	Freshwater or brackish water marshes	-/-/1B.2	+	+	Yes	-	-	No
Munz's tidy-tips *Layia munzii*	USR	Chenopod scrub, valley and foothill grassland; generally alkaline clay soils	-/-/1B.2	-	-	No	-	-	No

Table 2-2. Screening of Plant Species Potentially Affected by CVFPP (including the Conservation Strategy) for Target Species and Focused Conservation Planning

Common Name Scientific Name	Regional Distribution in SPA[a]	Habitats	Status FED/CA/CRPR[b]	Associated with Target Habitat[c]	Major Potential CVFPP Effect[d]	Potential Target Species[e]	T/E Listed or Potential for T/E Listing[f]	Focused Conservation Needs[g]	Target Species Chosen for Focused Conservation Planning[h]
Colusa layia *Layia septentrionalis*	USR	Chaparral, cismontane woodland, valley and foothill grassland; sandy or serpentine substrates	-/-/1B.2	-	-	No	-	-	No
Legenere *Legenere limosa*	USR[i], LSR	Vernal pools, margins of water bodies, valley grassland	-/-/1B.1	+	-	No	+	-	No
Heckard's pepper-grass *Lepidium latipes* var. *heckardii*	USR, LSJR	Valley and foothill grassland; alkaline soils, wetland riparian	-/-/1B.2	-	-	No	-	-	No
Mason's lilaeopsis† *Lilaeopsis masonii*	LSR, LSJR	Freshwater or brackish water marshes and swamps, riparian scrub	-/-/1B.1	+	-	Yes	+	+	No
Butte County meadowfoam *Limnanthes floccosa* ssp. *californica*	FR, USR	Vernal pools and mesic valley and foothill grassland	E/E/1B.1	-	-	No	+	+	No
Delta mudwort *Limosella subulata*	LSR, LSJR	Freshwater marshes	-/-/2.1	+	+	Yes	-	-	No
Veiny monardella *Monardella venosa*	FR	Cismontane woodland and valley and foothill grassland; generally clay soils	-/-/1B.1	-	-	No	+	-	No
Baker's navarretia *Navarretia leucocephala* ssp. *bakeri*	FR, USR, LSR	Mesic soils in cismontane woodland, lower montane coniferous forest, meadows and seeps, valley and foothill grassland, vernal pools	-/-/1B.1	+	-	No	+	-	No
Prostrate vernal pool navarretia *Navarretia prostrata*	USJR	Mesic areas in coastal scrub, meadows and seeps, alkaline soils of valley and foothill grassland, vernal pools	-/-/1B.1	+	-	No	+	-	No
Colusa grass *Neostapfia colusana*	USR, LSR, USJR	Vernal pools	T/E/1B.1	-	-	No	+	-	No
Antioch Dunes evening-primrose *Oenothera deltoides* ssp. *howellii*	LSR	Inland dunes	E/E/1B.1	-	-	No	+	+	No
Bearded popcorn-flower *Plagiobothrys hystriculus*	LSR	Vernal pools and mesic valley and foothill grassland	-/-/1B.1	-	-	No	+	-	No
Eel-grass pondweed *Potamogeton zosteriformis*	LSR, LSJR	Marshes and shallow aquatic habitats	-/-/2.2	+	-	No	-	-	No
Hartweg's golden sunburst *Pseudobahia bahiifolia*	FR, USR	Valley and foothill grassland and cismontane woodland; often acidic, clay soils	E/E/1B.1	-	-	No	+	-	No
California beaked-rush *Rhynchospora californica*	USR	Bogs and fens, lower montane coniferous forest, meadows and seeps, marshes and swamps	-/-/1B.1	+	-	No	+	-	No
Sanford's arrowhead *Sagittaria sanfordii*	FR, USR, LSR, LSJR, USJR	Shallow freshwater aquatic habitats and marshes	-/-/1B.2	+	+	Yes	-	-	No
Marsh skullcap *Scutellaria galericulata*	LSR, LSJR	Marshes, seeps, mesic meadows, and lower montane coniferous forests	-/-/2.2	+	-	No	-	-	No
Side-flowering skullcap *Scutellaria lateriflora*	LSR, LSJR	Marshes, seeps, and mesic meadows	-/-/2.2	+	-	No	-	-	No

Table 2-2. Screening of Plant Species Potentially Affected by CVFPP (including the Conservation Strategy) for Target Species and Focused Conservation Planning

Common Name Scientific Name	Regional Distribution in SPA[a]	Habitats	Status FED/CA/CRPR[b]	Associated with Target Habitat[c]	Major Potential CVFPP Effect[d]	Potential Target Species[e]	T/E Listed or Potential for T/E Listing[f]	Focused Conservation Needs[g]	Target Species Chosen for Focused Conservation Planning[h]
Prairie wedge grass *Sphenopholis obtusata*	LSJR	Seeps, meadows, and cismontane woodland	-/-/2.2	+	-	No	-	-	No
Slender-leaved pondweed *Stuckenia filiformis*	USR, USJR	Shallow freshwater aquatic habitats, and marshes	-/-/2.2	+	-	No	-	-	No
Suisun Marsh aster *Symphyotrichum lentum*	USR[i], LSR, FR[i], LSJR	Freshwater and brackish water marshes	-/-/1B.2	+	+	Yes	-	-	No
Crampton's tuctoria or Solano grass *Tuctoria mucronata*	LSR	Valley grassland, Vernal pools	E/E/1B.1	-	-	No	+	-	No
Wright's trichocoronis *Tricocoronis wrightii* var. *wrightii*	USR, USJR, LSJR	Marshes, riparian forest, vernal pools, seeps, and meadows	-/-/2.1	+	-	No	-	-	No
Brazilian watermeal *Wolffia brasiliensis*	USR, FR	Shallow freshwater habitats, marshes	-/-/2.3	+	-	No	-	-	No

Sources: CDFW 2014; California Native Plant Society 2012.

Key:
CNPS = California Native Plant Society
CVFPP = Central Valley Flood Protection Plan
SPA = Systemwide Planning Area

Notes:

[a] **Regional Distribution in SPA**
FR = CVFPP Feather River Implementation Region
LSJR = Mid-San Joaquin, Lower San Joaquin, and Delta-South CVFPP Implementation Regions
LSR = Lower Sacramento River and Delta-North CVFPP Implementation Regions
USJR = Upper Sacramento River CVFPP Implementation Region
USR = Upper Sacramento River and Mid-Sacramento River CVFPP Implementation Regions
Distribution in upstream SPA aquatic and floodplain habitats is included in immediately downstream CVFPP Implementation Region.

[b] **Status FED/CA**
Federal
- = No listing
E = Listed as endangered under the federal Endangered Species Act (ESA)
T = Listed as threatened under ESA
California
- = No listing
E = Listed as endangered under the California Endangered Species Act (CESA)
T = Listed as threatened under CESA
FP = Fully protected under the California Fish and Game Code
CSC = California Species of Special Concern
R = Listed as rare under the Native Plant Protection Act
California Rare Plant Rank (CRPR)
1A = Presumed extinct
1B = Plants, rare, threatened, or endangered in California and elsewhere
2 = Fairly endangered in California, but more common elsewhere
Extensions:
.1 = Seriously endangered in California
.2 = Fairly endangered in California
.3 = Not very endangered in California

[c] **Associated with Target Habitat**
+ = Species is associated with riverine aquatic (including shaded riverine aquatic), riparian, perennial wetland, and/or periodically inundated floodplain habitats.

[d] **Major Potential CVFPP Effect**
+ = Implementation of CVFPP (flood management and conservation actions) could substantially affect California populations of species, based on distribution, habitat associations, and ecology of species. Effects may be adverse or beneficial.

[e] **Target Species**
Yes = Species both associated with a target habitat and could be substantially affected by CVFPP implementation
No = Species either not associated with a target habitat or not substantially affected by CVFPP implementation
Target species are species with greatest potential to benefit from or be adversely affected by CVFPP implementation.

[f] **Potential for T/E Listing**
+ = Species is currently state- or federally listed as threatened or endangered, or has high potential of being listed during the next 5–10 years (i.e., CNPS List 1B.1 plants).

[g] **Focused Conservation Needs**
+ = Species has restricted distribution in SPA, requires habitat elements with restricted distribution (e.g., cut banks), or requires large-scale connectivity of habitat features for completion of life cycle.

[h] **Focused Conservation Planning**
Yes = Species is a target species with listing potential and focused conservation needs.
No = Species is not a target species, or does not have listing potential or focused conservation needs.
Focused conservation planning addresses specific conservation needs that otherwise may not be met by enhancement and restoration of ecological processes and habitats within each region.

† **Mason's lilaeopsis:** recent genetic research does not support the status of *L. masonii* as a distinct taxon; rather, that it is part of a widespread, common species ranging into the Pacific Northwest (Fiedler et al. 2011).

Table 2-3. Distribution of Proposed Target Species and Focused Conservation Plans

Species	Conservation Planning Area				
	USR	FR	LSR	USJR	LSJR
Delta button-celery *Eryngium racemosum*				✓	✓
Slough thistle *Cirsium crassicaule*				✓[1]	✓
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	✓	✓	✓	✓	✓
California Central Valley steelhead DPS *Oncorhyncus mykiss*	✓	✓	✓	✓[1]	✓
Chinook salmon—Central Valley fall-/late fall–run ESU *Oncorhynchus tshawytscha*	✓	✓	✓	✓[1]	✓
Chinook salmon—Central Valley spring-run ESU *Oncorhynchus tshawytscha*	✓	✓	✓	✓[1]	✓
Chinook salmon—Sacramento River winter-run ESU *Oncorhynchus tshawytscha*	✓		✓		
Green sturgeon—Southern DPS *Acipenser medirostris*	✓	✓	✓		✓
Giant garter snake *Thamnophis gigas*	✓	✓	✓	✓	✓
Bank swallow *Riparia riparia*	✓	✓	✓		
California black rail *Laterallus jamaicensis coturniculus*			✓		✓
Greater sandhill crane *Grus canadensis tabida*	✓	✓	✓	✓	✓
Least Bell's vireo *Vireo bellii pusillus*	✓[1]	✓[1]	✓[1]	✓[1]	✓
Swainson's hawk *Buteo swainsoni*	✓	✓	✓	✓	✓
Western yellow-billed cuckoo *Coccyzus americanus occidentalis*	✓	✓	✓[1]	✓[1]	✓[1]
Riparian brush rabbit *Sylvilagus bachmani riparius*					✓
Riparian (= San Joaquin Valley) woodrat *Neotoma fuscipes riparia*					✓

Source: DWR, compiled for this document

Key: FR = Feather River; LSR = Lower Sacramento River; LSJR = Lower San Joaquin River; USJR = Upper San Joaquin River; USR = Upper Sacramento River

Note:

[1] Potential distribution based on historic records or poorly known.

contributes to the recovery of such species, focused conservation plans were prepared for target species that met the following additional criteria:

1. **Existing or potential status as threatened or endangered**—Species is currently State- or federally listed as threatened or endangered, or has a high potential of being listed during the next 5–10 years (e.g., species with California Rare Plant Rank 1B.1 status).
2. **Specialized or localized conservation requirements**—Species has conservation needs unlikely to be met without focused measures because of restricted range (e.g., riparian brush rabbit), specialized habitat requirements (e.g., bank swallow), or landscape-level habitat requirements, such as proximity of nesting and breeding habitat or connectivity of multiple habitats (e.g., Swainson's hawk and giant garter snake).
3. **Need for additional conservation planning to support the Conservation Strategy**—Other conservation plans do not address the relationship between the species' conservation needs and flood management activities in sufficient detail to support the development of the Conservation Strategy.

3.1 Development of Focused Conservation Plans

A set of focused, species-specific conservation plans was developed, targeting the relationship between flood management and the conservation of each selected species. In each plan, a synthesis of information on the following topics was prepared and is presented in this appendix:

- **Status and trends:** The species' historical and current status in the SPA for the CVFPP, as well as trends in the distribution and size of its population(s).
- **Life history:** The stages of the species' life cycle, and the annual timing of activities (including migration) and development documented for the species.
- **Habitat and ecological process associations:** The species' habitat requirements including specific features, land cover types, landscape attributes, physical tolerances, important interspecific relationships, combined with the major physical processes affected by flood management (e.g., channel migration and floodplain inundation).
- **Conceptual models:** A visual representation of the relationships among priority habitat conditions for the species (allocated by life stage if applicable), ecosystem processes affected by flood management, and the aspects of flood management adversely affecting those processes (i.e., stressors).
- **Management issues:** The scope and severity of threats to the species and impacts related to flood management in the SPA, as well as limitations in our understanding of the species (data gaps) that may hinder effective conservation through the operation, maintenance, and improvement of the State Plan of Flood Control (SPFC).

- **Conservation and recovery opportunities:** Particular opportunities to conserve the species in the SPA's CPAs.

- **Identified conservation needs:** Significant needs of the species population in the SPA, enumerated and with clear descriptions of the need, the reason for its importance, and its relationship to the SPFC—these descriptions provide the framework for prescribing beneficial management actions

- **Integration of conservation and restoration in flood management:** The major long-term effects of the actions involved in operating, maintaining, and improving the SPFC; and specific ways in which conservation of the species can be integrated with these flood management actions, either by reducing potential negative effects on the species or by optimizing benefits to the species—each recommendation relates directly to one or more of the conservation needs identified

- **Recovery plan alignment:** Identification of any state or federal plans for the recovery of the species, and a description of how the species-specific conservation plan will contribute to the attainment of the goals of these plans

- **Measures of positive contribution:** Identification of the ecosystem process, habitat, and stressor objectives of the Conservation Strategy that, if attained, would contribute to conservation of the target species, and provision of additional detail on how these objectives can benefit the species; this additional detail has been incorporated into the objectives of the Conservation Strategy

As indicated above, the target species objectives of the Conservation Strategy are based on, and have incorporated content from, other relevant conservation plans. Specifically, the measures of positive contribution identify locations and design criteria that will focus the strategy's objectives toward benefiting target species. The species-specific conservation plans will also inform adaptive management of the Conservation Strategy; future conservation actions will be developed, as needed, to address the particular needs of these species. Finally, selected data gaps and key uncertainties identified in the conservation plans will be addressed through targeted scientific studies, the results of which will be applied through adaptive management of the strategy's implementation.

4.0 References

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5.0 Acronyms and Other Abbreviations

The following acronyms and other abbreviations are used in the focused conservation plans.

Abbreviation	Definition
BANS-TAC	Bank Swallow Technical Advisory Committee
BDCP	Bay Delta Conservation Plan
BLM	U.S. Bureau of Land Management
CalPIF	California Partners in Flight
Caswell SP	Caswell Memorial State Park
CCH	California Consortium of Herbaria
CCR	California Code of Regulations
CCV	California Central Valley
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CDPR	California Department of Pesticide Regulation
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CPA	Conservation Planning Area
CRPR	California Rare Plant Rank
CV	Central Valley
CVFPP	Central Valley Flood Protection Plan
CWHR	California Wildlife Habitat Relationships
Delta	Sacramento–San Joaquin River Delta
DIDSON	Dualfrequency IDentification SONar
DPS	Distinct Population Segment
DWR	California Department of Water Resources
EAH	expected annual habitat
ESA	Endangered Species Act
ESRP	Endangered Species Recovery Program
ESU	Evolutionarily Significant Unit
FR	Federal Register
GPS	Global Positioning System
HCP	Habitat Conservation Plan
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
NCCP	Natural Community Conservation Plan
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWR	National Wildlife Refuge
PEIR	program environmental impact report
PVA	Population Viability Analysis
RHJV	Riparian Habitat Joint Venture
RM	River Mile
SBFCA	Sutter Buttes Flood Control Agency
sDPS	southern Distinct Population Segment
SJRRP	San Joaquin River Restoration Program
SPA	Systemwide Planning Area
SPFC	State Plan of Flood Control
SR	Sacramento River
SRA	shaded riverine aquatic
SRBPP	Sacramento River Bank Protection Project
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VELB	valley elderberry longhorn beetle
VMZ	Vegetation Management Zone
YC HCP/NCCP JPA	Yolo County HCP/NCCP Joint Powers Agency

G1. Focused Conservation Plan: Delta Button-Celery

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Conservation Status

This conservation plan addresses needs and opportunities for conserving Delta button-celery (*Eryngium racemosum*) in the SPA for the CVFPP.

Delta button-celery is an endemic California native plant that was listed by the State as an endangered species under CESA in 1981. This species is not protected under the ESA; however, it has been considered for listing as endangered or threatened on several occasions (USFWS 1985, 1990, 1993). CNPS considers Delta button-celery to be seriously rare, threatened, or endangered across its range, with more than 80 percent of known occurrences threatened (California Rare Plant Rank 1B.1) (CNPS 2012). It is ranked as critically imperiled both globally and at the state level according to the CDFW's CNDDB, which means that Delta button-celery is at a very high risk of extinction because of its extreme rarity.

Status and Trends

Historical Distribution

Delta button-celery's historical distribution included floodplains along the San Joaquin River, into Stanislaus, San Joaquin, and Contra Costa Counties (CDFW 2013). The species was also recorded as occurring on reservoir margins in Stanislaus, Calaveras, Marin, and Sonoma Counties (CDFW 2013; California Consortium of Herbaria [CCH] 2013). Reports of occurrences in Stanislaus and Calaveras Counties have been recently field checked by species experts, but the plants could not be located, probably because the reports were erroneous (CDFW 2013). Occurrences in Sonoma and Marin Counties have no record of subsequent review; however, based on their reported location outside the San Joaquin Valley, and because reports of Delta button-celery from similar lake-margin habitats were determined to be in error, the observations of these two occurrences are similarly assumed to be erroneous.

Current Distribution

Delta button-celery is found in the northern San Joaquin Valley, in the Upper and Lower San Joaquin River CPAs. The CNDDB (CDFW 2013) lists 19 extant occurrences across the species' range; however, two of these observations (in Stanislaus and Calaveras Counties) are thought to be erroneous reports, as described above. The 17 verified occurrences are found along the San Joaquin River and associated flood bypasses in areas subject to seasonal flooding in Merced County and adjacent parts of southern San Joaquin County. Thirteen of the 17 known occurrences are located in federal or state wildlife areas or California State Parks (CDFW 2013), with the most occurrences situated in the Merced National Wildlife Refuge (NWR) and San Luis NWR. In the Merced NWR, Delta button-celery is found within the floodway of the Eastside Bypass. In the San Luis NWR, the plant is found throughout the refuge between flood control levees, and on the San Joaquin River floodplain in the Freitas Unit, west of Highway 165 where the flood control levees end (Wollington pers. comm.).

Population Trends

The CNDDB contains 26 historical and current observations of Delta button-celery, and an additional three observations, not contained in CNDDB, were found in the CCH database (CCH 2013; CDFW 2013). As discussed above, four of these 29 reported observations occurred on seasonally flooded lake margins outside the San Joaquin River and its tributaries, and are assumed to be erroneous.

Of the remaining 25 occurrence records, eight are presumed extirpated and 17 are presumed extant (CDFW 2013). One of the eight extirpated populations was lost to disking within the last 15 years. The remaining extirpated populations were last observed in the 1960s or earlier, and either cannot be relocated or have been resurveyed and determined to be extirpated. The most common cause of extirpation was agricultural development along the San Joaquin River. All extirpated populations were located in the Lower San Joaquin River CPA in Contra Costa, San Joaquin, or Stanislaus Counties.

Of the 17 populations presumed extant, 11 have not been surveyed in more than 20 years; therefore, the current status and trends of these populations are unknown. The remaining six populations that have been surveyed relatively recently (between 1999 and 2010) ranged in size from hundreds to thousands of plants. Five of these six populations were subsequently resurveyed. Three of the populations showed a stable or apparently stable trend in population size, whereas two populations showed an apparent decline, with no plants observed at one of the two sites. Competition with other plants was implicated as a potential cause of the observed declines in both populations (CDFW 2013). However, because this species can disappear in years with unfavorable growing conditions and then reappear in more favorable years (Wollington pers. comm.), a temporary reduction in population size or the absence of plants from known populations is not necessarily indicative of extirpation.

Life History

Delta button-celery is a low-growing (average height: 4 to 20 inches), herbaceous biennial or perennial plant of the carrot family (Apiaceae). It is a disturbance follower that germinates in open habitats created by floods, develops a taproot and rosette with stems that grow along the ground, occasionally developing adventitious roots at stem nodes, and flowers between June and October (CNPS 2012; NatureServe 2012). Its ability to develop adventitious roots from stem nodes differentiates this species from other members of its genus and may be an adaptation to growing in locations subject to frequent flooding and sediment deposition. Delta button-celery reproduces via seed. The species likely develops a persistent seedbank in sites where it occurs because it has been observed to disappear from known locations in years with unfavorable growing conditions and reappear in subsequent years. The timing of germination and methods of seed dispersal are not documented, but given its habit of growing on floodplains along the San

Joaquin River, it is possible that water and floodplain inundation play a strong role in both processes.

Habitat and Ecological Process Associations

Delta button-celery is a wetland obligate that occurs in seasonally flooded clay depressions in floodplains and alkaline clay deltas (Preston et al. 2012; ICF International 2013). Specifically, it grows in areas adjacent to streams and rivers on young, seasonally wetted floodplains consisting of heavy, low-pH clay soils that become fully drained after spring runoff (NatureServe 2012). Associated species in this habitat type include common lippia (*Phyla nodiflora*), spike rush (*Eleocharis* spp.), American bird's foot trefoil (*Lotus unifoliolatus* var. *unifoliolatus*), Goodding's black willow (*Salix gooddingii*), saltgrass (*Distichlis spicata*), and common sunflower (*Helianthus annuus*) (CDFW 2013; ICF International 2013). Delta button-celery also occurs in alkaline clay deltas of Coast Ranges tributaries, in association with saltgrass, alkali heath (*Frankenia salina*), and iodine bush (*Allenrolfea occidentalis*) (ICF International 2013).

Periodic flooding is likely an important ecological process for Delta button-celery (NatureServe 2012) because it creates disturbed areas free of competing vegetation, allowing germination and growth of the species. Periodic, seasonal flooding also maintains wetland hydrology that supports this species and discourages other, potentially competitive species that cannot tolerate inundation (National Resources Defense Council 2002). Livestock grazing may be an important management option for controlling strong competitors such as spike rush and nonnative, invasive plants; however, overgrazing may be detrimental to Delta button-celery (NatureServe 2012), and incompatible grazing, other agricultural activities, and floodway maintenance activities are frequently listed as threats to extant populations (CDFW 2013).

Conceptual Models

A conceptual model has been developed to assist in development of a targeted conservation strategy for Delta button-celery within the SPA (Figure 1). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by Delta button-celery within the SPA;
- the specific CPAs within which these habitat conditions occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and stressors related to SPFC facilities and their operation and maintenance.

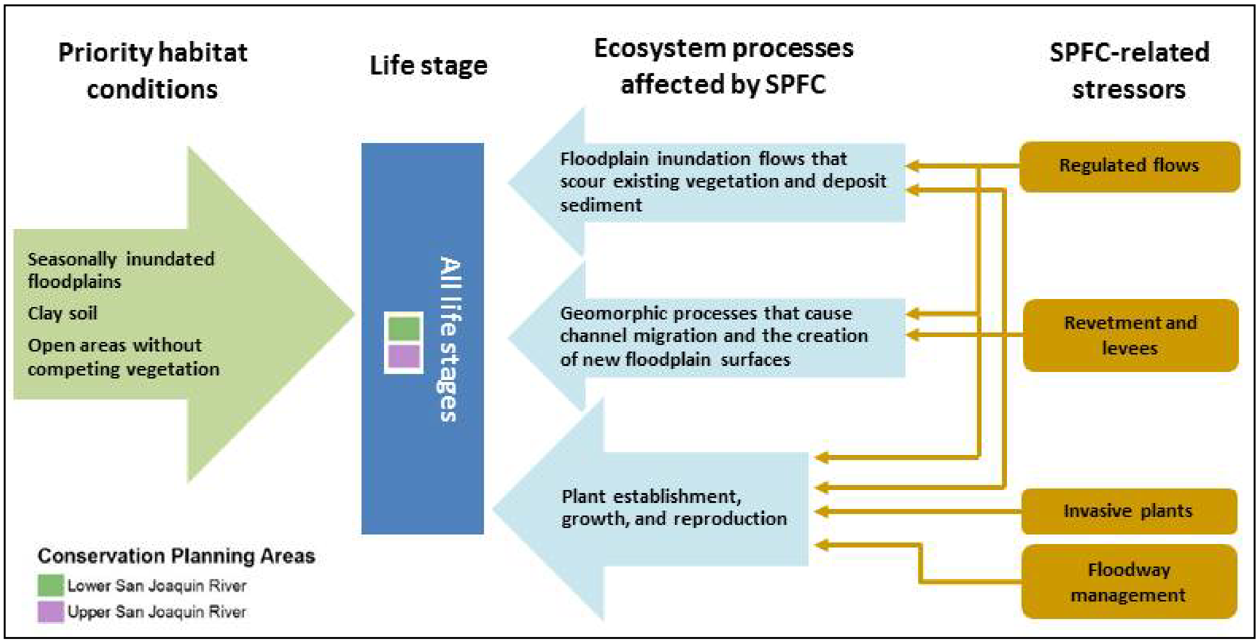

Figure 1. Conceptual Model for Delta Button-Celery within the SPA

Management Issues

Threats and Sensitivities Range-Wide

Based on observations of extirpated and existing populations, the primary threat to Delta button-celery is the conversion of seasonal floodplain habitat to agriculture (CDFW 2013). Although a significant number of existing populations are protected from land conversion because they occur in State Parks and California and federal wildlife refuges, these populations are still threatened by channel maintenance activities, levee construction and reservoir operations, competition with other plants (particularly invasive species), and improperly managed livestock grazing (NatureServe 2012; CDFW 2013). Channel maintenance activities that could directly affect Delta button-celery include dredging, disking, mowing, and other disturbances. Reservoir operations and levee construction have altered the historical flooding regime of much of the San Joaquin River system and reduced the extent of potentially suitable Delta button-celery habitat. Competition from nonnative and native plants, including common sunflower and cockle bur (*Xanthium* spp.), may have contributed to the recent extirpation of one Delta button-celery population and may be adversely affecting other populations (CDFW 2013). Finally, overgrazing by cattle may be detrimental to this species because it may promote competing weeds, and improperly managed cattle might eat or trample Delta button-celery plants (NatureServe 2012). The limited distribution of the species and relative rarity of populations increase the probability that localized threats or stressors (e.g., flow alteration or invasive species) or chance events (e.g., disease) could adversely affect the survival of Delta button-celery.

Ongoing and Future Impacts

The stressors described above are expected to continue to negatively affect Delta button-celery populations. Furthermore, climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the Sierra Nevada as rain rather than snow, thus reducing snowpack and summer water availability (Cayan et al. 2006). Changes in the amount and timing of rain and snowfall may also affect the amount and timing of runoff and flooding in the Central Valley. Delta button-celery is characterized by several ecological attributes that make it particularly vulnerable to these potential effects of climate change, including:

- specialized habitat and/or microhabitat requirements;
- dependence on seasonal flooding that may be disrupted by climate change;
- poor ability to disperse to a new or more suitable range;
- small population sizes and a narrow distribution range; and
- extreme fluctuations in interannual population sizes.

The potential for negative effects from climate change on Delta button-celery, when combined with other stressors and considering the species' limited distribution, may be significant.

Key Information Gaps or Uncertainties

To better understand Delta button-celery ecology, the following information is critically needed: data on current populations, analysis of how floodway maintenance practices affect the species, a better understanding of the species' life history and ecological associations, methods for propagating and restoring populations, and techniques for managing potential habitat to promote Delta button-celery recovery. These data gaps are discussed below.

- **Ecological associations and life history.** Basic information on the ecology and metapopulation dynamics of Delta button-celery is lacking or has been inferred from similar species or anecdotal observations, which may not be accurate. Specific information characterizing flood dynamics that support the species (magnitude, timing, and duration of inundation), seedbank dynamics, edaphic settings, and other factors that affect Delta button-celery colonization, germination, growth, seed production, seedbank persistence, and gene flow among adjacent populations would inform conservation efforts for the species that would be implemented to support the Conservation Strategy (e.g., reintroduction into suitable habitats).

- **Population status and trends.** The current status and trends of most extant Delta button-celery populations are unknown. Focused surveys for this species, particularly in the Upper San Joaquin River CPA in the Merced NWR and San Luis NWR and adjacent areas and within the Lower San Joaquin River CPA in areas that formerly supported the species, would establish an updated baseline for the distribution and size of extant Delta button-celery populations. This baseline would allow assessments of how Delta button-celery populations change after implementation of specific Conservation Strategy actions (e.g., levee relocation or changes in reservoir operations). Focused surveys would be required over multiple years to adequately characterize the species' distribution and population size under a variety of climatic and flow conditions.

- **Effects of floodway maintenance practices.** Current floodway maintenance practices, such as prescribed burning, herbicide use, and mowing, could have unintended, negative effects on Delta button-celery, but these impacts are not well understood. Better information regarding these effects could inform the development of appropriate avoidance and minimization measures to guide floodway maintenance activities in areas where Delta button-celery is known to occur.

- **Propagation methods.** Methods to successfully propagate and reintroduce Delta button-celery into potentially suitable habitat are unknown. Information on the restoration potential of the species is needed to characterize the feasibility of actions that could be implemented as part of the Conservation Strategy, particularly within areas of potentially suitable habitat created through other Conservation Strategy actions (e.g., relocating levees and constructing/expanding bypasses).

- **Conservation-friendly management methods.** Vegetation management techniques that support and maintain Delta button-celery are not well known. Managed livestock grazing may be important for maintaining Delta button-celery populations because it can reduce the competitive influence of nonnative, invasive species and more vigorous native species. However, improperly managed grazing (i.e., inappropriate grazing intensity, timing, or duration) may be detrimental to this species, so detailed studies are needed to develop livestock grazing approaches that support the species without resulting in unintended adverse effects.

Conservation Strategy

Conservation and Recovery Opportunities

Increasing the amount of potentially suitable Delta button-celery habitat, modifying the operation and maintenance of the SPFC to support existing populations of this plant, and establishing new populations of Delta button-celery where feasible are the most effective means to conserve and restore this species in the SPA.

Identified Conservation Needs

1. **Increase the amount of potentially suitable Delta button-celery habitat and maintain existing populations in the Upper and Lower San Joaquin River CPAs:** Delta button-celery appears to be found most often in areas of clay soil that are seasonally flooded on an annual basis and dominated by open, herbaceous vegetation. The operation and maintenance of the SPFC currently limit the amount of these potentially suitable habitats by reducing floodplain accessibility and threaten existing populations by altering inundation timing, frequency, and duration. The operation and maintenance of the SPFC also modify riverine geomorphic processes (e.g., scour, meander, and sediment deposition) that help to create new, potentially suitable habitat and sustain existing Delta button-celery populations. Invasive plants and SPFC operation and maintenance activities have the potential to further limit habitat suitability and adversely affect existing populations of this plant. The CVFPP and Conservation Strategy could address this conservation need by constructing new SPFC facilities that would benefit Delta button-celery (e.g., flood bypasses), by modifying existing facilities (e.g., constructing setback levees), or by modifying operation and maintenance of the SPFC (e.g., reservoir releases and floodway vegetation management practices). These actions would be particularly beneficial for Delta button-celery if they targeted areas currently known to support this species such as the Eastside Bypass and other areas of the Merced NWR and San Luis NWR.

2. **Expand the distribution of Delta button-celery in the Upper and Lower San Joaquin River CPAs:** The conservation of Delta button-celery is adversely affected by its limited distribution and small number of existing populations within that distribution, both of which make the species more susceptible to future climate change, changes to the operation and maintenance of the SPFC, and chance events (e.g., disease). Targeted restoration actions, including grading to lower floodplain surfaces and increase Delta button-celery habitat suitability adjacent to known populations within the San Luis NWR and Merced NWR, creating or enhancing areas of potentially suitable habitat in other parts of the Upper and Lower San Joaquin CPAs (i.e., in areas of suitable soils where modification of floodplain topography could create hydrologic conditions suitable for the species), and introducing the plant into areas of potentially suitable habitat (including created and enhanced habitat) within the Upper and Lower San Joaquin CPAs, could be supported by the CVFPP and Conservation Strategy to address this conservation need.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions that have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of Delta button-celery are summarized in Table 1. In many cases, the conservation needs of Delta button-celery are likely to be addressed by implementing management actions that integrate conservation/restoration elements with

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of Delta Button-Celery[a]

CVFPP Management Actions	Conservation Need	
	1. Increase Suitable Habitat and Sustain Populations	2. Expand Distribution
Operations, Maintenance, and Floodway Management		
Floodwater storage and reservoir forecasting, operations, and coordination	+/-	+
Facility maintenance		
Levee vegetation management		
Floodway maintenance	+	
Modification of floodplain topography	+	+
Support of floodplain agriculture		
Invasive plant management	+	
Restoration of riparian, SRA, and marsh habitats		+
Wildlife-friendly agriculture		
Structural Improvements		
Levee and revetment removal	+/-	+
Levee relocation	+/-	+
Bypass expansion and construction	+/-	+
Levee construction and improvement	-	-
Flood control structures		

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

SPFC operation and maintenance, floodway management, and structural improvements in the Upper and Lower San Joaquin River CPAs. However, better information on the distribution of this species within the SPA, particularly within the Lower San Joaquin River CPA, and on the ecological relationships between Delta button-celery and riverine hydrologic and geomorphic processes are needed, as previously described under Key Information Gaps or Uncertainties, to ensure that CVFPP management actions incorporate appropriate elements specifically intended to address Delta button-celery conservation. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

For populations in the Upper San Joaquin River CPA, the San Joaquin River Restoration Program (SJRRP) is developing a Delta button-celery conservation plan that will include a strategy for preserving and adaptively managing existing populations along the San Joaquin River and in the bypass system (SJRRP 2011). CVFPP management actions could support implementation of the SJRRP conservation plan for Delta button-celery.

Operations, Maintenance, and Floodway Management

Floodwater storage and reservoir forecasting, operations, and coordination: Modifying and coordinating flood operations could provide flow releases that seasonally inundate floodplains, scour existing vegetation, create new floodplain, and modify floodplain topography, all of which may benefit Delta button-celery. Modification of flood operations would be particularly beneficial for Delta button-celery if these processes occurred within the Merced NWR and San Luis NWR or adjacent areas in the Upper San Joaquin River CPA. Also, to the extent that modification of flood operations results in creation of potentially suitable habitat in the Lower San Joaquin River CPA (e.g., where suitable soils would be subject to seasonal inundation), this action could contribute to expanding the distribution of Delta button-celery. However, modifications to floodwater storage and reservoir operations could change the habitat and growing conditions of existing populations and negatively affect the species; for example, altering the timing, frequency, or depth of inundation or physically altering habitat by causing scouring or similar floodplain modifications could have adverse effects on the plant.

Floodway maintenance: Floodway maintenance practices, such as livestock grazing, that eliminate or reduce competing vegetation could be used to conserve Delta button-celery by enhancing the habitat of existing populations. Implementation of conservation-oriented floodway management actions would be most effective in the known range of Delta button-celery within the Merced NWR and San Luis NWR as well as adjacent areas where the species occurs.

Modification of floodplain topography: Lowering floodway elevations to produce frequent and sustained inundation of lower floodplain surfaces and modifying the floodway to achieve greater topographic and hydrologic diversity could positively affect Delta button-celery by enhancing habitat conditions for known populations in the Upper San Joaquin River CPA and by creating new areas of potentially suitable habitat in both the Upper and Lower San Joaquin River CPAS.

Invasive plant management: Treating invasive plants where Delta button-celery occurs in the Upper and Lower San Joaquin River CPA would benefit this plant by reducing competition and increasing resources (e.g., soil nutrients, light, and water) available for germination, growth, and seed production.

Restoration of riparian, SRA cover, and marsh habitat: Delta button-celery occurs only on floodplains that are subject to frequent, seasonal inundation. Restoring seasonal wetland habitat in the Upper and Lower San Joaquin River CPAs would support the expansion of existing Delta button-celery populations in the Upper San Joaquin River CPA and could contribute to the introduction of this plant into the Lower San Joaquin River CPA.

Structural Improvements

Levee and revetment removal: Removing levees and bank revetment could reconnect rivers with floodplain habitats and allow more natural riverine geomorphic processes, such as river meander, over-bank flows, and associated disturbances. These processes could contribute to the creation of new floodplain habitats and enhance existing Delta button-celery habitat. These actions would especially benefit Delta button-celery populations in the Upper San Joaquin River CPA and, if combined with other actions (e.g., focused restoration and reintroduction), could contribute to expanding Delta button-celery populations in the Lower San Joaquin River CPA. Levee and revetment removal could negatively affect existing Delta button-celery populations if these actions modified hydrologic and geomorphic processes that currently contribute to the creation and maintenance of suitable habitat for this plant.

Levee relocation: Relocating levees to expand floodway widths would reconnect floodplains to the river and could expand or enhance suitable Delta button-celery habitat. Combined with targeted restoration efforts, levee relocation could also contribute to expanding the distribution of Delta button-celery in the Lower San Joaquin River CPA. Levee relocation could negatively affect existing Delta button-celery populations if this action modified hydrologic and geomorphic processes that currently contribute to the creation and maintenance of suitable habitat for this plant.

Bypass expansion and construction: Construction of new or expanded bypasses would create new seasonal floodplain habitat that could benefit Delta button-celery, particularly in the Eastside Bypass where Delta button-celery occurs. New bypass construction could incorporate targeted restoration efforts to expand the distribution of Delta button-celery. Bypass expansion could negatively affect existing Delta-button celery populations if this action modified hydrologic and geomorphic processes that currently contribute to the creation and maintenance of suitable habitat for this plant.

Levee construction and improvement: Constructing and improving levees could negatively affect Delta button-celery, particularly if levees were constructed or improved along the Upper San Joaquin River CPA within the San Luis NWR and adjacent areas where this plant often occurs along portions of the river that are not leveed (Wollington pers. comm.). Also, the construction of levees along other portions of the San Joaquin River could reduce the potential of these areas to support Delta button-celery by eliminating seasonal flooding that is required to provide suitable habitat.

Recovery Plan Alignment

There are no California or federal recovery plans for Delta button-celery. The conservation needs of this species in the SPA are addressed in previous sections of this document.

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 Delta button-celery. Therefore, building on the preceding discussion, this section of the Delta button-celery 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 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 inundated floodplain is an indicator of progress toward the Conservation Strategy's inundated floodplain habitat objective. To measure the contribution of CVFPP actions to conservation of Delta button-celery, requirements would be added to increase acreage that would provide inundation in the locations and with the frequency, depth, and duration of inundation that would be required to support existing populations and to support the expansion of this plant into other parts of the SPA.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of Delta button-celery, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit Delta button-celery may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of Delta Button-Celery

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	Annual, seasonal floodplain inundation is required to provide suitable Delta button-celery habitat.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	No	
	Habitat Connectivity—median patch size (acres)	No	
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Delta button-celery most commonly occurs within seasonal wetland habitat.
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G2. Focused Conservation Plan: Slough Thistle

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Conservation Status

This conservation plan addresses needs and opportunities for conserving slough thistle (*Cirsium crassicaule*) in the SPA for the CVFPP.

Slough thistle is a native plant species listed by CNPS as seriously endangered in California, with more than 80 percent of occurrences threatened (California Rare Plant Rank 1B.1; CNPS 2012). It is ranked by the CNDDB as imperiled both globally and at the state level, which means that slough thistle is at a high risk of extinction because of its very restricted range, very few populations, steep population declines, or other factors that make the species vulnerable to extirpation. Slough thistle is not listed as threatened or endangered by CDFW or USFWS; however, it has been evaluated for its potential to be listed on several occasions (USFWS 1985, 1990, 1993).

Status and Trends

Historical Distribution

Slough thistle is endemic to the San Joaquin Valley. Within the SPA, slough thistle was historically found in the Lower San Joaquin River CPA in the vicinity of Lathrop, with two occurrences documented in the CNDDB (CDFW 2013) and an additional three occurrences, that did not appear to be duplicates of the CNDDB records, documented in the CCH (2013). Outside the SPA, slough thistle occurred along the Kings and Kern Rivers and along sloughs, floodways, and canals associated with these two river systems in the San Joaquin Valley (CCH 2013; CDFW 2013).

Current Distribution

It is probable that slough thistle no longer occurs in the SPA. All five documented slough thistle occurrences in the SPA were last observed decades ago. One of these populations was most recently observed in 1974, and it still listed in CNDDB as being extant. A second occurrence was also visited in 1974, but could not be located. The remaining three populations have not been observed since the 1930s, or are only known from historical herbarium collections from the late 1800s to early 1900s (CCH 2013; CDFW 2013). Slough thistle was not observed during 2009–2011 field surveys of waterways in the Sacramento–San Joaquin River Delta (which included portions of the Lower San Joaquin and Lower Sacramento River CPAs), conducted to support preparation of the Bay Delta Conservation Plan (BDCP) (ICF International 2013). It is not known whether the area surveyed for the BDCP included the areas where slough thistle was previously observed around Lathrop.

Outside the SPA, there are 17 occurrences of slough thistle reported from the Kern and Kings Rivers in Kern and Kings Counties and along sloughs, flood channels, and canals associated with these rivers (CDFW 2013). Additionally, there are approximately seven slough thistle herbarium specimens from this same region reported in the CCH that do not appear to have a corresponding CNDDB record (CCH 2013). Most extant populations occur in private lands; however, a small number of populations occur in the Kern National Wildlife Refuge.

Population Trends

Population trends for slough thistle are uncertain because there have been no recent surveys for most of the documented populations. Within the SPA, slough thistle is considered possibly extirpated, based on information contained in the CNDDB and recent field surveys (CDFW 2013; ICF International 2013). As described above, this species is known to have occurred in only five locations in the SPA. Three of these five populations were last observed between the late 1800s and the 1930s, and are considered possibly extirpated based on the lack of recent observations. The remaining two populations were last surveyed in 1974. One population was believed to be extirpated at that time, whereas the other population was considered to be threatened; the current status of this population is unknown.

Of the 17 remaining occurrences located outside the SPA, eight are considered to be in good condition, one is considered to be possibly extirpated, and the status of the remaining eight is unknown (CDFW 2013). However, the current population status and trend of most of these populations cannot be inferred from CNDDB data because only one population has been surveyed since 1990 (CDFW 2013; Moe pers. comm.). According to knowledgeable individuals and notes recorded in the CNDDB, the species is likely declining in response to competition with invasive plants, land conversion, and hydrologic modification (CDFW 2013; Griggs pers. comm.; Moe pers. comm.).

Life History

Slough thistle is an herbaceous, annual/perennial plant of the composite family (Asteraceae). It grows between 3.3 and 9.8 feet tall and produces pale, rose-purple, or sometimes white, flowers that bloom from May through August (CNPS 2012; Keil 2012). Very little is known about this plant. As with other members of its genus, slough thistle seeds are likely adapted for wind dispersal (Craddock and Huenneke 1997), and slough thistle seeds may be adapted to aquatic dispersal, particularly given the species' typical growing location along waterways. Population sizes fluctuate widely (CNPS 2012), perhaps because of very specific seed germination and habitat requirements (D'Ulisse and Maun 1996; Chen and Maun 1998), which have been observed in other *Cirsium* species but are not well documented or understood for slough thistle.

Habitat and Ecological Process Associations

Slough thistle is a wetland obligate that occurs in chenopod scrub, freshwater marsh, and riparian scrub habitat. It grows on friable clay soils along or adjacent to high floodflow areas near sloughs, riverbanks, canals, and marshes (CDFW 2013; ICF International 2013). Associated species in locations where slough thistle occurs south of the SPA include iodine bush (*Allenrolfea occidentalis*), mugwort (*Artemisia douglasiana*), narrow leaf milkweed (*Asclepias* *fascicularis*), saltbush (*Atriplex* spp.), mule fat (*Baccharis salicifolia*), annual hairgrass (*Deschampsia danthonioides*), saltgrass (*Distichlis spicata*), horseweed (*Erigeron canadensis*), alkali heath (*Frankenia salina*), common gumplant (*Grindelia camporum*), heliotrope (*Heliotropium curassavicum*), rush (*Juncus* spp.), lippia (*Phyla nodiflora*), willow (*Salix* spp.), hardstem bulrush (*Schoenoplectus acutus*), wire lettuce (*Stephanomeria pauciflora*), bush seepweed (*Suaeda nigra*), and common cattail (*Typha latifolia*) (CDFW 2013).

Based on observations of slough thistle habitat conditions recorded in the CNDDB, ecological processes that are likely important to slough thistle include flooding, sediment deposition, and disturbance. These processes can maintain wetland hydrology, reduce competition with flood-intolerant weeds, supply nutrients and substrate for germination, and, based on studies of other *Cirsium* species, may provide a means of seed dispersal (Craddock and Huenneke 1997).

Conceptual Models

A conceptual model has been developed to assist in development of a targeted conservation strategy for slough thistle within the SPA (Figure 1). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by slough thistle within the SPA;
- the specific CPAs within which these habitat conditions occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Management Issues

Threats and Sensitivities Range-Wide

Based on observations of extirpated and existing populations, the primary threats to slough thistle are habitat loss or alteration and competition with nonnative plants (CNPS 2012; CDFW 2013). Potentially suitable slough thistle habitat formerly extended from the Lower San Joaquin River CPA south through the San Joaquin Valley and Tulare Basin into Kern and Kings Counties, along river channels, sloughs, and marshes, and in chenopod and riparian scrub. However, most of this habitat has been lost as a result of flood control efforts, hydrologic modification (e.g., reservoir construction and operation), agricultural development, and groundwater pumping (Holland 1986). Remaining areas of potentially suitable habitat and known populations are threatened by agricultural activities, including inappropriate livestock grazing, and by channel clearing and maintenance activities (CDFW 2013). In particular, the reduction of water in the Kern River and the elimination of natural hydrology from much of the

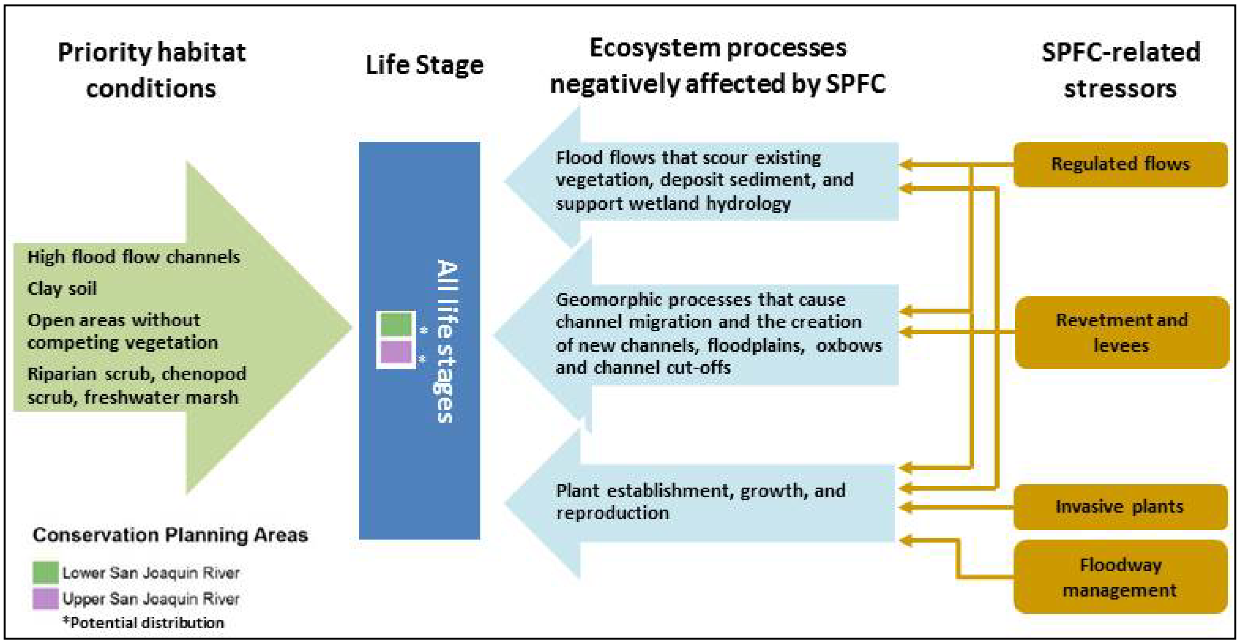

Figure 1. Conceptual Model for Slough Thistle within the SPA

Kern River in the Central Valley and its associated sloughs and canals has greatly reduced habitat suitability in many areas where slough thistle formerly occurred or where it still occurs but appears to be declining (Griggs pers. comm.; Moe pers. comm.). Competition with nonnative plants may also be adversely affecting slough thistle (CDFW 2013); of particular concern is tamarisk (*Tamarix* spp.), which was reported as co-occurring with slough thistle in three locations (CDFW 2013). Finally, slough thistle's rarity and limited geographic distribution increase the probability that localized threats or stressors (e.g., flow alteration or invasive species) or chance events (e.g., disease) could adversely affect the species.

Ongoing and Future Impacts

The stressors described above are expected to continue to negatively affect slough thistle populations. Furthermore, climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the Sierra Nevada as rain rather than snow, thus reducing snowpack and summer water availability (Cayan et al. 2006). Changes in the amount and timing of rain and snowfall may also affect the amount and timing of runoff and flooding within the Central Valley. Slough thistle is characterized by several ecological attributes that make it particularly vulnerable to these potential effects of climate change, including:

- specialized habitat and/or microhabitat requirements;
- dependence on a predictable water supply that may be disrupted by climate change;
- poor ability to disperse to a new or more suitable range;

- small population sizes and a narrow distribution range; and
- extreme fluctuations in interannual population sizes.

The potential for negative effects from climate change on slough thistle, when combined with other stressors and considering the species' limited distribution, may be significant.

Key Information Gaps or Uncertainties

To better understand slough thistle ecology, the following information is critically needed: data on current populations, a better understanding of the species' life history and ecological associations, methods for propagating and restoring populations, and techniques for managing potential habitat to promote slough thistle recovery. These data gaps are discussed below.

- **Population status and trends.** The current status and trends of slough thistle populations are unknown, and it is possible that the species no longer occurs in the SPA. Focused surveys for this species, particularly in potentially suitable habitat in the Upper San Joaquin River CPA, and along the San Joaquin River in the general vicinity of Lathrop (where the species was known to occur historically), would establish an updated baseline for the distribution and size of extant slough thistle populations. This baseline would allow assessment of how slough thistle populations change after implementation of specific Conservation Strategy actions (e.g., levee relocation or changes in reservoir operations). Focused surveys would be required over multiple years to adequately characterize the species' distribution and population size under a variety of climatic and flow conditions.
- **Ecological associations and life history.** Basic information on the ecology and metapopulation dynamics of slough thistle is lacking or has been inferred from similar species or anecdotal observations, which may not be accurate. Specific information characterizing hydrologic dynamics that support the species (magnitude, timing, and duration of floodflows), seedbank dynamics, edaphic settings, and other factors that affect slough thistle colonization, germination, growth, seed production, seedbank persistence, and gene flow among adjacent populations would inform conservation efforts for the species.
- **Propagation methods.** Methods to successfully propagate and reintroduce slough thistle into potentially suitable habitat are unknown. Information on the restoration potential of the species is needed to characterize the feasibility of actions that could be implemented as part of the Conservation Strategy, particularly in areas of potentially suitable habitat created through other Conservation Strategy actions (e.g., changing reservoir operations, lowering the floodplain to create marsh habitat, and relocating levees).
- **Conservation-friendly management methods.** Vegetation management techniques and channel maintenance activities that avoid, enhance, or maintain slough thistle are not well known. If extant populations are located in the SPA, or if slough thistle were reintroduced to the SPA, guidelines for vegetation management and channel maintenance activities (e.g., vegetation or sediment removal) would be needed to maintain and enhance these populations and to avoid causing adverse effects.

Conservation Strategy

Conservation and Recovery Opportunities

Increasing the amount of potentially suitable slough thistle habitat and establishing new populations of slough thistle where feasible are the most effective means to conserve and restore this species within the SPA.

Identified Conservation Needs

1. **Increase the amount and distribution of potentially suitable slough thistle habitat in the Upper and Lower San Joaquin River CPAs:** Areas along active river channels that periodically experience high floodflows, riparian and chenopod scrub, and freshwater marsh all provide potential habitat for slough thistle. These habitats are limited in the Upper and Lower San Joaquin River CPAs by operation and maintenance of the SPFC, which alters the timing, frequency, and duration of floodflows that could otherwise inundate marsh habitats, scour existing vegetation, deposit new sediment, and create new river channels, oxbows, and channel cutoffs. The CVFPP and Conservation Strategy could address this conservation need by modifying the operation and maintenance of the SPFC, removing or relocating revetment and levees to encourage the creation of suitable slough thistle habitat, or modifying floodplain topography to create areas of suitable habitat.

2. **Expand the geographic range of slough thistle to reduce the probability of its extinction:** The known distribution of slough thistle is limited to historical observations in the Lower San Joaquin River CPA and to a small number of populations in a limited geographic range outside the SPA, in Kern and Kings Counties. Its limited distribution increases the probability that survival of the species could be negatively affected by chance events, localized stressors, or changes in climate. As part of marsh restoration actions, the CVFPP and Conservation Strategy could address this conservation need by restoring suitable marsh habitats and introducing slough thistle into these habitats.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of slough thistle; these are summarized in Table 1. In many cases, the conservation needs of slough thistle are likely to be addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements in the Upper

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of Slough Thistle[a]

CVFPP Management Actions	Conservation Need	
	1. Increase Potential Habitat	2. Expand Geographic Range
Operations, Maintenance, and Floodway Management		
Floodwater storage and reservoir forecasting, operations, and coordination	+	
Facility maintenance		
Levee vegetation management		
Floodway maintenance		
Modification of floodplain topography	+	
Support of floodplain agriculture		
Invasive plant management	+	
Restoration of riparian, shaded riverine aquatic (SRA) cover, and marsh habitats		+
Wildlife-friendly agriculture		
Structural Improvements		
Levee and revetment removal	+	
Levee relocation	+	
Bypass expansion and construction	+	
Levee construction and improvement		
Flood control structures		

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

and Lower San Joaquin River CPAs. However, better information on the distribution of this species within the SPA and on the ecological relationships between slough thistle and riverine hydrologic and geomorphic processes are needed, as previously described under Key Information Gaps or Uncertainties, to ensure that CVFPP management actions incorporate appropriate elements specifically intended to address slough thistle conservation. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward 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 provide flow releases along the San Joaquin River and its tributaries that seasonally inundate floodplains, scour existing vegetation, create new floodplain, and modify floodplain topography. These actions could benefit slough thistle by creating habitat conditions that would support reintroduction of the species in the Upper and Lower San Joaquin River CPAs.

Modification of floodplain topography: Strategically lowering floodway elevations to form marsh habitat and modifying the floodway to achieve greater topographic and hydrologic diversity could create habitat conditions that would support reintroduction of slough thistle to the Upper and Lower San Joaquin River CPAs.

Invasive plant management: Treating invasive plants within the potential distribution area of slough thistle in the Upper and Lower San Joaquin River CPAs would benefit the species. Invasive plants can compete with slough thistle for light, space, water, and soil nutrients; therefore, reducing invasive plants infestations, even if slough thistle does not currently occur in the SPA, could contribute to recovery of the species by creating habitat conditions that would support its reintroduction.

Restoration of riparian and marsh habitats: Restoring marsh and riparian scrub habitats would create suitable habitat conditions for the reintroduction of slough thistle in the Upper and Lower San Joaquin River CPAs. Riparian scrub and marsh restoration actions would be most effective when combined with other conservation and restoration actions intended to restore riverine hydrologic and geomorphic processes.

Structural Improvements

Levee and revetment removal: Removing levees and bank revetment could reconnect rivers with floodplain habitats and allow more natural riverine geomorphic processes. These processes could help create marsh and riparian scrub habitats (e.g., by forming meander bends and cutoffs or new floodplain surfaces) and enhance existing habitat. Habitat enhancement and creation would benefit slough thistle, particularly if combined with other actions (e.g., focused restoration and reintroduction), by increasing the amount of potentially suitable habitat and by supporting expansion of the species' range in the Upper and Lower San Joaquin River CPAs.

Levee relocation: As described for levee and revetment removal, relocating levees to expand floodway widths would reconnect floodplains to the river and could thereby expand or enhance suitable slough thistle habitat. Combined with targeted restoration efforts (e.g., focused restoration and reintroduction), levee relocation could also contribute to the establishment of slough thistle in the Upper and Lower San Joaquin River CPAs.

Bypass expansion and construction: Construction of new or expanded bypasses would contribute to creating marsh habitats that could benefit slough thistle. New bypass construction could incorporate targeted restoration efforts (e.g., focused restoration and reintroduction) to expand the distribution of slough thistle.

Recovery Plan Alignment

There are no California or federal recovery plans for slough thistle. The conservation needs of this species in the SPA are addressed in previous sections of this document.

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 slough thistle. Therefore, building on the preceding discussion, this section of the slough thistle conservation plan identifies 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 2 lists the process, habitat, and stressor targets and identifies those used to indicate a contribution to conservation of slough thistle. For example, an increase in the acreages of riparian and marsh habitats is expected to support establishment of additional populations of slough thistle in the SPA. However, specific acreage values are not provided because data on the species' requirements and distribution are severely limited.

Because management actions intended to benefit slough thistle may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of Slough Thistle

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	No	
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	
	Habitat Connectivity—median patch size (acres)	No	
Marsh	Habitat Amount— total amount and total amount on active floodplain (acres)	Yes	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G3. Focused Conservation Plan: Valley Elderberry Longhorn Beetle

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the valley elderberry longhorn beetle (VELB; *Desmocerus californicus dimorphus*) and its habitat in the SPA for the CVFPP.

The valley elderberry longhorn beetle is fully protected under the ESA. USFWS formally listed VELB as threatened in 1980. Critical habitat was also designated at this time. A VELB recovery plan was published by USFWS in 1984, and conservation guidelines were issued by USFWS in 1999. In 2006, USFWS completed a 5-year review that recommended the species be delisted based on the number of sightings throughout its range and the reduction of primary threats to the species (mainly riparian habitat loss). A petition from the Pacific Legal Foundation to delist the beetle was received by USFWS in 2010. In 2011, USFWS issued a 90-day finding, which found that the petition presented substantial scientific information indicating that delisting VELB may be warranted (USFWS 2012). Based on this finding, USFWS initiated a status review of the species to determine whether delisting was warranted. In 2012, USFWS proposed to remove VELB from the federal list of endangered and threatened species, but the proposal was withdrawn in 2014 (79 FR 55879–55917; USFWS 2014).

Status and Trends

Distribution

The valley elderberry longhorn beetle is endemic to the Central Valley of California and adjacent Sierra Nevada foothill regions, up to approximately 2,000–3,000 feet in elevation (Barr 1991). The species inhabits riparian and upland habitats where its host plant, the elderberry (*Sambucus* spp.) grows. Because of taxonomic difficulties associated with differentiating blue elderberry (*S. nigra* ssp. *caerulea*) from red elderberry (*S. racemosa* var. *racemosa*), particularly in areas where the two species' distributions overlap, there has been disagreement historically over whether both elderberry species are potential hosts for VELB or if the beetles are exclusively associated with blue elderberry (Barr 1991). More recent studies (e.g., Fremier and Talley 2009 and Vaghti et al. 2009) have concluded that blue elderberry is the sole host for VELB, and the recent revision to the Jepson Manual (Bell 2012) indicates that red elderberry does not occur in the Central Valley of California, where most VELB observations have been recorded.

The valley elderberry longhorn beetle occurs throughout the SPA (Barr 1991); however, at the time of the beetle's listing by the USFWS in 1980, it was known to occur in fewer than 10 locations. These locations included sites along the American River and Putah Creek in the Lower Sacramento River CPA and along the Merced River in the Upper and Lower San Joaquin River CPAs. Currently, VELB is known from 201 occurrence records at 26 locations, which are distributed between Redding in Shasta County, in the northern Sacramento Valley, and Caliente, southeast of Bakersfield in Kern County, in the southern San Joaquin Valley (USFWS 2012).

Although the beetles can be locally common, they typically occur at very low densities (Collinge et al. 2001). The species is also not evenly distributed across its known range, and beetles are often found in population clusters (Barr 1991; Collinge et al. 2001) (Figure 1). Frequently, only particular clumps of shrubs in an area harbor VELB, and other similar clumps of shrubs do not. The presence of unoccupied elderberry shrubs does not necessarily indicate that a particular cluster of shrubs constitutes poor-quality habitat or is otherwise uninhabitable (Talley et al. 2007).

Population Trends

As discussed above, at the time of listing, VELB were documented in fewer than 10 locations along three rivers in the Central Valley. Since this time, the number of documented occurrences has increased by several orders of magnitude, to more than 200 observations. This apparent increase likely does not represent an actual increase in the numbers of VELB or a population trend, but is rather the by-product of increased protection and regulatory agency oversight for the species, which has, in turn, greatly increased the number of surveys for the species and the detection of VELB.

Determination of VELB population trends is further complicated by the relative rarity of VELB and the low densities at which they typically occur (Collinge et al. 2001), the difficulty associated with conducting surveys for the species, and the potentially ambiguous characteristics that are often used to document VELB occurrence (USFWS 2006). Elderberry shrubs often occur in thickets of riparian vegetation along with species such as Himalayan blackberry (*Rubus armeniacus*), poison oak (*Toxicodendron diversilobum*), and other dense riparian vegetation that can preclude access to elderberry shrubs for VELB surveys, and many larger, older elderberry shrubs form dense thickets of living and dead stems that are difficult to survey for VELB. Additionally, adult VELB are rarely observed during field surveys (Lang et al. 1989; Barr 1991; Collinge et al. 2001); thus, surveyors frequently rely on the presence of exit holes that are indicative of VELB occupancy in elderberry stems. These holes can be difficult to observe in larger, older shrubs with many stems and in dense thickets of riparian vegetation. VELB holes can also be confused with holes made by other burrowing insects (USFWS 2006), and VELB holes can be modified by birds and other predators such that they no longer display their diagnostic morphological characteristics (Lang et al. 1989). Thus, the determination of occupancy requires a careful and complete survey of elderberry plants and an expert diagnosis of the characteristics of the exit holes observed.

Collinge et al. (2001) provided a quantitative estimation of short-term VELB population trends in the northern part of the species' range by resurveying many sites originally surveyed by Barr (1991). Both studies noted evidence of recent beetle occupation (i.e., exit holes) at approximately 20 percent of the survey sites and 25 percent of the total number of elderberry shrubs examined within each of those sites. Collinge et al. (2001) found that, although the proportions of sites and shrubs with diagnostic VELB exit holes were similar between the two studies, the actual availability of potential beetle habitat was lower because the density of elderberry shrubs in several sites had declined between survey periods. Additionally, although apparent VELB exit

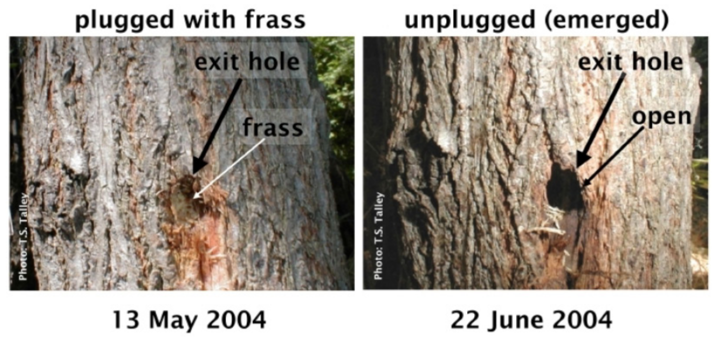
Source: Base map and VELB symbols from Talley et al. 2006;
V = adult male, typical coloration;
C = adult male, atypical coloration

Figure 1. VELB Distribution Area (Blue) Based on VELB Exit Holes (USFWS 1999) Is Larger Than VELB Area Based on Observation (Indicated by V and C Symbols)

holes were found in elderberry clusters of all densities, exit holes were most commonly observed in dense stands of elderberry shrubs, so the decline in stand density between the two survey periods may be further indication of an overall decline in habitat quality for VELB.

Life History

The entire VELB life cycle depends on the beetle's host plant, the elderberry shrub. After mating, the female lays her eggs in the crevices of the elderberry bark. Upon hatching (after approximately 10 days), the larvae bore into the pith of the shrub and feed inside the stems. Each larva cuts a single hole from the stem, then plugs the hole from within using wood shavings, or frass (Figure 2). An assortment of elderberry branch sizes are used for larval development and pupation (0.5 to 7.8 inches in diameter) (Lang et al. 1989; Barr 1991; Collinge et al. 2001); however, exit holes are most frequently found in stems approximately 2 to 4 inches in diameter (Barr 1991; Collinge et al. 2001). Larvae remain in the elderberry stems for 1 to 2 years, until they mature.



Source: (Talley et al. 2006)

Figure 2. Exit Holes of the VELB

VELB emerge during spring as adults through the exit holes they created as larvae (Figure 2). Exit holes are slightly oval and are approximately 0.3 to 0.4 inches in diameter (Barr 1991). Adult beetles are active from March to June (USFWS 1984; Barr 1991). They are herbivores, feeding on elderberry foliage, flowers, and nectar until they mate and complete their life cycle. Adult VELB appear to be poor dispersers (Barr 1991; Collinge et al. 2001) because they have rarely been observed to colonize new, unoccupied sites, particularly when unoccupied sites are greater than approximately 12 miles from occupied sites (Collinge et al. 2001) or not within the same river reach.

Habitat and Ecological Process Associations

Elderberry is a common component of riparian forest and riparian scrub habitats in the Central Valley. Unlike many other riparian species, elderberry is not flood tolerant, and is more commonly found in areas that do not experience regular floodplain inundation (Fremier and Talley 2009; Vaghti et al. 2009). Elderberry shrubs germinate in open habitats from seeds dispersed by birds and other animals. They prefer moist, well-drained soils in sunny sites, usually in early successional plant communities; however, they frequently persist in openings within mature riparian woodlands and as an understory species in riparian woodlands (Stevens and Nesom 2006). Elderberry seeds have a hard seed coat and compose long-lived seed banks;

seeds may remain viable for up to 16 years in storage, and germination under field conditions may be delayed for 2 to 5 years (Stevens and Nesom 2006).

Studies that have examined elderberry shrub locations in relation to variables such as floodplain age, distance from the river, relative height above the river, and similar attributes tied to riverine geomorphic processes and flooding have found either weak (but statistically significant) relationships or relationships that are significant in some river systems but not in others (Fremier and Talley 2009; Vaghti et al. 2009). Similarly, soil texture, shading, and other physical habitat attributes generally show little to no relationship to elderberry occurrence or are significant in some river systems but not in others. Fremier and Talley (2009) concluded that within many, but not all, river systems, elderberry presence is most commonly associated with intermediate relative floodplain elevations (i.e., approximately 5 to 15 feet above the river, which is indicative of areas not subject to regular inundation but where summer groundwater is still available), increased floodplain width, and increased lateral distances from the river channel; other studies (Lang et al. 1989) have found elderberry shrubs at a variety of floodplain elevations, at least along the Sacramento River between Sacramento and Red Bluff, with most shrubs observed in plant communities not indicative of regular flooding or disturbance (i.e., mature cottonwood forest or mixed riparian woodland). Ultimately, the factors that control elderberry presence and density are highly variable across river systems and within those systems, and, relative to environmental variables (like soil texture, light, and competition), stochastic factors may play a larger role in determining elderberry location and density, particularly at smaller spatial scales (Fremier and Talley 2009).

As might be expected, given the highly variable relationship between elderberry shrubs and riverine processes, shrubs are frequently observed in association with diverse riparian species, with community species composition varying with locality. Commonly associated plants include Fremont cottonwood (*Populus fremontii*), California sycamore (*Platanus racemosa*), black walnut (*Juglans hindsii*), arroyo willow (*Salix lasiolepis*), black willow (*S. gooddingii*), sandbar willow (*S. exigua*), valley oak (*Quercus lobata*), boxelder (*Acer negundo*), Oregon ash (*Fraxinus latifolia*), wild grape (*Vitis californica*), and poison oak (USFWS 1984; Vaghti et al. 2009). However, elderberry is not restricted to riparian areas, and it is the characteristic species of elderberry savannas, where it may occur with various species of oaks (e.g., valley oak, interior live oak [*Q. wislizenii*] or blue oak [*Q. douglasii*]), poison oak, and other upland shrubs of the Sierra Nevada foothills (Holland 1986).

As described above, indicators of VELB presence (i.e., diagnostic exit holes) are usually found at low densities in patches of elderberry shrubs (Talley et al. 2007). Populations typically occur as discrete clusters distributed along river reaches. Local aggregations of VELB are influenced by habitat patch characteristics such as the size of the patch, presence of large shrubs and diversity of stem sizes, and habitat connectivity (Talley 2007; Talley et al. 2007). River systems without VELB are unlikely to be colonized by VELB even if suitable habitat is present (Collinge et al. 2001). Conversely, river systems where VELB is present can experience localized extinctions within areas that formerly supported the species, and formerly unoccupied elderberry shrubs can be colonized by beetles from proximate populations (Collinge et al. 2001).

Island biogeography and metapopulation theory provide a conceptual framework for population-level studies of VELB and highlight the importance of habitat patch size, quality, and connectivity for VELB population persistence (Collinge et al. 2001; Talley 2007). The theory of island biogeography predicts that the numbers of beetles found in an undisturbed patch will be determined by rates of immigration and extinction. These rates are affected by the distance between patches and the size of each patch. Immigration of beetles into a patch should be greater for patches located close to other patches (Collinge et al. 2001), and the probability of extinction of a population occupying a patch should be lower in larger patches. Thus, large undisturbed patches of elderberry shrubs located close to one another are likely important for maintaining VELB metapopulations (Talley 2007).

Despite the importance of patch characteristics, stochastic factors likely play an equal or potentially even greater role in determining VELB occurrence, particularly at small spatial scales (Collinge et al. 2001; Talley 2007; Talley et al. 2007). The small population sizes commonly observed for VELB and the species' relative inability to readily disperse to other, potentially suitable habitat patches increase the probability that stochastic factors (i.e., factors other than habitat patch characteristics or other environmental variables) influence the distribution of VELB (Collinge et al. 2001; Talley 2007; Talley et al. 2007). Overall, the relationships between the beetle and its habitat are complex, scale-dependent, and difficult to generalize (Talley 2007), and these relationships are further confounded and complicated by the similarly complex and location- and scale-dependent relationships that govern the establishment, growth, and persistence of VELB's elderberry host plants (Fremier and Talley 2009).

Conceptual Models

A conceptual model has been developed to assist in development of a targeted conservation strategy for VELB within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by VELB within the SPA;
- the specific CPAs within which these habitat conditions occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

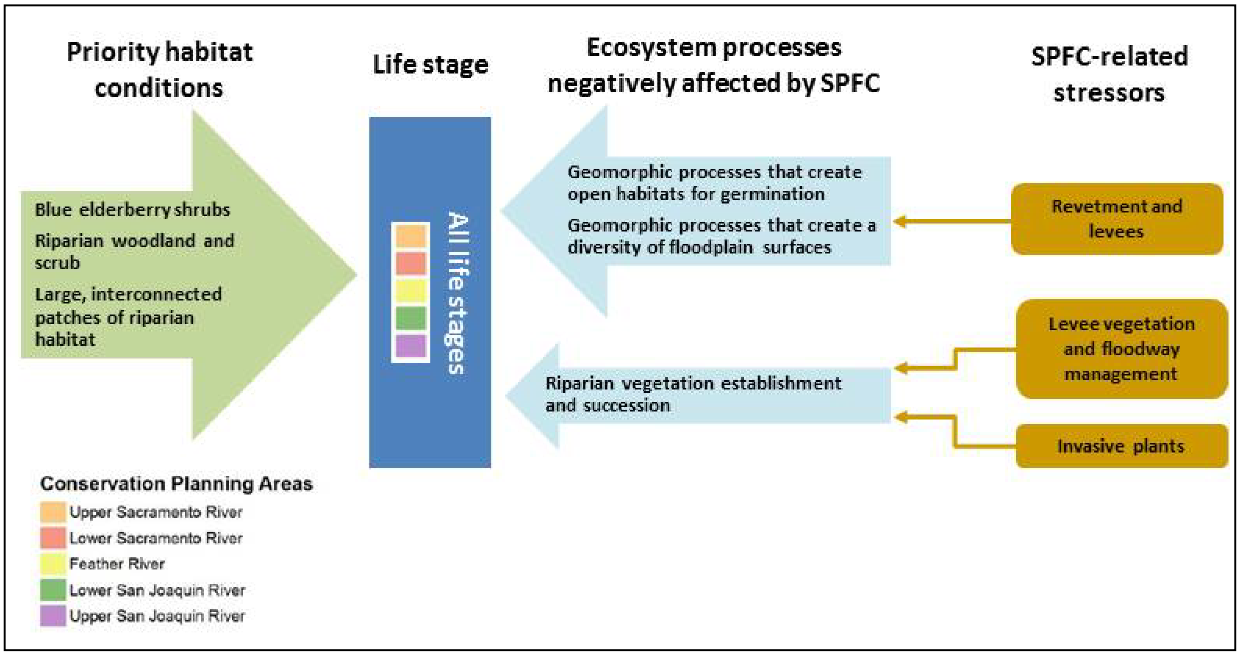


Figure 3. Conceptual Model for Valley Elderberry Longhorn Beetle within the SPA

Management Issues

Threats and Sensitivities Range-Wide

At the time of listing, habitat loss was identified as one of the most significant threats to VELB, based on the estimated 90 percent loss of riparian habitat in the Central Valley (Barr 1991). Agricultural, flood control, and urban development have decimated the Central Valley's riparian forests during the last 150 years. Between 1980 and 2006, the loss slowed because so little riparian habitat remained, protections were provided under ESA for the VELB (and other species found in Central Valley riparian habitats), and other regulatory protections and restoration efforts took effect (USFWS 2006). Although loss of riparian forests has been extensive, it is unclear how much of the lost habitat contained elderberry shrubs or was occupied by the beetle (USFWS 2006).

Riparian habitat loss has created fragmented and isolated remnants of VELB habitat. Competition between elderberry shrubs and invasive species such as Bermuda grass (*Cynodon dactylon*) (Vaghti et al. 2009) or nitrogen-fixing trees like black locust (*Robinia pseudoacacia*) (Talley et al. 2007) may adversely affect elderberry germination and persistence. Subpopulations of VELB, confined to small habitat areas, are likely vulnerable to extirpation by random, unpredictable environmental, genetic, and demographic events and the adverse effects of competition with invasive species such as the Argentine ant (*Linepithema humile*) (Huxel 2000). The distances between subpopulations, along with VELB's limited dispersal range, could make recolonization difficult if extirpation occurred (Collinge et al. 2001).

Ongoing and Future Impacts

Ongoing and future impacts on the VELB and its habitat in the SPA include vegetation management practices used on levees and in floodways, competition between elderberry shrubs and invasive plants, and the use of pesticides. Two other factors, dust from traffic and climate change, may have impacts on the species, but are not likely to be significant to the beetle's recovery.

- Changes to policies governing the management of vegetation on levees and in floodways may result in continued loss of riparian habitat that includes elderberry shrubs, and thus a net degradation of VELB habitat (DWR 2012). Although vegetation management efforts have avoided impacts on elderberry shrubs where their presence was recognized, companion species are frequently removed, as well as elderberry seedlings with stems less than 1 inch in diameter. Implementation of the U.S. Army Corps of Engineers' (USACE's) policy (ETL 1110-2-571) requiring the removal of trees and shrubs from federal levees may result in further degradation of VELB habitat. Mitigation options for VELB habitat in the SPA are often limited by the lack of suitable floodplain habitat. This lack results both from the presence of flood control levees immediately adjacent to the river channel and from a resistance, on the part of the Central Valley Flood Protection Board and Local Maintaining Agencies, to restore VELB habitat in areas where it could pose an unacceptable threat to levee integrity or hamper the inspection and maintenance of federal flood control levees.

- Nonnative invasive plants, including fig (*Ficus carica*), Himalayan blackberry, giant reed (*Arundo donax*), black locust, scarlet sesban (*Sesbania punicea*), tree of heaven (*Ailanthus altissima*), ripgut brome (*Bromus diandrus*), and Bermuda grass, are a major threat to Central Valley riparian habitats because they compete with native riparian species, including elderberry, and may elevate fire risk (Talley et al. 2006, 2007; Vaghti et al. 2009).

- Throughout the Central Valley, agricultural land uses neighbor riparian habitats. Given the amount and scope of agricultural pesticide use, along with unreported household and other uses, it is likely that pesticides are affecting the VELB and its elderberry habitat. However, the magnitude and population-level importance of pesticide effects on the beetle remain uncertain (USFWS 2006).

- The species recovery plan (USFWS 1984) lists dust as a threat to the VELB. However, Talley et al. (2006) found that dust from low-traffic dirt and paved access roads and trails in the American River Parkway did not significantly affect beetle presence, either directly or indirectly, through changed elderberry conditions.

- Climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the Sierra Nevada as rain rather than snow, reducing snowpack and summer water availability (Cayan et al. 2006, as cited in USFWS 2012). Blue elderberry is well adapted to warm temperatures, so the extent of its range is not likely to decrease as a result of increased temperatures; however, the shrub's response to potential climate-related changes in the hydrologic cycle is uncertain (USFWS 2012).

Key Information Gaps or Uncertainties

The following information would contribute to the long-term conservation of VELB within the SPA: better data on VELB populations, including dynamics, genetic variability, and distribution; appropriate guidelines for the restoration of VELB habitat to increase habitat suitability, contribute to the maintenance of regional metapopulation processes, and increase the probability that VELB will persist or colonize restoration sites; data on the magnitude of adverse effects of invasive species on VELB and its habitat; and an analysis of the impacts of floodway maintenance activities, particularly herbicide and pesticide use, on VELB and its habitat. Specific data gaps are discussed below.

- **Population status and trends.** To date, there has been only one attempt to quantify a VELB population trend (Collinge et al. 2001), and this study examined population trends over a relatively short period. VELB populations are assumed to be stable or increasing because riparian habitat in general, and elderberry shrubs specifically, have received increased protection and have been the foci of many habitat restoration efforts in the Central Valley (USFWS 2012); however, this assumption is based largely on increasing numbers of elderberry shrubs, not necessarily numbers of VELB. An inventory of blue elderberry shrub distribution in and adjacent to the SPFC, along with surveys of elderberry shrubs to determine the presence of recent exit holes (to the extent that such a survey would be feasible), would positively contribute to VELB conservation in the SPA. Better information on genetic variability within VELB populations and the potential for small, isolated populations to persist over the long term would also support conservation of the beetle (Talley et al. 2006).

- **Appropriate habitat restoration guidelines.** As described above, the relationships between VELB and its habitat are complex, frequently site specific, and may be strongly determined by stochastic factors that cannot be predicted or managed. Therefore, the effectiveness of restoration efforts and the ability of restored areas to support long-term populations of VELB are uncertain (Holyoak and Koch-Munz 2008; Gilbert 2009; Holyoak et al. 2010; USFWS 2012). Given these challenges, additional surveys of existing restoration sites to determine both the landscape-scale and site-scale factors most frequently associated with successful elderberry establishment, elderberry persistence, VELB presence (as indicated by the presence of diagnostic exit holes), and increased VELB density would facilitate the development of appropriate habitat restoration guidelines. These guidelines could be incorporated into Conservation Strategy actions to increase the probability that restoration sites would continue to function as potential VELB habitat over the long term.

- **Interaction with invasive species.** Invasive species, both plants and invertebrates, are assumed to compete with and adversely affect VELB and its habitat (Huxel 2000; Talley et al. 2006, 2007; Vaghti et al. 2009); however, studies have, in general, not found a strong relationship between invasive species and VELB presence or elderberry shrub occurrence, even though a negative relationship is presumed to exist. Additional information on the potential effects of specific invasive species is needed so that targeted control efforts can be incorporated into Conservation Strategy actions and routine SPFC operation and maintenance activities in an effort to conserve VELB and its habitat.

- **Conservation-friendly management actions.** The level of sensitivity of blue elderberry to herbicides applied by flood managers is not known. Furthermore, the sensitivity of VELB to pesticides and pesticide drift, and the overall effect of pesticides on the beetle and its habitat, are uncertain (USFWS 2012). A better understanding of the effects of herbicides and pesticides on VELB and the development of appropriate guidelines regarding pesticide and herbicide use in the SPA would positively contribute to VELB conservation.

Conservation Strategy

Conservation and Recovery Opportunities

The most effective way to conserve and restore this species in the SPA will be to restore both suitable habitat and riverine geomorphic processes, with the goal of increasing potentially suitable VELB habitat and promoting connectivity among patches.

Identified Conservation Needs

1. **Increase the amount, connectivity, and quality of VELB habitat:** Large, dense patches of elderberry shrubs that have a diversity of stem sizes (including many smaller stems between 2 and 4 inches in diameter) and that are located close to one another and to known VELB populations, provide the best habitat for VELB (Lang et al. 1989; Collinge et al. 2001; Talley 2007; Talley et al. 2007). Generally, patches of elderberry shrubs having these attributes occur within a matrix of riparian habitat ranging from relatively open riparian scrub to denser riparian woodland associated with wider floodways (i.e., floodways less constrained by levees), in areas with minimal annual flooding and summer groundwater availability (i.e., at intermediate floodplain elevations). Increasing the number of elderberry shrub clusters and their distribution throughout the SPA would provide more potential habitat for the beetle and would create new dispersal corridors, particularly when areas of habitat are restored in close proximity to known VELB population clusters such as those found within the Upper Sacramento, Lower Sacramento, and Feather River CPAs. Habitat restoration actions within or in close proximity to the Sacramento River Wildlife Area, Sacramento River National Wildlife Refuge, Oroville Wildlife Area, and Feather River Wildlife Area would be particularly beneficial for VELB as these areas currently support dense and diverse riparian habitats and VELB populations that could be enhanced or expanded by focused

restoration actions. In addition, the range of VELB throughout the SPA could potentially be expanded by restoring riparian scrub and woodland habitats and incorporating dense patches of elderberry shrubs as components of restored riparian habitats.

2. **Restore riverine geomorphic processes:** Aside from active restoration of VELB habitat (i.e., planting elderberry shrubs), the restoration of riverine geomorphic processes, particularly within areas known to support VELB as described above, would contribute to long-term VELB conservation. Riverine geomorphic processes result in disturbances that create suitable sites for elderberry germination, and create diverse floodplain surfaces of different ages and heights above the river, which support a wide variety of riparian habitats within which elderberry shrubs can grow. Like active habitat restoration, the restoration of geomorphic processes should, over the long term, contribute to an increase in potentially suitable VELB habitat and increase habitat connectivity among adjacent VELB population clusters.

3. **Eliminate competition from invasive species:** Although prior studies have not found a strong, negative effect on elderberry shrubs or VELB from invasive plants (Talley et al. 2007; Vaghti et al. 2009), invasive species are generally recognized as having a negative effect on native species and ecosystems, and given the highly variable and scale-dependent relationships among elderberry shrubs, VELB, and environmental conditions, the absence of a negative effect in some circumstances should not be interpreted to mean that invasive species would not negatively affect elderberry shrubs or VELB in all situations. Eliminating invasive species within the SPA, with a focus on areas of the Upper Sacramento, Feather River, and Lower Sacramento CPAs that are known to support VELB, would create areas of bare ground for possible elderberry recruitment and, when combined with elderberry planting, would create larger, contiguous patches of elderberry shrubs that provide suitable VELB habitat.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of VELB; these are summarized in Table 1 of this section. In many cases, the conservation needs of VELB can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Valley Elderberry Longhorn Beetle[a]

CVFPP Management Actions	Conservation Need		
	1. Increase VELB Habitat	2. Restore Riverine Geomorphic Processes	3. Eliminate Competition from Invasive Species
Operations, Maintenance, and Floodway Management			
Floodwater storage and reservoir forecasting, operations, and coordination	+/-	+	
Facility maintenance			
Levee vegetation management	+/-		+
Floodway maintenance	+/-		+
Modification of floodplain topography			
Support of floodplain agriculture			
Invasive plant management	+		+
Restoration of riparian, SRA, and marsh habitats	+		
Wildlife-friendly agriculture			
Structural Improvements			
Levee and revetment removal	+	+	
Levee relocation	+	+	
Bypass expansion and construction	+/-		
Levee construction and improvement			
Flood control structures			

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

Operations, Maintenance, and Floodway Management

Floodwater storage and reservoir forecasting, operations, and coordination: Modifying reservoir releases to increase the frequency of riverine geomorphic processes (e.g., scouring, floodplain creation) in downstream reaches could positively contribute to VELB conservation by creating potentially suitable sites for elderberry germination and recruitment. However, modified reservoir operations that increase inundation of existing elderberry habitat would negatively affect VELB because increased or prolonged inundation of elderberry shrubs would lead to greater shrub mortality and a decline in the amount of potentially suitable VELB habitat.

Levee vegetation management: Managing levee vegetation, by mowing, dragging, grading, burning, grazing, or applying herbicides, may negatively affect VELB even though these activities are typically required to avoid all direct effects on mature elderberry shrubs (i.e., shrubs with stems greater than 1 inch in diameter). Evidence suggests that VELB are most frequently found in stems ranging in size from roughly 2 to 4 inches in diameter (Lang et al. 1989; Collinge et al. 2001) within large, dense clumps of elderberry shrubs that contain large plants and a diversity of stem sizes (Talley et al. 2007); thus, natural recruitment of elderberry shrubs is likely important to maintain or increase stand density and to create a diversity of stem sizes, including the small- and medium-diameter stems that most frequently support VELB. Vegetation management actions that remove elderberry seedlings may therefore negatively affect VELB by preventing recruitment of new shrubs that could increase overall elderberry density within a site and add to the number of stems that provide potentially suitable VELB habitat. However, to the extent that levee vegetation management focuses on the removal of invasive plants (as described below), these actions could positively affect VELB and its habitat. VELB could also be positively affected if DWR and other levee maintenance agencies routinely include elderberries when revegetating areas other than levees, which are not subject to frequent maintenance.

Floodway maintenance: Floodway maintenance practices are likely to negatively affect VELB for the reasons described above for levee vegetation management. However, to the extent that floodway maintenance focuses on the removal of invasive plants (as described below), maintenance actions could positively affect VELB and its habitat. VELB could also be positively affected if DWR and other floodway maintenance agencies routinely include elderberries when revegetating floodways following maintenance (e.g., sediment removal) projects.

Invasive plant management: Treating invasive plants where elderberry shrubs occur in the SPA, particularly in areas known to support dense clusters of VELB within the Upper Sacramento, Feather River, and Lower Sacramento CPAs (or adjacent areas) would benefit VELB's host plant by reducing competition and increasing the resources (e.g., soil nutrients, light, and water) available for elderberry shrub germination, growth, and seed production.

Restoration of riparian, SRA cover, and marsh habitats: Restoring riparian scrub and woodland habitats that include large clusters of elderberry shrubs, particularly when restored habitats are close to sites of known VELB occurrences such as those found within the Upper and Lower Sacramento CPAs and Feather River CPA, would contribute to long-term VELB conservation by increasing the amount of potentially suitable habitat and connecting localized clusters of VELB. Added connectivity would facilitate movement among population clusters and support VELB colonization after localized extirpation events.

Structural Improvements

Levee and revetment removal: The removal of levees or rock revetment from armored riverbanks would positively affect elderberry shrubs (and thus VELB) by improving the hydrologic and geomorphic processes that are important for creating and sustaining riparian habitats.

Levee relocation: As described for levee and revetment removal, relocating levees (i.e., constructing setback levees) would improve ecosystem functions and restore natural riverine geomorphic processes, creating opportunities to provide suitable habitat for VELB. Specifically, expanded floodways would allow for natural river meander, sediment erosion and deposition, and natural ecosystem disturbance processes that could create new patches of suitable habitat. These actions would be particularly beneficial in areas where levees currently exist in close proximity to known VELB populations such as the Feather River CPA.

Bypass expansion and construction: To the extent that bypass construction and expansion could accommodate, or lead to the eventual establishment of, riparian habitat that would include patches of elderberry shrubs, these actions could positively affect VELB conservation. However, if these actions resulted in more flooding (i.e., increased area or frequency) or longer-duration flooding relative to current conditions, existing elderberry shrubs, and thus VELB, would be negatively affected.

Recovery Plan Alignment

This focused conservation plan was developed to be consistent with the VELB recovery plan. The VELB recovery plan summarizes what was known of the species as of 1984, prescribes actions to acquire biological data, and offers preliminary recommendations for actions necessary to preserve, maintain, and recover VELB populations (USFWS 1984). The primary objectives of the plan are to:

- protect known VELB colonies and habitat,
- find unknown VELB colonies and habitat,
- protect remaining VELB habitat within the beetle’s suspected historical range,
- determine the number of sites and populations needed before the species can be delisted,
- determine ecological requirements and management needs,
- restore VELB habitat and populations,
- educate the public about the beetle and its habitat, and
- protect VELB by enforcing existing laws and regulations.

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 VELB. Therefore, building on the preceding discussion, this section of the VELB 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 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 habitat and the degree of connectivity among patches of riparian habitat are indicators of progress toward the Conservation Strategy's riparian habitat objective. To measure the contribution of CVFPP actions to the conservation of VELB, requirements could be added to increase the acreage of riparian habitat that would include clusters of elderberry shrubs planted in close proximity to existing VELB populations, in an effort to sustain local VELB populations and support the expansion of VELB into parts of the SPA where it does not currently occur.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of VELB, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit VELB may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Valley Elderberry Longhorn Beetle

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	No	
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	Natural banks close to known VELB populations would provide the greatest conservation value.
	River Meander Potential—total amount (acres)	Yes	Meandering rivers close to known VELB populations would provide the greatest conservation value.
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Valley Elderberry Longhorn Beetle

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Planting riparian habitat that includes large clusters of elderberry shrubs with a variety of stem sizes at sites close to existing VELB population clusters would provide the greatest immediate value; however, systemwide restoration of riparian habitat containing large clusters of elderberry shrubs would create opportunities to restore the range of the species and add resiliency and redundancy to its populations.
	Habitat Connectivity—median patch size (acres)	Yes	VELB is a poor disperser and has been shown to more commonly occur in large patches of elderberry shrubs; connectivity among adjacent patches of shrubs (within approximately 12 miles) has been shown to increase the probability of VELB dispersal and recolonization following localized extirpations.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	No	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	Revetment removal would be most effective if targeted toward areas that are close to known VELB populations. Systemwide revetment removal would create opportunities to expand the range of the species.
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	Levee removal or relocation would be most effective if targeted toward areas that are close to known VELB populations. Systemwide levee removal or relocation would create opportunities to expand the range of the species.
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	Invasive plant treatments are most likely to positively affect VELB when they are completed in the vicinity of existing elderberry shrubs and VELB population clusters.

Key: EAH = expected annual habitat.

Note:

[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 2 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).

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G4. Focused Conservation Plan: California Central Valley Steelhead

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the California Central Valley (CCV) steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS) in the SPA for the CVFPP. The DPS occupies all five CPAs in the SPA, and includes all naturally spawned populations of steelhead in the Sacramento and San Joaquin Rivers and their tributaries, as well as populations from the Coleman National Fish Hatchery and Feather River Fish Hatchery (63 FR 13347).

The CCV steelhead DPS was federally listed as threatened under the ESA in 1998 (63 FR 13347); this threatened status was reaffirmed in 2005 (71 FR 834). In 2002, an ESA Section 4(d) protective regulation was declared for this DPS that applied the ESA Section 9 take prohibitions but also created several limits for the application of take prohibitions (60 FR 37160).

Critical habitat for the CCV steelhead DPS was designated in 2005. Critical habitat includes all river reaches accessible to listed steelhead in the Sacramento and San Joaquin Rivers and their tributaries. Also included are river reaches and estuarine areas of the Delta (in the Sacramento Delta and San Joaquin Delta Hydrologic Units); all waters from Chipps Island west to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay west of the Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge), from San Pablo Bay to the Golden Gate Bridge (70 FR 52488). The primary constituent elements considered essential for the conservation of CCV steelhead are (1) freshwater spawning sites, (2) freshwater rearing sites, (3) freshwater migration corridors, (4) estuarine areas, (5) near-shore marine areas, and (6) offshore marine areas.

The most recent 5-year review of the ESA listing classification of CCV steelhead (NMFS 2011) concluded that the fish will remain listed as threatened, 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.”

NMFS released a draft recovery plan in 2009 which was finalized in 2014 after undergoing public review: the *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead* (NMFS 2014) is a guidance and planning document that delineates reasonable actions that may be necessary for the conservation and survival of listed species.

Status and Trends

Historical Distribution

Historically, CCV steelhead occurred throughout the Sacramento and San Joaquin River systems, but large dams block access to an estimated 80 percent of their historical habitat, as well as blocking access to the entire habitat of 38 percent of the 81 historically independent populations of steelhead (Figure 1) (Lindley et al. 2006; NMFS 2014).

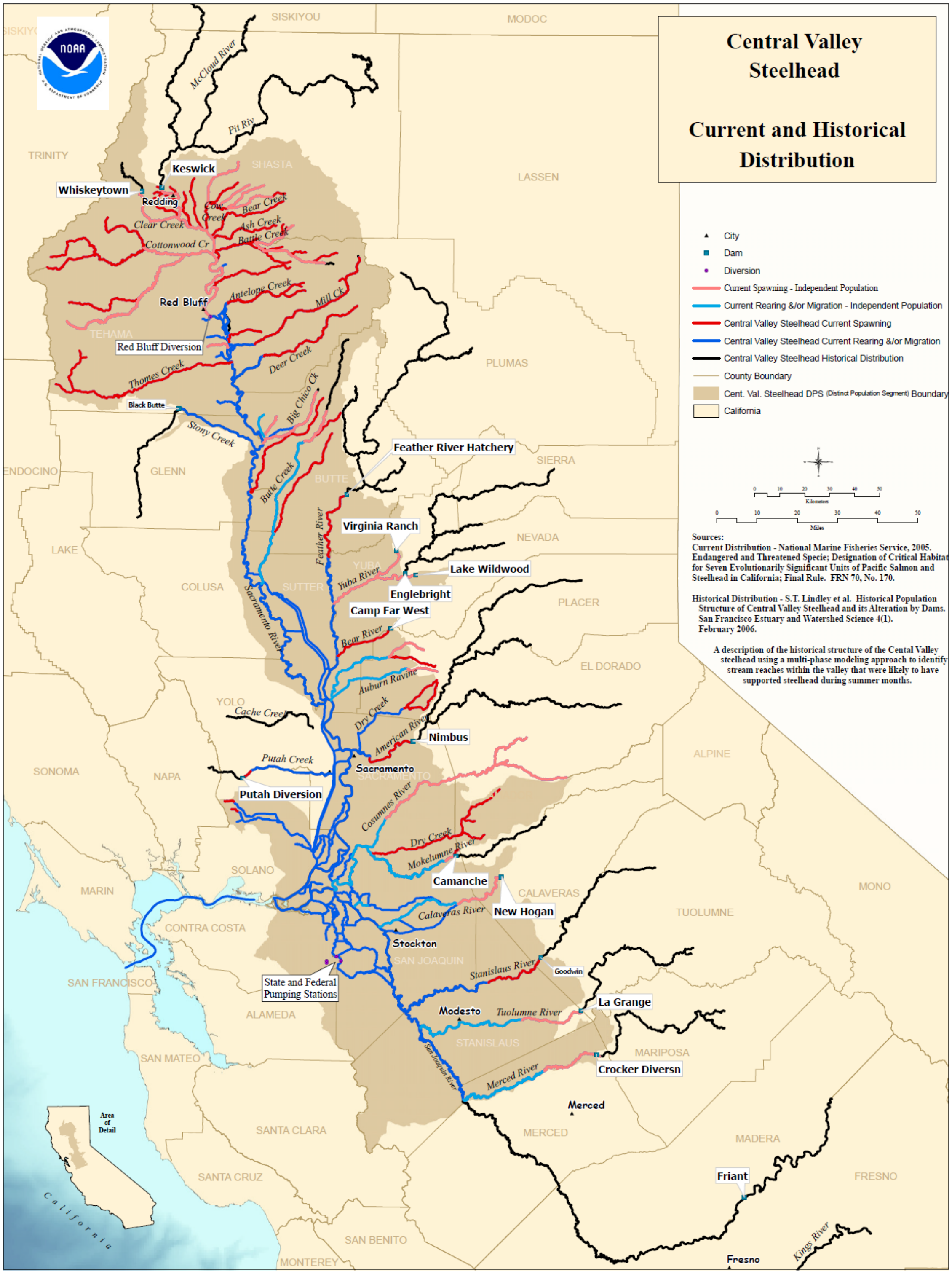
Current Distribution

Currently, CCV steelhead spawn downstream of dams on every major tributary in the SPA (Figure 1) (NMFS 2014). They occur in the Sacramento River and its tributaries, including Antelope, Deer, Clear, and Mill Creeks in the Upper Sacramento River CPA; in the Feather, Bear, and Yuba Rivers in the Feather River CPA; in the American River in the Lower Sacramento River CPA; and in the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced Rivers in the Lower San Joaquin River CPA (Figure 1). Some CCV steelhead populations are heavily influenced or sustained by hatchery-produced steelhead, such as Feather River Hatchery steelhead in the Feather River and Nimbus Hatchery fish in the American River (NMFS 2014).

In the tributaries of the Lower San Joaquin River CPA, the majority of *O. mykiss* in this system may comprise resident forms that spend their entire life in freshwater and are commonly referred to as "rainbow trout" (Zimmerman et al. 2009; NMFS 2014). Restoration efforts on the San Joaquin River downstream of Friant Dam, related to reintroduction of spring-run Chinook salmon, will likely improve habitat conditions for CCV steelhead in the Upper San Joaquin River CPA (NMFS 2014). Populations of resident rainbow trout persist upstream of most of the dams; these are likely descended from formerly anadromous steelhead populations (Lindley et al. 2006) and are not considered part of the listed DPS (Williams et al. 2011).

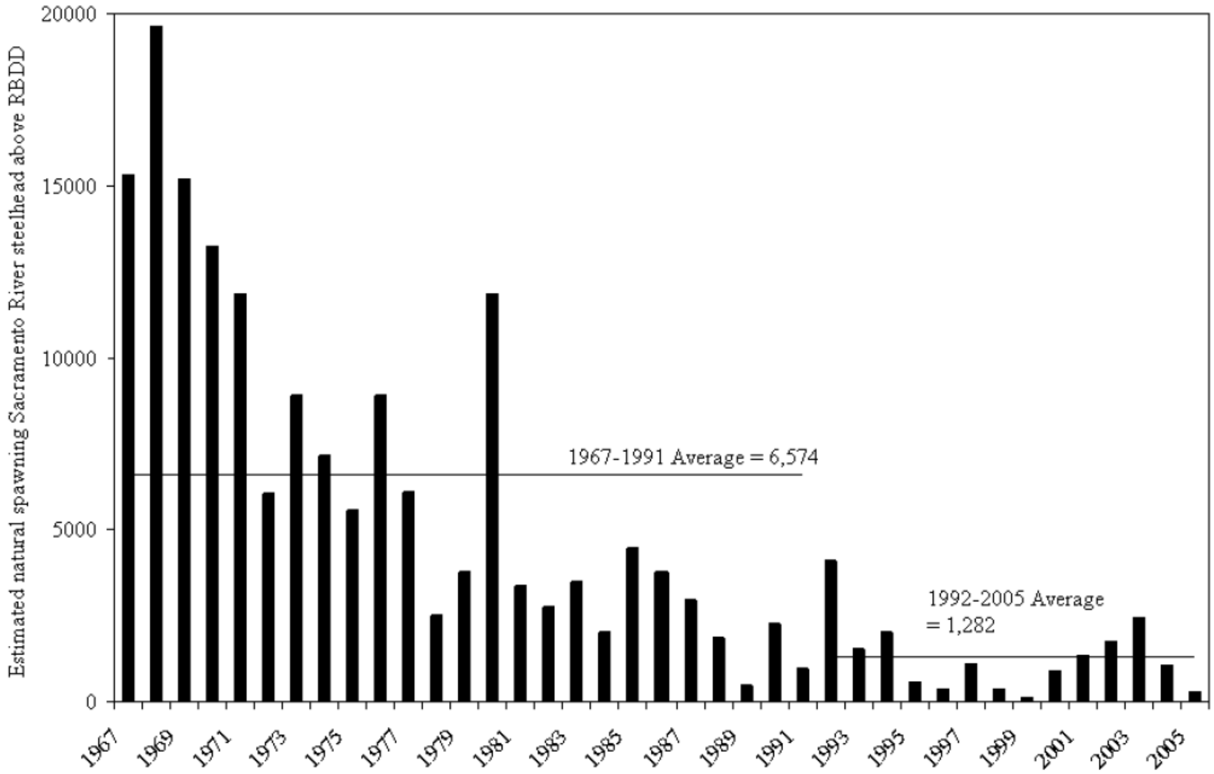
Population Trends

Historical population numbers of CCV steelhead may once have been as high as 1–2 million adults (NMFS 2014). The average run size of steelhead in the Sacramento River basin was estimated at 20,540 adults in the 1950s and 40,000 in the early 1960s (McEwan and Jackson 1996). Since then, the population has declined significantly; estimates from the early 1990s were fewer than 10,000 adults (McEwan and Jackson 1996). At Red Bluff Diversion Dam in the Upper Sacramento River CPA, wild steelhead numbers declined from an average annual run size of 12,900 in the late 1960s to 1,400 adults in 1991–1996 (Figure 2) (DWR 2012a). More recent population estimates are limited; the best population-level data are from the weir at Battle Creek in the Upper Sacramento River CPA, which showed a 10-year declining trend from 2000 to 2010 (Williams et al. 2011). The 2011 status review (Williams et al. 2011) for CCV steelhead indicates that their status has diminished since the 2005 status review (Good et al. 2005), with updated information indicating an increased risk of extinction.



Source: NMFS 2014

Figure 1. CCV Steelhead DPS—Current and Historical Distribution



Source: DWR 2012b

Figure 2. Steelhead Population Trends in the Sacramento River Upstream from Red Bluff Diversion Dam, 1967–2005

Life History

O. mykiss can be either resident or anadromous: resident *O. mykiss,* which spend their entire lives in freshwater, are referred to as "rainbow trout," whereas anadromous *O. mykiss* are referred to as "steelhead." Steelhead typically spend 1–3 years in freshwater followed by 1–3 years at sea, then return to freshwater to spawn at about 4 or 5 years of age (Moyle 2002). Unlike other species of *Oncorhynchus*, adult steelhead can spawn more than once before they die. Postspawning adults that migrate downstream to return to the ocean, or that remain in freshwater and become residents, are referred to as "kelts" (Moyle 2002). CCV steelhead are considered "ocean-maturing": they enter freshwater in winter with well-developed gonads and spawn shortly thereafter, although steelhead that entered freshwater in summer may have been present prior to construction of large dams (Moyle 2002). When spawning, females dig nests ("redds") in the gravel with their tails and deposit eggs, and males immediately fertilize the eggs. The eggs incubate in the gravel for 1.5–4 months prior to hatching. Fry emerge from the gravel 2–6 weeks after hatching and begin actively feeding. Juveniles rear in freshwater habitats for one or more years, and migrate downstream to the ocean as smolts at 1–3 years of age (Moyle 2002), peaking in the Delta in March and April. Adult CCV steelhead enter freshwater from August through March, generally peaking in January and February, and migrate into tributaries for spawning

(Moyle 2002; NMFS 2014). They generally spawn from December through April, peaking from January through March (McEwan 2001; NMFS 2014).

Habitat and Ecological Process Associations

The jumping ability of steelhead allows them to migrate farther upstream during high flows than the other salmonid species in the Central Valley, giving them access to more spawning and rearing habitat. This advantage also helps to reduce competition between steelhead and Chinook salmon. Suitable freshwater spawning habitat for CCV steelhead includes clean, loose gravel where there is flow through the gravel (such as in the transitional area between a pool and a riffle), with cool water temperatures (30–52°F), depths of 0.3–5 feet, and water velocities of 0.6–5 feet/second (Moyle 2002). Optimum water temperatures for egg incubation are 44.6–50°F, but eggs can survive at temperatures of 35.6–58°F (Myrick and Cech 2001).

After emergence, the fry rear in shallow, slow-moving waters with bank cover composed of overhanging and submerged vegetation, root wads, and woody material, where they feed on zooplankton and small insects. These elements of fry and juvenile rearing habitat are largely defined by the three attributes of SRA cover: overhanging vegetation, in-water cover, and natural eroding banks (Fris and DeHaven 1993). Such conditions are best supported by natural geomorphic processes.

For the first year or more, juvenile rearing habitat includes cool (optimum range is 59–64.4°F), clear, fast-flowing perennial streams and rivers where riffles predominate over pools, with ample cover from riparian vegetation or undercut banks, and available invertebrate food resources (Moyle 2002). Juveniles can be found at a wider range of water temperatures (32–81°F), but warmer temperatures can cause physiological stress and higher energetic costs. Suitable winter rearing habitat includes interstitial spaces between cobbles and boulders that protect the fish from high flows and predation. Habitat preferences change as the steelhead grow: smaller fish prefer riffles, intermediate-size fish prefer runs, and larger juveniles tend to be found in pools (Moyle 2002). They may establish feeding territories soon after emergence. Prior to migrating to the ocean, some juveniles may briefly inhabit tidal or freshwater marshes or other shallow-water areas in the Delta (NMFS 2014); however, no strong relationships have been found between smolts and shallow riverine and tidal habitats along the Sacramento River (Zajanc et al. 2013).

Compared to Chinook salmon, CCV steelhead may realize fewer growth benefits from floodplain rearing because they can rear mostly in mid- to high-elevation reaches where water temperatures remain suitable through the summers (U.S. Bureau of Reclamation [USBR] 2012). Also, CCV steelhead tend to outmigrate at a larger size than Chinook salmon, so any benefits to growth from floodplain rearing are likely to be minimal; however, if floodplains were inundated from February through March, any benefits of floodplain rearing could be realized before negative effects could occur from potentially unsuitable springtime temperatures (USBR 2012).

Conceptual Models

A conceptual model has been developed to assist in development of a targeted conservation strategy for CCV steelhead within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by CCV steelhead within the SPA;
- the specific CPAs within which these habitat conditions occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Under current conditions, a conceptual model prepared by Stillwater Sciences (2007) suggests that tributary rearing habitat for fry as well as for older juveniles (ages 1+ and 2+), rather than spawning habitat, is more likely to be a limiting factor for CCV steelhead. Fry production may be limited by the availability of gravel riffles in higher-gradient reaches (which are naturally patchy), and, in lower reaches, by competition with larger salmonids (juvenile spring-run Chinook salmon and ages 1+ and 2+ steelhead) that have established territories in suitable rearing habitat (Stillwater Sciences 2007). However, it is considered more likely that winter rearing habitat for ages 1+ and 2+ steelhead is the primary limiting factor, because these fish have narrower winter habitat requirements compared to those of younger age classes. Refugia during high flows in winter and spring, in the form of interstitial spaces between cobbles and boulders and eddies associated with large woody debris, may be more limited for larger, older juveniles than for smaller juveniles, which can find cover in a wider range of gravels and water depths (Stillwater Sciences 2007).

Outmigrating juveniles in the Lower Sacramento and San Joaquin River CPAs may be limited in late spring by high water temperatures, toxicants, flows that divert juveniles into the central and southern Delta, entrainment in unscreened or poorly screened diversions, loss of SRA habitat, loss of natural river morphology and function, loss of floodplain and tidal marsh habitats, invasive species and changes to food webs, predation, and hatchery effects, such as larger steelhead released from hatcheries competing with or preying on smaller wild juvenile steelhead (NMFS 2014). However, improving floodplain rearing habitat for the larger juvenile steelhead may have fewer benefits than it would for smaller juvenile fall-run Chinook salmon, because steelhead can take advantage of a long tributary rearing period that normally takes place in mid- to high-elevation tributary reaches, where suitable water temperatures can be maintained (McEwan 2001; USBR 2012). Smolts move into the tidal reaches of the Lower Sacramento and San Joaquin River CPAs at a large size (NMFS 2014), and tend to move rapidly out of the Delta beyond Chipps Island once emigration has begun (Williams 2006). Nevertheless, the historical

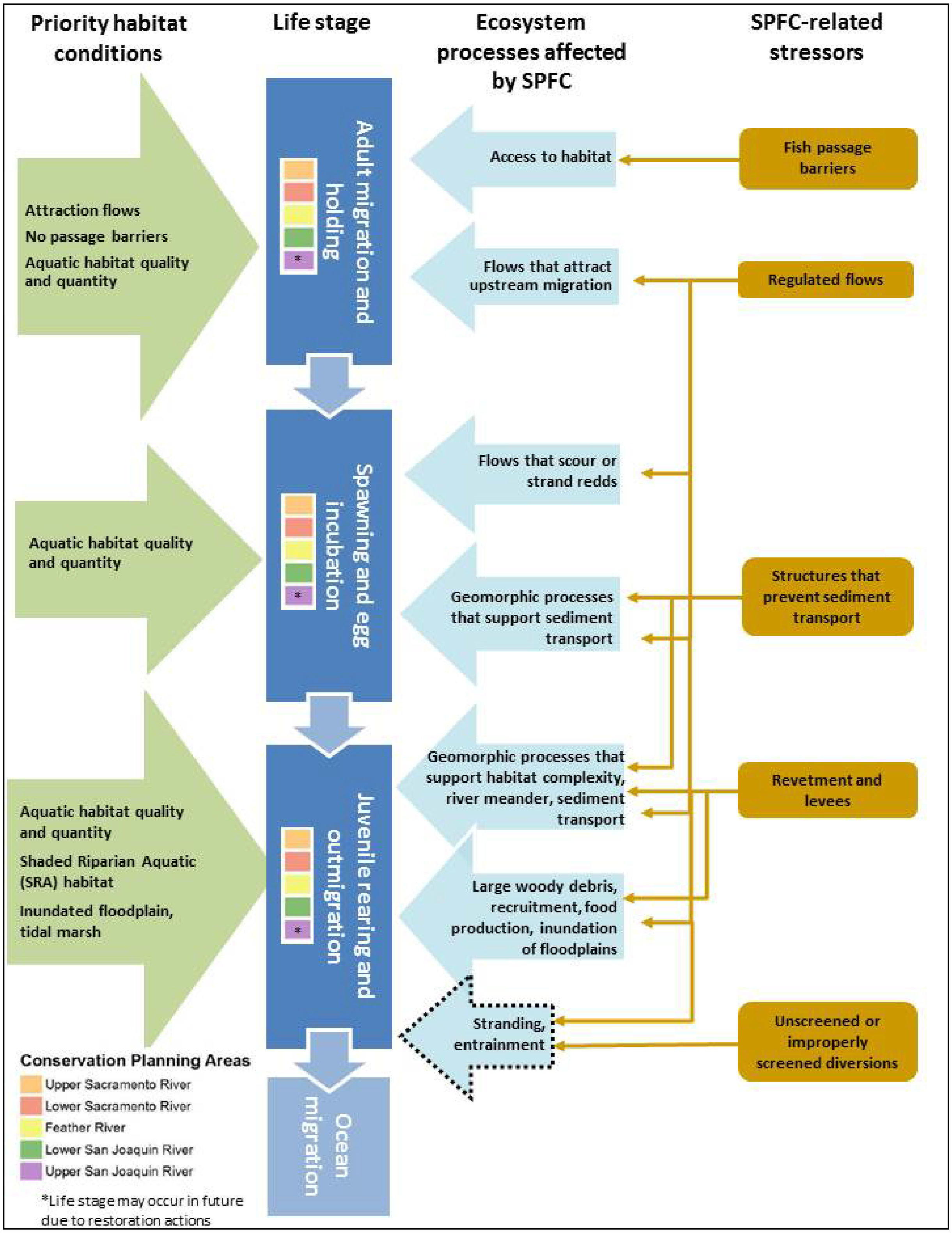


Figure 3. Conceptual Model for California Central Valley Steelhead within the SPA

reduction and degradation of habitats poses the greatest threat to the persistence of CCV steelhead. Impacts, challenges, and management issues for the species are discussed further in the following section.

Management Issues

Threats and Sensitivities Range-Wide

The historical reduction of spawning and rearing habitats throughout the SPA poses the greatest threat to the persistence of the CCV steelhead (Good et al. 2005; NMFS 2014). Spawning and rearing habitat that persists downstream of dams on streams throughout the Sacramento and San Joaquin River Basins remains severely degraded by the operation of ineffective fish screens, fish ladders, and diversion dams. Also, levees and flood control operations and maintenance practices have greatly simplified riverine habitat by channelizing rivers and removing SRA cover along channels, and have disconnected rivers from the floodplain (NMFS 2011). Other threats to CCV steelhead include water diversions and water operations that exacerbate low-flow conditions and, at times, result in dewatering of redds; harvest impacts; warm water temperatures during rearing; limited quantity and quality of rearing habitat; and predation by nonnative species (NMFS 2014). In addition, there are concerns that genetic integrity is being compromised by interbreeding between hatchery-raised steelhead and naturally spawned CCV steelhead (NMFS 2014).

Ongoing and Future Impacts

Ongoing impacts on CCV steelhead in the SPA include construction, operation and maintenance of flood control facilities that affect habitat access, flows, and the quality and availability of downstream habitat; water diversions that entrain juveniles and affect habitat quality; and the effects of climate change, which will likely include degradation of water quality and habitat suitability.

- The availability of suitable habitat likely will continue to be the most critical factor in CCV steelhead recovery (NMFS 2014). Particularly, loss of rearing habitat throughout the SPA will continue to be a significant stressor to CCV steelhead (NMFS 2014). Of the CCV steelhead spawning and rearing habitat that has been lost, the majority was lost as a result of water system developments in Central Valley watersheds: large dams (e.g., Shasta and Oroville Dams) and their associated hydropower development projects have prevented CCV steelhead from accessing significant areas of upstream spawning and rearing habitat (NMFS 2014). Aside from these total barriers, many other partial barriers have been identified that may delay or impair fish migration (see Attachment 9C of DWR 2012a and Conservation Strategy Appendix K, “Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System”) and have been prioritized for improvements based on impacts on fish (see Appendix K). In particular, the Fremont Weir (the primary inundation source for the Yolo Bypass) currently provides adult fish passage at a single fish ladder that is opened once overtopping at the Fremont Weir ceases (USBR 2012). Adult salmon and steelhead passage is impeded at the ladder due to poor attraction flows and other irregularities; however, some steelhead migrate during a time of year when the floodplain would not have been inundated historically (August through November), and these fish would be more likely to be attracted to the greater flows of the Sacramento River mainstem (USBR 2012). Flow management in winter and spring can also affect CCV steelhead access to some tributaries (e.g., Bear Creek) on the upper Sacramento River, usually when lack of rain is coupled with low-flow releases from Keswick Dam (McEwen 2012). CVFPP modifications or projects that contribute to simplified or degraded riverine habitat, such as levee armoring, are expected to negatively affect CCV steelhead. Numerous activities and events can reduce water quality and are expected to continue to negatively affect steelhead. For example, vegetation removal near waterways can increase water temperatures, and dredging activities can resuspend sediment and contaminants, clogging fish gills, smothering eggs, and reducing benthic prey availability. Catastrophic fires can severely affect water quality until vegetation is reestablished. Contaminants in discharges to the rivers and the Delta can affect food webs, degrade habitats, and directly harm juvenile salmonids (Mount et al. 2012).

- Entrainment at diversions continues to be an ongoing impact affecting juvenile steelhead in the Upper and Lower Sacramento River CPAs, the Feather River CPA, and Lower San Joaquin River CPA (NMFS 2014). Entrainment will also be an issue for reintroduced steelhead in the Upper San Joaquin River CPA. Entrainment at both large diversions (such as the Central Valley Project and State Water Project) and numerous unscreened or inadequately screened diversions will likely continue to affect juvenile CCV steelhead (NMFS 2014). Large diversions can also affect water quality (Monsen et al. 2007) and provide habitat for introduced fish predators (Cavallo et al. 2013).

- Climate change will affect habitat for CCV steelhead in the future, but the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the catchment as rain rather than snow, thus reducing snowpack and water availability from snowmelt in spring and summer (Cayan et al. 2006). In the Upper Sacramento River CPA, flow releases from Keswick and Shasta Dams are essential for providing suitable thermal regimes for CCV steelhead rearing; climate change may affect water managers' ability to store water in the reservoir "cold-water pool," ultimately decreasing habitat quantity and quality for juvenile rearing in the Sacramento River between Keswick Dam and Red Bluff, especially during dry years (USBR 2013). Ecologists are only beginning to understand climate change threats to riparian ecosystems (Seavy et al. 2009). Climate change models predict warming temperatures in streams and rivers (Moyle et al. 2013) and increases in sea level, estuarine salinity, and freshwater temperatures (Cloern et al. 2011). CCV steelhead and other cold-water adapted native fish are likely to respond negatively to climate change effects such as changes in streamflows and increased temperatures (Katz et al. 2012; Moyle et al. 2013).

Key Information Gaps or Uncertainties

To better understand how current and future CVFPP activities affect the conservation and potential recovery of CCV steelhead, and to help guide future actions of the CVFPP and Conservation Strategy, the following information is needed: modeling of impacts related to flood management, a better understanding of habitat functions, and data on the effects of predation and stranding.[1] These data gaps are discussed below.

- **Impact models.** Flood managers need an improved understanding of the impacts on salmonid habitats caused by levee erosion repair projects. Currently, the Standard Assessment Methodology is used to systematically compare selected fish species' responses to habitat features affected by levee erosion repair projects. This method involves applying conceptual response models to quantified habitat changes to assess the near- and long-term impacts or benefits to species. The method is based on conceptual response models of indicator fish species, and evaluates effects of levee erosion repair designs that incorporate SRA components (overhanging shade, reduced substrate size, instream woody material, etc.), revetment size, bank slope, and length of the proposed levee project site.

  The conceptual response models were developed using professional opinion and assume relationships between the presence or abundance of an organism and habitat quality. However, habitat quality would be better assessed by evaluating the effects of levee erosion repair designs on the condition (e.g., growth) and survival of indicator fish species (Sommer et al. 2005; Bond et al. 2008). Additionally, the current Standard Assessment Methodology fails to evaluate the loss of riverine processes (lateral migration, reworked floodplain, vegetation regeneration, etc.) and should consider the effects of changes in levee configuration in order to evaluate the benefits or impacts of repairing existing levees versus changing levee alignment to promote natural river processes. These issues can be addressed by evaluating how juvenile CCV steelhead (both young-of-the-year and yearlings) use specific levee repair designs, including the duration of time spent at the site (minutes, hours, days, weeks) and effects on growth and survival. Additionally, there is concern that, in the warmer reaches of the mainstems, habitat features incorporated as mitigation for levee repair projects (e.g., instream wood) may be providing or improving habitat conditions for predators of juvenile CCV steelhead (Vogel 2011), which is being evaluated by resource agencies.

- **Habitat functions.** There is a lack of information on the function of certain habitats in the life history of the species; in particular, the quality and quantity of habitats used by juveniles as they move downstream in the Sacramento and San Joaquin River mainstems and the Delta during rearing and outmigration (Vogel 2011; NMFS 2014). The importance of inundated floodplains and bypasses as rearing habitat is not well understood, nor is the magnitude of stranding or entrainment for adults and juveniles in bypasses and their associated canals and diversions (USBR 2012). There is uncertainty about the importance of the distribution and amounts of SRA habitat on fish populations; for example, is the relationship between SRA habitat and fish numbers linear, or are minimum thresholds of SRA required, and what is the importance of habitat connectivity? Actions that provide habitat for juvenile rearing, coupled

[1] "Stranding" herein refers broadly to any event in which fish are trapped in detrimental conditions by being physically separated from a main body of water or from their natural migration route to natal streams. Stranding includes both entrapment in lethal or sublethal conditions and cases in which fish stray into nonnatal streams or unsuitable habitat because of system operations or attraction flows. Types of stranding are further discussed in Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System."

with studies that evaluate habitat use through an adaptive management approach, could inform and improve future activities associated with levee maintenance and erosion repair.

- **Predation.** Especially in the lower mainstems and Delta, the extent of predation on juvenile steelhead by nonnative fish is not well understood (Williams 2010). The Central Valley has many nonnative, introduced fish species that are potential predators of juvenile steelhead. Actions that could inadvertently increase habitat for predators need to be evaluated.

Conservation Strategy

Conservation and Recovery Opportunities

The integration of environmental stewardship into all flood management activities by (DWR and Local Maintaining Agencies) during project planning, design, operation, 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 CCV steelhead is to increase the availability of suitable spawning and rearing habitats by encouraging riverine processes that improve natural river morphology and function. Improving the distribution and quality of SRA habitat, the amount and distribution of inundated floodplain, connectivity of fish passages, and channel-margin restoration would benefit the species. These conservation needs and opportunities, which align with the recovery plan (NMFS 2014), are discussed in detail below.

Identified Conservation Needs

1. **Improve the distribution and quality of SRA habitat throughout the SPA:** The elements of SRA habitat (overhanging vegetation, instream cover, and natural eroding banks) each offer important habitat resources to adult and juvenile steelhead. SRA habitat provides organic material input, differential velocities, cover, food, temperature regulation, and improved water quality. Because juveniles can rear both in tributaries, mainstems and bypasses, large-scale restoration of SRA habitat is needed to improve their rearing and outmigration habitat, most of which was lost because of construction, operation, and maintenance of SPFC facilities, as well as alteration of flows in the SPA.

2. **Improve the distribution and quality of channel-margin habitat in tidally influenced waterways throughout the Delta region of the Lower Sacramento and Lower San Joaquin River CPAs:** Marsh and channel-margin habitats are an important food and cover resource for emigrating steelhead smolts. Historical reclamation of wetlands and construction of levee systems in the Delta region of the Lower San Joaquin and Lower Sacramento River CPAs has removed most of this habitat. Large-scale restoration of the

distribution and amount of tidally influenced channel-margin habitat is needed (NMFS 2014).

3. **Increase the amount and distribution of inundated floodplain habitat throughout the SPA:** Compared to mainstem channels, inundated off-channel floodplain habitats have higher temperatures and food production rates, and may contribute to higher growth and survival rates for juvenile CCV steelhead. These habitats include bypasses (e.g., Yolo and Sutter) as well as mainstem and tributary floodplains. Inundated floodplain habitats are currently limited by both regulated streamflows (particularly in the bypasses) and levee systems (particularly along mainstems and tributaries). Improving floodplain connectivity will require large-scale restoration actions that take into account the interaction of floodplain elevations and the timing, duration, and quantity of flow releases.

4. **Improve natural river morphology and function:** Flood control measures downstream of dams, such as bank protection, have affected riparian and instream habitat, particularly in the Lower Sacramento River and Feather River CPAs. Constructed levees that narrow channels have increased velocities and channelized rivers so that natural geomorphic processes (e.g., channel meander) are no longer possible. Improving geomorphic processes to support natural bank erosion, sediment deposition, and the establishment and growth of riparian vegetation is essential for providing beneficial SRA habitat, reconnecting floodplains, and recruiting woody material and improving channel complexity important for rearing habitat for juvenile CCV steelhead.

5. **Improve fish passage and decrease entrainment throughout the SPA:** During winter and spring high-flow events, water is diverted into bypasses (e.g., Sutter and Yolo). Adult CCV steelhead can enter the bypasses, but their migration may then be delayed or prevented by control structures (e.g., Fremont and Tisdale Weirs) and potentially into unscreened canals and drains (Cannon 2013; McEwen 2013; Conservation Strategy Appendix K). Therefore, there is a need for improving or eliminating these types of flood control structures in order to provide for adult anadromous fish passage (see Conservation Strategy Appendix K). In addition, juveniles can become entrained by unscreened or inadequately screened diversions, and stranded in bypasses when flows recede, making adequately screening all diversions another high priority conservation action. Finally, upstream passage barriers may prevent some adult CCV steelhead from accessing spawning tributaries during years with only low-flow releases and low rainfall. Consideration of these connectivity issues for both upstream adult migration and downstream juvenile rearing and outmigration is necessary to minimize these impacts.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the CCV steelhead; these are summarized in Table 1 of this section. In many cases, the conservation needs of CCV steelhead can be addressed through the implementation of management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements to facilities. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward 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 limited reoperation of reservoirs and weirs. These could provide flow releases that improve aquatic habitat conditions by changing the timing and amount of releases and ramping rates from November/early December to the end of April. These modifications could reduce fish stranding, dewatering of redds, and passage barriers; initiate upstream adult migration and juvenile outmigration; and generate other environmental benefits, including promoting floodplain connectivity, enhancing meander migration rates, improving spawning gravel dynamics (recruitment, flushing, and mobilization), and improving conditions to promote development of SRA habitat.

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 fish-rearing habitat.

Levee vegetation management: The 2012 CVFPP introduced an interim vegetation management strategy, under which levee vegetation in the Vegetation Management Zone (VMZ; see Figures 2-1 and 2-2 in Appendix D of the Conservation Strategy) is managed for visibility and accessibility, and to reduce threats to levee integrity. Consequently, levee riparian vegetation in the VMZ 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 may also have detrimental effects on water temperature (Poole and Berman 2001) and fish habitat (e.g., instream wood recruitment and cover).

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the CCV Steelhead[a]

SPFC Conservation Actions	Conservation Need				
	1. Increase/ Improve SRA Habitat	2. Increase/ Improve Marsh Habitat	3. Increase Inundated Floodplain	4. Improve Natural River Function	5. Improve Fish Passage and Decrease Entrainment
Operations, Maintenance, and Floodway Management					
Floodwater storage and reservoir forecasting, operations, and coordination	+		+	+	+
Facility maintenance					
Levee vegetation management	-				
Floodway maintenance	+				
Modification of floodplain topography	+		+	+	+
Support of floodplain agriculture			+		+
Invasive plant management				+	
Restoration of riparian, SRA, and marsh habitats	+	+		+	
Wildlife-friendly agriculture					
Structural Improvements					
Levee and revetment removal	+	+	+	+	
Levee relocation	+	+	+	+	
Bypass expansion and construction		+	+	+	+
Levee construction and improvement	+			+	
Flood control structures					+

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

On the whole, levee vegetation management is likely to negatively affect habitat for CCV steelhead. However, lower waterside vegetation could be retained below the VMZ of levees when it does not present an unacceptable threat to levee integrity. Allowing vegetation to grow on the water side 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. This approach would also preserve, in the near term, other vegetation within the VMZ that does not impair visibility and accessibility. Under the Conservation Strategy, additional habitat could be developed to offset the gradual die-off of trees and the removal of trees that pose an unacceptable threat to levee integrity. This vegetation would be more valuable to CCV steelhead if it is (1) located close to water bodies, or at least where juvenile fish could access the vegetation during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) regionally distributed.

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). Fill-placement and rock-repair projects could incorporate reduced particle sizes, instream woody material, SRA elements, and planting berms, where relevant.

Modification of floodplain topography: Floodway topography modifications could increase floodway capacity, inundation frequency and duration, and habitat amounts and diversity, and could also eliminate areas that strand fish. Floodplain elevations could be lowered to provide more frequent and sustained inundation. Elevations could also be modified to provide greater topographic and hydrologic diversity (creating or opening secondary channels or overflow swales) and to eliminate features (such as gravel pits or deep borrow pits in the Feather River CPA and the Upper and Lower San Joaquin River CPAs) that strand fish. These actions would increase riverine and floodplain habitat values (e.g., resting or rearing areas for fish migrating downstream) and provide escape routes for fish during receding flows.

Support of floodplain agriculture: Managing floodways to maintain the compatibility of flood management with agriculture would support agriculture in the bypasses and on floodplain agricultural lands between levees while accommodating access to rearing habitat by juvenile steelhead. Addressing the problems posed by unscreened diversions and other structures that trap or impede movement of any juvenile or adult fish would provide benefits to CCV steelhead. However, it is important that diversions be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; Conservation Strategy Appendix K).

Invasive plant management: Nonnative invasive plants that may be removed from DWR-managed lands and facilities would include submerged aquatic vegetation (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 nonnative submerged aquatic vegetation generally support nonnative fishes such as centrarchids (Grimaldo et al. 2012), particularly in the Lower Sacramento River and Lower San Joaquin River CPAs, which may be predators of juvenile salmonids. Established nonnative terrestrial vegetation in riparian areas displaces important native plants (e.g., willows and cottonwood) that facilitate river meander and natural geomorphic processes. Removal of nonnative invasive plants could therefore benefit CCV steelhead by improving rearing and outmigration habitat and reducing predation by nonnative fishes.

Restoration of riparian, SRA, and marsh habitats: Riparian and marsh habitats could be restored at selected locations in the floodway to benefit juvenile CCV steelhead. Riparian restoration opportunities generally would be found in nonriparian land cover in the floodway, particularly as part of other management actions to increase floodway capacity. Riparian, SRA cover, and marsh restoration would be most beneficial in areas where restoration expands or connects existing habitat patches or where restoration provides habitat in areas with little or no riparian vegetation, or at locations to be identified by future conservation or recovery planning for juvenile steelhead, and in conserved areas. In the bypass system, marsh restoration would be generally beneficial to juvenile steelhead and would be implemented in conjunction with bypass expansion and construction.

Structural Improvements

Levee and revetment removal: Removing levees and revetment that provide little value to local and systemwide flood management could 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 waterways used by juvenile CCV steelhead for rearing, and where removal contributes to a larger zone of active river meander migration.

Levee relocation: Relocating levees farther from rivers (i.e., constructing set back levees) is an important approach to increasing floodway capacity, creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. Often, these benefits can be realized while still supporting agriculture within expanded floodways. Levee relocation would also provide an opportunity for hydraulically connecting the river systems to mitigation plantings associated with the VMZ, and for creating and enhancing rearing habitat for juvenile CCV steelhead in all of the CPAs.

Bypass expansion and construction: Bypass expansion could enhance juvenile rearing habitat (e.g., food resources and cover) by increasing the connectivity of the floodplain to the river system and thus restoring floodplain ecosystems that contribute to food web productivity. However, because bypasses are flooded irregularly, in order to benefit juvenile CCV steelhead bypass flooding needs to occur more frequently (e.g., annual) with the appropriate timing and duration to provide suitable rearing habitat. Modifying bypass weirs (e.g., those in the Yolo and Sutter Bypasses, and at Paradise Cut) could improve inundation timing and duration to benefit fish, provided that other passage conditions are improved (as described in Appendix K).

As part of bypass improvements, adult fish passage could be enhanced at flood control structures (e.g., the Sacramento, Tisdale and Fremont Weirs) (McEwen 2013; Conservation Strategy Appendix K). Also, bypass expansion could address “sinks” where juvenile CCV steelhead could become stranded; for example, the number of isolated pools could be reduced, and connectivity to Tule Canal could be improved (USBR 2012).

Levee construction and improvement: Levee construction and reconstruction objectives that would provide benefits to CCV steelhead include restoring geomorphic processes and, where significant hydraulic impacts would not occur, protecting riparian habitat and incorporating planting berms and riparian plantings. In addition, new levees could be designed to accommodate hydrologic changes expected to result from climate change.

Flood control structures: One priority action for State operated and maintained diversions in the SPA is reconfiguring the Tisdale Weir in the Sutter Bypass and 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 allow passage by adult fish and to increase floodplain inundation (DWR 2012a; Conservation Strategy Appendix K). It is important that diversions be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; McEwen 2013; Conservation Strategy Appendix K). However, improving any structure that traps or impedes movement of juvenile or adult fish would provide benefits to CCV steelhead.

Recovery Plan Alignment

CCV steelhead recovery is based on 2 key conservation principles: 1) sufficient functioning, diverse and interconnected habitats that provide capacity and diversity to allow steelhead to withstand and adapt to environmental changes such as droughts, and 2) steelhead viability is determined by its spatial structure, diversity (e.g., life history, genetics, and megapopulation organization), productivity and abundance (NMFS 2014). CCV steelhead DPS viability depends on the number of populations in the DPS, their individual status, their spatial arrangement with respect to each other and sources of catastrophic disturbance, and the diversity of the populations and their habitats (NMFS 2014). In the most general terms, DPS viability increases with the number, viability, spatial distribution, and diversity of populations, and with the diversity of the habitats that they occupy (NMFS 2014).

NMFS has identified four Diversity Groups for CCV steelhead: Northwestern California, Basalt and Porous Lava, Northern Sierra Nevada, and Southern Sierra Nevada Regions: these are geographically identifiable areas that encompass multiple watersheds (NMFS 2014). For the DPS to achieve recovery, each Diversity Group should support both viable and independent populations and meet goals for redundancy and distribution (NMFS 2014). Thus, an overall goal is to sustain populations in each Diversity Group.

The biological recovery criteria for CCV steelhead are to obtain:

- at least one population at low risk of extinction in the Northwestern California Region,
- at least two populations at low risk of extinction in Basalt and Porous Lava Region,
- at least four populations at low risk of extinction in Northern Sierra Nevada Region,
- at least two populations at low risk of extinction in the Southern Sierra Nevada Region, and

- multiple populations present in each region at moderate risk of extinction.(NMFS 2014)

The recovery plan also identifies reintroduction priority areas for CCV steelhead. They are the McCloud River above Shasta Dam in the Basalt and Porous Lava Region, the Yuba River above Englebright Dam in the Northern Sierra Region, and one candidate watershed in the Southern Sierra Nevada Region (NMFS 2014). There are no candidate reintroduction watersheds yet identified for the Northwestern California Region (NMFS 2014). The recovery plan specifically identifies the need to "incorporate ecosystem restoration including breaching and setting back levees into the Central Valley flood control plans (i.e., FloodSafe Strategic Plan and the Central Valley Flood Protection Plan)". Table 2 lists examples of specific near- and long-term restoration actions and recovery actions identified by NMFS (2014) that could be partially or fully implemented through CVFPP management actions.

Measures of Positive Contribution

Contributing to the recovery and stability of native species populations and overall biotic community diversity is a primary goal of the Conservation Strategy. The objective for this goal is a measurable contribution to the conservation of target species, including CCV steelhead. Therefore, building on the preceding discussion, this section of the CCV steelhead 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 3). 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 conservation of CCV steelhead, requirements would be added to increase the acreage of restored riparian areas that positively contribute to adjacent rearing habitat, providing terrestrial inputs and creating the cover needed by the species.

Table 3 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of CCV steelhead, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit CCV steelhead may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Examples of Near- and Long-Term Restoration and Recovery Actions, by Region, that Could Be Implemented through the CVFPP

CPA	Restoration Action
Upper Sacramento River	• Implement projects to increase Big Chico Creek floodplain habitat availability to improve habitat conditions for juvenile rearing. • Identify stream reaches in Big Chico Creek that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. • Restore and maintain riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types including riparian forest, gravel bars and bare cut banks, shady vegetated banks, side channels, and sheltered wetlands such as sloughs and oxbow lakes. • Ensure that river bank stabilization projects along the Sacramento River utilize biotechnical techniques that restore riparian habitat, rather than solely using the conventional technique of adding riprap. • Implement projects that promote native riparian (e.g., willows) species including eradication projects for nonnative species (e.g., *Arundo*, tamarisk). • Implement short and long-term solutions to minimize the loss of adult steelhead in the Sutter- Butte basin, including consideration of exclusion devices at specific locations.
Feather River	• Utilize fish friendly designs (e.g., levee setbacks, inclusion of riparian vegetation) for levee construction and maintenance. • Implement projects to improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other nonnative predators. • Implement projects to minimize predation at weirs, diversion dams, and related structures. • Develop and implement programs and projects that focus on retaining, restoring and creating active floodplain and riparian corridors. • Implement and maintain projects to increase side channel habitats in order to improve steelhead spawning habitat availability and quality. • Modify Sunset Pumps to provide unimpeded passage of adult steelhead and to minimize predation of juveniles moving downstream. • Develop and implement a large woody material restoration program along the lower Yuba river utilizing sources of wood that enter upstream of reservoirs. • Utilize biotechnical techniques that integrate riparian restoration for river bank stabilization instead of conventional riprap in the Yuba River. • Implement short and long-term solutions to minimize the loss of adult steelhead in the Sutter- Butte basin, including consideration of exclusion devices at specific locations.
Lower Sacramento River	• Restore and maintain riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types including riparian forest, gravel bars and bare cut banks, shady vegetated banks, side channels, and sheltered wetlands such as sloughs and oxbow lakes. • Restore floodplain connectivity and channel meander by constructing set back levees and by removing revetment (e.g., alongside changes to the Fremont Weir and West Sacramento Levee Improvement). • Restore floodplain connectivity by expanding and changing the Sutter and Yolo Bypasses. • Restore floodplain connectivity by constructing set back levees and island breaching (e.g., South Yolo Bypass improvements such as Cache Slough and Prospect Island). • Implement short and long-term solutions to minimize the loss of adult steelhead in the Yolo bypass, including consideration of exclusion devices at specific locations. • Develop and implement programs and projects that focus on retaining, restoring and creating river riparian corridors in the American River watershed.

Table 2. Examples of Near- and Long-Term Restoration and Recovery Actions, by Region, that Could Be Implemented through the CVFPP

CPA	Restoration Action
	• Ensure that river bank stabilization projects along the Sacramento River utilize biotechnical techniques that restore riparian habitat, rather than solely using the conventional technique of adding riprap. • Implement projects that promote native riparian (e.g., willows) species including eradication projects for nonnative species (e.g., *Arundo*, tamarisk). • Create shallow inundated floodplain habitat for multi-species benefits and implement where suitable opportunities are available.
Lower San Joaquin River	• Implement channel modifications as outlined in the SJRRP including increasing channel capacity to accommodate restoration flows. • Minimize entrainment and fish losses to both adult and juvenile life stages to nonviable migration pathways as outlined in the SJRRP. • Provide fish passage at existing structures as outlined in the SJRRP. • Implement projects to protect and restore riparian and floodplain habitats along the San Joaquin River and its tributaries. • Implement habitat enhancement or augmentation actions designed to minimize predation on steelhead in the San Joaquin River and its tributaries. • Develop and implement design criteria and projects to minimize predation at weirs, diversion dams, and related structures in the San Joaquin River and its tributaries. • Identify and implement floodplain and side channel projects to improve river function and increase habitat diversity in tributaries of the San Joaquin River (e.g., Merced, Tuolumne, Stanislaus Rivers).
Upper San Joaquin River	• Implement channel modifications as outlined in the SJRRP including increasing channel capacity to accommodate restoration flows. • Minimize entrainment and fish losses to both adult and juvenile life stages to nonviable migration pathways as outlined in the SJRRP. • Provide fish passage at existing structures as outlined in the SJRRP. • Implement projects to protect and restore riparian and floodplain habitats along the San Joaquin River. • Implement habitat enhancement or augmentation actions designed to minimize predation on steelhead in the San Joaquin River. • Develop and implement design criteria and projects to minimize predation at weirs, diversion dams, and related structures in the San Joaquin River.

Source: NMFS 2014

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the CCV Steelhead

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	Timing and duration of floodplain inundation are important to providing benefits to rearing habitat (e.g., February through March [USBR 2012]; see “Habitat and Ecological Process Associations” above). Floodplain inundation benefits for juveniles can be increased by minimizing stranding potential (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches, and by ramping flows so that surface elevations do not decrease rapidly), and benefits for adults can be increased by minimizing potential for entrainment and trapping (by eliminating or screening diversions or ditches where fish could be trapped, and by implementing solutions to address fish passage barriers; see Conservation Strategy Appendix K).
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	Yes	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	Yes	
Riparian	Habitat Amount— total amount and total amount on active floodplain (acres)	Yes	Provide riparian habitat throughout the riverine rearing and outmigration corridors: (1) located where juvenile fish could access the vegetation during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) distributed along tributaries and mainstems of the Sacramento, Feather, and San Joaquin Rivers.
	Habitat Connectivity—median patch size (acres)	Yes	Provide connected riparian habitat inside the levee system.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide marsh habitat that does not include, and minimizes the likelihood of establishment of, nonnative submerged aquatic vegetation, particularly in the Lower Sacramento and San Joaquin River CPAs.

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the CCV Steelhead

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	Floodplain agriculture should minimize risks of stranding for juvenile fish (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches), and should minimize entrainment or trapping of adults (by eliminating or screening diversions or ditches where fish could be trapped, and by implementing solutions to address fish passage barriers; Conservation Strategy Appendix K) in the bypasses and mainstem Sacramento, Feather, and San Joaquin Rivers.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	Yes	Remove/modify barriers at the Fremont, Sacramento, and Tisdale Weirs, as well as other barriers identified and prioritized in McEwen (2013) and Conservation Strategy Appendix K.
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	Remove or decrease populations of nonnative invasive aquatic plants (e.g., *Egeria* sp. and *Myriophyllum aquaticum*) that affect fish habitat, and terrestrial plant species that affect river geomorphology (e.g., *Arundo* and saltcedar).

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G5. Focused Conservation Plan: Central Valley Fall-/Late Fall–Run Chinook Salmon

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the Central Valley (CV) fall- and late fall–run Chinook salmon (*Oncorhynchus tshawytscha*) Evolutionarily Significant Unit (ESU) in the SPA for the CVFPP. This ESU occupies the Upper and Lower Sacramento River, Lower San Joaquin River, and Feather River CPAs.

In 1999, NMFS determined that federal listing of the CV fall- and late fall–run Chinook salmon ESU was not warranted (64 FR 50394). The ESU was designated a federal species of concern in 2004 (69 FR 19975). Although CV fall- and late fall–run Chinook salmon can be distinguished genetically and have different life histories, NMFS combined them into the same ESU (West Coast Chinook Salmon Biological Review Team 1999; Williams 2006). Because this ESU is not listed, critical habitat was not designated, and no recovery plan is being developed.

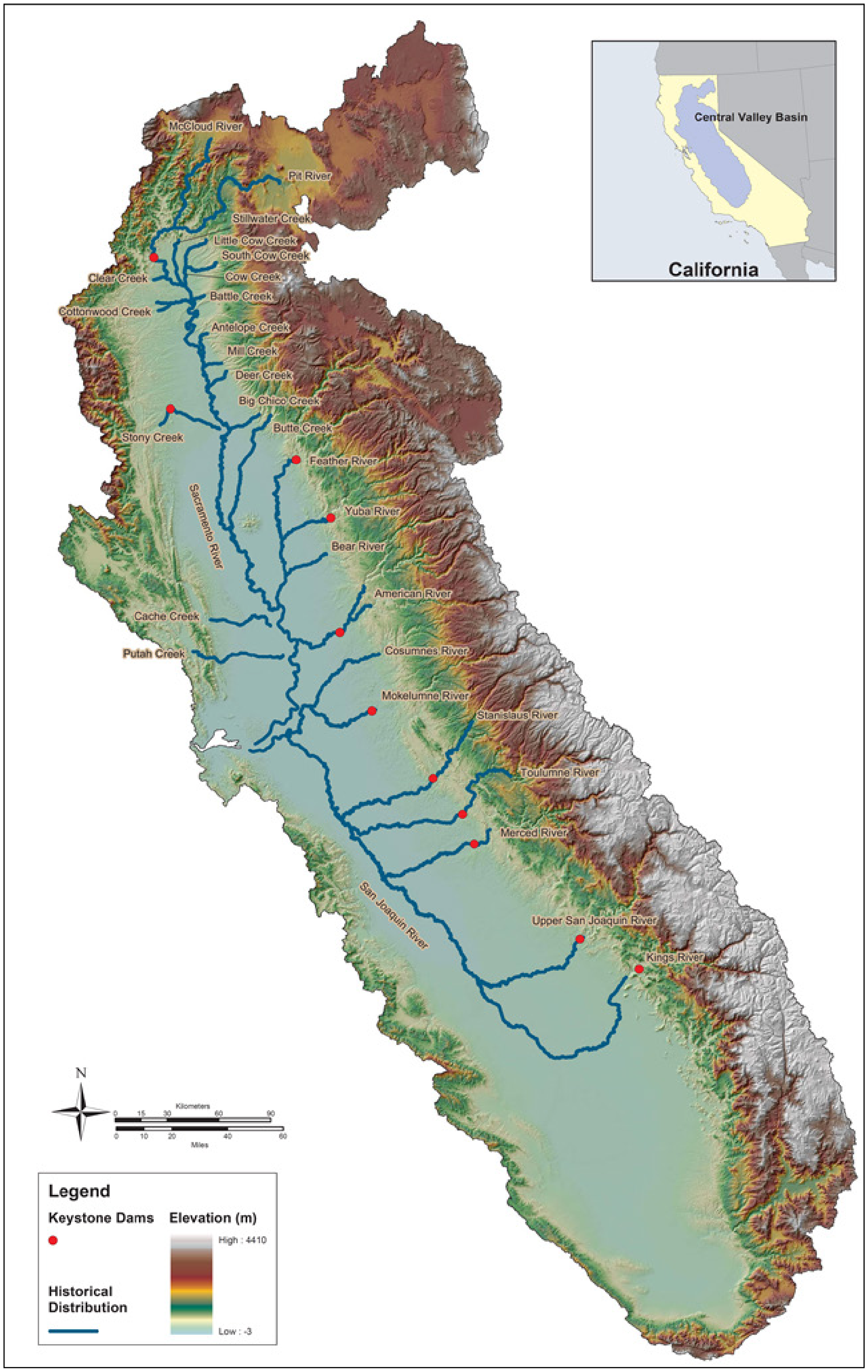
Status and Trends

Historical Distribution

The historical distribution of these Chinook salmon runs included the upper mainstem reaches of the Sacramento–San Joaquin River system (for the late fall–run) and lower-elevation rivers and tributaries (for the fall-run) (Yoshiyama et al. 1998). Fall-run Chinook salmon spawned in valley floor and foothill reaches below 500–1,000 feet in elevation (Yoshiyama et al. 2001) (Figure 1). Access to some lower-elevation rivers and tributaries has been blocked by major water projects; however, the distribution of these two runs has not been as severely reduced as that of the other salmon runs, which rely on higher-elevation streams and headwaters for spawning (Yoshiyama et al. 1998).

Current Distribution

CV fall-run Chinook salmon are the most widely distributed salmonid in the Sacramento–San Joaquin River Basin, occurring as far north as Keswick Dam on the Sacramento River (Upper Sacramento River CPA), and in tributaries of the Sacramento River, including Clear, Battle, and Butte Creeks (Upper Sacramento River CPA), the American River up to Nimbus Dam (Lower Sacramento River CPA) and the Feather, Yuba, and Bear Rivers (Feather River CPA) (Williams 2006). They also occur in the San Joaquin, Mokelumne, Cosumnes, Stanislaus, Tuolumne, and Merced Rivers (Lower San Joaquin River CPA) (Williams 2006).



Source: Schick et al. 2005

Figure 1. Central Valley Fall-Run Chinook Salmon ESU—Historical Distribution, with Major Dams That Block Upstream Passage Indicated

CV late fall–run Chinook salmon spawn primarily in the mainstem Sacramento River, between Red Bluff Diversion Dam and Keswick Dam (Upper Sacramento River CPA). Spawning populations also occur in tributaries of the Sacramento River, including Battle, Cottonwood, Cow, Clear, and Mill Creeks (Upper Sacramento River CPA) and the Feather and Yuba Rivers (Feather River CPA) (USFWS 1996).

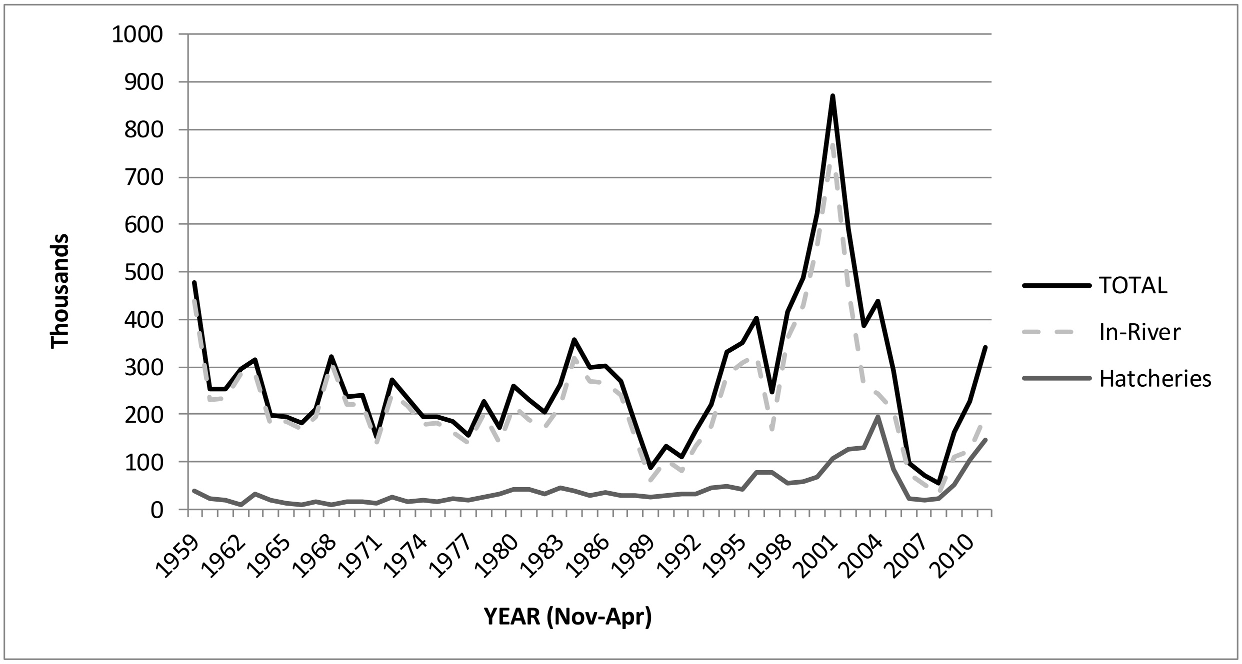
Population Trends

Since 1960, the Anadromous Resource Assessment Unit of CDFW's Fisheries Branch has compiled annual estimates of CV fall- and late fall–run Chinook salmon populations for streams surveyed in the Sacramento–San Joaquin River system (Azat 2013). These escapement surveys provide data to inform ocean and inland harvest management, to assess recovery of listed stocks, and to evaluate the success of restoration programs and the contribution of hatchery fish to Central Valley populations (Low 2007). Population estimates are based on counts of adults as they enter hatcheries and migrate past dams, surveys of postspawning adult carcasses, live counts, and ground and aerial redd counts conducted by CDFW, USFWS, DWR, the East Bay Municipal Utilities District, USBR, the Lower Yuba River Management Team, and the Fisheries Foundation of California (Low 2007). Surveys are also conducted of juveniles in tributaries and mainstems, to provide information on juvenile rearing and emigration, habitat use, growth, and stranding (Low 2007).[1] Information from juvenile surveys is used to evaluate the success of habitat restoration programs and the impacts of water project operations on salmonid survival, to manage water project operations for the protection of salmonids on a real-time basis, and to evaluate hatchery propagation programs (Low 2007).

Both CV fall- and late fall–run Chinook salmon are artificially propagated in hatcheries and released into the Sacramento and San Joaquin Rivers; five hatcheries produce and release approximately 30 to 40 million juvenile fall-run smolts (Lindley et al. 2009), whereas one hatchery (Coleman National Fish Hatchery on Battle Creek) produces and releases approximately 1 million late fall–run smolts (Williams 2006).

Fall-run Chinook salmon are the most abundant run in the Central Valley; escapement of naturally spawning adults has varied widely, but exceeded 200,000 in 27 of the past 50 years (Figure 2). Escapement in the Sacramento River Basin (Upper and Lower Sacramento River CPAs and Feather River CPA) dropped to record low levels (50,000–100,000 fish) from 2007 to 2009 because of poor ocean conditions; this population drop led to closures of marine and freshwater recreational and commercial salmon fisheries south of Cape Falcon, Oregon, in 2008 and 2009 (Lindley et al. 2009). The run has since rebounded, exceeding 100,000 fish in 2010, 200,000 fish in 2011, and 300,000 fish in 2012 (Azat 2013; Low pers. comm.). Fall-run Chinook salmon escapement in the San Joaquin River exhibits more pronounced cyclicity than the runs in the Sacramento River and its tributaries (Williams 2006).

[1] "Stranding" herein refers broadly to any event in which fish are trapped in detrimental conditions by being physically separated from a main body of water or from their natural migration route to natal streams. Stranding includes both entrapment in lethal or sublethal conditions and cases in which fish stray into nonnatal streams or unsuitable habitat because of system operations or attraction flows. Types of stranding are further discussed in Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System."



Source: Azat 2013

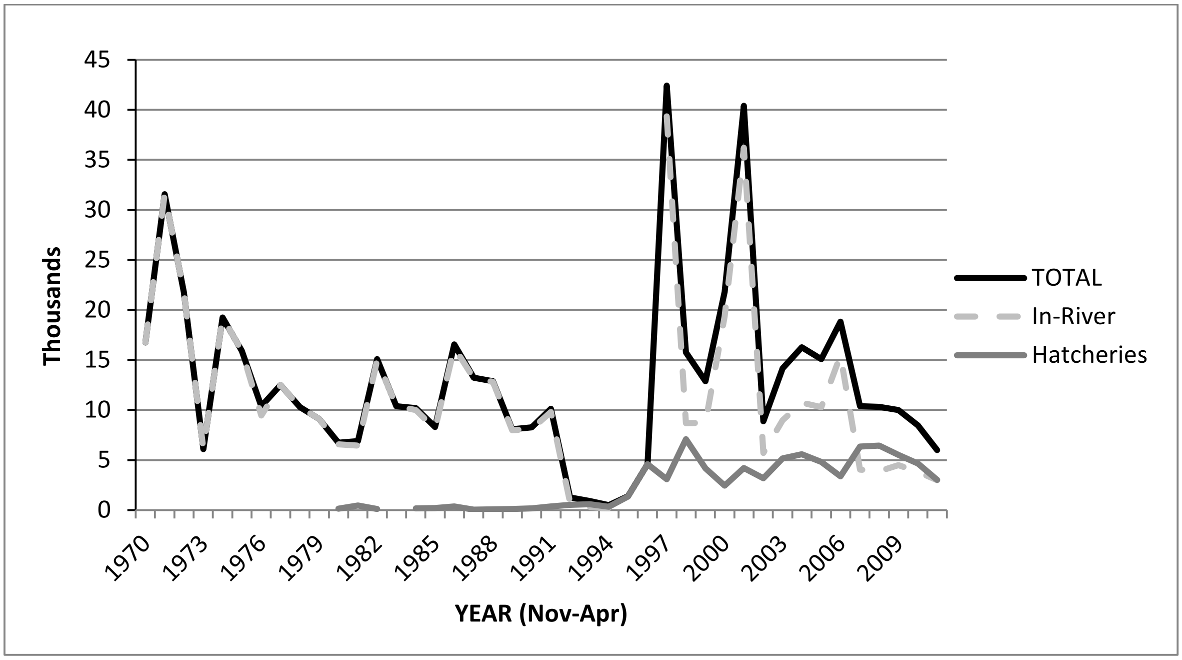
Figure 2. Escapement of Central Valley Fall-Run Chinook Salmon in the Sacramento and San Joaquin River Systems

Late fall–run Chinook salmon are not as abundant as fall-run Chinook salmon in the Central Valley; escapement of naturally spawning late fall–run adults in the past 40 years mostly ranged from 5,000–15,000, and exceeded 30,000 in only 3 of the past 40 years (Figure 3). In-river spawning escapement has been relatively low in recent years: fewer than 5,000 fish have returned to spawn each year in the past 5 years (2008–2012).

Life History

Chinook salmon are anadromous (i.e., they migrate to the ocean, where they spend most of their lives and grow large before returning to freshwater, where they spawn, then hatch and rear) and semelparous (i.e., adults die after spawning). Adults remain at sea for 1–6 years (usually 2–4 years), although some males, called jacks or grilse, either mature in freshwater or return after only a year or two at sea. The adults return to freshwater and migrate up rivers and streams to spawn; unlike spring-run Chinook salmon, adult fall-run Chinook salmon do not require summer holding habitat (Moyle 2002).

Adult CV fall-run Chinook salmon enter the Sacramento–San Joaquin River Basin (Lower Sacramento and San Joaquin River CPAs) between June and December, peaking in September and October. They spawn from late September to December, peaking in October and November. Embryos hatch after 3–4 months of incubation, and the alevins (yolk-sac fry) remain in the gravel for an additional 2–3 weeks before emerging from the gravel. The fry emerge from the



Source: Azat 2013

Figure 3. Escapement of Central Valley Late Fall–Run Chinook Salmon in the Sacramento–San Joaquin River System

gravel from December to March, with juveniles rearing in freshwater for 1–7 months, then emigrating downstream and to the ocean from December through June (Yoshiyama et al. 1998; Moyle 2002).

Adult CV late fall–run Chinook salmon enter the Sacramento River Basin (Lower Sacramento River and Feather River CPAs) between October and April, peaking in December. They spawn in mid-December to April, peaking from January to March. The fry emerge from the gravel between April and June and rear in freshwater or estuaries for 7–13 months (Moyle 2002). The juveniles typically emigrate downstream to the ocean as yearlings in fall or winter (Williams 2006).

Habitat and Ecological Process Associations

Freshwater spawning habitat requirements for Chinook salmon include clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, with cool water temperatures (<60°F, Sauter et al. 2001), water depths of approximately 10–39 inches, and moderate velocity of about 12–31 inches per second (Moyle 2002). After emergence, fry rear in habitats with shallow, slow-moving waters and bank cover composed of overhanging and submerged vegetation, root wads, and woody material; in these habitats, the fry feed on zooplankton and small insects. The elements of suitable fry and juvenile rearing habitat are largely defined by the three attributes of SRA cover: overhanging vegetation, instream cover, and natural eroding banks (Fris and DeHaven 1993). Such conditions are best supported by natural geomorphic processes.

Juvenile Chinook salmon rear in riverine and estuarine habitats of the Sacramento and San Joaquin Rivers, their tributaries, the Sacramento–San Joaquin River Delta (Delta), and the Yolo Bypass when it is flooded (Maslin et al. 1999; Snider 2001). Off-channel floodplain habitats that are seasonally inundated support much higher growth rates of juvenile Chinook salmon than adjacent main channel or riverine habitats (Jeffres et al. 2008; Limm and Marchetti 2009). The off-channel habitats tend to have higher temperatures and support increased food production, resulting in increased growth of juveniles (Jeffres et al. 2008; Limm and Marchetti 2009). When flows are sufficient to cause inundation of the Yolo Bypass, juveniles are known to rear for several months in the seasonally inundated agricultural floodplains in spring. Here, the greater availability of drift invertebrates contributes to higher juvenile growth rates than found in adjacent river channels (Sommer et al. 2001). In the tidally influenced Lower Sacramento River CPA, juveniles forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960; Healey 1980), and are less abundant where shorelines incorporate revetment (McLain and Castillo 2009). However, juvenile Chinook salmon (young-of-the-year) from the Central Valley tend to emigrate quickly from the Delta to the ocean, spending only about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002); larger yearling Chinook salmon (e.g., late fall–run) move from the Delta to the ocean entry even more quickly, in 9 to 17 days (Michel et al. 2013).

The Knaggs Ranch Restoration Study is evaluating the Yolo Bypass as winter floodplain habitat for Chinook salmon to improve understanding of how juvenile salmonids use various habitat types (USBR 2012). The study is located on an agricultural parcel, with a total area of 1,703.55 acres, in the northern part of the Yolo Bypass. The multiyear experimental study is evaluating aquatic food resources and juvenile salmonid growth in a variety of agricultural habitat types (e.g., long rice stubble, short rice stubble, disked, and fallow). Study results to date appear to corroborate earlier findings that fish that rear in the bypass have high growth rates and survival (Katz et al. 2012). Other benefits of rearing in the Yolo Bypass and floodplain habitat include: (1) delayed outmigration timing, which results in later ocean entry and better synchronizes juveniles that reach the coast with the high productivity associated with spring/summer winds that drive upwelling conditions, and (2) routing of fish away from the interior Delta and export pumps, where there is an increased risk of mortality (Katz 2012).

Floodplain benefits for juvenile Chinook salmon rearing should increase with longer durations of flooding, but relatively short periods of access may still provide benefits (Jeffres et al. 2008). Improved habitat conditions for juvenile CV fall- and late fall–run Chinook salmon may be achieved by inundating the bypasses (e.g., Yolo and Sutter) for at least 14 days (for food production to occur), particularly between late November/early December and the end of April (USBR 2012). Specific inundation flows would need to take into account any structural changes to the weirs (e.g., the Fremont Weir) that might allow lower flows to provide inundation; currently, the vast majority of the Yolo Bypass is inundated at flows above 74,000 cubic feet per second (cfs) (USBR 2012). To improve passage of upstream migrating adult CV late fall–run Chinook salmon in the Yolo Bypass, inundation would need to occur at least from November through March, and ideally between mid-November and May to provide maximum benefits, depending on water year type and any structural changes made to improve fish passage at the weirs (USBR 2012).

Conceptual Models

A conceptual model has been developed to assist in development of a targeted conservation strategy for CV fall- and late fall–run Chinook salmon within the SPA (Figure 4). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by CV fall- and late fall–run Chinook salmon in the SPA;
- the specific CPAs within which these habitat conditions occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Adults of both fall- and late fall–run Chinook salmon enter freshwater in fall. This timing corresponds to the cooling of water temperatures. Adults spawn in the lower mainstem reaches of rivers, where spawning habitat is more abundant than in the higher reaches, where most other salmonid runs spawn.

After emergence, fall-run fry from the Upper and Lower Sacramento River CPAs, Feather River CPA, and Lower San Joaquin River CPA emigrate at a relatively small size (<4 inches; referred to as "fry migrants") before water temperatures increase too much in summer, to rear in the lower river reaches or Delta and often in the floodplains when they are inundated (Williams 2012). Rearing habitat may be limited in the Sacramento River (USFWS 2005) and Delta (Lindley et al. 2009), although the floodplains of the Yolo Bypass may offer important and suitable rearing habitat (Sommer et al. 2001) in years in which it is inundated.

Fry migrants are susceptible to predation during outmigration because of their small size, but they compensate for their vulnerability by migrating and rearing in large numbers, effectively swamping their predators. In addition, they are generally found in shallow water along channel margins or in runs and riffles, whereas aquatic predators often occupy pools.

Over-summering habitat is likely limiting for fall-run juvenile Chinook salmon in the Sacramento and San Joaquin River systems (Stillwater Sciences 2007; SJRRP 2008). As juveniles grow, their survival may be limited by water temperature (which in turn is affected by SRA habitat), insufficient flow, water diversion,

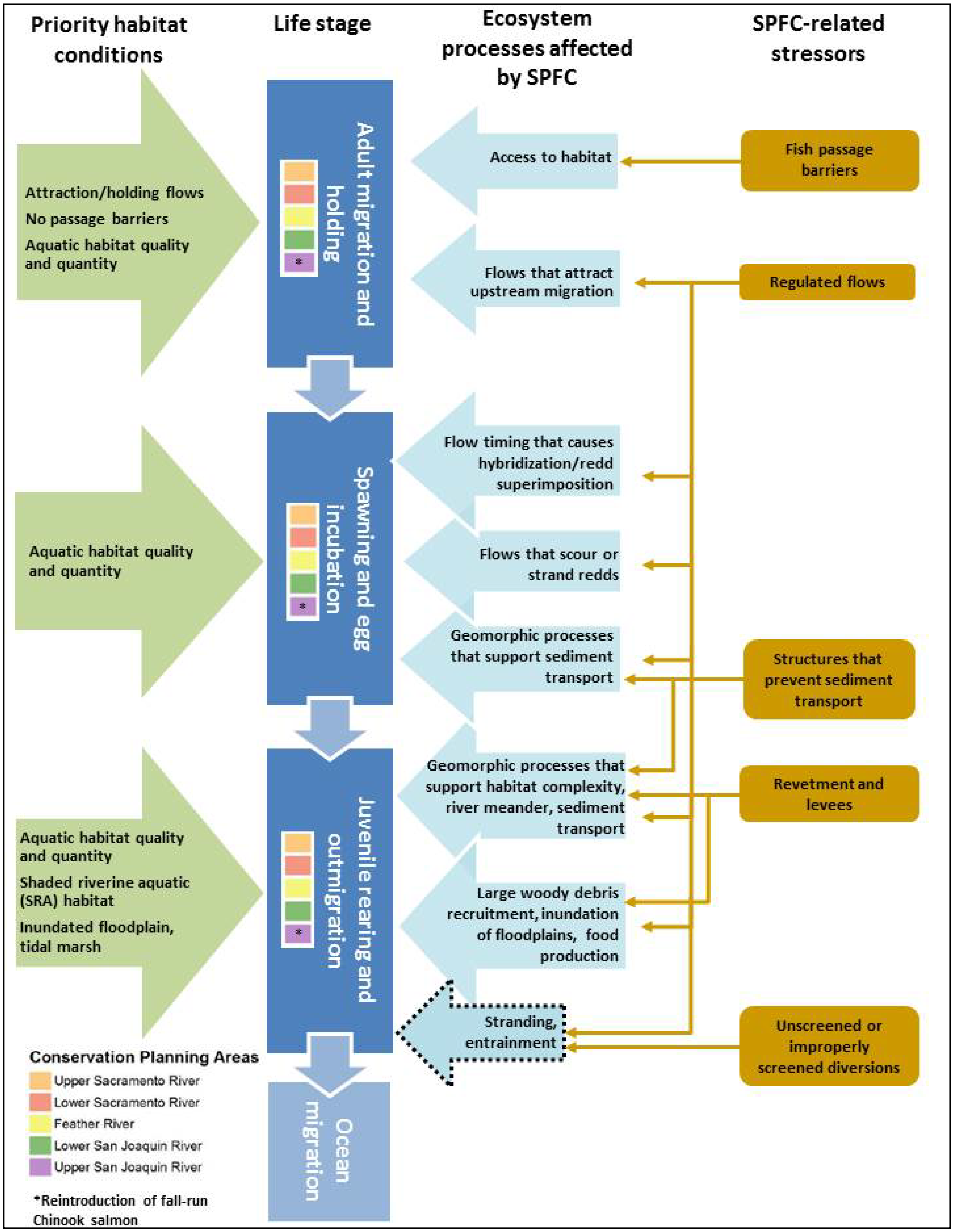


Figure 4. Conceptual Model for Central Valley Fall-Run and Late Fall–Run Chinook Salmon within the SPA

contaminants, levees, competition with hatchery-raised fish, and increased predation (Williams 2010, 2012). Late fall–run fry tend to rear in the upper reaches of the Upper Sacramento River and Feather River CPAs, where summer temperatures are cooler than in the lower reaches, then emigrate in fall or winter (Williams 2006).

Spawning habitat may also be limiting for fall-run Chinook salmon in all of the CPAs, because large dams prevent gravel transport, coarsen the streambed, and create flows that can dewater redds (Stillwater Sciences 2007; Olsen et al. 2012). Also, in some spawning areas, competition for spawning habitat may limit fall-run Chinook salmon reproduction: later-arriving females from the fall run and late fall run sometimes dig redds on top of existing redds (termed "redd superimposition"), which can result in the mortality of previously deposited eggs (Stillwater Sciences 2007). Although later spawning would appear to have a reproductive advantage, the young of late-arriving females may be at greater risk of mortality when they emerge in spring, because they must rear as water temperatures are rising. However, in the Upper Sacramento River CPA, the late fall–run Chinook salmon are apparently able to reproduce successfully; cold-water releases from Shasta Dam in summer have created over-summering habitat in which juveniles can survive (Stillwater Sciences 2007).

Dams that block access to upstream spawning habitat for Chinook salmon, and that disrupt gravel transport, have limited the amount of spawning habitat downstream of dams, and increased hybridization of runs. In the Feather River CPA, spring-run and fall-run Chinook salmon populations can spawn only in the lower basin of the Feather River, and until there are means to spatially separate them, some level of genetic introgression of the runs is expected to continue (NMFS 2009). The SJRRP has a goal of returning a self-sustaining Chinook salmon fishery to the San Joaquin River, including reintroducing CV spring-run and fall-run Chinook salmon in the Upper San Joaquin River CPA. Because spawning habitat in the mainstem upper San Joaquin River is limited to that found downstream of Friant Dam, and will likely be used by spring-run Chinook salmon, there is potential for redd superimposition and hybridization with fall-run Chinook salmon (SJRRP 2008).

Management Issues

Threats and Sensitivities Range-Wide

Some spawning and rearing habitat for CV fall- and late fall–run Chinook salmon has been lost as a consequence of dam construction in the Sacramento–San Joaquin River Basin, although the extent of the loss for these salmon runs is much less than for winter-run and spring-run Chinook salmon. Another major threat to CV fall- and late fall–run Chinook salmon is the degradation of spawning and rearing habitat; specifically, (1) water diversions and dams have degraded habitat by causing excessively high water temperatures, altered sediment dynamics, and altered flows that can dewater redds (Olsen et al. 2012); (2) riparian and estuarine habitats have been lost and floodplains have been disconnected; and (3) water quality has been diminished by agriculture and urbanization (Lindley et al. 2009). Predation by nonnative aquatic species, the interaction between natural-origin and hatchery-reared Chinook salmon, and the evolutionary, genetic, and ecological effects of ocean harvest represent additional concerns. Finally, in the long term, climate change may have significant effects on freshwater and ocean habitats (Williams 2006).

Ongoing and Future Impacts

Ongoing impacts on CV fall- and late fall–run Chinook salmon in the SPA include construction, operation and maintenance of flood control facilities that affect habitat access, flows, and the quality and availability of downstream habitat; catastrophic fires; water diversions that entrain juveniles and affect habitat quality; nonnative invasive aquatic species; and the effects of climate change, which will likely include degradation of water quality and habitat suitability.

- The lack of available suitable habitat likely will continue to negatively affect CV fall- and late–fall run Chinook salmon (Williams 2006). Particularly, loss of rearing habitat in the Upper and Lower Sacramento, Feather, and Lower San Joaquin River CPAs will continue to be a significant stressor to CV fall- and late fall–run Chinook salmon (Williams 2006, 2012). Many partial barriers have been identified that may delay or impair fish migration (see Attachment 9C of the CVFPP and Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System") and have been prioritized for improvements based on impacts on fish (see Appendix K). In particular, the Fremont Weir (the primary inundation source for the Yolo Bypass) currently provides adult fish passage at a single fish ladder that is opened once overtopping at the Fremont Weir ceases (USBR 2012). Adult CV late fall–run Chinook salmon passage may be impeded at the ladder because of poor attraction flows and other irregularities. NMFS has identified the need to reduce migratory delays and minimize stranding (and resultant mortality) of upstream-migrating Chinook salmon at the Fremont Weir (USBR 2012). CVFPP modifications or projects that contribute to simplified or degraded riverine habitat, such as levee armoring, are expected to negatively affect CV fall- and late fall–run Chinook salmon. Numerous activities and events can reduce water quality and are expected to continue to negatively affect salmon. For example, vegetation removal near waterways can increase water temperatures, and dredging activities can resuspend sediment and contaminants, clogging fish gills, smothering eggs, and reducing benthic prey availability. Catastrophic fires can severely affect water quality until vegetation is reestablished. Contaminants in discharges to the rivers and the Delta can affect food webs, degrade habitats, and directly harm juvenile salmonids (Mount et al. 2012).

- Entrainment at water diversions continues to negatively affect juvenile CV fall- and late fall–run Chinook salmon in the Upper and Lower Sacramento River CPAs, the Feather River CPA, and the Lower San Joaquin River CPA. Entrainment will also be an issue for reintroduced fall-run Chinook salmon in the Upper San Joaquin River CPA. Entrainment at both large screened diversions (such as the Central Valley Project and State Water Project) and numerous small, unscreened or inadequately screened diversions will likely continue to affect juvenile fall- and late fall–run Chinook salmon. Large diversions can also affect water quality (Monsen et al. 2007) and provide habitat for introduced fish predators (Cavallo et al. 2013).

- Recent observations indicate that adult fish can migrate into the Yolo or Sutter Bypasses when they are flooded, or into the Knights Landing Outfall Gates, then swim into canals and drains such as the Colusa Drain, where they strand and die unless rescued (Cannon 2013; Hendrick and Swart 2013; Vincik and Johnson 2013). However, the severity of adult stranding on an annual basis, particularly for late fall–run Chinook salmon, is not known (Hendrick and Swart 2013).

- Climate change will affect habitat for CV fall- and late fall–run Chinook salmon in the future, but the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the catchment as rain rather than snow, reducing snowpack and water availability from snowmelt in spring and summer (Cayan et al. 2006). Ecologists are only beginning to understand climate change threats to riparian ecosystems (Seavy et al. 2009). Climate change models predict warming temperatures in streams and rivers (Moyle et al. 2013) and increases in sea level, estuarine salinity, and freshwater temperatures (Cloern et al. 2011). CV fall- and late fall–run Chinook salmon and other cold-water adapted native fish are likely to respond negatively to climate change effects such as changes in streamflows and increased temperatures (Katz et al. 2012; Moyle et al. 2013).

Key Information Gaps or Uncertainties

To better understand how current and future CVFPP activities affect the conservation and potential recovery of CV fall- and late fall–run Chinook salmon, and to help guide future actions of the CVFPP and Conservation Strategy, the following information is needed: modeling of impacts related to flood management, a better understanding of habitat functions, and data on the effects of predation and stranding. These data gaps are discussed below.

- **Impact models.** Flood managers need an improved understanding of the impacts on salmonid habitats caused by levee erosion repair projects. Currently, the Standard Assessment Methodology is used to systematically compare fish species' responses to habitat features affected by levee erosion repair projects. This method involves applying conceptual response models to quantified habitat changes to assess the near- and long-term impacts or benefits to species. The method is based on conceptual response models of indicator fish species, and evaluates effects of levee erosion repair designs that incorporate SRA components (overhanging shade, reduced substrate size, instream woody material, etc.), revetment size, bank slope, and length of the proposed levee project site.

  The conceptual response models were developed using professional opinion and assume relationships between the presence or abundance of an organism and habitat quality. However, habitat quality would be better assessed by evaluating the effects of levee erosion repair designs on the condition (e.g., growth) and survival of indicator fish species (Sommer et al. 2005; Bond et al. 2008). Additionally, the current Standard Assessment Methodology fails to evaluate the loss of riverine processes (lateral migration, reworked floodplain, vegetation regeneration, etc.) and should consider the effects of changes in levee configuration in order to evaluate the benefits or impacts of repairing existing levees versus changing levee alignment to promote natural river processes. These issues can be addressed by evaluating how juvenile CV fall- and late-fall-run Chinook salmon (both young-of-the-year and yearlings) use specific levee repair designs, including the duration of time spent at the site (minutes, hours, days, weeks) and effects on growth and survival. Additionally, there is concern that, in the warmer reaches of the mainstems, habitat features incorporated as mitigation for levee repair projects (e.g., instream wood) may be providing or improving habitat conditions for predators of juvenile CV fall- and late fall–run Chinook salmon (Vogel 2011), an issue that is being evaluated by resource agencies.

- **Habitat functions.** There is a lack of information on the function of certain habitats in the life history of the species; in particular, the quality and quantity of habitats used by juveniles as they move downstream in the Sacramento and San Joaquin River mainstems and the Delta during rearing and outmigration (Vogel 2011). The vegetation types providing preferred habitat for juvenile Chinook salmon in floodplains and bypasses are not well understood, although the most important characteristics of vegetation are its effects on prey availability and cover (Opperman 2012). Nevertheless, there is uncertainty about the importance of the distribution and amounts of SRA habitat on fish populations; for example, is the relationship between SRA habitat and fish numbers linear or are minimum thresholds of SRA required, and what is the importance of habitat connectivity? Actions that provide habitat for juvenile rearing, coupled with studies that evaluate habitat use through an adaptive management approach, could inform and improve future activities associated with levee maintenance and erosion repair.

- **Predation.** Especially in the lower mainstems and Delta, the extent of predation on juvenile salmon by nonnative fish is not well understood (Williams 2010). The Central Valley and Delta have many nonnative fish species, some of which are known predators of juvenile salmon. Actions that could inadvertently increase habitat for predators need to be evaluated.

- **Stranding and straying effects.** Stranding and straying of CV fall- and late fall–run Chinook salmon juveniles and late fall–run Chinook salmon adults in bypasses and in the Colusa Drain (likely only late fall–run adults because of the timing of migration and bypass inundation) when high flows recede has the potential to occur, but quantification is difficult (Hendrick and Swart 2013). Therefore, the impact of stranding on the populations of CV fall- and late fall–run Chinook salmon is poorly understood (Sommer et al. 2005; Cannon 2013; Vincik and Johnson 2013). Actions that increase connectivity to bypasses and floodplains could incorporate measures to minimize stranding, such as flow-reduction ramping rates. The interaction of channel conveyance capacity, infrastructure, water diversions, and fish habitat needs with flow magnitude and timing could be addressed by CVFPP actions for tributaries (Feather River CPA) and mainstem rivers and bypasses (Upper and Lower Sacramento and San Joaquin River CPAs).

Conservation Strategy

Conservation and Recovery Opportunities

The integration of environmental stewardship into all flood management activities (by DWR and Local Maintaining Agencies) during project planning, design, operation, 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 CV fall- and late fall–run Chinook salmon is to increase spawning and rearing habitat throughout the SPA by encouraging riverine processes that improve natural river morphology and function. Improving the distribution and quality of SRA habitat, the amount and distribution of inundated floodplain, connectivity of fish passages, and channel-margin restoration would benefit the species. These conservation needs and opportunities are discussed in detail below.

Identified Conservation Needs

1. **Improve the distribution and quality of SRA habitat throughout the SPA:** The elements of SRA habitat (overhanging vegetation, instream cover, and natural eroding banks) each offer important habitat resources to adult and juvenile fall- and late fall–run Chinook salmon. SRA habitat provides organic material input, differential velocities, cover, food, temperature regulation, and improved water quality. Because juveniles can rear both in tributaries, mainstems and bypasses, large-scale restoration of SRA habitat is needed to improve their rearing habitat, most of which was lost because of construction, operation, and maintenance of SPFC facilities, as well as alteration of flows in the SPA.

2. **Improve the distribution and quality of channel-margin habitat in tidally influenced waterways throughout the Delta region of the Lower Sacramento and Lower San Joaquin River CPAs:** Marsh and channel-margin habitats are an important food and cover resource for emigrating smolts and rearing juvenile fall- and late fall–run Chinook salmon. Historical reclamation of wetlands and construction of levee systems in the Delta region of the Lower San Joaquin and Lower Sacramento River CPAs removed most of this habitat. Large-scale restoration of the distribution and amount of tidally influenced channel-margin habitat is needed (Williams 2012).

3. **Increase the amount and distribution of inundated floodplain habitat throughout the SPA:** Compared to mainstem channels, inundated off-channel floodplain habitats have higher temperatures and food production rates, and contribute to higher growth and survival rates for juvenile fall- and late fall–run Chinook salmon. These habitats include bypasses (e.g., Yolo and Sutter) as well as mainstem and tributary floodplains. Inundated floodplain habitats are currently limited by both regulated streamflows (particularly in the bypasses) and levee systems (particularly along mainstems and tributaries). Improving

floodplain connectivity will require large-scale restoration actions that take into account the interaction of floodplain elevations and the timing, duration, and quantity of flow releases. Increasing the quantity and quality of floodplain habitat in the mainstem and tributaries of the Sacramento, Feather and San Joaquin Rivers and would provide beneficial rearing habitat for juvenile fall-run Chinook salmon and in the mainstem Sacramento River upstream of Deer Creek for late fall–run Chinook salmon (Appendix H of the Conservation Strategy, "Central Valley Chinook Salmon Rearing Habitat Needed to Satisfy the Anadromous Fish Restoration Program Doubling Goal.").

4. **Improve natural river morphology and function:** Flood control measures downstream of dams, such as bank protection, have affected riparian and instream habitat, particularly in the Lower Sacramento River, Feather River, and Lower San Joaquin River CPAs. Constructed levees that narrow channels have increased velocities and channelized the river so that natural geomorphic processes (e.g., channel meander) are no longer possible. Improving geomorphic processes to support natural bank erosion, sediment deposition, and the establishment and growth of riparian vegetation is essential for providing beneficial SRA habitat, reconnecting floodplains, and recruiting woody material that improves rearing habitat for juvenile CV fall- and late fall–run Chinook salmon.

5. **Improve fish passage throughout the SPA:** During winter and spring high-flow events, water is diverted into bypasses (e.g., Sutter and Yolo), which can overlap with the timing of upstream migration for late fall–run Chinook salmon along with the winter and spring runs, but is not likely to overlap with the fall-run Chinook salmon. Thus, adult late fall–run Chinook salmon can enter the bypasses when inundated, but their migration may then be delayed or prevented by control structures (e.g., Sacramento, Tisdale and Fremont Weirs). In addition, they can enter through flood control structures or drain gate structures and become stranded and perish in unscreened canals and drains, such as in the Colusa Basin Drain canal system (Cannon 2013; Hendrick and Swart 2013). Therefore, there is a need for improving or eliminating these types of flood control structures in order to provide for adult anadromous fish passage. Juveniles (both fall-run and late fall–run Chinook salmon) can become entrained by unscreened or inadequately screened diversions, and stranded when flows recede in bypasses or along mainstems, making adequately screening all diversions another high priority conservation action. This may include limiting passage through weirs and gates to prevent adult stranding in drains and canals, improving fish passage along mainstems and tributaries, and adequately screening all diversions.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the CV fall- and late fall–run Chinook salmon; these are summarized in Table 1 of this section. In many cases, the life history needs and conservation actions for CV fall- and late fall–run Chinook salmon can be positively addressed

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Central Valley Fall- and Late Fall–Run Chinook Salmon[a]

	Conservation Need				
SPFC Conservation Actions	**1. Increase/ Improve SRA Habitat**	**2. Increase/ Improve Marsh Habitat**	**3. Increase Inundated Floodplain**	**4. Improve Natural River Function**	**5. Improve Fish Passage and Decrease Entrainment**
Operations, Maintenance, and Floodway Management					
Floodwater storage and reservoir forecasting, operations, and coordination	+		+	+	+
Facility maintenance					
Levee vegetation management	-				
Floodway maintenance	+				
Modification of floodplain topography	+		+	+	+
Support of floodplain agriculture			+		+
Invasive plant management				+	+
Restoration of riparian, SRA, and marsh habitats	+	+		+	
Wildlife-friendly agriculture					
Structural Improvements					
Levee and revetment removal	+	+	+	+	
Levee relocation	+	+	+	+	
Bypass expansion and construction		+	+	+	+
Levee construction and improvement	+			+	
Flood control structures					+

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward 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 limited reoperation of reservoirs and weirs. These could provide flow releases that improve aquatic habitat conditions by changing the timing and amount of releases and ramping rates from November/early December to the end of April. These modifications could reduce fish stranding and passage barriers, reduce dewatering of redds, initiate upstream adult migration and juvenile outmigration, and generate other environmental benefits, including promoting floodplain connectivity, enhancing meander migration rates, improving spawning gravel dynamics (recruitment, flushing, and mobilization), and improving conditions to promote development of SRA habitat.

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 fish-rearing habitat.

Levee vegetation management: The 2012 CVFPP introduced an interim vegetation management strategy, under which levee vegetation in the VMZ (see Figures 2-1 and 2-2 in Appendix D of the Conservation Strategy) is managed for visibility and accessibility, and to reduce threats to levee integrity. Consequently, levee riparian vegetation in the VMZ has been significantly trimmed or removed, reducing inputs of terrestrial insects, leaf litter, and waterside natural vegetation recruitment, thereby reducing food availability and nutrient input. Trimming and removal of waterside vegetation may also have detrimental effects on water temperature (Poole and Berman 2001) and fish habitat (e.g., instream wood recruitment and cover).

On the whole, levee vegetation management is likely to negatively affect habitat for CV fall- and late fall–run Chinook salmon. However, lower waterside vegetation could be retained below the VMZ of levees when it does not present an unacceptable threat to levee integrity. Allowing vegetation to grow on the water side 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. This approach would also preserve, in the near term, other vegetation within the VMZ that does not impair visibility and accessibility. Under the Conservation Strategy, additional habitat could be developed to offset the gradual die-off of trees and the removal of trees that pose an unacceptable threat to levee integrity. This vegetation would be more valuable to Chinook salmon if it is (1) located close to water bodies, or at least where juvenile fish could access the vegetation during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) regionally distributed.

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). Fill-placement and rock-repair projects could incorporate reduced particle size, instream woody material, SRA elements, and planting berms, where relevant.

Modification of floodplain topography: Floodway topography modifications could increase floodway capacity, inundation frequency and duration, and habitat amounts and diversity, as well as eliminating areas that strand fish and creating channels that facilitate recession of floodwater back into main waterways. In addition, floodplain elevations could be lowered to provide more frequent and sustained inundation. Elevations could also be modified to provide greater topographic and hydrologic diversity (creating or opening secondary channels or overflow swales) and to eliminate features (e.g., filling and restoring gravel pits and deep borrow pits in the Feather River CPA and the Upper and Lower San Joaquin River CPAs) that strand fish. These actions would increase riverine and floodplain habitat values (e.g., resting or rearing areas for fish migrating downstream) and provide escape routes for fish during receding flows.

Support of floodplain agriculture: Managing floodways to maintain the compatibility of flood management with agriculture would support agriculture in the bypasses and on floodplain agricultural lands between levees while accommodating access to rearing habitat by juvenile salmon. Addressing the problems posed by unscreened diversions and other structures that trap or impede the movement of any juvenile or adult Chinook salmon would provide benefits to CV fall- and late fall–run Chinook salmon. However, it is important that diversions be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; Conservation Strategy Appendix K).

Invasive plant management: Nonnative invasive plants that may be removed from State-managed lands and facilities would include submerged aquatic vegetation (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 nonnative submerged aquatic vegetation generally support nonnative fishes such as centrarchids (Grimaldo et al. 2012), particularly in the Lower Sacramento River and Lower San Joaquin River CPAs, which may be predators of juvenile salmonids. Established nonnative terrestrial vegetation in riparian areas displaces important native plants (e.g., willows and cottonwood) that facilitate river meander and natural geomorphic processes. Removal of nonnative invasive plants could therefore benefit CV fall- and late fall–run Chinook salmon by improving juvenile rearing and outmigration habitat and reducing predation by nonnative fishes.

Restoration of riparian, SRA, and marsh habitats: Riparian and marsh habitats could be restored at selected locations in the floodway to benefit juvenile CV fall- and late fall–run Chinook salmon. Riparian restoration opportunities generally would be found in nonriparian land cover in the floodway, particularly as part of other management actions to increase floodway capacity. Riparian, SRA cover, and marsh restoration would be most beneficial in areas where restoration expands or connects existing habitat patches or where restoration provides habitat in areas with little or no riparian vegetation, or at locations to be identified by future conservation or recovery planning for juvenile Chinook salmon, and in conserved areas. In the bypass system, marsh restoration would be generally beneficial to juvenile Chinook salmon and would be implemented in conjunction with bypass expansion and construction.

Structural 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 floodplain processes in the riverine and floodplain environments. This action would have greater ecological benefits if implemented along waterways that could be used by juvenile CV fall- and late fall–run Chinook salmon for rearing, and where removal contributes to an increase in the zone of active river meander migration, such as (potentially) in the Upper and Lower San Joaquin River CPAs.

Levee relocation: Relocating levees farther from rivers (i.e., constructing set back levees) is an important approach to increasing floodway capacity, creating space for river meanders, reconnecting floodways, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. Often, these benefits can be realized while still supporting agriculture within expanded floodways. Levee relocation would also provide an opportunity for hydraulically connecting the river systems to mitigation plantings associated with the VMZ, and for creating and enhancing rearing habitat for juvenile CV fall- and late fall–run Chinook salmon.

Bypass expansion and construction: Bypass expansion could enhance juvenile rearing habitat (e.g., food resources and cover) by increasing the connectivity of the floodplain to the river system and thus restoring floodplain ecosystems that contribute to food web productivity. However, because bypasses are flooded irregularly, in order to benefit juvenile CV fall- and late fall–run Chinook salmon bypass flooding needs to occur more frequently (e.g., annual) with the appropriate timing and duration to provide suitable rearing habitat. Modifying bypass weirs (e.g., the Yolo and Sutter Bypasses in the Lower Sacramento River CPA, and Paradise Cut in the Lower San Joaquin River CPA) could improve inundation timing and duration to benefit fish, provided that other passage conditions are improved (as described in Appendix K).

As part of bypass improvements, adult fish passage (for late fall–run Chinook salmon) could be enhanced at flood control structures (e.g., the Sacramento, Tisdale and Fremont Weirs) (McEwen 2013; Conservation Strategy Appendix K). Also, bypass expansion could address “sinks” where juvenile CV fall- and late fall–run Chinook salmon become stranded; for example, the number of isolated pools could be reduced, and connectivity to Tule Canal could be improved (USBR 2012).

Levee construction and improvement: Levee construction and reconstruction objectives that would benefit CV fall- and late fall–run Chinook salmon include restoring geomorphic processes, and, where significant hydraulic impacts would not occur, protecting riparian habitat and incorporating planting berms and riparian plantings. In addition, new levees could be designed to accommodate hydrologic changes expected to result from climate change.

Flood control structures: One priority action for State-operated and maintained diversions in the SPA is reconfiguring the Tisdale Weir in the Sutter Bypass and the Fremont and Sacramento Weirs in the Yolo Bypass (in the Lower Sacramento River CPA) to allow passage by adult fish (late fall–run Chinook salmon) and to increase floodplain inundation (DWR 2012; McEwen 2013; Conservation Strategy Appendix K). It is important that other diversions also be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; McEwen 2013; Conservation Strategy Appendix K). However, improving any structure that traps or impedes the movement of juvenile or adult fish would benefit CV fall- and late fall–run Chinook salmon.

Recovery Plan Alignment

NMFS does not have a recovery plan for CV fall- and late fall–run Chinook salmon because the ESU is not listed. If NMFS produces a recovery plan for the ESU, it is likely to include many of the main components of this plan. The adaptive management component of the Conservation Strategy would facilitate alignment with the recovery plan, should it be created, as needed.

Measures of Positive Contribution

Contributing to the recovery and stability of native species populations and overall biotic community diversity is a primary goal of the Conservation Strategy. The objective for this goal is a measurable contribution to the conservation of target species, including CV fall- and late fall–run Chinook salmon. Therefore, building on the preceding discussion, this section of the CV fall- and late fall–run Chinook salmon 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 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 conservation of CV fall- and late fall–run Chinook salmon, requirements would be added to increase the acreage of restored riparian areas that positively contribute to adjacent rearing habitat, providing terrestrial inputs and creating the cover needed by the species.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of CV fall- and late fall–run Chinook salmon, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit CV fall- and late fall–run Chinook salmon may simultaneously affect conservation of other species in the SPA, these measures of contribution

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Central Valley Fall- and Late Fall–Run Chinook Salmon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	Timing and duration of floodplain inundation are important to providing beneficial rearing habitat (e.g., inundate for at least 14 days for food production to occur, particularly between late November/early December and the end of April [USBR 2012]; see "Habitat and Ecological Process Associations," above). Floodplain inundation benefits for juveniles can be increased by minimizing stranding potential (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches, and ramping flows so that surface elevations do not decrease rapidly), and for adults (late fall–run Chinook salmon) by minimizing potential for entrainment and trapping (by eliminating or screening diversions or ditches where fish could be trapped, and implementing solutions to address fish passage barriers; see Conservation Strategy Appendix K).
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	Yes	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	Yes	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide riparian habitat throughout the riverine rearing and outmigration corridors: (1) located where juvenile fish could access the vegetation during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) distributed along tributaries and mainstems of the Sacramento, Feather, and San Joaquin Rivers.
	Habitat Connectivity—median patch size (acres)	Yes	Provide connected riparian habitat inside the levee system.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Central Valley Fall- and Late Fall–Run Chinook Salmon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide marsh habitat that does not include, and minimizes the likelihood of establishment of, nonnative submerged aquatic vegetation, particularly in the Lower Sacramento and San Joaquin River CPAs.
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	Yes	Floodplain agriculture should minimize the potential for stranding juvenile fish (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches), and minimize entrainment or trapping of adults (by eliminating or screening diversions or ditches where fish could be trapped, and implementing solutions to address fish passage barriers; see Conservation Strategy Appendix K) in the bypasses and mainstem Sacramento, Feather, and San Joaquin Rivers.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	Yes	Remove/modify passage barriers at Fremont and Tisdale Weirs, Colusa Drain, and others identified and prioritized in McEwen (2013) and Conservation Strategy Appendix K.
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	Remove or decrease populations of nonnative invasive aquatic plants (e.g., *Egeria* and parrot's feather) that affect fish habitat, and terrestrial plant species that affect river geomorphology (e.g., *Arundo* and saltcedar).

Key: EAH = expected annual habitat.
Note:
[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 2 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).

have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

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G6. Focused Conservation Plan: Central Valley Spring-Run Chinook Salmon

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the CV spring-run Chinook salmon (*Oncorhynchus tshawytscha*) ESU in the SPA for the CVFPP.

The CV spring-run Chinook salmon was federally listed as threatened under the ESA in 1999. The ESU includes all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries (64 FR 50394). In 2002, an ESA 4(d) protective regulation was declared for this ESU; the regulation applied ESA Section 9 take prohibitions, but also created several limits for the application of take prohibitions (67 FR 1116). The ESU was revised in 2005 to include the natural population of spring-run Chinook salmon in the Feather River, as well as the Feather River Hatchery spring-run Chinook stock (70 FR 37160). Additionally, spring-run Chinook salmon in the Sacramento River drainage were listed as threatened by the State of California in 1999 (CDFW 2014).

Critical habitat for the CV spring-run Chinook salmon ESU was designated in 2005; this critical habitat comprises reaches in the Upper and Lower Sacramento River and Feather River CPAs, including reaches of the Feather and Yuba Rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks; the Sacramento River; and portions of the northern Delta (70 FR 52488). The primary constituent elements considered essential for conservation of the CV spring-run Chinook salmon ESU are (1) freshwater spawning sites, (2) freshwater rearing sites, (3) freshwater migration corridors, (4) estuarine areas, (5) nearshore marine areas, and (6) offshore marine areas. The CVFPP affects only the freshwater and estuarine primary constituent elements.

The most recent 5-year review of the ESA listing classification of CV spring-run Chinook salmon (NMFS 2011) concluded that the fish will remain listed as threatened, 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."

NMFS released a draft recovery plan in 2009 which was finalized in 2014 after undergoing public review: the *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead* (NMFS 2014) is a guidance and planning document that delineates reasonable actions that may be necessary for the conservation and survival of listed species.

Status and Trends

Historical Distribution

Historically, CV spring-run Chinook salmon occurred in streams throughout the Sacramento–San Joaquin River Basin, including the upper and middle reaches of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit Rivers (Figure 1) (NMFS 2014). The Central Valley Technical Recovery Team identified 18 or 19 independent populations, of which only three are extant: in Deer, Mill, and Butte Creeks in the Upper Sacramento River CPA (NMFS 2011). However, CV spring-run Chinook salmon are repopulating Battle Creek, where they were historically distributed (NMFS 2011).

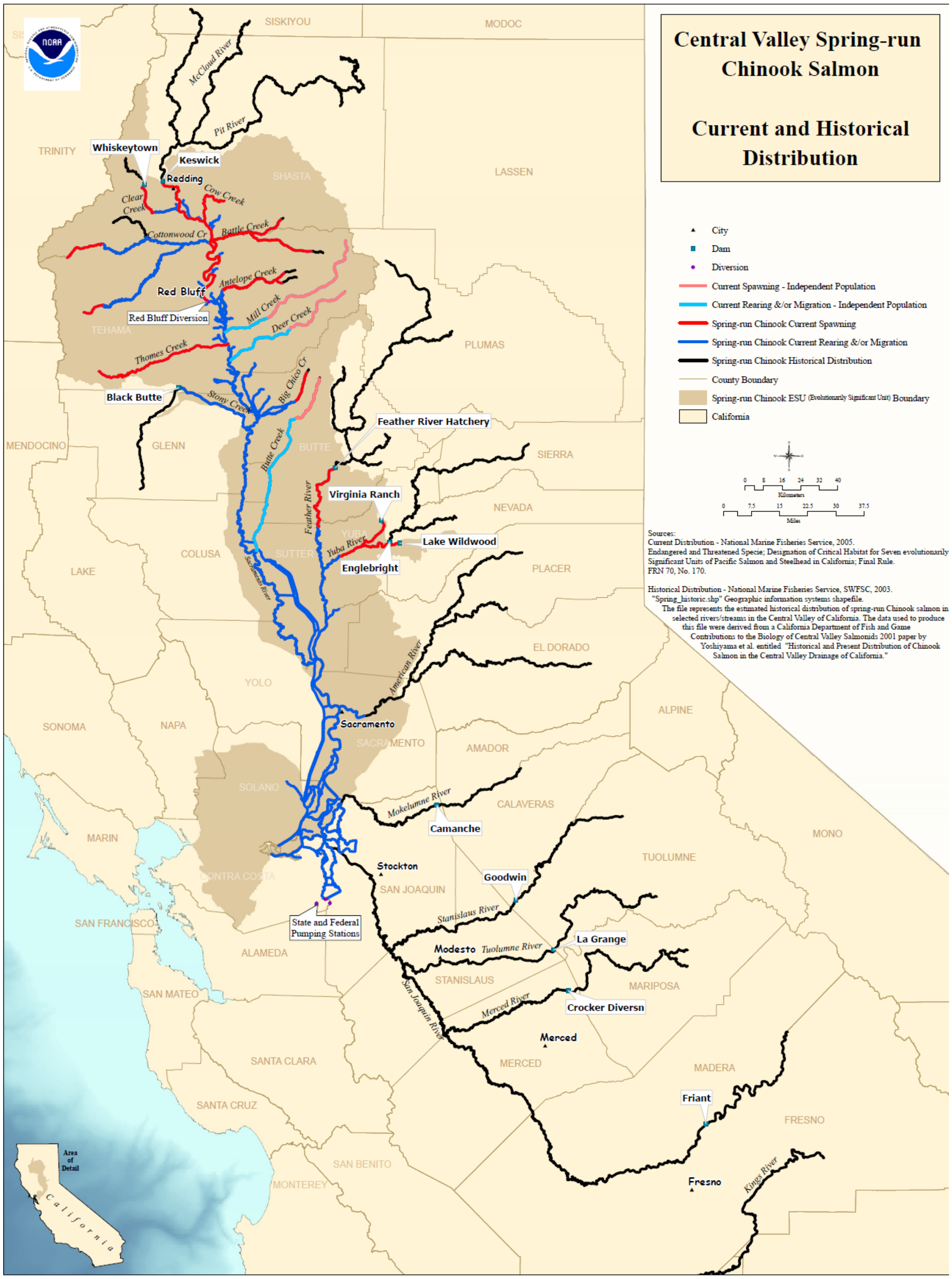
Current Distribution

Currently, most of the spawning populations (including hatchery fish) are located in the east-side tributaries to the Sacramento River that are north of the American River as well as the mainstem Sacramento River downstream of Keswick Dam; these are located in the Upper Sacramento River and Feather River CPAs (Figure 1) (NMFS 2014). Numerous ongoing and future restoration efforts may eventually increase CV spring-run Chinook salmon distribution in the SPA; these efforts include removing five dams on Battle Creek in the Upper Sacramento River CPA and repopulating CV spring-run Chinook salmon, reintroducing CV spring-run Chinook salmon in the Upper San Joaquin River CPA downstream of Friant Dam, and facilitating fish passage upstream of Englebright Dam on the Yuba River in the Feather River CPA. Juvenile CV spring-run Chinook salmon originating from the Upper Sacramento and Feather River CPAs are entrained at the State and federal water export facilities in the Lower San Joaquin River CPA (Kimmerer 2008).

Population Trends

CV spring-run Chinook salmon were probably the most abundant salmonid in the Central Valley under historical conditions, but are considered to be the Chinook salmon run that has suffered the most severe declines as a result of dams eliminating access to historical habitat (NMFS 2014). Between the 1880s and 1940s, CV spring-run Chinook salmon runs were estimated to have contained as many as 600,000 adult fish (NMFS 2014). Compounding the effect of dams, fish harvest, water project development, and habitat degradation significantly reduced the number and range of CV spring-run Chinook salmon.

Since 1960, the Anadromous Resource Assessment Unit of CDFW’s Fisheries Branch has compiled annual estimates of CV spring-run Chinook salmon populations for streams surveyed in the Sacramento–San Joaquin River system (Azat 2013). These escapement surveys provide data to inform ocean and inland harvest management, to assess recovery of listed stocks, and to evaluate the success of restoration programs and the contribution of hatchery fish to Central Valley populations (Low 2007). Population estimates are based on counts of adults as they enter hatcheries and migrate past dams, surveys of postspawning adult carcasses, live counts, and ground and aerial redd counts conducted by CDFW, USFWS,



Source: NMFS 2014

Figure 1. Central Valley Spring-Run Chinook Salmon ESU—Current and Historical Distribution

DWR, the East Bay Municipal Utilities District, USBR, the Lower Yuba River Management Team, and the Fisheries Foundation of California (Low 2007). Various methods are applied to monitor juveniles in some tributaries and mainstems to provide information on juvenile rearing and emigration, habitat use, growth, and stranding (Low 2007).[3] Information from juvenile surveys is used to evaluate the success of habitat restoration programs and the impacts of water project operations on salmonid survival, to manage water project operations for the protection of salmonids on a real-time basis, and to evaluate hatchery propagation programs (Low 2007).

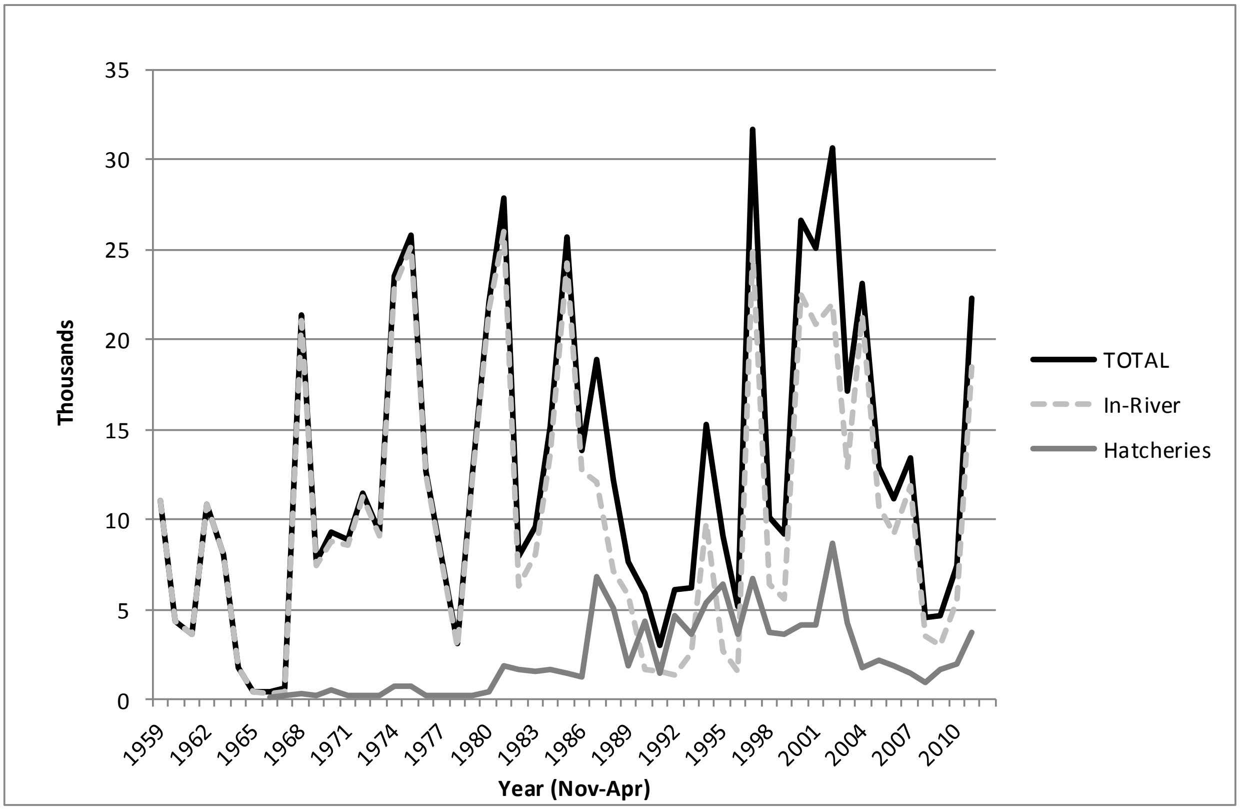
Between 1970 and 2008, the estimated annual run size of in-river CV spring-run Chinook salmon has fluctuated from a low of about 3,000 fish to a high just over 30,000 fish (Figure 2) (NMFS 2014). From 1999 to 2009, in eight out of eleven monitored creeks, declining trends of 27–67 percent occurred (NMFS 2011). These declines were attributed to (1) unusual ocean conditions in spring 2005 and 2006 that led to poor ocean survival (Lindley et al. 2009) and (2) droughts in the Central Valley from 2007 to 2009 (NMFS 2011). Both of these factors were exacerbated by a long-term degradation of freshwater and estuarine habitat conditions that has reduced Chinook salmons' ability to withstand normal environmental stressors (NMFS 2011). These trends appear to be reversing (Figure 2), which may be due to a return to more favorable ocean conditions.

The only populations that increased from 1999 to 2009 were in Battle Creek and Clear Creek, in the Upper Sacramento River CPA; these population increases were attributed in part to extensive habitat restoration actions, such as dam removal/fish passage improvements, gravel augmentation, flow releases, and revegetation (National Park Service [NPS] and U.S. Bureau of Land Management [BLM] 2008; NMFS 2011).

Life History

Chinook salmon are anadromous (i.e., they migrate to the ocean, where they spend most of their lives and grow large before returning to freshwater, where they spawn, then hatch and rear) and semelparous (i.e., adults die after spawning). Adults remain at sea for 1–6 years (usually 2–4 years), although some males, called jacks, either mature in freshwater or return after only 2–3 months at sea (69 FR 33102). They return to freshwater to spawn, and both Sacramento River winter-run and CV spring-run Chinook salmon migrate upstream, where they hold, delaying spawning for weeks or months (Moyle 2002). Embryos hatch after 40 to 60 days (or more) of incubation, and the alevins (yolk-sac fry) remain in the gravel for an additional 4–6 weeks before emerging from the gravel (NMFS 2014). The fry may remain in their natal stream for several weeks to more than a year; sometimes they are displaced downstream by flows and continue downstream to rear in mainstems or the estuary (Moyle 2002) before emigrating as smolts to the ocean.

[3] "Stranding" herein refers broadly to any event in which fish are trapped in detrimental conditions by being physically separated from a main body of water or from their natural migration route to natal streams. Stranding includes both entrapment in lethal or sublethal conditions and cases in which fish stray into nonnatal streams or unsuitable habitat because of system operations or attraction flows. Types of stranding are further discussed in Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System."



Source: Azat 2013

Figure 2. Escapement of Central Valley Spring-Run Chinook Salmon in the Sacramento and San Joaquin River Systems

CV spring-run Chinook salmon presence in the CPAs depends on time of year and life stage. Adult CV spring-run Chinook salmon leave the ocean in late January and early February (California Department of Fish and Game [CDFG] 1998) and enter the Lower Sacramento River CPA between March and September, primarily in May and June (Yoshiyama et al. 1998; Moyle 2002). They migrate through the Lower and Upper Sacramento River CPAs and the Feather River CPA to their spawning tributaries in March through July, peaking in April and May, during spring snowmelt flows. They hold in these tributaries over summer, and then spawn in September and October (NMFS 2014). The fry emerge from the gravel between November and March (Moyle 2002; NMFS 2014). Juveniles may spend a year or more rearing in freshwater (as "fingerling residents") before emigrating; they are known to rear upstream of the Delta in the lower reaches of nonnatal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin et al. 1999; Snider 2001; Williams 2010; NMFS 2014). However, some juveniles may emigrate to the ocean in late fall, after only a few months of rearing ("fingerling migrants") (Williams 2010). It is not known what proportion of adult returns represents juvenile CV spring-run Chinook salmon that rear in tributary habitats and leave as yearlings, versus those that migrate downstream to rear. Because of the variable juvenile life history, the timing of emigration through the Lower Sacramento River CPA and Delta to the ocean is highly variable, occurring from November through May (NMFS 2014).

Habitat and Ecological Process Associations

Habitat requirements for CV spring-run Chinook salmon vary with life stage, but, in general, what sets them apart from the other Chinook salmon runs in the Central Valley is that they enter rivers as immature fish in spring and early summer and require freshwater streams with cold temperatures over summer to hold and mature (NMFS 2014). The holding habitat preference is for cool (<60°F), deep (>7 feet) pools with moderate velocities (0.5–2 feet/second); spawning occurs in gravel riffles in fall (NMFS 2014). However, the vast majority of tributaries with high-elevation holding and spawning habitats have been blocked by dams (Stillwater Sciences 2007; Pasternack et al. 2010; NMFS 2014).

For freshwater spawning, Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, with cool water temperatures, low depths (0.5–4 feet), and moderate velocity (2–4 feet/second) (Moyle 2002; Pasternack et al. 2010). The embryo incubation life stage of CV spring-run Chinook salmon is sensitive to elevated water temperatures, with preferred water temperatures for egg incubation and embryo development between 46°F and 56°F, a significant reduction in egg viability above 57.5°F, and potential mortality above 62°F (NMFS 2014). Construction of dams has eliminated major sources of suitable gravel recruitment to current spawning reaches (NMFS 2014). In addition, flow fluctuations can have potentially adverse effects on the embryo incubation life stage because of the potential for redd dewatering, particularly in the upper Sacramento River downstream of Keswick Dam (NMFS 2014).

After emergence, fry rear in the streams and rivers where they were spawned for several months to more than a year, in habitats with shallow, slow-moving waters and bank cover composed of overhanging and submerged vegetation, root wads, and woody material; in these habitats, the fry feed on zooplankton and small insects. The elements of suitable fry and juvenile rearing habitat are largely defined by the three attributes of SRA cover: overhanging vegetation, instream cover, and natural eroding banks (Fris and DeHaven 1993). Such conditions are best supported by natural geomorphic processes.

In the Upper and Lower Sacramento River and Feather River CPAs, juvenile Chinook salmon, including CV spring-run salmon, can rear in riverine and estuarine habitats of the Sacramento River, the Delta, and their tributaries, including the Yolo and Sutter Bypasses when flooded (Maslin et al. 1999; Snider 2001). Off-channel floodplain habitats that are seasonally inundated (e.g., in years with sufficiently high flows, usually during winter and spring when temperatures are suitable for rearing) support much higher growth rates of juvenile Chinook salmon than adjacent main-channel or riverine habitats (Jeffres et al. 2008; Limm and Marchetti 2009). These off-channel habitats tend to have higher temperatures and rates of food production compared to riverine habitats, resulting in increased growth of juveniles (Jeffres et al. 2008; Limm and Marchetti 2009). In the seasonally inundated agricultural floodplains of the Yolo Bypass, juveniles are known to rear for several months in winter and spring. Here, the greater availability of drift invertebrates contributes to higher juvenile growth rates than are found in adjacent river channels (Sommer et al. 2001).

The Knaggs Ranch Restoration Study is evaluating the Yolo Bypass as winter floodplain habitat for Chinook salmon to improve understanding of how juvenile salmonids use various habitat types (USBR 2012). The Knaggs Ranch Restoration Study is located on an agricultural parcel, with a total area of 1,703.55 acres, in the northern part of the Yolo Bypass. The multiyear experimental study is evaluating aquatic food resources and juvenile salmonid growth in a variety of habitat types (e.g., long rice stubble, short rice stubble, disked, and fallow). Study results to date appear to corroborate earlier findings that fish that rear in the bypass have high growth rates and survival (Katz 2012). Other benefits of rearing in the Yolo Bypass and floodplain habitat include (1) delayed outmigrating timing, which results in later ocean entry and better synchronizes juveniles that reach the coast with the high productivity associated with spring and summer winds that drive upwelling conditions, and (2) routing of fish away from the interior Delta and export pumps where there is an increased risk of mortality (Katz 2012).

Floodplain benefits for juvenile Chinook salmon rearing should increase with longer durations of flooding, but relatively short periods of access may still provide benefits (Jeffres et al. 2008). Improved habitat conditions for juvenile CV spring-run Chinook salmon may be achieved by inundating the bypasses (e.g., Yolo and Sutter) for at least 14 days (for food production to occur), particularly between late November and early December and the end of April (USBR 2012). Specific inundation flows would need to take into account any structural changes to the weirs (e.g., the Fremont Weir) that might allow lower flows to provide inundation; currently, the vast majority of the Yolo Bypass is inundated at flows above 74,000 cubic feet per second (USBR 2012). To improve the passage of upstream migrating adults in the Yolo Bypass, inundation would need to occur at least from March through April, and ideally from January through mid-May to provide maximum benefits, depending on the water year type and any structural changes made to improve fish passage at the weirs (USBR 2012).

In the Delta region of the Lower Sacramento River CPA, juveniles forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960; Healey 1980), and are less abundant where shorelines have riprap (McLain and Castillo 2009). However, juvenile Chinook salmon (young-of-the-year) from the Central Valley tend to emigrate through the Delta to the mouth of San Francisco Bay in about 40 days (MacFarlane and Norton 2002); larger yearling Chinook salmon move from the Delta to the ocean even more quickly, in 9 to 17 days (Michel et al. 2013).

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for CV spring-run Chinook salmon within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by CV spring-run Chinook salmon within the SPA;
- the specific CPAs within which these habitat conditions occur;

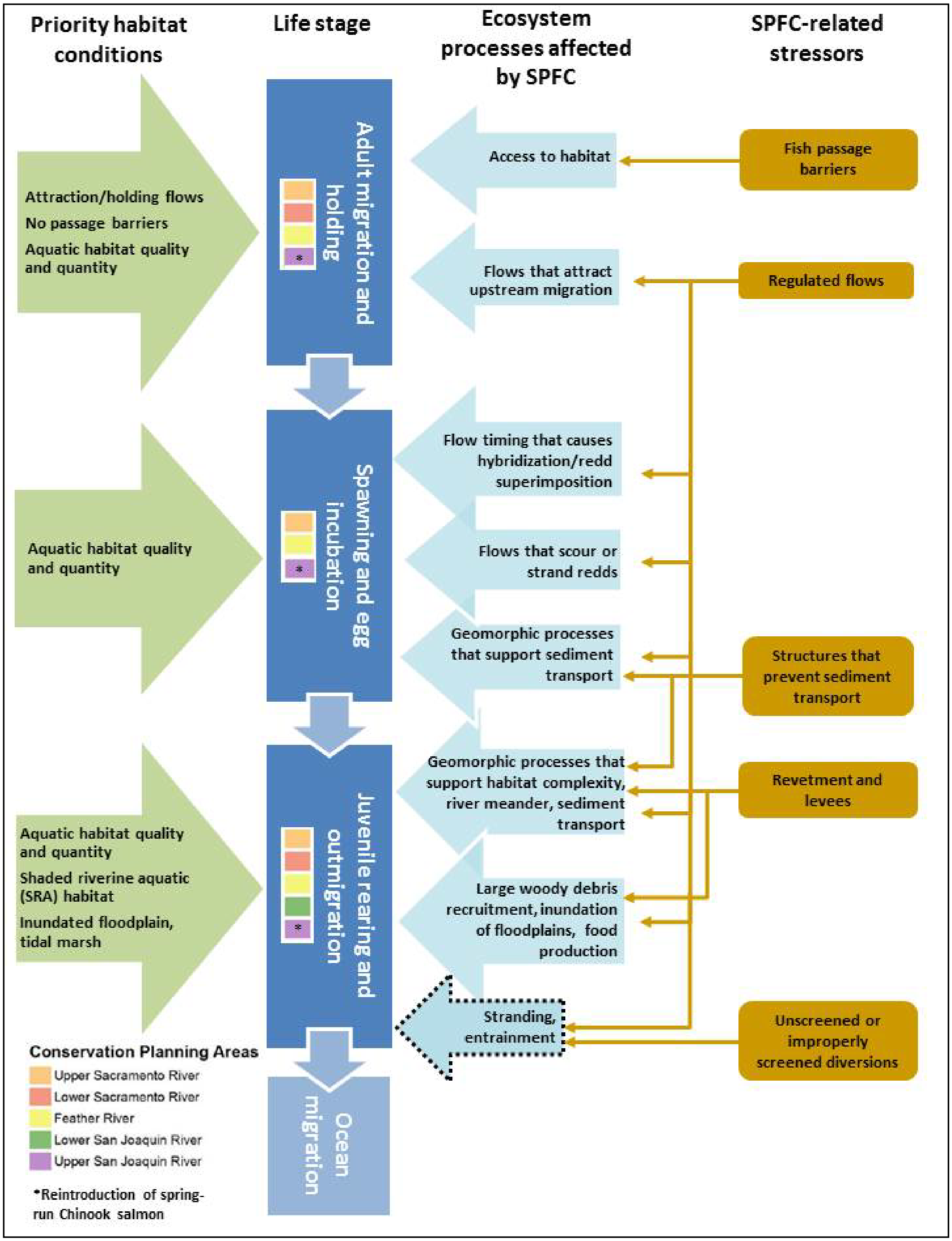


Figure 3. Conceptual Model for Central Valley Spring-Run Chinook Salmon within the SPA

- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Impassable dams that prevent CV spring-run Chinook salmon from reaching historical holding and spawning habitat have resulted in greater competition for spawning habitat and hybridization with fall-run Chinook salmon (e.g., in the Feather River). CV spring-run Chinook salmon are distinguished by the fact that they migrate upstream in spring, hold all summer without feeding while maturing, and then spawn in early fall. By migrating upstream during high spring flows (before impassable dams were built), they were able to access high-elevation reaches that had cool water throughout summer (Pasternack et al. 2010). Under current conditions, spawning habitat may be limited for CV spring-run Chinook salmon, because although cold pools suitable for over-summering adults may exist downstream of dams, the gravel needed for spawning may be limited, and some adults may need to migrate downstream of their holding habitat to spawn (Stillwater Sciences 2007). Despite this limitation, higher-elevation reaches (above 1,500 feet) historically were inaccessible to fall-run Chinook salmon attempting to migrate upstream in fall during lower flows, resulting in spatial segregation and reduced competition for spawning habitat between spring-run and fall-run Chinook salmon. In areas where impassable dams are causing spring- and fall-run Chinook salmon to use the same spawning habitats, fall-run Chinook salmon have been shown to have a competitive advantage over spring-run Chinook salmon, and hybridization between the runs has also been known to occur (Stillwater Sciences 2007; NMFS 2014). In addition, because adults have to spawn downstream of impassable dams, redds are potentially more susceptible to stranding, unless dam operations that affect flows address ramping (NMFS 2014).

Historically, CV spring-run Chinook salmon reared in cold, high-elevation habitats, but because of impassable dams, they now must rear in lower-elevation habitats (e.g., in mainstems and the Delta), which maybe limited (NMFS 2014). Currently, many factors influence the quality of rearing habitat for CV spring-run Chinook salmon. In the mainstems of the Upper and Lower Sacramento River and Feather River CPAs, and in the Upper San Joaquin River CPA (where spring-run Chinook salmon are being reintroduced), rearing habitats such as inundated floodplains and riparian vegetation provide prey production and refuge from predators, important for juvenile growth and survival. However, limiting factors for juvenile CV spring-run Chinook salmon in the Upper and Lower Sacramento River and Feather River CPAs include alteration of flows, blockage of access to historical rearing habitat, loss of natural river morphology and function, predation, entrainment by project diversions, interactions with hatchery fish, toxicants, and significant reduction of floodplain and SRA habitat (Williams 2010; NMFS 2014).

If CV spring-run Chinook salmon are successfully reintroduced in the Upper San Joaquin River CPA, limiting factors for adults and juveniles in the Upper and Lower San Joaquin River CPAs include numerous barriers, flows altered by Friant Dam, and numerous flow-control structures that degrade habitat (e.g., by raising spring water temperatures) and affect access to habitat, levee construction that has channelized and simplified habitat, lack of spawning gravel recruitment, significant reduction of floodplain and SRA habitat, introduction of nonnative species that may compete with or prey on juvenile Chinook salmon, the potential presence of fall-run Chinook salmon that could compete with spring-run Chinook salmon, toxicants, and a lack of adult Chinook salmon carcasses (particularly in the Upper San Joaquin River CPA), which had been historically deposited each year after spawning, and which provided food for invertebrates and contributed marine-derived nutrients to the food chain (SJRRP 2008).

Overall, the historical reduction and degradation of habitat remains the greatest ongoing threat to the persistence of CV spring-run Chinook salmon. Impacts, challenges, and management issues are discussed further in the following section.

Management Issues

Threats and Sensitivities Range-Wide

The historical reduction of holding, spawning, and rearing habitats throughout the SPA poses the greatest threat to the persistence of the CV spring-run Chinook salmon ESU (Good et al. 2005; NMFS 2014). Loss of historical holding and spawning habitat is being addressed in some watersheds by removing dams (e.g., on Battle, Clear, and Cottonwood Creeks) and by plans to reintroduce spring-run Chinook salmon to historical habitat (e.g., on the San Joaquin River, upstream of Shasta Dam on the Sacramento River, and upstream of Englebright Dam on the Yuba River) (NMFS 2011). Access to spawning and rearing habitat that persists downstream of existing dams on streams throughout the Sacramento River Basin remains impaired by the operation of ineffective fish screens, fish ladders, and diversion dams. Levees and flood control operations and maintenance practices have greatly simplified riverine habitat by channelizing rivers and removing SRA cover along channels, and have disconnected rivers from the floodplain (NMFS 2011). Finally, dams used for hydroelectric generation and irrigation have affected stream hydrology and habitat quality, particularly on the mainstem Sacramento River (Central Valley Project), and the Feather River (State Water Project) (NMFS 2011). To offset these factors, large-scale recovery of connected floodplain and SRA habitats is needed to improve juvenile rearing habitat that was lost to construction of major levee systems and widespread tidal marsh reclamation (NMFS 2011).

Other threats to the ESU include predation by nonnative species, poor water quality, excessively high water temperatures, and genetic contamination from the Feather River hatchery spring-run Chinook salmon program (Good et al. 2005; NMFS 2014).

Ongoing and Future Impacts

Ongoing impacts on CV spring-run Chinook salmon in the SPA include construction, operation, and maintenance of flood control facilities that affect habitat access, flows, and the quality and availability of downstream habitat; catastrophic fires; water diversions that entrain juveniles and affect habitat quality; nonnative invasive aquatic species; hatcheries; and the effects of climate change, which will likely include degradation of water quality and habitat suitability.

- The availability of suitable habitat likely will continue to be the most critical factor in CV spring-run Chinook salmon recovery (NMFS 2014). Particularly, loss of rearing habitat in the Upper and Lower Sacramento River and Feather River CPAs will continue to be a significant stressor to CV spring-run Chinook salmon (NMFS 2014). Of the CV spring-run Chinook salmon holding, spawning, and rearing habitat that has been lost, the majority was lost as a result of water system developments in Central Valley watersheds: large dams (e.g., Shasta and Oroville Dams) and their associated hydropower development projects have prevented CV spring-run Chinook salmon from accessing significant areas of historical upstream summer holding, spawning, and rearing habitat (NMFS 2014).

  Aside from these total barriers, many other partial barriers have been identified that may delay or impair fish migration (see Attachment 9C of the CVFPP and Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System") and have been prioritized for improvements based on impacts on fish (see Appendix K). In particular, the Fremont Weir (the primary inundation source for the Yolo Bypass) currently provides adult fish passage at a single fish ladder that is opened once overtopping at the Fremont Weir ceases (USBR 2012). Adult passage is impeded at the ladder because of poor attraction flows and other irregularities. NMFS has identified the need to reduce migratory delays and minimize stranding (and resultant mortality) of upstream-migrating adult CV spring-run Chinook salmon at the Fremont Weir (USBR 2012).

  CVFPP modifications or projects that contribute to simplified or degraded riverine habitat, such as levee armoring, are expected to negatively affect CV spring-run Chinook salmon. Numerous activities and events can reduce water quality and are expected to continue to negatively affect salmon. For example, vegetation removal near waterways can increase water temperatures, and dredging activities can resuspend sediments and contaminants, clogging fish gills, smothering eggs, and reducing benthic prey availability. Catastrophic fires can severely affect water quality until vegetation is reestablished. Contaminants in discharges to the rivers and the Delta can affect food webs, degrade habitats, and directly harm juvenile salmonids (Mount et al. 2012).

- Entrainment at diversions continues to be an impact affecting juvenile CV spring-run Chinook salmon in the Upper and Lower Sacramento River CPAs and the Feather River CPA (NMFS 2014). Entrainment will also be an issue for reintroduced spring-run Chinook salmon in the Upper and Lower San Joaquin River CPAs. Entrainment at both large diversions (the Central Valley Project and the State Water Project) and numerous unscreened or inadequately screened diversions will likely continue to affect juvenile CV spring-run Chinook salmon (NMFS 2014). Large diversions can also affect water quality (Monsen et al. 2007) and provide habitat for introduced fish predators (Cavallo et al. 2013).

- Recent observations indicate that adult fish can migrate into the Yolo or Sutter Bypasses when they are flooded, or into the Knights Landing Outfall Gates, then swim into canals and drains such as the Colusa Drain, where they strand and die unless rescued (Cannon 2013; Hendrick and Swart 2013; Vincik and Johnson 2013). However, the severity of adult stranding on an annual basis is not known (Hendrick and Swart 2013).

- Climate change will affect habitat for CV spring-run Chinook salmon in the future, but the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the Sierra Nevada as rain rather than snow, thus reducing snowpack and water availability from snowmelt in spring and summer (Cayan et al. 2006). In the Upper Sacramento River CPA, flow releases from Keswick and Shasta Dams are essential for providing suitable thermal regimes for CV spring-run Chinook salmon rearing; climate change may affect water managers' ability to store water in the reservoir "cold-water pool," ultimately decreasing habitat quantity and quality for holding, spawning, and juvenile rearing in the Sacramento River between Keswick Dam and Red Bluff (USBR 2013) and in Butte Creek (Thompson et al. 2012). Ecologists are only beginning to understand climate change threats to riparian ecosystems (Seavy et al. 2009). Climate change models also predict increases in sea level, estuarine salinity, and freshwater temperature (Cloern et al. 2011). CV spring-run Chinook salmon and other cold-water adapted native fish are likely to respond negatively to climate change effects such as changes in streamflows and increased temperatures (Katz et al. 2012; Moyle et al. 2013).

Key Information Gaps or Uncertainties

To better understand how current and future CVFPP activities affect the conservation and potential recovery of CV spring-run Chinook salmon, and to help guide future actions of the CVFPP and Conservation Strategy, the following information is needed: modeling of impacts related to flood management, a better understanding of habitat functions, and data on the effects of predation and stranding. These data gaps are discussed below.

- **Impact models.** Flood managers need an improved understanding of the impacts on salmonid habitats caused by levee erosion repair projects. Currently, the Standard Assessment Methodology is used to systematically compare selected fish species' responses to habitat features affected by levee erosion repair projects. This method involves applying conceptual response models to quantified habitat changes to assess the near- and long-term impacts or benefits to species. The method is based on conceptual response models of indicator fish species, and evaluates effects of levee erosion repair designs that incorporate SRA components (overhanging shade, reduced substrate size, instream woody material, etc.), revetment size, bank slope, and length of the proposed levee project site.

  The conceptual response models were developed using professional opinion and assume relationships between the presence or abundance of an organism and habitat quality. However, habitat quality would be better assessed by evaluating the effects of levee erosion repair designs on the condition (e.g., growth) and survival of indicator fish species (Sommer et al. 2005; Bond et al. 2008). Additionally, the current Standard Assessment Methodology fails to evaluate the loss of riverine processes (lateral migration, reworked floodplain, vegetation regeneration, etc.) and should consider the effects of changes in levee configuration in order to evaluate the benefits or impacts of repairing existing levees versus changing levee alignment to promote natural river processes. These issues can be addressed by evaluating how juvenile CV spring-run Chinook salmon (both young-of-the-year and yearlings) use specific levee repair designs, including the duration of time spent at the site (minutes, hours, days, weeks) and effects on growth and survival. Additionally, there is concern that, in the warmer reaches of the mainstems, habitat features incorporated as mitigation for levee repair projects (e.g., instream wood) may be providing or improving habitat conditions for predators of juvenile CV spring-run Chinook salmon (Vogel 2011), which is being evaluated by resource agencies.

- **Habitat functions.** There is a lack of information on the function of certain habitats in the life history of the species; in particular, the quality and quantity of habitats used by juveniles as they move downstream in the Sacramento River mainstem and the Delta during rearing and outmigration (Vogel 2011; NMFS 2014). The vegetation types providing preferred habitat for juvenile Chinook salmon in floodplains and bypasses are not well understood, although the most important characteristics of vegetation are its effects on prey availability and cover (Opperman 2012). Nevertheless, there is uncertainty about the importance of the distribution and amounts of SRA habitat on fish populations; for example, is the relationship between SRA habitat and fish numbers linear, or are minimum thresholds of SRA required, and what is the importance of habitat connectivity? Models have been developed to determine the amount of habitat (e.g., floodplain habitat area) needed to support juvenile rearing for the reintroduction of spring-run Chinook salmon in the San Joaquin River, but the actual timing, growth, survival, required habitat per fish, and habitat preferences assumed in the models cannot be verified until a population exists (SJRRP 2012). Actions that provide habitat for juvenile rearing, coupled with studies that evaluate habitat use through an adaptive management approach, could inform and improve future activities associated with levee maintenance and erosion repair.

- **Predation.** Especially in the lower mainstems and Delta, the extent of predation on juvenile salmon by nonnative fish is not well understood (Williams 2010). The Central Valley has many nonnative, introduced fish species that are known predators of juvenile salmon. Actions that could inadvertently increase habitat for predators need to be evaluated.

- **Stranding and straying effects.** Stranding and straying of juveniles and adults in bypasses (and of adults in the Colusa Drain) when high flows recede is known to occur, but quantification is difficult; therefore, the impact of stranding on the population of CV spring-run Chinook salmon is poorly understood (Cannon 2013; Vincik and Johnson 2013). Actions that increase connectivity to bypasses and floodplains could incorporate ways to minimize stranding, such as flow-reduction ramping rates. The interaction of flow magnitude and timing with channel conveyance capacity, infrastructure, water diversions, and fish habitat needs could be addressed by CVFPP actions for tributaries (Feather River CPA) and mainstem rivers and bypasses (Upper and Lower Sacramento and San Joaquin River CPAs).

Conservation Strategy

Conservation and Recovery Opportunities

The integration of environmental stewardship into all flood management activities (by DWR and Local Maintaining Agencies) during project planning, design, operation, 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 CV spring-run Chinook salmon is to increase the availability of suitable spawning and rearing habitats by encouraging riverine processes that improve natural river morphology and function. Improving the distribution and quality of SRA habitat, the amount and distribution of inundated floodplain, connectivity of fish passages, and channel-margin restoration would benefit the species. These conservation needs and opportunities, which align with the recovery plan (NMFS 2014), are discussed in detail below.

Identified Conservation Needs

1. **Improve the distribution and quality of SRA habitat throughout the SPA:** The elements of SRA habitat (overhanging vegetation, instream cover, and natural eroding banks) each offer important habitat resources to adult and juvenile CV spring-run Chinook salmon. SRA habitat provides organic material input, differential velocities, cover, food, temperature regulation, and improved water quality. Because juveniles can rear both in tributaries, mainstems and bypasses, large-scale restoration of SRA habitat is needed to improve their rearing habitat, most of which has been lost because of construction, operation, and maintenance of SPFC facilities, as well as alteration of flows in the SPA.

2. **Improve the distribution and quality of channel-margin habitat in tidally influenced waterways throughout the Delta region of the Lower Sacramento and Lower San Joaquin River CPAs:** Marsh and channel-margin habitats are an important food and cover resource for emigrating smolts and rearing juvenile CV spring-run Chinook salmon. Historical reclamation of wetlands and construction of levee systems in the Delta region of the Lower San Joaquin and Lower Sacramento River CPAs removed most of this habitat. Large-scale restoration of the distribution and amount of tidally influenced channel-margin habitat is needed (NMFS 2014).

3. **Increase the amount and distribution of inundated floodplain habitat throughout the SPA:** Compared to mainstem channels, inundated off-channel floodplain habitats have higher temperatures and food production rates, and contribute to higher growth and survival rates for juvenile spring-run Chinook salmon. These habitats include bypasses (e.g., Yolo and Sutter) as well as mainstem and tributary (e.g., Deer, Mill, Butte Creeks) floodplains. Inundated floodplain habitats are currently limited by both regulated

streamflows (particularly in the bypasses) and levee systems (particularly along mainstems and tributaries). Improving floodplain connectivity will require large-scale restoration actions that take into account the interaction of floodplain elevations and the timing, duration, and quantity of flow releases. Increasing the quantity and quality of floodplain habitat in the Upper and Lower Sacramento River and Feather River CPAs would provide beneficial rearing habitat for juvenile CV spring-run Chinook salmon (Appendix H of the Conservation Strategy, "Central Valley Chinook Salmon Rearing Habitat Needed to Satisfy the Anadromous Fish Restoration Program Doubling Goal.").

4. **Improve natural river morphology and function:** Flood control measures downstream of dams, such as bank protection, have affected riparian and instream habitat, particularly in the Lower Sacramento River and Feather River CPAs. Constructed levees that narrow channels have increased velocities and channelized rivers so that natural geomorphic processes (e.g., channel meander) are no longer possible. Improving geomorphic processes to support natural bank erosion, sediment deposition, and the establishment and growth of riparian vegetation is essential for providing beneficial SRA habitat, reconnecting floodplains, and recruiting woody material that improves rearing habitat for juvenile CV spring-run Chinook salmon.

5. **Improve fish passage throughout the SPA:** During winter and spring high-flow events, water is diverted into bypasses (e.g., Sutter and Yolo). Adult CV spring-run Chinook salmon can enter the bypasses, but their migration may then be delayed or prevented by control structures (e.g., the Sacramento, Fremont and Tisdale Weirs) and unscreened canals and drains (e.g., Knight's Landing Outfall Gates) (Cannon 2013; McEwen 2013; Conservation Strategy Appendix K). Therefore, there is a need for improving or eliminating these types of flood control structures to provide for adult anadromous fish passage. In addition, juveniles can become entrained by unscreened or inadequately screened diversions, and stranded in bypasses when flows recede, making adequately screening all diversions another high-priority conservation action.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the CV spring-run Chinook salmon; these are summarized in Table 1 of this section. In many cases, the conservation needs of CV spring-run Chinook salmon can be addressed through the implementation of management actions that integrate conservation and restoration elements with SPFC operation and maintenance, floodway management, and structural improvements to facilities. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Central Valley Spring-Run Chinook Salmon[a]

SPFC Conservation Actions	Conservation Need				
	1. Increase/ Improve SRA Habitat	2. Increase/ Improve Marsh Habitat	3. Increase Inundated Floodplain	4. Improve Natural River Function	5. Improve Fish Passage and Decrease Entrainment
Operations, Maintenance, and Floodway Management					
Floodwater storage and reservoir forecasting, operations, and coordination	+		+	+	+
Facility maintenance					
Levee vegetation management	-				
Floodway maintenance	+				
Modification of floodplain topography	+		+	+	+
Support of floodplain agriculture			+		+
Invasive plant management				+	
Restoration of riparian, SRA, and marsh habitats	+	+		+	
Wildlife-friendly agriculture					
Structural Improvements					
Levee and revetment removal	+	+	+	+	
Levee relocation	+	+	+	+	
Bypass expansion and construction		+	+	+	+
Levee construction and improvement	+			+	
Flood control structures					+

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

Operations, Maintenance, and Floodway Management

Floodwater storage and reservoir forecasting, operations, and coordination: Modifying and coordinating flood operations could include limited reoperation of reservoirs and weirs. These could provide flow releases that improve aquatic habitat conditions by changing the timing and amount of releases and ramping rates from November/early December to the end of April, particularly at Oroville and Englebright Dams in the Feather River CPA, and Shasta and Keswick Dams in the Upper Sacramento River CPA. These modifications could reduce fish stranding and passage barriers, reduce dewatering of redds, initiate upstream adult migration and juvenile outmigration, and generate other environmental benefits, including promoting floodplain connectivity, enhancing meander migration rates, improving spawning gravel dynamics (recruitment, flushing, and mobilization), and improving conditions to promote development of SRA habitat.

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 fish-rearing habitat.

Levee vegetation management: The 2012 CVFPP introduced an interim vegetation management strategy, under which levee vegetation in the VMZ (see Figures 2-1 and 2-2 in Appendix D of the Conservation Strategy) is managed for visibility and accessibility, and to reduce threats to levee integrity. Consequently, levee riparian vegetation in the VMZ 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 may also have detrimental effects on water temperature (Poole and Berman 2001) and fish habitat (e.g., instream wood recruitment and cover).

On the whole, levee vegetation management is likely to negatively affect habitat for CV spring-run Chinook salmon. However, lower waterside vegetation could be retained below the VMZ of levees when it does not present an unacceptable threat to levee integrity. Allowing vegetation to grow on the water side 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. This approach would also preserve, in the near term, other vegetation within the VMZ that does not impair visibility and accessibility. Under the Conservation Strategy, additional habitat could be developed to offset the gradual die-off of trees and the removal of trees that pose an unacceptable threat to levee integrity. This vegetation would be more valuable to Chinook salmon if it is (1) located close to water bodies, or at least where juvenile fish could access the vegetation during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) regionally distributed.

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). Fill-placement and rock-repair projects could incorporate reduced particle sizes, instream woody material, SRA elements, and planting berms, where relevant.

Modification of floodplain topography: Floodway topography modifications could increase floodway capacity, inundation frequency and duration, and habitat amounts and diversity, and could also eliminate areas that strand fish. Floodplain elevations could be lowered to provide more frequent and sustained inundation. Elevations could also be modified to provide greater topographic and hydrologic diversity (creating or opening secondary channels or overflow swales) and to eliminate features (such as gravel pits or deep borrow pits in the Feather River CPA and the Upper and Lower San Joaquin River CPAs) that strand fish. These actions would increase riverine and floodplain habitat values (e.g., resting or rearing areas for fish migrating downstream) and provide escape routes for fish during receding flows.

Support of floodplain agriculture: Managing floodways to maintain the compatibility of flood management with agriculture would support agriculture in the bypasses and on floodplain agricultural lands between levees while accommodating access to rearing habitat by juvenile salmon. Addressing the problems posed by unscreened diversions and other structures that trap or impede movement of any juvenile or adult Chinook salmon would provide benefits to CV spring-run Chinook salmon. However, it is important that diversions be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; Conservation Strategy Appendix K).

Invasive plant management: Nonnative invasive plants that may be removed from State-operated and maintained lands and facilities would include submerged aquatic vegetation (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 nonnative submerged aquatic vegetation generally support nonnative fishes such as centrarchids (Grimaldo et al. 2012), particularly in the Lower Sacramento River and Lower San Joaquin River CPAs, which may be predators of juvenile salmonids. Established nonnative terrestrial vegetation in riparian areas displaces important native plants (e.g., willows and cottonwood) that facilitate river meander and natural geomorphic processes. Removal of nonnative invasive plants could therefore benefit CV spring-run Chinook salmon by improving rearing and outmigration habitat and reducing predation by nonnative fishes.

Restoration of riparian, SRA, and marsh habitats: Riparian and marsh habitats could be restored at selected locations in the floodway to benefit juvenile CV spring-run Chinook salmon. Riparian restoration opportunities generally would be found in nonriparian land cover in the floodway, particularly as part of other management actions to increase floodway capacity. Riparian, SRA cover, and marsh restoration would be most beneficial in areas where restoration expands or connects existing habitat patches, where restoration provides habitat in areas with little or no riparian vegetation, at locations to be identified by future conservation or recovery planning for juvenile Chinook salmon, and in conserved areas. In the bypass system, marsh restoration would be generally beneficial to juvenile Chinook salmon and would be implemented in conjunction with bypass expansion and construction.

Structural 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 waterways used by juvenile CV spring-run Chinook salmon for rearing, and where removal contributes to a larger zone of active river meander migration.

Levee relocation: Relocating levees farther from rivers (i.e., constructing set back levees) is an important approach to increasing floodway capacity, creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. Often, these benefits can be realized while still supporting agriculture within expanded floodways. Levee relocation would also provide an opportunity for hydraulically connecting the river systems to mitigation plantings associated with the VMZ, and for creating and enhancing rearing habitat for juvenile CV spring-run Chinook salmon in all of the CPAs.

Bypass expansion and construction: Bypass expansion could enhance juvenile rearing habitat (e.g., food resources and cover) by increasing the connectivity of the floodplain to the river system and thus restoring floodplain ecosystems that contribute to food web productivity. However, because bypasses are flooded irregularly, in order to benefit juvenile CV spring-run Chinook salmon bypass flooding needs to occur more frequently (e.g., annual) with the appropriate timing and duration to provide suitable rearing habitat. Modifying bypass weirs (e.g., those in the Yolo and Sutter Bypasses, and at Paradise Cut) could improve inundation timing and duration to benefit fish, provided that other passage conditions are improved (as described in Appendix K).

As part of bypass improvements, adult fish passage could be enhanced at flood control structures (e.g., the Sacramento, Tisdale and Fremont Weirs) (McEwen 2013; Conservation Strategy Appendix K). Also, bypass expansion could address “sinks” where juvenile CV spring-run Chinook salmon become stranded; for example, the number of isolated pools could be reduced, and connectivity to Tule Canal could be improved (USBR 2012).

Levee construction and improvement: Levee construction and reconstruction objectives that would provide benefits to CV spring-run Chinook salmon include restoring geomorphic processes and, where significant hydraulic impacts would not occur, protecting riparian habitat and incorporating planting berms and riparian plantings. In addition, new levees could be designed to accommodate hydrologic changes expected to result from climate change.

Flood control structures: One priority action for State-operated and maintained diversions in the SPA is reconfiguring the Tisdale Weir in the Sutter Bypass and 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 allow passage by adult fish and to increase floodplain inundation (DWR 2012; McEwen 2013; Conservation Strategy Appendix K). It is important that diversions be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; McEwen 2013; Conservation Strategy Appendix K); however, improving any structure that traps or impedes the movement of juvenile or adult fish would provide benefits to CV spring-run Chinook salmon.

Recovery Plan Alignment

CV spring-run Chinook salmon recovery is based on 2 key conservation principles: 1) sufficient functioning, diverse and interconnected habitats that provide capacity and diversity to allow spring-run Chinook salmon to withstand and adapt to environmental changes such as droughts, and 2) CV spring-run Chinook salmon viability is determined by its spatial structure, diversity (e.g., life history, genetics, and megapopulation organization), productivity and abundance (NMFS 2014). CV spring-run Chinook salmon ESU viability depends on the number of populations in the ESU, their individual status, their spatial arrangement with respect to each other and sources of catastrophic disturbance, and the diversity of the populations and their habitats (NMFS 2014). In the most general terms, ESU viability increases with the number of populations (redundancy), the viability of these populations, the spatial distribution of the populations, the diversity of the populations, and the diversity of habitats that they occupy (NMFS 2014).

NMFS has identified four Diversity Groups for CV spring-run Chinook salmon—Northwestern California, Basalt and Porous Lava, Northern Sierra Nevada, and Southern Sierra Nevada Regions—these are geographically identifiable areas that encompass multiple watersheds (NMFS 2014). For the ESU to achieve recovery, each Diversity Group should support both viable and independent populations and meet goals for redundancy and distribution (NMFS 2014). Thus, an overall goal is to sustain populations in each Diversity Group.

The biological recovery criteria for CV spring-run Chinook salmon are to obtain:

- at least one population at low risk of extinction in the Northwestern California Region,
- at least two populations at low risk of extinction in Basalt and Porous Lava Region,
- at least four populations at low risk of extinction in Northern Sierra Nevada Region,
- at least two populations at low risk of extinction in the Southern Sierra Nevada Region, and
- populations present in each region at moderate risk of extinction (NMFS 2014).

The recovery plan also identifies candidate reintroduction watersheds, upstream of existing dams, where habitat is of sufficient quality and quantity to support CV spring-run Chinook salmon. These locations include habitat upstream of Keswick, Shasta, and Englebright Dams, and two others (NMFS 2014). In addition, the plan calls for establishing a population in the San Joaquin River upstream of the Merced River confluence and downstream of Friant Dam (NMFS 2014). The recovery plan specifically identifies the need to "incorporate ecosystem restoration including breaching and setting back levees into the Central Valley flood control plans (i.e., FloodSafe Strategic Plan and the Central Valley Flood Protection Plan)". Table 2 lists examples of specific near- and long-term restoration and recovery actions identified by NMFS (2014) that could be partially or fully implemented through the CVFPP.

Measures of Positive Contribution

Contributing to the recovery and stability of native species populations and overall biotic community diversity is a primary goal of the Conservation Strategy. The objective for this goal is a measurable contribution to the conservation of target species, including CV spring-run Chinook salmon. Therefore, building on the preceding discussion, this section of the CV spring-run Chinook salmon 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 3). 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 conservation of CV spring-run Chinook salmon, requirements would be added to increase the acreage of restored riparian areas that positively contribute to adjacent rearing habitat, providing terrestrial inputs and creating the cover needed by the species.

Table 3 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of CV spring-run Chinook salmon, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit CV spring-run Chinook salmon may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Examples of Near- and Long-Term Restoration and Recovery Actions, by Region, That Could Be Implemented through the CVFPP

CPA	Restoration Action
Upper Sacramento River	• Implement projects to increase Big Chico Creek floodplain habitat availability to improve habitat conditions for juvenile rearing. • Identify stream reaches in Big Chico Creek that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows. • Restore and maintain riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types including riparian forest, gravel bars and bare cut banks, shady vegetated banks, side channels, and sheltered wetlands such as sloughs and oxbow lakes. • Ensure that river bank stabilization projects along the Sacramento River utilize biotechnical techniques that restore riparian habitat, rather than solely using the conventional technique of adding riprap. • Implement projects that promote native riparian (e.g., willows) species including eradication projects for nonnative species (e.g., *Arundo*, tamarisk). • Implement short and long-term solutions to minimize the loss of adult CV spring-run Chinook salmon in the Sutter- Butte basin, including consideration of exclusion devices at specific locations.
Feather River	• Utilize fish friendly designs (e.g., levee setbacks, inclusion of riparian vegetation) for levee construction and maintenance. • Implement projects to improve nearshore refuge cover for salmonids to minimize predatory opportunities for striped bass and other nonnative predators. • Implement projects to minimize predation at weirs, diversion dams, and related structures. • Develop and implement programs and projects that focus on retaining, restoring and creating active floodplain and riparian corridors. • Implement and maintain projects to increase side channel habitats in order to improve CV spring-run Chinook salmon spawning habitat availability and quality. • Modify Sunset Pumps to provide unimpeded passage of adult CV spring-run Chinook salmon and to minimize predation of juveniles moving downstream. • Develop and implement a large woody material restoration program along the lower Yuba river utilizing sources of wood that enter upstream of reservoirs. • Utilize biotechnical techniques that integrate riparian restoration for river bank stabilization instead of conventional riprap in the Yuba River. • Implement short and long-term solutions to minimize the loss of adult CV spring-run Chinook salmon in the Sutter- Butte basin, including consideration of exclusion devices at specific locations. •
Lower Sacramento River	• Restore and maintain riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types including riparian forest, gravel bars and bare cut banks, shady vegetated banks, side channels, and sheltered wetlands such as sloughs and oxbow lakes. • Restore floodplain connectivity and channel meander by constructing set back levees and by removing revetment (e.g., alongside changes to the Fremont Weir and West Sacramento Levee Improvement). • Restore floodplain connectivity by expanding and changing the Sutter and Yolo Bypasses. • Restore floodplain connectivity by constructing set back levees and island breaching (e.g., South Yolo Bypass improvements such as Cache Slough and Prospect Island).

Table 2. Examples of Near- and Long-Term Restoration and Recovery Actions, by Region, That Could Be Implemented through the CVFPP

CPA	Restoration Action
	• Implement short and long-term solutions to minimize the loss of adult CV spring-run Chinook salmon in the Yolo bypass, including consideration of exclusion devices at specific locations. • Develop and implement programs and projects that focus on retaining, restoring and creating river riparian corridors in the American River watershed. • Ensure that river bank stabilization projects along the Sacramento River utilize biotechnical techniques that restore riparian habitat, rather than solely using the conventional technique of adding riprap. • Implement projects that promote native riparian (e.g., willows) species including eradication projects for nonnative species (e.g., *Arundo*, tamarisk). • Create shallow inundated floodplain habitat for multi-species benefits and implement where suitable opportunities are available.
Lower San Joaquin River	• Implement channel modifications as outlined in the SJRRP including increasing channel capacity to accommodate restoration flows. • Minimize entrainment and fish losses to both adult and juvenile life stages to nonviable migration pathways as outlined in the SJRRP. • Provide fish passage at existing structures as outlined in the SJRRP. • Implement projects to protect and restore riparian and floodplain habitats along the San Joaquin River and its tributaries. • Implement habitat enhancement or augmentation actions designed to minimize predation on CV spring-run Chinook salmon in the San Joaquin River and its tributaries. • Develop and implement design criteria and projects to minimize predation at weirs, diversion dams, and related structures in the San Joaquin River and its tributaries. • Identify and implement floodplain and side channel projects to improve river function and increase habitat diversity in tributaries of the San Joaquin River (e.g., Merced, Tuolumne, Stanislaus Rivers).
Upper San Joaquin River	• Implement channel modifications as outlined in the SJRRP including increasing channel capacity to accommodate restoration flows. • Minimize entrainment and fish losses to both adult and juvenile life stages to nonviable migration pathways as outlined in the SJRRP. • Provide fish passage at existing structures as outlined in the SJRRP. • Implement projects to protect and restore riparian and floodplain habitats along the San Joaquin River. • Implement habitat enhancement or augmentation actions designed to minimize predation on CV spring-run Chinook salmon in the San Joaquin River. • Develop and implement design criteria and projects to minimize predation at weirs, diversion dams, and related structures in the San Joaquin River.

Source:NMFS 2014

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the Central Valley Spring-Run Chinook Salmon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	Timing and duration of floodplain inundation are important to providing benefits to rearing habitat (e.g., inundate for at least 14 days for food production to occur, particularly between late November/early December and the end of April [USBR 2012]; see "Habitat and Ecological Process Associations" above). Floodplain inundation benefits for juveniles can be increased by minimizing stranding potential (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches, and ramping flows so that surface elevations do not decrease rapidly), and for adults by minimizing potential for entrainment and trapping (by eliminating or screening diversions or ditches where fish could be trapped, and implementing solutions to address fish passage barriers), particularly in the tributaries and mainstems of the Sacramento and Feather Rivers in the Upper Sacramento, Lower Sacramento, and Feather River CPAs (McEwen 2013; Conservation Strategy Appendix K).
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	Yes	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	Yes	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide SRA habitat throughout the riverine rearing and outmigration corridors in the tributaries and mainstems of the Sacramento and Feather Rivers.
	Habitat Connectivity—median patch size (acres)	Yes	Provide connected riparian habitat inside the levee system.

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the Central Valley Spring-Run Chinook Salmon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide marsh habitat that does not include, and minimizes the likelihood of establishment of, nonnative submerged aquatic vegetation, particularly in the Lower Sacramento and San Joaquin River CPAs.
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	Yes	Floodplain agriculture should minimize stranding potential of juvenile fish (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches), and entrainment or trapping of adults (by eliminating or screening diversions or ditches where fish could be trapped, and implementing solutions to address fish passage barriers; see Conservation Strategy Appendix K) in the bypasses and mainstem Sacramento and Feather Rivers.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	Yes	Remove/modify barriers at the Fremont, Sacramento, and Tisdale Weirs, Colusa Drain, and others identified and prioritized in McEwen (2013) and Conservation Strategy Appendix K.
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	Remove or decrease populations of nonnative invasive aquatic plants (e.g., *Egeria* and parrot's feather) that affect fish habitat, and terrestrial plant species that affect river geomorphology (e.g., *Arundo* and saltcedar).

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G7. Focused Conservation Plan: Sacramento River Winter-Run Chinook Salmon

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the Sacramento River (SR) winter-run Chinook salmon (*Oncorhynchus tshawytscha*) ESU in the SPA for the CVFPP.

The SR winter-run Chinook salmon ESU was federally listed as threatened under the ESA in 1989 and reclassified as endangered in 1994 (59 FR 440). The ESU includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries in the Upper and Lower Sacramento River CPAs, as well as fish propagated at the Livingston Stone National Fish Hatchery (70 FR 37160). SR winter-run Chinook salmon were also listed as endangered by the State of California in 1989 (CDFW 2014).

Critical habitat for the SR winter-run Chinook salmon ESU was designated in 1993. It includes the Sacramento River from Keswick Dam to Chipps Island at the westward margin of the Delta, Honker Bay, Grizzly Bay, Suisun Bay, the Carquinez Strait, San Pablo Bay, and San Francisco Bay (58 FR 33212). The habitat features considered essential for the conservation of the SR winter-run Chinook salmon ESU are the river water, river bottom (including gravel used as spawning substrate), and adjacent riparian zone used for fry and juvenile rearing in the Sacramento River; in the areas westward of Chipps Island, the essential habitat features are the estuarine water column and foraging habitat and food resources used during juvenile outmigration or adult spawning migration. The CVFPP would affect only the adjacent riparian zone element and the freshwater and estuarine elements.

The most recent 5-year review of the ESA listing classification of SR winter-run Chinook salmon (NMFS 2011) concluded that the fish will remain listed as endangered, because the most recent biological information suggests that the extinction risk of this ESU has increased since the last status review. Several listing factors have contributed to the decline, including recent years of drought and poor ocean conditions. The best available information on the biological status of the ESU and continuing and new threats to the ESU indicate that its ESA classification as an endangered species is appropriate. Long-term recovery of this ESU will require improved freshwater habitat conditions, abatement of a wide range of threats, and the establishment of a second population in Battle Creek or elsewhere (NMFS 2011).

Formal direction from NMFS, in the form of a biological opinion for the long-term operations of the Central Valley Project and State Water Project (NMFS 2009), directs the USBR to develop a step-wise process to evaluate the improvement of passage around several major dams, including Shasta, Folsom, and New Melones Dams. This will be a long-term effort in which DWR will collaborate with USBR and other organizations.

NMFS released a draft recovery plan in 2009 which was finalized in 2014 after undergoing public review: the *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead* (NMFS 2014) is a guidance and planning document that delineates reasonable actions that may be necessary for the conservation and survival of listed species.

Status and Trends

Historical Distribution

Historically, SR winter-run Chinook salmon occurred in the upper Sacramento River system, including the headwaters of the upper Sacramento, Little Sacramento, Fall, Pit, and McCloud Rivers, where cold, spring-fed summer flows provided suitable spawning, incubation, and rearing habitat (Yoshiyama et al. 1998; Williams 2006; NMFS 2014). Winter-run Chinook salmon also occurred in Battle Creek but likely did not occur in any of the other drainages in the Upper or Lower Sacramento River CPAs (Yoshiyama et al. 1998).

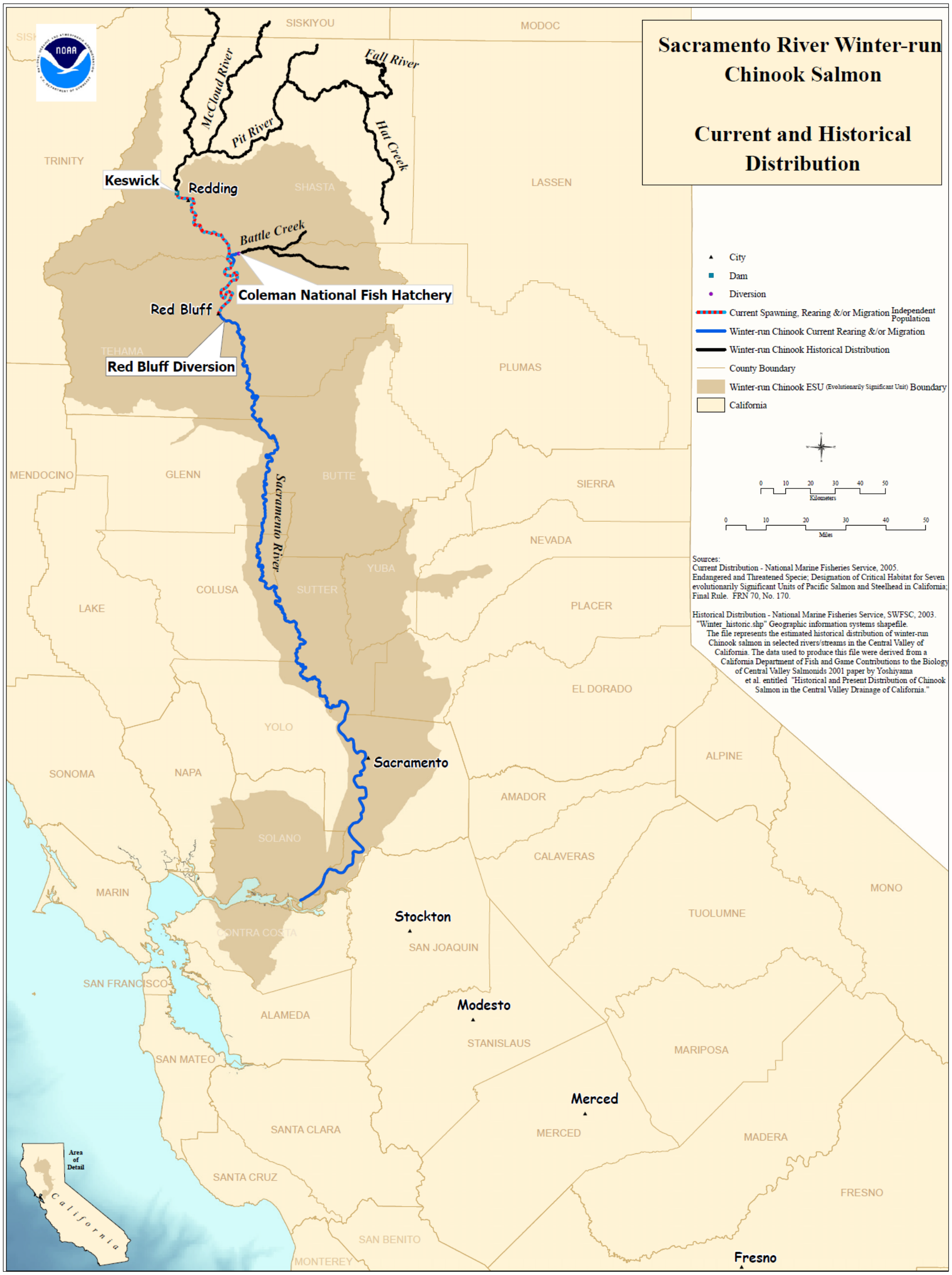
Current Distribution

Currently, the SR winter-run Chinook salmon population is limited to the Sacramento River downstream of Keswick Dam, and spawning is limited to a 50-mile reach of the Sacramento River from Keswick Dam downstream to the Red Bluff Diversion Dam in the Upper Sacramento River CPA (NMFS 2014, Figure 1), upstream of the SPFC's levees. Numerous ongoing and future restoration efforts to remove five dams and restore habitat on Battle Creek in the Upper Sacramento River CPA may eventually increase the distribution of this fish and establish a second population in the CPA.

Population Trends

Since the late 1960s, the Anadromous Resource Assessment Unit of CDFW's Fisheries Branch has compiled annual estimates of SR winter-run Chinook salmon populations for streams surveyed in the Sacramento River system (Azat 2013). These escapement surveys provide data to inform ocean and inland harvest management, to assess recovery of listed stocks, and to evaluate the success of restoration programs and the contribution of hatchery fish to Central Valley populations (Low 2007). Population estimates are based on counts of adults as they enter hatcheries and migrate past dams, surveys of postspawning adult carcasses, live counts, and ground and aerial redd counts conducted by CDFW, USFWS, DWR, the East Bay Municipal Utility District, USBR, the Lower Yuba River Management Team, and the Fisheries Foundation of California (Low 2007). Surveys are also conducted of juveniles in tributaries and mainstems to provide information on juvenile rearing and emigration, habitat use, growth, and stranding (Low 2007).[1]

[1] "Stranding" herein refers broadly to any event in which fish are trapped in detrimental conditions by being physically separated from a main body of water or from their natural migration route to natal streams. Stranding includes both entrapment in lethal or sublethal conditions and cases in which fish stray into nonnatal streams or unsuitable habitat because of system operations or attraction flows. Types of stranding are further discussed in Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System."

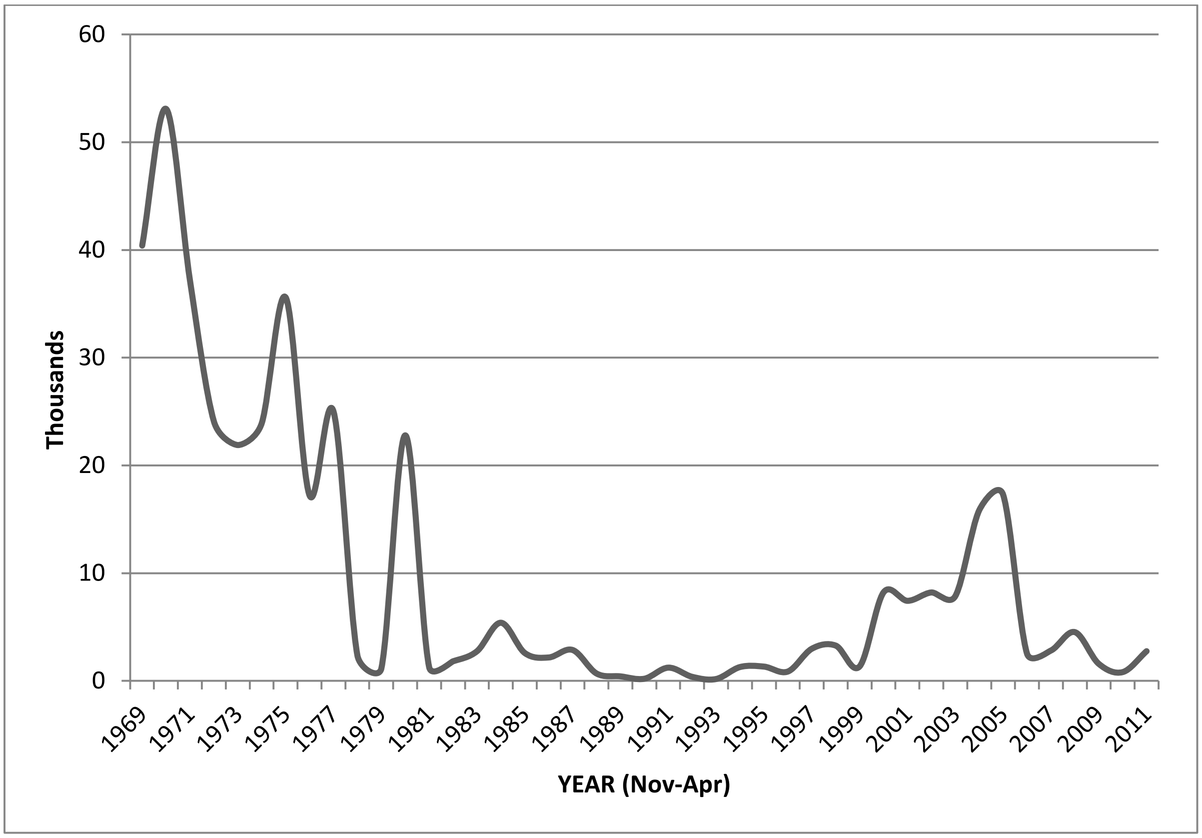


Source: NMFS 2014

Figure 1. SR Winter-Run Chinook Salmon ESU—Current and Historical Distribution

Information from juvenile surveys is used to evaluate the success of habitat restoration programs and the impacts of water project operations on salmonid survival, to manage water project operations for the protection of salmonids on a real-time basis, and to evaluate hatchery propagation programs (Low 2007).

The population of SR winter-run Chinook salmon was estimated to be more than 50,000 in the early 1970s. The population declined throughout the 1970s, and was low throughout the 1980s and 1990s (usually estimated at fewer than 4,000 individuals). The population showed some improvement in the early 2000s (NMFS 2014, Figure 2). However, it has shown a negative trend during the last 6 years (2007–2012), which could be a result of poor ocean conditions (NMFS 2011).



Source: Azat 2013

Figure 2. Escapement of SR Winter-Run Chinook Salmon in the Sacramento River

Life History

Chinook salmon are anadromous (i.e., they migrate to the ocean, where they spend most of their lives and grow large before returning to freshwater, where they spawn, then hatch and rear) and semelparous (i.e., adults die after spawning). Adults remain at sea for 1–4 years, usually returning to spawn in freshwater as mature adults at age 3, although some adults return to spawn at age 4 or 5, and some 2-year-old males, termed jacks, return after only 1 year in the ocean. They return to freshwater to spawn, and both SR winter-run and Central Valley spring-run Chinook salmon migrate upstream, where they hold, delaying spawning for weeks or months (Moyle 2002). Embryos hatch after 40 to 60 days (or more) of incubation, and the alevins (yolk-sac fry) remain in the gravel for an additional 4–6 weeks before emerging from the gravel (NMFS 2014). The fry may remain in their natal stream for several weeks or months or become displaced downstream by flows (Moyle 2002). Some continue downstream to rear in the estuary before emigrating as smolts to the ocean (Moyle 2002).

SR winter-run Chinook salmon presence in the CPAs depends on time of year and life stage. However, SR winter-run Chinook salmon are distinguished from other Chinook salmon runs by the fact that they spawn in late spring/summer, and juveniles emerge in late summer and early fall, when no other salmonids in the Sacramento River are emerging. Adult SR winter-run Chinook salmon leave the ocean and migrate through the Delta and into the Lower Sacramento River CPA from December through July, peaking in March (NMFS 2014). Adults migrate upstream in pulses during freshets (high flows resulting from winter rains), which allow passage to higher-elevation reaches. They hold in cold-water pool habitat upstream of the Red Bluff Diversion Dam (no longer in operation) in the Upper Sacramento River CPA for a few months, then spawn there from late April through mid-August, peaking in mid-June. The fry emerge from the gravel from July through mid-October (Kimmerer and Brown 2006; NMFS 2014) and move past the Red Bluff Diversion Dam in early fall (Williams 2006), during the time of year when no other salmonids in the Sacramento River are emerging. As a result, the juveniles may have less competition with other runs for rearing habitat as they migrate downstream toward the estuary. Juveniles emigrate downstream in fall as water temperatures are cooling, and winter water temperatures in the Sacramento River remain warm enough to support juvenile rearing. Juveniles also outmigrate during freshets, possibly because the accompanying high turbidity reduces visibility for predators and thus predation risk for juveniles (Stillwater Sciences 2007; Del Rosario et al. 2013). Juveniles rear for a relatively long period (e.g., from fall through the following spring) throughout the mainstem Sacramento River, the Yolo Bypass (when inundated), and the Delta, entering the ocean from January through June (Kimmerer and Brown 2006; Williams 2006; Del Rosario et al. 2013; NMFS 2014).

Habitat and Ecological Process Associations

Habitat requirements for SR winter-run Chinook salmon vary with life stage, but, in general, what sets them apart from the other Chinook salmon runs in the Central Valley is that they enter rivers as immature fish in winter and spring, and require freshwater streams with cold temperatures over summer to spawn and for eggs to incubate in redds (NMFS 2014). Upstream migration in the Sacramento River occurs during freshets, when water temperatures are 57–67°F, water depths are more than 0.8 feet, and water velocities are less than 8 feet/second (NMFS 2014). Before spawning, the salmon hold in deep pools (>5 feet deep, with cover from overhanging vegetation, undercut banks, boulders, or large instream woody material) with moderate water velocities (0.5–1.3 feet/second) between the Red Bluff Diversion Dam and Keswick Dam.

For freshwater spawning, Chinook salmon require clean, loose gravel (0.75–4 inches in diameter) in swift, relatively shallow riffles or along the margins of deeper runs in cool water temperatures (50–59°F) (Moyle 2002; NMFS 2014). SR winter-run Chinook salmon are reported to spawn in a variety of water depths (a few inches to several feet). Managed releases from Shasta and Keswick Dams of 13,000–15,000 cubic feet per second start in April and continue through summer specifically to support SR winter-run Chinook salmon recovery (NMFS 2014). Water temperatures required for egg incubation range from 42ºF to 56°F. After emergence, fry rear in habitats with shallow, slow-moving waters and bank cover composed of overhanging and submerged vegetation, root wads, and woody material; in these habitats, the fry feed on zooplankton and small insects. The elements of suitable fry and juvenile rearing habitat are largely defined by the three attributes of SRA cover: overhanging vegetation, instream cover, and natural eroding banks (Fris and DeHaven 1993). Such conditions are best supported by natural geomorphic processes. As they grow larger, juveniles move into deeper, swifter waters to rear (NMFS 2014).

In the Upper and Lower Sacramento River CPAs, juvenile Chinook salmon, including SR winter-run Chinook salmon, can rear in riverine and estuarine habitats of the Sacramento River, the Delta, and bypasses, including the Yolo Bypass when it is flooded (Maslin et al. 1999; Snider 2001). Off-channel floodplain habitats that are seasonally inundated (e.g., in years with sufficiently high flows, usually during winter and spring when temperatures are suitable for rearing) support much higher growth rates of juvenile Chinook salmon than adjacent main-channel or riverine habitats (Jeffres et al. 2008; Limm and Marchetti 2009). These off-channel habitats tend to have higher temperatures and rates of food production compared to riverine habitats, resulting in increased growth of juveniles (Jeffres et al. 2008; Limm and Marchetti 2009). In the seasonally inundated agricultural floodplains of the Yolo Bypass, juveniles are known to rear for several months in winter and spring. Here, the greater availability of drift invertebrates contributes to higher juvenile growth rates than are found in adjacent river channels (Sommer et al. 2001).

The Knaggs Ranch Restoration Study is evaluating the Yolo Bypass as winter floodplain habitat for Chinook salmon to improve understanding of how juvenile salmonids use various habitat types (USBR 2012). The Knaggs Ranch Restoration Study is located on an agricultural parcel, with a total area of 1,704 acres, in the northern part of the Yolo Bypass. The multiyear experimental study is evaluating aquatic food resources and juvenile salmonid growth in a variety of habitat types (e.g., long rice stubble, short rice stubble, disked, and fallow). Study results to date appear to corroborate earlier findings that fish that rear in the bypass have high growth rates and survival (Katz et al. 2012). Other benefits of rearing in the Yolo Bypass and floodplain habitat include (1) delayed outmigration timing, which results in later ocean entry and better synchronizes juveniles that reach the coast with the high productivity associated with spring and summer winds that drive upwelling conditions, and (2) routing of fish away from the interior Delta and export pumps, where there is an increased risk of mortality (Katz et al. 2012).

Floodplain benefits for juvenile Chinook salmon rearing should increase with longer durations of flooding, but relatively short periods of access may still provide benefits (Jeffres et al. 2008). Improved habitat conditions for juvenile SR winter-run Chinook salmon may be achieved by inundating the bypasses (e.g., Yolo and Sutter) for at least 14 days (for food production to occur), particularly between late November/early December and the end of April (USBR 2012). Specific inundation flows would need to take into account any structural changes to the weirs (e.g., the Fremont Weir) that might allow lower flows to provide inundation; currently, the vast majority of the Yolo Bypass is inundated at flows above 74,000 cubic feet per second (USBR 2012). To improve passage of upstream migrating adults in the Yolo Bypass, inundation would need to occur at least from February through April, and ideally between mid-November and May to provide maximum benefits, depending on water year type and any structural changes made to improve fish passage at the weirs (USBR 2012).

In the Delta region of the Lower Sacramento River CPA, juveniles forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960; Healey 1980), and are less abundant where shorelines have riprap (McLain and Castillo 2009). However, juvenile Chinook salmon (young-of-the-year) from the Central Valley spend only about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002); larger yearling Chinook salmon (e.g., late fall–run) move from the Delta to the ocean entry even more quickly, in 9–17 days (Michel et al. 2013).

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for SR winter-run Chinook salmon within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by SR winter-run Chinook salmon within the SPA;
- the specific CPAs within which these habitat conditions occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Spawning habitat may have been historically limited for SR winter-run Chinook salmon (compared to other runs), because they require cool water temperatures in summer as well as appropriately sized gravels. These conditions were probably restricted to the upper reaches of the McCloud River and other spring-fed tributaries (Stillwater Sciences 2007) that are now upstream of impassable dams. Loss of access to historical cold-water spawning habitat remains a major threat, because Keswick and Shasta Dams completely restrict the naturally spawning population to the mainstem Sacramento River downstream of the two dams, where cold-water releases from the reservoir behind Shasta Dam are managed specifically to create favorable temperatures for spawning and rearing in the reach between Keswick Dam and the Red Bluff Diversion Dam

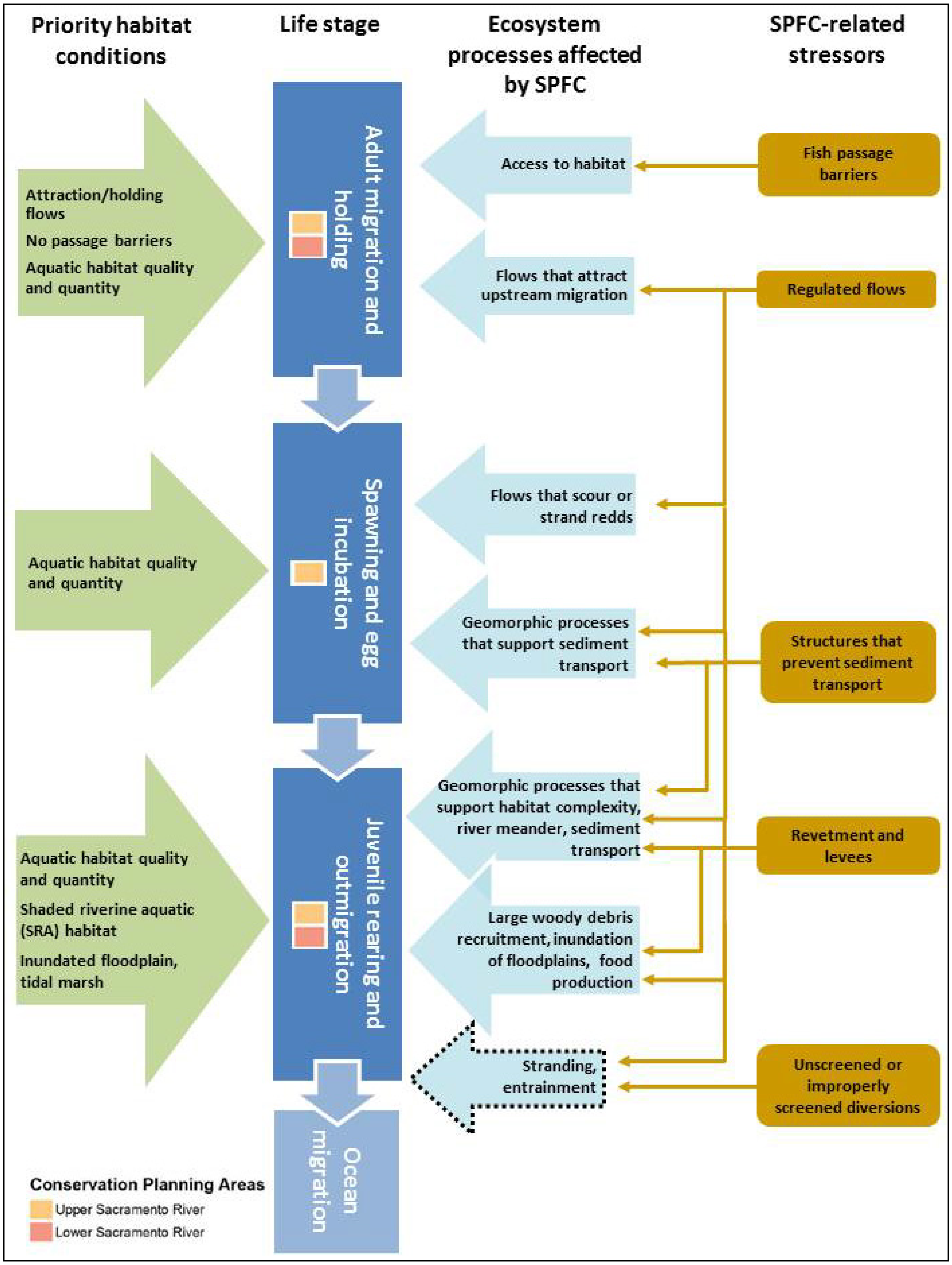


Figure 3. Conceptual Model for Sacramento River Winter-Run Chinook Salmon within the SPA

(NMFS 2011). The majority of spawning occurs in the upper 14 miles, from Keswick Dam to the Redding Water Treatment Plant (NMFS 2014). However, the dam is also degrading spawning habitat over time by causing bed coarsening, and has degraded juvenile rearing habitat by reducing floodplains and altering the timing and magnitude of flood peaks (Stillwater Sciences 2007; NMFS 2014).

Management Issues

Threats and Sensitivities Range-Wide

Threats to SR winter-run Chinook salmon include barriers (Shasta and Keswick Dams) to historical habitat and the resulting degradation of spawning and rearing habitat downstream, which have resulted primarily from altered flows and disruption of gravel transport. Spawning and rearing habitat that persists downstream of Shasta and Keswick Dams on the Sacramento River remains severely degraded by the operation of ineffective fish screens and fish ladders. Rearing habitat has also been degraded by levees and flood control operations and maintenance practices that have greatly simplified riverine habitat by channelizing rivers and removing SRA cover along channels, and have disconnected rivers from the floodplain (NMFS 2011).

Other threats to the ESU include entrainment of fish in water diversions, predation by native and nonnative fish species (particularly at artificial structures), passage barriers or delays at Sutter and Yolo Bypasses, heavy metal contamination and toxicants, ocean harvest, water exports in the Delta (especially during consecutive dry years), altered river flows, and high summer water temperatures (NMFS 2011, 2014). The run is at risk because it is limited to a single population in the Sacramento River, making it particularly vulnerable to extinction. However, Livingston Stone National Fish Hatchery is expected to play a continuing role as a conservation hatchery to protect and enhance the existing SR winter-run Chinook salmon population, and should contribute to reestablishing winter-run Chinook salmon to habitat upstream of Shasta Dam, and to Battle Creek (NMFS 2014).

Ongoing and Future Impacts

Ongoing impacts on SR winter-run Chinook salmon in the SPA include construction, operation, and maintenance of flood control facilities that affect habitat access, flows, water temperature, and the quality and availability of downstream habitat; catastrophic fires; water diversions that entrain juveniles and affect habitat quality; nonnative invasive aquatic fish and invertebrate species; and the effects of climate change, which will likely include degradation of water quality and habitat suitability (NMFS 2014).

- The availability of suitable spawning and rearing habitat likely will continue to be the most critical factor in SR winter-run Chinook salmon recovery (NMFS 2014). Particularly, loss of rearing habitat in the Upper and Lower Sacramento River CPAs will continue to be a significant stressor to SR winter-run Chinook salmon (NMFS 2014). Of the SR winter-run Chinook salmon holding, spawning, and rearing habitat that has been lost, the majority was lost as a result of water system developments in Central Valley watersheds: large dams (e.g., Shasta and Keswick Dams) and their associated hydropower development projects have prevented SR winter-run Chinook salmon from accessing significant areas of historical upstream summer holding, spawning, and rearing habitat (NMFS 2014). Aside from these total barriers, many other partial barriers have been identified that may delay or impair fish migration (see Attachment 9C of the CVFPP and Conservation Strategy Appendix K, “Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System”) and have been prioritized for improvements based on impacts on fish (see Appendix K). In particular, the Fremont Weir (the primary inundation source for the Yolo Bypass) currently provides adult fish passage at a single fish ladder that is opened once overtopping at the Fremont Weir ceases (USBR 2012). Adult passage is impeded at the ladder because of poor attraction flows and other irregularities. NMFS has identified the need to reduce migratory delays and minimize stranding (and resultant mortality) of upstream-migrating adult SR winter-run Chinook salmon at the Fremont Weir (USBR 2012). CVFPP modifications or projects that contribute to simplified or degraded riverine habitat, such as levee armoring, are expected to negatively affect SR winter-run Chinook salmon. In addition, numerous activities and events can reduce water quality and are expected to continue to negatively affect salmon. For example, vegetation removal near waterways can increase water temperatures, and dredging activities can resuspend sediment and contaminants, clogging fish gills, smothering eggs, and reducing benthic prey availability. Catastrophic fires can severely affect water quality until vegetation is reestablished. Contaminants in discharges to the rivers and the Delta can affect food webs, degrade habitats, and directly harm juvenile salmonids (Mount et al. 2012).

- Entrainment at diversions continues to be an impact affecting juvenile SR winter-run Chinook salmon in the Upper and Lower Sacramento River CPAs (NMFS 2014). Entrainment at both large diversions (the Central Valley Project and the State Water Project) and numerous unscreened or inadequately screened small to medium-size diversions will likely continue to affect juvenile SR winter-run Chinook salmon (NMFS 2014). Large diversions can also affect water quality (Monsen et al. 2007) and provide habitat for introduced fish predators (Cavallo et al. 2013).

- Recent observations indicate that adult fish can migrate into the Yolo or Sutter Bypasses when they are flooded, or into the Knights Landing Outfall Gates, then swim into canals and drains such as the Colusa Drain, where they strand and die unless rescued (Cannon 2013; Hendrick and Swart 2013; Vincik and Johnson 2013). However, the severity of adult stranding on an annual basis is not known (Hendrick and Swart 2013).

- Climate change will affect habitat for SR winter-run Chinook salmon in the future, but the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the catchment as rain rather than snow, thus reducing snowpack and water availability from snowmelt in spring and summer (Cayan et al. 2006). In the Upper Sacramento River CPA, flow releases from Keswick and Shasta Dams are essential for providing suitable thermal regimes for SR winter-run Chinook salmon spawning and rearing; climate change may affect water managers’ ability to store water in the reservoir "cold-water pool," ultimately decreasing habitat quantity and quality for holding, spawning, and juvenile rearing in the Sacramento River between Keswick Dam and Red Bluff (USBR 2013). Ecologists are only beginning to understand climate change threats to riparian ecosystems (Seavy et al. 2009). Climate change models predict warming temperatures in streams and rivers (Moyle et al. 2013) and increases in sea level, estuarine salinity, and water temperatures in the Delta (Cloern et al. 2011). SR winter-run Chinook salmon and other cold-water-adapted native fish are likely to respond negatively to climate change effects such as changes in streamflows and increased temperatures (Katz et al. 2012; Moyle et al. 2013).

Key Information Gaps or Uncertainties

To better understand how current and future CVFPP activities affect the conservation and potential recovery of SR winter-run Chinook salmon, and to help guide future actions of the CVFPP and Conservation Strategy, the following information is needed: modeling of impacts related to flood management, a better understanding of habitat functions, and data on the effects of predation and stranding. These data gaps are discussed below.

- **Impact models.** Flood managers need an improved understanding of the impacts on salmonid habitats caused by levee erosion repair projects. Currently, the Standard Assessment Methodology is used to systematically compare selected fish species' responses to habitat features affected by levee erosion repair projects. This method involves applying conceptual response models to quantified habitat changes to assess the near- and long-term impacts or benefits to species. The method is based on conceptual response models of indicator fish species, and evaluates effects of levee erosion repair designs that incorporate SRA components (overhanging shade, reduced substrate size, instream woody material, etc.), revetment size, bank slope, and length of the proposed levee project site.

  The conceptual response models were developed using professional opinion and assume relationships between the presence or abundance of an organism and habitat quality. However, habitat quality would be better assessed by evaluating the effects of levee erosion repair designs on the condition (e.g., growth) and survival of indicator fish species (Sommer et al. 2005; Bond et al. 2008). Additionally, the current Standard Assessment Methodology fails to evaluate the loss of riverine processes (lateral migration, reworked floodplain, vegetation regeneration, etc.) and should consider the effects of changes in levee configuration in order to evaluate the benefits or impacts of repairing existing levees versus changing levee alignment to promote natural river processes. These issues can be addressed by evaluating how juvenile SR winter-run Chinook salmon (both young-of-the-year and yearlings) use specific levee repair designs, including the duration of time spent at the site (minutes, hours, days, weeks) and effects on growth and survival. Additionally, there is concern that, in the warmer reaches of the mainstems, habitat features incorporated as mitigation for levee repair projects (e.g., instream wood) may be providing or improving habitat conditions for predators of juvenile SR winter-run Chinook salmon (Vogel 2011), which is being evaluated by resource agencies.

- **Habitat functions.** There is a lack of information on the function of certain habitats in the life history of the species; in particular, the quality and quantity of habitats used by juveniles as they move downstream in the Sacramento River mainstem and the Delta during rearing and outmigration (Vogel 2011; NMFS 2014). The vegetation types providing preferred habitat for juvenile Chinook salmon in floodplains and bypasses are not well understood, although the most important characteristics of vegetation are its effects on prey availability and cover (Opperman 2012). Nevertheless, there is uncertainty about the importance of the distribution and amounts of SRA habitat on fish populations; for example, is the relationship between SRA habitat and fish numbers linear or are minimum thresholds of SRA required, and what is the importance of habitat connectivity? Actions that provide habitat for juvenile rearing, coupled with studies that evaluate habitat use through an adaptive management approach, could inform and improve future activities associated with levee maintenance and erosion repair.

- **Predation.** Especially in the lower mainstems and Delta, the extent of predation on juvenile salmon by nonnative fish is not well understood (Williams 2010). The Central Valley watersheds and the Delta contain nonnative fish species; some are known predators of juvenile salmon. Actions that could inadvertently increase habitat for predators need to be evaluated.

- **Stranding and straying effects.** Stranding and straying of juveniles and adults in the bypasses (and of adults in the Colusa Drain) is known to occur when high flows recede, but quantification is difficult; therefore, the impact of stranding on the population of SR winter-run Chinook salmon is just starting to be understood (Cannon 2013; Hendrick and Swart 2013; Vincik and Johnson 2013). Actions that increase connectivity to bypasses and floodplains could incorporate ways to minimize stranding, such as optimal flow-reduction ramping rates. The interaction of flow magnitude and timing with channel conveyance capacity, infrastructure, water diversions, and fish habitat needs could be addressed by CVFPP actions in the Sacramento River and bypasses (Upper and Lower Sacramento River CPAs). Stranding of juveniles is also known to occur along the Sacramento River mainstem because of flows released from Keswick Dam; however, the magnitude and frequency of stranding is poorly understood.

Conservation Strategy

Conservation and Recovery Opportunities

The integration of environmental stewardship into all flood management activities (by DWR and Local Maintaining Agencies) during project planning, design, operation, 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 SR winter-run Chinook salmon is to increase the availability of suitable spawning and rearing habitats by encouraging riverine processes that improve natural river morphology and function. Improving the distribution and quality of SRA habitat, the amount and distribution of inundated floodplain, connectivity of fish passages, and channel-margin restoration would benefit the species. These conservation needs and opportunities, which align with the recovery plan (NMFS 2014), are discussed in detail below.

Identified Conservation Needs

1. **Improve the distribution and quality of SRA habitat in the Upper and Lower Sacramento River CPAs:** The elements of SRA habitat (overhanging vegetation, instream cover, and natural eroding banks) each offer important habitat resources to adult and juvenile SR winter-run Chinook salmon, particularly in the mainstem Sacramento River in the Upper Sacramento River CPA where adult holding and spawning, and juvenile rearing occurs. SRA habitat provides organic material input, differential velocities, cover, food, temperature regulation, and improved water quality. Large-scale restoration of SRA habitat is needed to improve juvenile rearing habitat, most of which was lost because of construction, operation, and maintenance of SPFC facilities, as well as alteration of flows in the SPA.

2. **Improve the distribution and quality of channel-margin habitat in tidally influenced waterways throughout the Delta region of the Lower Sacramento River CPA:** Marsh and channel-margin habitats are an important food and cover resource for emigrating smolts and rearing juvenile SR winter-run Chinook salmon. Historical reclamation of wetlands and construction of levee systems in the Delta region of the Lower Sacramento River CPA removed most of this habitat. Large-scale restoration of the distribution and amount of tidally influenced channel-margin habitat is needed (NMFS 2014).

3. **Increase the amount and distribution of inundated floodplain habitat throughout the Lower and Upper Sacramento River CPAs:** Compared to mainstem channels, inundated off-channel floodplain habitats have higher temperatures and food production rates, and contribute to higher growth and survival rates for juvenile winter-run Chinook salmon. These habitats include bypasses (e.g., Yolo and Sutter) as well as mainstem floodplains. Inundated floodplain habitats are currently limited by both regulated streamflows (particularly in the bypasses) and levee systems (particularly along mainstems). Improving floodplain connectivity will require large-scale restoration actions that take into account the interaction of floodplain elevations and the timing, duration, and quantity of flow releases. Increasing the quantity and quality of floodplain habitat in the mainstem Sacramento River in the Upper and Lower Sacramento River CPAs would provide beneficial rearing habitat for juvenile SR winter-run Chinook salmon (Appendix H of the Conservation Strategy, "Central Valley Chinook Salmon Rearing Habitat Needed to Satisfy the Anadromous Fish Restoration Program Doubling Goal.").

4. **Improve natural river morphology and function:** Flood control measures downstream of dams, such as bank protection, have affected riparian and instream habitat, particularly in the Upper and Lower Sacramento River CPAs. Constructed levees that narrow channels have increased velocities and channelized rivers so that natural geomorphic processes (e.g., channel meander) are no longer possible. Improving geomorphic processes to support natural bank erosion, sediment deposition, and the establishment and growth of riparian vegetation is essential for providing beneficial SRA habitat, reconnecting floodplains, and recruiting woody material that improves rearing habitat for juvenile SR winter-run Chinook salmon.

5. **Improve fish passage throughout the Upper and Lower Sacramento River CPAs:** During winter and spring high-flow events, water is diverted into bypasses (e.g., Sutter and Yolo). Adult SR winter-run Chinook salmon can enter the bypasses, but their migration may then be delayed or prevented by control structures (e.g., Sacramento, Tisdale and Fremont Weirs) and unscreened canals and drains (e.g., Knight's Landing Outfall Gates) (Cannon 2013; McEwen 2013; Conservation Strategy Appendix K). Therefore, there is a need for improving or eliminating these types of flood control structures to provide for adult anadromous fish passage. In addition, juveniles can become entrained by unscreened or inadequately screened diversions, and stranded when flows recede in bypasses or along the mainstem in the Upper Sacramento River CPA, making adequately screening all diversions another high-priority conservation action.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the SR winter-run Chinook salmon; these are summarized in Table 1 of this section. In many cases, the conservation needs of SR winter-run Chinook salmon can be addressed through the implementation of management actions that integrate conservation and restoration elements with SPFC operation and maintenance, floodway management, and structural improvements to facilities. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following sections) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward 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 limited reoperation of reservoirs and weirs. These could provide flow releases that improve aquatic habitat conditions by changing the timing and

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the SR Winter-Run Chinook Salmon[a]

SPFC Conservation Actions	Conservation Need				
	1. Increase/ Improve SRA Habitat	2. Increase/ Improve Marsh Habitat	3. Increase Inundated Floodplain	4. Improve Natural River Function	5. Improve Fish Passage and Decrease Entrainment
Operations, Maintenance, and Floodway Management					
Floodwater storage and reservoir forecasting, operations, and coordination	+		+	+	+
Facility maintenance					
Levee vegetation management	-				
Floodway maintenance	+				
Modification of floodplain topography	+		+	+	+
Support of floodplain agriculture			+		+
Invasive plant management				+	
Restoration of riparian, SRA, and marsh habitats	+	+		+	
Wildlife-friendly agriculture					
Structural Improvements					
Levee and revetment removal	+	+	+	+	
Levee relocation	+	+	+	+	
Bypass expansion and construction		+	+	+	+
Levee construction and improvement	+			+	
Flood control structures					+

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

amount of releases and ramping rates from November/early December to the end of April, particularly at Shasta and Keswick Dams. These modifications could reduce fish stranding and passage barriers, initiate upstream adult migration and juvenile outmigration, and generate other environmental benefits, including promoting floodplain connectivity, enhancing meander migration rates, improving spawning gravel dynamics (recruitment, flushing, and mobilization), and improving conditions to promote development of SRA habitat.

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 fish-rearing habitat.

Levee vegetation management The 2012 CVFPP introduced an interim vegetation management strategy, under which levee vegetation in the VMZ (see Figures 2-1 and 2-2 in Appendix D of the Conservation Strategy) is managed for visibility and accessibility, and to reduce threats to levee integrity. Consequently, levee riparian vegetation in the VMZ 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 may also have detrimental effects on water temperature (Poole and Berman 2001) and fish habitat (e.g., instream wood recruitment and cover).

On the whole, levee vegetation management is likely to negatively affect habitat for SR winter-run Chinook salmon. However, lower waterside vegetation could be retained below the VMZ of levees when it does not present an unacceptable threat to levee integrity. Allowing vegetation to grow on the water side 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. This approach would also preserve, in the near term, other vegetation within the VMZ that does not impair visibility and accessibility. Under the Conservation Strategy, additional habitat could be developed to offset the gradual die-off of trees and the removal of trees that pose an unacceptable threat to levee integrity. This vegetation would be more valuable to Chinook salmon if it is (1) located close to water bodies, or at least where juvenile fish could access the vegetation during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) regionally distributed.

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). Fill-placement and rock-repair projects could incorporate reduced particle sizes, instream woody material, SRA elements, and planting berms, where relevant.

Modification of floodplain topography: Floodway topography modifications could increase floodway capacity, inundation frequency and duration, and habitat amounts and diversity, and could also eliminate areas that strand fish. Floodplain elevations could be lowered to provide more frequent and sustained inundation. Elevations could also be modified to provide greater topographic and hydrologic diversity (creating or opening secondary channels or overflow swales) and to eliminate features (such as gravel pits or deep borrow pits) that could strand fish. These actions would increase riverine and floodplain habitat values (e.g., by creating resting or rearing areas for fish migrating downstream) and provide escape routes for fish during receding flows.

Support of floodplain agriculture: Managing floodways to maintain the compatibility of flood management with agriculture would support agriculture in the bypasses and on floodplain agricultural lands between levees while accommodating access to rearing habitat by juvenile salmon. Addressing the problems posed by unscreened diversions and other structures that trap or impede movement of any juvenile or adult Chinook salmon would provide benefits to SR winter-run Chinook salmon. However, it is important that diversions be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; Conservation Strategy Appendix K).

Invasive plant management: Nonnative invasive plants that may be removed from State-operated and maintained lands and facilities would include submerged aquatic vegetation (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 nonnative submerged aquatic vegetation generally support nonnative fishes such as centrarchids (Grimaldo et al. 2012), particularly in the lower Sacramento River CPA, which may be predators of juvenile salmonids. Established nonnative terrestrial vegetation in riparian areas displaces important native plants (e.g., willows and cottonwood) that facilitate river meander and natural geomorphic processes. Removal of nonnative invasive plants could therefore benefit SR winter-run Chinook salmon by improving rearing and outmigration habitat and reducing predation by nonnative fishes.

Restoration of riparian, SRA, and marsh habitats: Riparian and marsh habitats could be restored at selected locations in the floodway to benefit juvenile SR winter-run Chinook salmon. Riparian restoration opportunities generally would be found in nonriparian land cover in the floodway, particularly where other management actions would increase floodway capacity. Riparian, SRA cover, and marsh restoration would be most beneficial in areas where restoration expands or connects existing habitat patches or where it provides habitat in areas with little or no riparian vegetation, or at locations to be identified by future conservation or recovery planning for juvenile Chinook salmon, and in conserved areas. Functional riparian habitat is particularly degraded on the mainstem Sacramento River downstream of Colusa; however, restoration of natural river functions, including those of riparian habitat between Red Bluff Diversion Dam and Colusa, would provide benefits to juvenile survival and growth (NMFS 2014). In the bypass system, marsh restoration would be generally beneficial to juvenile Chinook salmon and would be implemented in conjunction with bypass expansion and construction.

Structural 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 waterways that could be used by juvenile SR winter-run Chinook salmon for rearing, and where removal contributes to a larger zone of active river meander migration. NMFS (2009) has identified the need to improve natural river functions for juvenile rearing habitat between Red Bluff Diversion Dam and Colusa.

Levee relocation: Relocating levees farther from rivers (i.e., constructing set back levees) is an important approach to increasing floodway capacity, creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. Often, these benefits can be realized while still supporting agriculture within expanded floodways. Levee relocation would also provide an opportunity for hydraulically connecting the river systems to mitigation plantings associated with the VMZ, and for creating and enhancing rearing habitat for juvenile SR winter-run Chinook salmon. NMFS (2009) has identified the need to improve natural river functions for juvenile rearing habitat between Red Bluff Diversion Dam and Colusa.

Bypass expansion and construction: Bypass expansion could enhance juvenile rearing habitat (e.g., food resources and cover) by increasing the connectivity of the floodplain to the river system and thus restoring floodplain ecosystems that contribute to food web productivity. However, because bypasses are flooded irregularly, in order to benefit juvenile SR winter-run Chinook salmon bypass flooding needs to occur more frequently (e.g., annual) with the appropriate timing and duration to provide suitable rearing habitat. Modifying bypass weirs (e.g., those in the Yolo and Sutter Bypasses) could improve inundation timing and duration.

As part of bypass improvements, adult fish passage could be enhanced at flood control structures (e.g., the Sacramento, Tisdale and Fremont Weirs) (McEwen 2013; Conservation Strategy Appendix K). Also, bypass expansion could address “sinks” where juvenile SR winter-run Chinook salmon become stranded; for example, the number of isolated pools could be reduced, and connectivity to Tule Canal could be improved (USBR 2012).

Levee construction and improvement: Levee construction and reconstruction objectives that would provide benefits to SR winter-run Chinook salmon include restoring geomorphic processes and, where significant hydraulic impacts would not occur, protecting riparian habitat and incorporating planting berms and riparian plantings. In addition, new levees could be designed to accommodate hydrologic changes expected to result from climate change.

Flood control structures: One priority action for State-operated and maintained diversions in the SPA is reconfiguring the Tisdale Weir in the Sutter Bypass and the Fremont and Sacramento Weirs in the Yolo Bypass (in the Lower Sacramento River CPA) to allow passage by adult fish and to increase floodplain inundation (DWR 2012; McEwen 2013; Conservation Strategy Appendix K). It is important that other diversions also be identified and prioritized (e.g., see Appendix K) so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; McEwen 2013; Conservation Strategy Appendix K). However, improving any structure that traps or impedes the movement of juvenile or adult fish would provide benefits to SR winter-run Chinook salmon.

Recovery Plan Alignment

SR winter-run Chinook salmon recovery is based on 2 key conservation principles: 1) sufficient functioning, diverse and interconnected habitats that provide capacity and diversity to allow SR winter-run Chinook salmon to withstand and adapt to environmental changes such as droughts, and 2) SR winter-run Chinook salmon viability is determined by its spatial structure, diversity (e.g., life history, genetics, and megapopulation organization), productivity and abundance (NMFS 2014). SR winter-run Chinook salmon ESU viability depends on the number of populations in the ESU, their individual status, their spatial arrangement with respect to each other and sources of catastrophic disturbance, and the diversity of the populations and their habitats (NMFS 2014). In the most general terms, ESU viability increases with the number of populations (redundancy), the viability of these populations, the spatial distribution of the populations, the diversity of the populations, and the diversity of habitats that they occupy (NMFS 2014).

NMFS has identified a single Diversity Group for SR winter-run Chinook salmon: the Basalt and Porous Lava Region, which is a geographically identifiable area that encompasses multiple watersheds (NMFS 2014). For the ESU to achieve recovery, the Diversity Group should support both viable and independent populations and meet goals for redundancy and distribution (NMFS 2014). Thus, an overall goal is to sustain populations in the Diversity Group.

The biological recovery criterion for SR winter-run Chinook salmon is to obtain at least three populations in the Basalt and Porous Lava Region at low risk of extinction (NMFS 2014). The recovery plan also identifies reintroduction priorities for winter-run Chinook salmon. These are watersheds upstream of existing dams, where habitat is of sufficient quality and quantity to support SR winter-run Chinook salmon. These are the McCloud River upstream of Keswick and Shasta Dams and Battle Creek (NMFS 2014). The recovery plan specifically identifies the need to "incorporate ecosystem restoration including breaching and setting back levees into the Central Valley flood control plans (i.e., FloodSafe Strategic Plan and the Central Valley Flood Protection Plan)." Table 2 lists examples of specific near- and long-term restoration and recovery actions identified by NMFS (2014) that could be partially or fully implemented through the CVFPP.

Measures of Positive Contribution

Contributing to the recovery and stability of native species populations and overall biotic community diversity is a primary goal of the Conservation Strategy. The objective for this goal is a measurable contribution to the conservation of target species, including SR winter-run Chinook salmon. Therefore, building on the preceding discussion, this section of the SR winter-run Chinook salmon 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.

Table 2. Examples of Near and Long-Term Restoration and Recovery Actions, by Region, That Could Be Implemented through the CVFPP

CPA	Restoration Action
Upper Sacramento River	• Restore and maintain riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types including riparian forest, gravel bars and bare cut banks, shady vegetated banks, side channels, and sheltered wetlands such as sloughs and oxbow lakes. • Ensure that river bank stabilization projects along the Sacramento River utilize biotechnical techniques that restore riparian habitat, rather than solely using the conventional technique of adding riprap. • Implement projects that promote native riparian (e.g., willows) species including eradication projects for nonnative species (e.g., *Arundo*, tamarisk). • Implement short and long-term solutions to minimize the loss of adult SR winter-run Chinook salmon in the Sutter- Butte basin, including consideration of exclusion devices at specific locations.
Lower Sacramento River	• Restore and maintain riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types including riparian forest, gravel bars and bare cut banks, shady vegetated banks, side channels, and sheltered wetlands such as sloughs and oxbow lakes. • Restore floodplain connectivity and channel meander by constructing set back levees and by removing revetment (e.g., alongside changes to the Fremont Weir and West Sacramento Levee Improvement). • Restore floodplain connectivity by expanding and changing the Sutter and Yolo Bypasses. • Restore floodplain connectivity by constructing set back levees and island breaching (e.g., South Yolo Bypass improvements such as Cache Slough and Prospect Island). • Implement short and long-term solutions to minimize the loss of adult SR winter-run Chinook salmon in the Yolo bypass, including consideration of exclusion devices at specific locations. • Ensure that river bank stabilization projects along the Sacramento River utilize biotechnical techniques that restore riparian habitat, rather than solely using the conventional technique of adding riprap. • Implement projects that promote native riparian (e.g., willows) species including eradication projects for nonnative species (e.g., *Arundo*, tamarisk). • Create shallow inundated floodplain habitat for multi-species benefits and implement where suitable opportunities are available.

Source: NMFS 2014

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 3). 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 conservation of SR winter-run Chinook salmon, requirements would be added to increase the acreage of restored riparian areas that positively contribute to adjacent rearing habitat, providing terrestrial inputs and creating the cover needed by the species.

Table 3 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of SR winter-run Chinook salmon, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit SR winter-run Chinook salmon may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the SR Winter-Run Chinook Salmon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain and total amount of expected annual inundated floodplain habitat[a]	Yes	Timing and duration of floodplain inundation are important to providing benefits to rearing habitat (e.g., for at least 14 days for food production to occur, particularly between late November/early December and the end of April [USBR 2012]; see "Habitat and Ecological Process Associations" above). Floodplain inundation benefits for juveniles can be increased by minimizing stranding potential (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches, and ramping flows so that surface elevations do not decrease rapidly), and for adults by minimizing potential for entrainment and trapping (by eliminating or screening diversions or ditches where fish could be trapped, and implementing solutions to address fish passage barriers), particularly in the mainstem Sacramento River and Yolo and Sutter Bypasses (McEwen 2013; Conservation Strategy Appendix K).
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	Yes	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	Yes	
Riparian	Habitat Amount—total amount and total	Yes	Provide riparian habitat throughout the riverine rearing and outmigration corridors: (1) located where juvenile fish could access the vegetation during high flows; (2)

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the SR Winter-Run Chinook Salmon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
	amount on active floodplain (acres)		connected to the river system inside the levee system (even if within the bypasses); and (3) distributed along the mainstem Sacramento River.
	Habitat Connectivity—median patch size (acres)	Yes	Provide connected riparian habitat inside the levee system.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide marsh habitat that does not include, and minimizes the likelihood of establishment of, nonnative submerged aquatic vegetation, particularly in the Lower Sacramento River CPA.
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	Yes	Floodplain agriculture should minimize risks of stranding for juvenile fish (by modifying floodplain topography to allow fish to follow receding flows off the floodplain and not become trapped in low-lying ponded areas or disconnected ditches), and should minimize entrainment or trapping of adults (by eliminating or screening diversions or ditches where fish could be trapped, and by implementing solutions to address fish passage barriers; see Conservation Strategy Appendix K) in the bypasses and mainstem Sacramento River.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	Yes	Remove/modify barriers at the Fremont, Sacramento, and Tisdale Weirs, as well as other barriers identified and prioritized in McEwen (2013) and Conservation Strategy Appendix K.
Invasive Plants	Invasive Plant-Dominated Vegetation—total area reduced (acres)	Yes	Remove or decrease populations of nonnative invasive aquatic plants (e.g., *Egeria* and parrot's feather) that affect fish habitat, and terrestrial plant species that affect river geomorphology (e.g., *Arundo* and saltcedar).

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G8. Focused Conservation Plan: Southern Distinct Population Segment of the North American Green Sturgeon

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the southern Distinct Population Segment of the North American green sturgeon (*Acipenser medirostris*) (sDPS green sturgeon) in the SPA for the CVFPP. The sDPS comprises all coastal and Central Valley populations south of the Eel River in California (71 FR 17757).

The sDPS green sturgeon was listed as threatened under the ESA in 2006. In 2010, an ESA Section 4(d) protective regulation applied ESA Section 9 take prohibitions for the sDPS green sturgeon, but also exempted some activities from take prohibitions, such as emergency fish rescue and salvage (75 FR 30714).

Critical habitat for the sDPS green sturgeon was designated in 2009 and encompasses:

- the Sacramento River, including waters of the Yolo and Sutter Bypasses in the Upper and Lower Sacramento River CPAs;
- the lower American River in the Lower Sacramento River CPA;
- the lower Feather River and the lower Yuba River in the Feather River CPA;
- the Sacramento–San Joaquin River Delta in the Lower Sacramento and Lower San Joaquin River CPAs;
- coastal marine waters out to the 60 fathom-depth bathymetry line (relative to mean lower low water) from Monterey Bay, California, north and east, to include waters in the Strait of Juan de Fuca, Washington; and
- numerous coastal bays and estuaries in California, Oregon, and Washington (74 FR 52300).

The primary constituent elements of designated critical habitat in freshwater habitats considered essential for conservation of the sDPS green sturgeon are (1) food resources, (2) substrate type or size for spawning, (3) water flow, (4) water quality, (5) migratory corridors, (6) depth of holding pools, and (7) sediment quality. The primary constituent elements of designated critical habitat in estuaries are (1) food resources, (2) water flow, (3) water quality, (4) migratory corridors, (5) depth (e.g., a diversity of depths, necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages), and (6) sediment quality.

To date, NMFS has developed only a *Federal Recovery Outline* for the sDPS green sturgeon (NMFS 2010); a full recovery plan is being prepared and may be publicly available in winter of 2014 (Woodbury pers. comm.).

Status and Trends

Historical Distribution

The species' original spawning distribution may have been reduced historically by harvest and other anthropogenic effects (Lindley et al. 2008); but both its historical and current spawning distributions are unclear. Historically, sDPS green sturgeon likely spawned in the Sacramento River upstream of Keswick Dam and the Feather River upstream of Oroville Dam; they are unlikely to have spawned in the San Joaquin River (National Oceanic and Atmospheric Administration [NOAA] 2005).

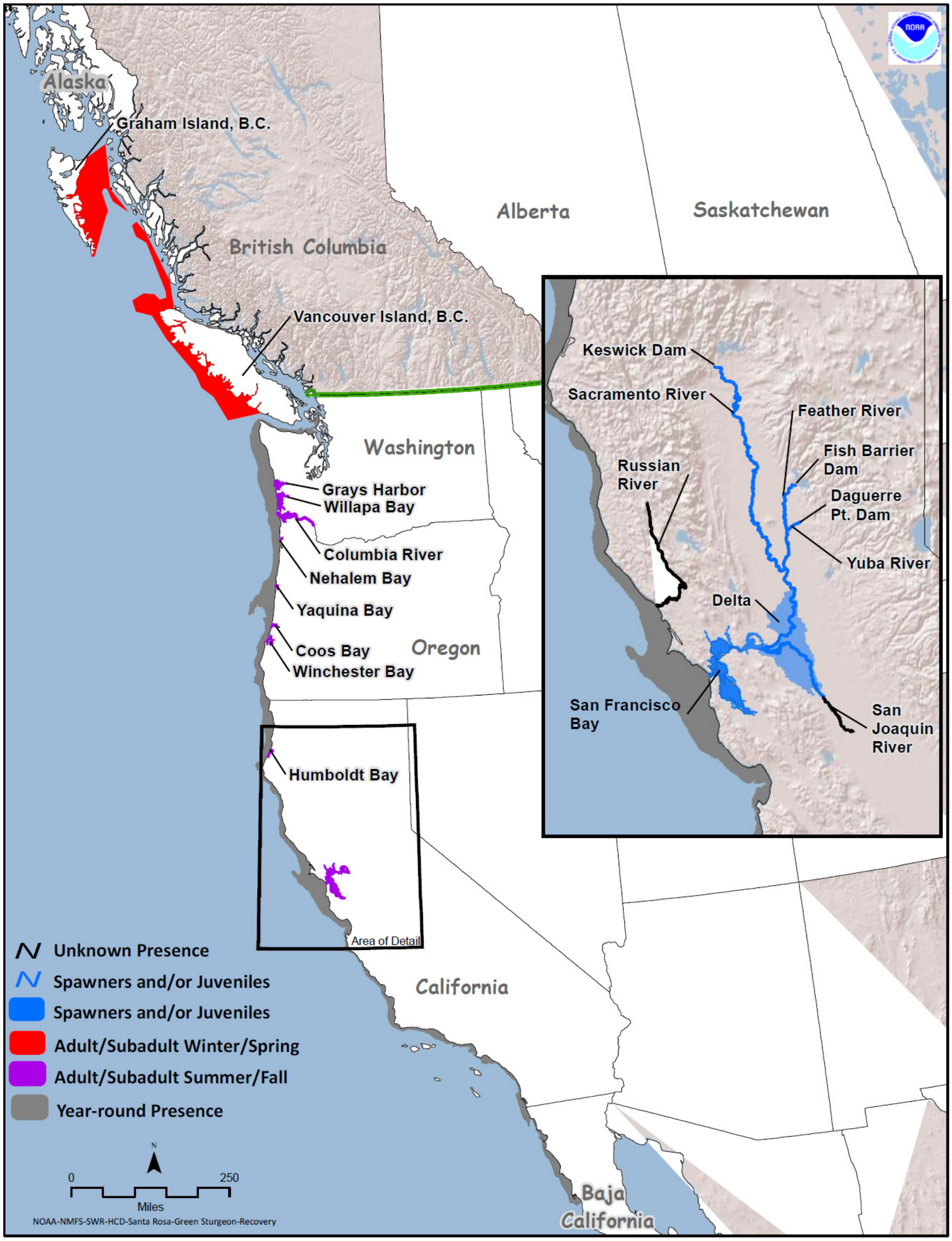
Current Distribution

North American green sturgeon are the most broadly distributed and wide-ranging species of the sturgeon family, occurring in ocean waters from Ensenada, Mexico, to the Bering Sea, and commonly occurring in coastal waters from San Francisco Bay to Canada (Huff et al. 2012) (Figure 1). Currently, the sDPS green sturgeon is known to spawn in the upper Sacramento River (Adams et al. 2007) downstream of Keswick Dam (Upper Sacramento River CPA), on the lower Feather River (Feather River CPA) in the Thermalito Afterbay overflow (USFWS 2012), and possibly on the Yuba River (Feather River CPA), because adults were observed immediately downstream of Daguerre Point Dam (Bergman et al. 2011).

Population Trends

Current population size and trends for the sDPS green sturgeon are not known (Adams et al. 2002; NOAA 2005), although there are several independent estimates of abundance. Population estimates for sDPS green sturgeon have been derived incidentally from white sturgeon monitoring in San Pablo Bay that was conducted intermittently from 1954 to 2001 (but more consistently since 1990) (Adams et al. 2007). Trammel nets were used to capture a total of 536 sDPS green sturgeon from 1954 to 2001, of which 233 were tagged. Population estimates of sDPS green sturgeon were derived by multiplying the legal-size white sturgeon population estimate (calculated from multiple-census or Peterson mark-recapture) to the ratio of legal-size (40–60 inches) green sturgeon to legal-size white sturgeon caught in the tagging program. The legal-size green sturgeon estimates ranged from 500 to 900 adults annually, with no long-term trends (Adams et al. 2007). The estimates, however, were based on potentially biased assumptions, including that both species were equally vulnerable to the capture gear, an unlikely assumption because green sturgeon concentrate in estuaries during summer and fall, whereas white sturgeon may remain in estuaries year-round (Adams et al. 2007).

Israel and May (2010) estimated the annual breeding population size to be 10–28 green sturgeon upstream of Red Bluff Diversion Dam, based on genetic evaluation of kinship over a 5-year period (2002–2006). This low figure contrasts with the San Pablo Bay estimates, possibly because very few adults that enter the Sacramento River spawn (e.g., the estimate based on genetics may reflect a small number of actual spawners), or because they are using alternative spawning grounds (e.g., areas downstream of Red Bluff Diversion Dam). Annual estimates of adult sDPS green sturgeon abundance in the Upper Sacramento River (between Highway 32 and



Source: NMFS 2010

Figure 1. sDPS Green Sturgeon—Current Distribution

Redding) were 163 and 245 fish from two surveys in 2010, and 220 fish from a survey in 2011; these surveys employed Dualfrequency IDentification SONar (DIDSON) (Mora 2013).

Because the spawning population of the sDPS green sturgeon is small and limited primarily to the Sacramento River, it is considered susceptible to catastrophic events (NMFS 2010). The population is also susceptible to the impacts of stranding, bycatch, and poaching.[1] Adults have been observed stranded in several years at the Tisdale and Fremont Weirs during receding high-flow events, during which some of the stranded fish were poached (Thomas et al. 2013). A population viability analysis predicted that, within 50 years, sDPS green sturgeon numbers will drop 33 percent below the population baseline if stranded fish are not rescued; in contrast, a 7-percent decrease is predicted if fish are rescued (Thomas et al. 2013). In addition to stranding, green sturgeon are captured as bycatch in several commercial fisheries, including the limited-entry California halibut fishery off San Francisco Bay. Seasonal bycatch estimates for this fishery were estimated from 2002 to 2010; the highest number of green sturgeon in the bycatch was estimated to be 786 in winter 2006, and no trends were observed (Al-Humaidhi et al. 2012). Data on North American green sturgeon captured by tribal fishing, recreational fishing, and as bycatch in other commercial fisheries do not separate the sDPS from the northern DPS green sturgeon; therefore, these data cannot be used to estimate population trends for sDPS green sturgeon.

Juvenile sDPS green sturgeon are salvaged at the State Water Project and Central Valley Project fish facilities in the South Delta; estimated numbers salvaged have decreased since the early 1980s, from several thousand fish per year to several hundred or fewer (Beamesderfer et al. 2007). Population equilibrium models indicate that, based on life history and population characteristics, sDPS green sturgeon are extremely sensitive to even small, incremental increases in mortality (Beamesderfer et al. 2007).

Life History

North American green sturgeon are long-lived, slow-growing anadromous fish (i.e., they migrate from the ocean, where they spend most of their lives and grow large before returning to freshwater, where they spawn, then hatch and rear) and the most marine-oriented of the sturgeon species. They reach sexual maturity when they are approximately 15 years old, after which they spawn in freshwater every 2–5 years (Moyle 2002; Van Eenennaam et al. 2006; 71 FR 17757), reaching peak reproduction between 25 and 40 years of age (Heppell 2007). Sturgeon can grow up to 9 feet long and likely live to a maximum age of 60–70 years (Moyle 2002).

Adult sDPS green sturgeon enter San Francisco Bay between mid-February and early May and migrate rapidly (i.e., over a few weeks) up the Sacramento River through the Lower and Upper

[1] "Stranding" herein refers broadly to any event in which fish are trapped in detrimental conditions by being physically separated from a main body of water or from their natural migration route to natal streams. Stranding includes both entrapment in lethal or sublethal conditions and cases in which fish stray into nonnatal streams or unsuitable habitat because of system operations or attraction flows. Types of stranding are further discussed in Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System."

Sacramento River CPAs (Heublein et al. 2009). Spawning has been confirmed (through detection of eggs) in the Upper Sacramento River CPA, from below the confluence of the Sacramento River with Battle Creek to just upstream of the Glenn-Colusa Irrigation District oxbow diversion intake, approximately 37 river miles south of Red Bluff (Poytress et al. 2013). Spawning occurs from April through early July, with activity fluctuating with water temperature and flows (Israel and Klimley 2008; Poytress et al. 2010, 2012). In June 2011, spawning was confirmed in the lower Feather River, in the Thermalito Afterbay overflow (USFWS 2012). After spawning, adults usually hold for several months in deep pools near their spawning sites, in both the upper mainstem Sacramento River and in the Feather River. They migrate back downstream when flows increase in fall, and reenter the ocean in winter (November through January) (Heublein et al. 2009; NMFS 2010; USFWS 2012).

When spawning, eggs and milt are released over deep pools, where they drift and stick onto substrate (Israel and Klimley 2008). The eggs hatch after approximately 6–8 days, and the 0.91–0.98-inch larvae begin feeding 10–15 days after hatching (Beamesderfer et al. 2007). Juveniles grow rapidly, reaching 2 feet within 2–3 years, and spend 1–4 years in fresh and estuarine waters before migrating to the Pacific Ocean as subadults (Beamesderfer and Webb 2002). Larvae and juveniles migrate downstream and rear in the San Francisco Bay estuary and the Delta, in the Lower Sacramento and Lower San Joaquin River CPAs, before migrating to the ocean (Beamesderfer et al. 2007). When not spawning, adults live in coastal waters as deep as 360 feet, as well as in coastal bays and estuaries north of San Francisco Bay (Lindley et al. 2011; Huff et al. 2011, 2012). They frequently make long migrations along the Pacific coast, generally to the north in fall and to the south in spring (Lindley et al. 2008). They congregate in coastal bays and estuaries of Washington, Oregon, and California in summer and fall, and along the coast of British Columbia, Canada, in winter and spring (Lindley et al. 2008, 2011).

Habitat and Ecological Process Associations

Adult sDPS green sturgeon spawn in deep pools or "holes" in large, freshwater rivers (Moyle et al. 1995; Beamesderfer et al. 2007; Thomas et al. 2014). Before and after spawning, adults and subadults hold in deep (>16-foot-deep) pools with little or no current, located in off-channel coves or low-gradient reaches often close to sharp river bends (Erickson et al. 2002; Thomas et al. 2014). Spawning occurs in cold, clean water, and suitable substrates (small to medium-sized gravel [Poytress et al. 2012]) are important for spawning success and embryonic development (Moyle et al. 1995; Nguyen and Crocker 2007). In the lab, temperatures of 51.8–62.6°F were optimal for hatching and developing embryos (Van Eenennaam et al. 2005). Larvae are primarily nocturnal, drifting or redistributing from hatching areas at night, and reclusive during the day (Poytress et al. 2012). Juveniles remain in freshwater until they are at least 6 months old, because they are sensitive to salinity (Allen et al. 2011). Optimal water temperatures for rearing during the first year are between 59°F and 66.2°F (Beamesderfer et al. 2007; Allen et al. 2011).

During their first winter in the river, juvenile sDPS green sturgeon occupy habitats with natural rock substrate and low light levels, and appear to be able to hold in these habitats during high flows (Israel and Klimley 2008). SRA habitat, including overhanging vegetation, instream cover, and natural eroding banks (Fris and DeHaven 1993), provides important allochthonous contributions to the river food web, supporting prey for juvenile sDPS green sturgeon (Israel and Klimley 2008). Such conditions are best supported by natural geomorphic processes.

The importance of floodplain habitat for juvenile rearing is not known (Israel and Klimley 2008). However, as described in the designation of critical habitat, "the quality of aquatic and estuarine habitats within stream channels and bays and estuaries is intrinsically related to the adjacent riparian zones and floodplain, to surrounding wetlands and uplands, and to non-fish-bearing streams above occupied stream reaches" (74 FR 52300). Adult sDPS green sturgeon are known to become stranded in the Yolo Bypass during their upstream spawning migration when Fremont Weir spills and high flows recede (Thomas et al. 2013). To effectively facilitate upstream migration in the Yolo Bypass, inundation would need to occur at least from late February through mid-May; however, until upstream passage is provided at the Fremont Weir back to the mainstem Sacramento River, any adults that migrate into the Yolo Bypass during flood events may be stranded in isolated pools as the flows recede and likely will die if not rescued (USBR 2012).

North American green sturgeon have subterminal mouths and are likely opportunistic benthic foragers (Kelly et al. 2007). Larval and juvenile sturgeon in riverine habitats are presumed to be generalists and opportunists (Israel and Klimley 2008), but no data are available on their diet. Larger young-of-the-year and 1-year-old sturgeon also rear in intertidal and subtidal estuarine habitats of the Lower Sacramento and Lower San Joaquin River CPAs (Israel and Klimley 2008). In San Francisco Bay, juvenile sDPS green sturgeon feed primarily on a variety of benthic organisms, including corophium, shrimp and amphipods, small fish, and mollusks (Radtke 1966; Houston 1998; Adams et al. 2002; Israel and Klimley 2008).

Conceptual Models

A conceptual model has been developed to assist in development of a targeted conservation strategy for sDPS green sturgeon within the SPA (Figure 2). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by sDPS green sturgeon within the SPA;
- the specific CPAs within which these habitat conditions occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

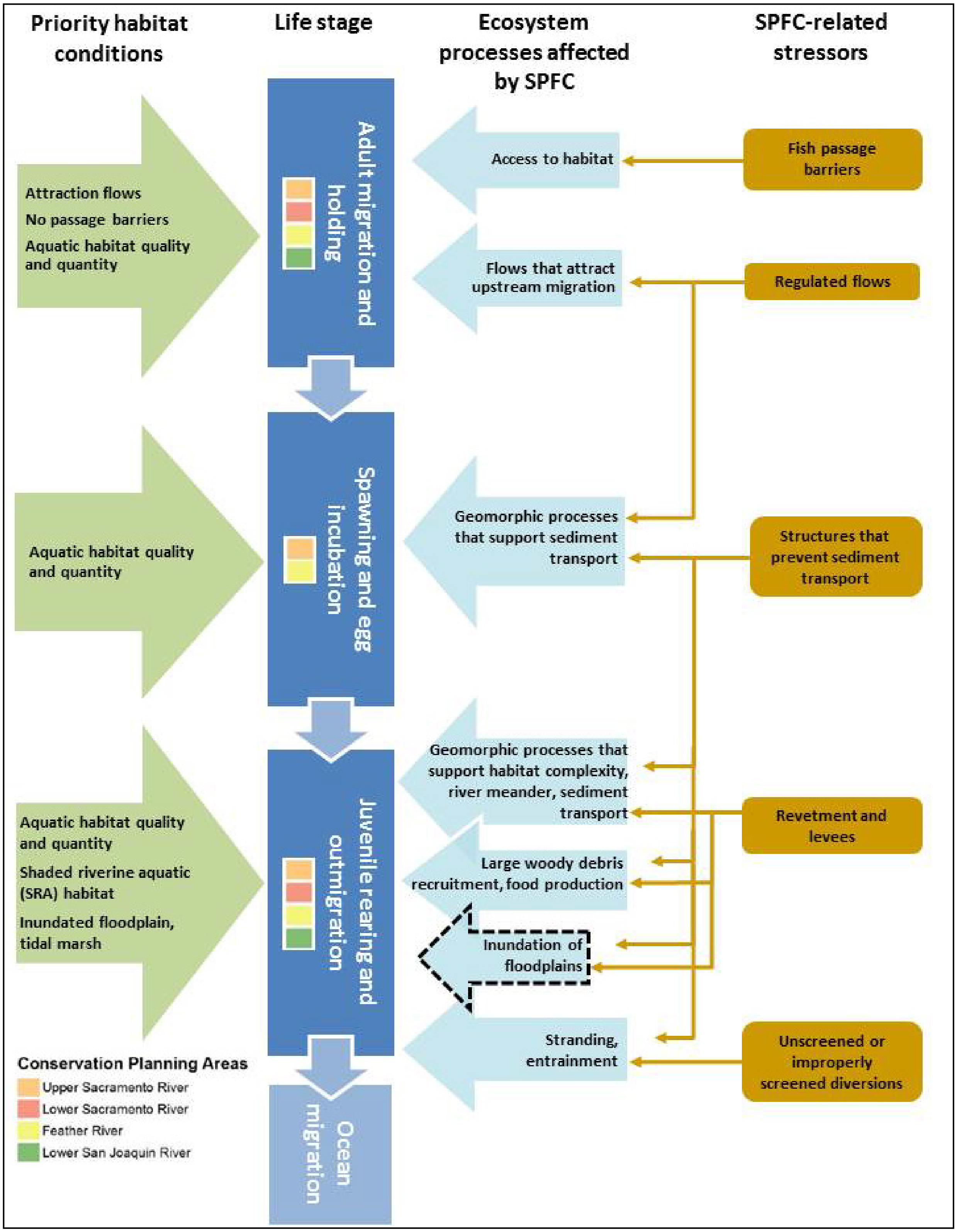


Figure 2. Conceptual Model for sDPS Green Sturgeon within the SPA

Historical habitat for sDPS green sturgeon spawning and rearing in the three major branches of the Sacramento River (the Little Sacramento River, the Pit River system, and the McCloud River [Adams et al. 2007]) is blocked by large dams (e.g., Shasta, Keswick, and Oroville Dams). A model used to evaluate historical habitat predicted that impassable dams likely block access to approximately 9 percent of historically available habitat; although this figure appears low, the blocked habitat likely contained a relatively large proportion of high-quality spawning habitat (Mora et al. 2009). In addition, the model predicted that sDPS green sturgeon would use the mainstem Sacramento and San Joaquin Rivers, as well as several major tributaries, including portions of the lower Feather River, lower American River, and lower Yuba River (Mora et al. 2009).

Factors that potentially limit the early life stages of sDPS green sturgeon include water temperatures, insufficient flows, low dissolved oxygen levels, lack of rearing habitat, and increased predation (Israel and Klimley 2008). For example, in the upper Sacramento River, cold-water releases from Shasta Dam that provide habitat for Sacramento River winter-run Chinook salmon may be detrimental to green sturgeon because they may limit upstream migration of adults and decrease larval growth (Woodbury pers. comm.). As larvae grow into juveniles, they become fairly tolerant of variations in temperature and dissolved oxygen levels (Israel and Klimley 2008). However, their survival may be limited by lack of habitat, insufficient food, and contaminants (Israel and Klimley 2008). Juveniles can also be entrained in water diversions, and are more susceptible to entrainment than juvenile Chinook salmon (Mussen et al. 2014).

Adults are susceptible to estuarine and ocean hazards, such as fishing, bycatch, and contaminants. In the river system, adults migrating upstream to spawn can be stranded at sites along their migration path (e.g., at the Tisdale and Fremont Weirs), where ladders support upstream migration of salmon but do not allow passage of the larger adult sDPS green sturgeon (Israel and Klimley 2008; Thomas et al. 2013). In addition, green sturgeon migrating upstream to spawn in the Upper Sacramento River CPA were historically impeded or killed by the Red Bluff Diversion Dam. When the Red Bluff Diversion Dam gates were only partially open or closed (15 June–1 September), adult sDPS green sturgeon could not migrate upstream to access spawning habitat downstream of Keswick Dam (Brown 2007). Those adults that did get upstream before the gates were closed risked injury or mortality after spawning as they moved downstream, because they were trapped or injured in the partially opened gates (NMFS 2009). To provide unimpeded upstream and downstream migration for sDPS green sturgeon, the Red Bluff Fish Passage Improvement Project installed a screened pumping plant, which eliminated the need for the gates to be closed; they are now open year-round (NMFS 2009).

Management Issues

Threats and Sensitivities Range-Wide

The sDPS green sturgeon status review (Adams et al. 2002) and status review update (NOAA 2005) analyzed the current threats to, and population trends of, the sDPS green sturgeon. Threats include a loss of spawning habitat, bycatch and discard by fisheries, poaching, potentially lethal water temperatures for larvae, entrainment by water diversions in the Central Valley, and the adverse effects of toxic materials and nonnative, aquatic, predatory species (Adams et al. 2002). The fish are particularly vulnerable to these threats because the DPS comprises a small population that spawns primarily in a single area in the Sacramento River (Adams et al. 2007), although spawning has been observed recently in the lower Feather River (USFWS 2012).

Ongoing and Future Impacts

Ongoing impacts on sDPS green sturgeon in the SPA include construction, operation, and maintenance of flood control facilities and other activities or events that affect habitat access, flows, and the quality and availability of downstream habitat; water diversions that entrain juveniles and affect habitat quality; barriers to fish passage; and the effects of climate change, which will likely include degradation of water quality and habitat suitability.

- The availability of suitable habitat likely will continue to be the most critical factor in sDPS green sturgeon recovery (NMFS 2010). Particularly, restricted spawning habitat in the Upper Sacramento River and Feather River CPAs will continue to be a significant stressor (NMFS 2010). CVFPP modifications or projects that contribute to simplified or degraded riverine habitat, such as levee armoring, are expected to negatively affect sDPS green sturgeon. In addition, numerous activities and events can reduce water quality and are expected to continue to negatively affect the species. For example, vegetation removal near waterways can increase water temperatures, and dredging activities can resuspend sediment and contaminants, smothering eggs and reducing benthic prey availability. Catastrophic fires can severely affect water quality until vegetation is reestablished. Contaminants in discharges to the rivers and the Delta can affect food webs, degrade habitats, and directly harm sDPS green sturgeon (especially because they spawn in limited areas) (Mount et al. 2012).

- Entrainment at diversions continues to affect juvenile sDPS green sturgeon in the Upper and Lower Sacramento River CPAs, the Feather River CPA, and the Lower San Joaquin River CPA (NMFS 2010). Entrainment at both large screened diversions (such as the Central Valley Project and State Water Project) and numerous small, unscreened or inadequately screened diversions will likely continue to affect juvenile sDPS green sturgeon (NMFS 2010; Mussen et al. 2014). Large diversions can also affect water quality (Monsen et al. 2007) and provide habitat for introduced fish predators (Cavallo et al. 2013).

- As stated, barriers delay or impair fish migration (see Attachment 9C of the CVFPP and Conservation Strategy Appendix K, "Synthesis of Fish Migration Improvement Opportunities in the Central Valley Flood System") and have been prioritized for improvements based on impacts on fish (see Appendix K). In particular, the ladder at the Fremont Weir (the primary inundation source for the Yolo Bypass) does not provide passage for adult sDPS green sturgeon. Currently, when high flows recede, adults become stranded at the weir and are rescued. NMFS has specifically identified the need to reduce migratory delays and minimize stranding of upstream migrating adult sDPS green sturgeon at the Fremont Weir (USBR 2012). The potential impacts of stranding on population viability have been modeled; results indicate that stranding would have a significant impact on population viability if adults were not rescued (Thomas et al. 2013).

- Climate change will affect habitat for sDPS green sturgeon in the future, but the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the catchment as rain rather than snow, thus reducing snowpack and water availability from snowmelt in spring and summer (Cayan et al. 2006). In the Upper Sacramento River CPA, flow releases from Keswick and Shasta Dams are essential for providing suitable thermal regimes for sDPS green sturgeon spawning and rearing; climate change may affect the ability of water managers to store water in the reservoir "cold-water pool," ultimately decreasing habitat quantity and quality for holding, spawning, and juvenile rearing in the Sacramento River between Keswick Dam and Red Bluff (USBR 2013). Similarly, thermal conditions in the Feather and Yuba Rivers may be affected downstream of Oroville and Englebright Dams. Ecologists are only beginning to understand climate change threats to riparian ecosystems (Seavy et al. 2009). Climate change models also predict increases in sea level, estuarine salinity, and freshwater temperatures (Cloern et al. 2011). Green sturgeon and other cold-water-adapted native fish are likely to respond negatively to climate change effects such as changes in streamflows and increased temperatures (Katz et al. 2012; Moyle et al. 2013).

Key Information Gaps or Uncertainties

To better understand how current and future CVFPP activities affect the conservation and potential recovery of sDPS green sturgeon, and to help guide future actions of the CVFPP and Conservation Strategy, the following information is needed: modeling of impacts related to flood management, a better understanding of habitat functions for juvenile rearing, and data on the effects of predation and stranding. These data gaps are discussed below.

- **Impact models.** Flood managers need an improved understanding of the impacts on sDPS green sturgeon habitats caused by levee erosion repair projects. Currently, the Standard Assessment Methodology is used to systematically compare selected fish species' responses to habitat features affected by levee erosion repair projects. This method applies conceptual response models to quantified habitat changes to assess the near- and long-term impacts or benefits to species. It is based on conceptual response models of indicator fish species, and evaluates levee erosion repair designs that incorporate SRA components (overhanging shade, reduced substrate size, instream woody material, etc.), revetment size, bank slope, and length of the proposed levee project site.

  The conceptual response models were developed using professional opinion and assume relationships between the presence or abundance of an organism and habitat quality. However, habitat quality would be better assessed by evaluating the effects of levee erosion repair designs on the condition (e.g., growth) and survival of indicator fish species (Sommer et al. 2005; Bond et al. 2008). Additionally, the current Standard Assessment Methodology fails to evaluate the loss of riverine processes (lateral migration, reworked floodplain, vegetation regeneration, etc.) and should consider the effects of changes in levee configuration to evaluate the benefits or impacts of repairing existing levees versus changing levee alignment to promote natural river processes. In particular, the deep holding pools where adult sDPS green sturgeon congregate before and after spawning are likely dependent on natural river processes, including channel migration. Some of these issues can be addressed by evaluating how juvenile sDPS green sturgeon use specific levee repair designs and natural banks, including the duration of time spent at the site (minutes, hours, days, weeks) and effects on growth and survival. Additionally, there is concern that, in the warmer reaches of the mainstems, habitat features incorporated as mitigation for levee repair projects (e.g., instream wood) may be providing or improving habitat conditions for predators of juvenile sDPS green sturgeon; however, the significance of predation by nonnative fish on juveniles is not known (NMFS 2010).

- **Habitat functions.** There is a lack of information on the function of certain habitats in the life history of the sDPS green sturgeon; in particular, a better understanding is needed of the quality and quantity of habitats used by juveniles as they move downstream in the Sacramento River mainstem and the Delta during rearing and outmigration (NMFS 2010). The vegetation types that may provide habitat for juvenile sDPS green sturgeon, and their use of floodplains and bypasses, are not well understood (NMFS 2010). There is also uncertainty about the importance of the distribution and amounts of SRA habitat on fish populations; for example, is the relationship between SRA habitat and fish numbers linear, or are minimum thresholds of SRA required, and what is the importance of habitat connectivity? Actions that provide habitat for juvenile rearing, coupled with studies that evaluate habitat use through an adaptive management approach, could inform and improve future activities associated with levee maintenance and erosion repair.

- **Predation.** Especially in the lower mainstems and Delta, the extent of predation on juvenile sturgeon by nonnative fish is not well understood (NMFS 2010). The Central Valley has many nonnative fish species that may be potential predators of juvenile sturgeon. Actions that could inadvertently increase habitat for predators need to be evaluated. Such actions include restoring marsh habitat in the Lower Sacramento and Lower San Joaquin River CPAs, which could enhance nonnative submerged aquatic vegetation that is used by fish predators (Grimaldo et al. 2012).

- **Stranding effects.** When bypasses are inundated, they likely provide habitat for juvenile sDPS green sturgeon; however, stranding of juvenile sDPS green sturgeon has not been observed. Increasing the connectivity of bypasses and floodplains for juvenile salmonids could incorporate measures to minimize stranding, such as optimal flow-reduction ramping rates that may also benefit juvenile sDPS green sturgeon. The interaction of channel conveyance capacity with infrastructure, water diversions, flow magnitude and timing, and fish habitat needs could be addressed by CVFPP actions for tributaries (Feather River CPA) and mainstem rivers and bypasses (Upper and Lower Sacramento and San Joaquin River CPAs). Screen and ladder criteria and designs have been established for salmonids, but not for green sturgeon.

Conservation Strategy

Conservation and Recovery Opportunities

The integration of environmental stewardship into all flood management activities during project planning, design, operation, 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. This focused conservation plan summarizes particular life history requirements and ecological process associations for sDPS green sturgeon, and uses this information to provide specific recommendations that align with the draft recovery outline (NMFS 2010) and create opportunities to benefit and conserve the species through the operation, maintenance, and improvement of the SPFC. This focused conservation plan specifically addresses the primary stressors of limited spawning and rearing habitat throughout the SPA, and suggests practices and multi-benefit approaches that would contribute to the recovery of sDPS green sturgeon.

Identified Conservation Needs

1. **Improve the distribution and quality of SRA habitat in the Upper and Lower Sacramento River, the Feather River, and the Lower San Joaquin River CPAs:** The elements of SRA habitat (overhanging vegetation, instream cover, and natural eroding banks) each offer important resources to juvenile and subadult sDPS green sturgeon. SRA habitat provides organic material input, differential velocities, cover, food, temperature regulation, and improved water quality. Large-scale restoration of SRA cover is needed to improve juvenile rearing and outmigration habitat, most of which has been lost because of construction, operation, and maintenance of the levee system, as well as alteration of flows, particularly in the Upper and Lower Sacramento, Feather, and Lower San Joaquin River CPAs.

2. **Improve the distribution and quality of intertidal and subtidal habitat throughout the Delta region of the Lower Sacramento and Lower San Joaquin River CPAs:** Intertidal and subtidal habitats are important for rearing, providing prey resources important for juvenile growth. Historical reclamation of wetlands and construction of levee systems in the Delta region of the Lower San Joaquin and Lower Sacramento River CPAs removed much of this habitat. Large-scale restoration of intertidal and subtidal habitats, where they have been channelized, is needed (Israel and Klimley 2008; NMFS 2010).

3. **Improve natural river morphology and function:** Flood control measures downstream of dams, such as bank protection, have affected riparian and instream habitat, particularly in the Lower Sacramento River, Feather River, and Lower San Joaquin River CPAs. Constructed levees that narrow channels have increased velocities and channelized rivers

so that natural geomorphic processes (e.g., meander) are no longer possible. Improving geomorphic processes to support natural bank erosion, sediment deposition, and the establishment and growth of riparian vegetation is essential for providing beneficial SRA habitat, reconnecting floodplains, recruiting woody material, and improving channel complexity. These factors are important elements of rearing habitat for juvenile sDPS green sturgeon and, in the Upper Sacramento River and Feather River CPAs, contribute to the quality of spawning and deep holding pool habitat for adult sDPS green sturgeon.

4. **Improve fish passage in the Upper and Lower Sacramento River, the Feather River, and the Lower San Joaquin River CPAs:** During winter and spring high-flow events, water is diverted into bypasses (e.g., Sutter and Yolo). Adult sDPS green sturgeon can enter the bypasses, but their spawning migration is prevented by control structures (e.g., the Lisbon, Tisdale and Fremont Weirs) (NMFS 2010; Thomas et al. 2013; McEwen 2013; Conservation Strategy Appendix K). Juveniles can become entrained by unscreened or inadequately screened diversions (Mussen et al. 2014), and may be stranded when flows recede in bypasses or along mainstems in the Upper and Lower Sacramento River, Lower San Joaquin River, and Feather River CPAs. These connectivity issues for both upstream adult migration and downstream juvenile rearing and outmigration must be addressed to minimize these impacts.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the sDPS green sturgeon; these are summarized in Table 1 of this section. In many cases, some of the conservation needs of sDPS green sturgeon can be addressed through the implementation of management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements to facilities. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following sections) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/or revetment removal at a site that may depend on levee relocation to allow for bank erosion. Wherever feasible, conservation objectives and indicators will informmanagement actions toward 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 limited reoperation of reservoirs and weirs. These could provide flow releases that improve aquatic habitat conditions by changing the timing and amount of releases and ramping rates from November/early December to the end of April

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the sDPS Green Sturgeon[a]

SPFC Conservation Actions	Conservation Need			
	1. Increase/ Improve SRA Habitat	2. Increase/ Improve Intertidal and Subtidal Habitats	3. Improve Natural River Function	4. Improve Fish Passage and Decrease Entrainment
Operations, Maintenance, and Floodway Management				
Floodwater storage and reservoir forecasting, operations, and coordination	+		+	+
Facility maintenance				
Levee vegetation management	-			
Floodway maintenance	+			
Modification of floodplain topography	+		+	+
Support of floodplain agriculture			+	+
Invasive plant management			+	
Restoration of riparian, SRA, and marsh habitats	+	+	+	
Wildlife-friendly agriculture				
Structural Improvements				
Levee and revetment removal	+	+	+	
Levee relocation	+	+	+	
Bypass expansion and construction	+	+	+	+
Levee construction and improvement	+		+	
Flood control structures				+

Note:
a CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

(USBR 2012). These modifications could be implemented to reduce fish stranding and passage barriers, initiate upstream adult migration and juvenile outmigration, and generate other environmental benefits, including promoting floodplain connectivity, enhancing meander migration rates, creating conditions that promote development of SRA habitat, and improving spawning gravel dynamics (recruitment, flushing, and mobilization of gravel in the mainstem Sacramento River upstream of Red Bluff, and in the Feather River downstream of the Thermalito Afterbay).

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 thus support a prey base for foraging juvenile sDPS green sturgeon.

Levee vegetation management: The 2012 CVFPP introduced an interim vegetation management strategy, under which levee vegetation in the VMZ (see Figures 2-1 and 2-2 in Appendix D of the Conservation Strategy) is managed for visibility and accessibility, and to reduce threats to levee integrity. Consequently, levee riparian vegetation in the VMZ has been significantly trimmed or removed, reducing inputs of terrestrial insects, leaf litter, and waterside natural vegetation recruitment, and thereby reducing food availability and nutrient inputs. Trimming and removal of waterside vegetation may also have detrimental effects on water temperature (Poole and Berman 2001) and fish habitat (e.g., instream wood recruitment and cover).

On the whole, levee vegetation management is likely to negatively affect habitat for sDPS green sturgeon. However, lower waterside vegetation could be retained below the VMZ of levees when it does not present an unacceptable threat to levee integrity. Allowing vegetation to grow on the water side 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. This approach would also preserve, in the near term, other vegetation within the VMZ that does not impair visibility and accessibility. Under the Conservation Strategy, additional habitat could be developed to offset the gradual die-off of trees and the removal of trees that pose an unacceptable threat to levee integrity. This vegetation would be more valuable to green sturgeon if it is (1) located close to water bodies, or at least where vegetation would provide cover for juvenile fish during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) distributed along the mainstems of the Sacramento, Feather, and Yuba Rivers and the Delta (Upper and Lower Sacramento River CPAs) and of the San Joaquin River and the Delta (Lower San Joaquin River CPA).

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). Fill-placement and rock-repair projects could incorporate reduced particle sizes, instream woody material, SRA elements, and planting berms, where relevant.

Modification of floodplain topography: Floodway topography modifications could increase floodway capacity, inundation frequency and duration, and habitat amounts and diversity, and could also eliminate areas that strand fish. Floodplain elevations could be lowered to provide more frequent and sustained inundation. Elevations could also be modified to provide greater topographic and hydrologic diversity (creating or opening secondary channels or overflow swales) and to eliminate features (e.g., filling and restoring gravel pits and deep borrow pits) that could strand fish. These actions would increase riverine and floodplain habitat values (e.g., by creating resting or rearing areas for fish migrating downstream) and provide escape routes for fish during receding flows.

Support of floodplain agriculture: Managing floodways to maintain the compatibility of flood management with agriculture would support agriculture in the bypasses and on floodplain agricultural lands between levees while accommodating access and decreasing stranding of sDPS green sturgeon. Addressing the problems posed by unscreened diversions and other structures that strand, trap, or impede movement of any juveniles or adults would benefit sDPS green sturgeon. However, it is important that diversions be identified and prioritized so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; Conservation Strategy Appendix K).

Invasive plant management: Nonnative invasive plants that may be removed from State-managed lands and facilities would include submerged aquatic vegetation (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 nonnative submerged aquatic vegetation generally support nonnative fishes such as centrarchids (Grimaldo et al. 2012), particularly in the Lower Sacramento River and Lower San Joaquin River CPAs, which may be predators of juvenile green sturgeon. Established nonnative terrestrial vegetation in riparian areas displaces important native plants (e.g., willows and cottonwood) that facilitate river meander and natural geomorphic processes. Removal of nonnative invasive plants could therefore benefit sDPS green sturgeon by improving rearing and outmigration habitat and reducing predation by nonnative fishes.

Restoration of riparian, SRA, and marsh habitats: Riparian and marsh habitats could be restored at selected locations in the floodway to benefit juvenile sDPS green sturgeon. Riparian restoration opportunities generally would be found in nonriparian land cover in the floodway; in particular, riparian restoration could be incorporated into management actions that increase floodway capacity. Riparian, SRA cover, and marsh restoration would be most beneficial in areas where restoration expands or connects existing habitat patches or provides habitat in areas with little or no riparian vegetation, at locations to be identified by future efforts (e.g., recovery planning) for juvenile sDPS green sturgeon, and in conserved areas. Restoration of natural river functions, especially those of riparian habitat on the mainstem Sacramento, Feather, and San Joaquin Rivers, would likely provide benefits to juvenile survival and growth (NMFS 2010). However, restoration must avoid promoting nonnative submerged aquatic vegetation, which can provide habitat for nonnative fish predators (Grimaldo et al. 2012).

Structural 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 waterways used by juvenile sDPS green sturgeon for rearing (e.g., the mainstem Sacramento, Feather, and San Joaquin Rivers) and by adults for holding and spawning, and where levee and revetment removal contributes to a larger zone of active river meander migration.

Levee relocation: Relocating levees farther from rivers (i.e., constructing set back levees) is an important approach to increasing floodway capacity, creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. In particular, natural river processes are critical for creating and sustaining the limited deep holding pools where adults congregate before and after spawning in the Upper Sacramento River and Feather River CPAs. Often, the benefits of levee relocation can be realized while still supporting agriculture within expanded floodways. Levee relocation would also provide an opportunity for restoring riparian vegetation that is hydraulically connected to the river systems, and for creating and enhancing rearing habitat for juvenile sDPS green sturgeon, particularly on the mainstem Sacramento, Feather, and San Joaquin Rivers.

Bypass expansion and construction: Bypass expansion may enhance juvenile rearing habitat (e.g., food resources and cover) by increasing the connectivity of the floodplain to the river system and thus restoring floodplain ecosystems that contribute to food web productivity; however, information on the use of bypasses by juvenile sDPS green sturgeon is scant. As part of bypass improvements, adult fish passage could be provided at flood control structures (e.g., the Lisbon, Tisdale and Fremont Weirs).

Levee construction and improvement: Levee construction and improvement objectives that would benefit sDPS green sturgeon include restoring geomorphic processes and, where significant hydraulic impacts would not occur, protecting riparian habitat and incorporating planting berms and riparian plants. In addition, new levees could be designed to accommodate the hydrologic changes (e.g., increasing frequency of extreme events) expected to result from climate change (Cloern et al. 2011).

Flood control structures: One priority action for State-operated and maintained diversions in the SPA is reconfiguring the weirs in the Yolo Bypass (e.g., Fremont and Tisdale Weirs and others in the Lower Sacramento River CPA) to allow passage by adult sturgeon and to increase floodplain inundation (DWR 2012; Conservation Strategy Appendix K). It is important that other diversions also be identified and prioritized (e.g., Sunset Pumps Diversion Dam) so that those with the greatest impact on fish populations are addressed accordingly (Moyle and Israel 2005; McEwen 2013; Conservation Strategy Appendix K); however, improving any structure that traps or impedes the movement of juvenile or adult green sturgeon would benefit the species.

Recovery Plan Alignment

The goal of the *Federal Recovery Outline* for the sDPS green sturgeon is to set out a plan for its conservation and recovery by identifying actions that may improve its potential for recovery (NMFS 2010). The recovery vision is that:

> *Healthy, self-sustained, viable populations of sDPS green sturgeon exist within their historic range. This includes spawning in multiple rivers, with the DPS represented by multiple strong year-classes. These green sturgeon are sufficiently abundant, productive, and diverse in healthy ecosystems to provide ecological and public benefits. (NMFS 2010)*

Identified recovery actions that could be partially implemented through CVFPP management activities include identifying and prioritizing potential contaminants of concern and evaluating the impacts of nonnative predatory fish. Another action identified by NMFS (2010) is to ensure that screens are placed on water diversions on the upper mainstem Sacramento River downstream of Keswick Dam, and that they are designed to protect larval and juvenile sDPS green sturgeon.

Measures of Positive Contribution

Contributing to the recovery and stability of native species populations and overall biotic community diversity is a primary goal of the Conservation Strategy. The objective for this goal is a measurable contribution to the conservation of target species, including sDPS green sturgeon. Therefore, building on the preceding discussion, this section of the sDPS green sturgeon 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 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 conservation of sDPS green sturgeon, requirements would be added to increase the acreage of restored riparian areas that positively contribute to adjacent rearing habitat, providing terrestrial inputs and creating the cover needed by the species.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of sDPS green sturgeon, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit sDPS green sturgeon may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the sDPS Green Sturgeon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	Timing and duration of floodplain inundation are important to providing benefits to adults during their upstream migration (e.g., from late February through mid-May [USBR 2012]; see “Habitat and Ecological Process Associations” above). Floodplain inundation benefits for adults can be increased by minimizing potential for entrainment and trapping (by eliminating or screening diversions or ditches where fish could be trapped, and implementing solutions to address fish passage barriers) (McEwen 2013; Conservation Strategy Appendix K).
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	Yes	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	Yes	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide riparian habitat throughout the riverine rearing and outmigration corridors: (1) located close to water bodies, or at least where juvenile fish could access the vegetation during high flows; (2) connected to the river system inside the levee system (even if within the bypasses); and (3) distributed along mainstems of the Sacramento, Feather, and San Joaquin Rivers.
	Habitat Connectivity—median patch size (acres)	Yes	Provide connected riparian habitat inside the levee system.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide marsh habitat that does not include, and minimizes the likelihood of establishment of, nonnative submerged aquatic vegetation, particularly in the Lower Sacramento and San Joaquin River CPAs.
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	Yes	Floodplain agriculture should minimize entrainment or trapping of adults (by eliminating or screening diversions or ditches where fish could be trapped, and implementing solutions to address fish passage barriers; see Conservation Strategy Appendix K) in

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the sDPS Green Sturgeon

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
			the mainstem Sacramento and Feather Rivers, and the bypasses.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	Yes	Remove/modify barriers at the Fremont and Tisdale Weirs, as well as other barriers identified and prioritized in McEwen 2013 and Conservation Strategy Appendix K.
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	Remove or decrease populations of nonnative invasive aquatic plants (e.g., *Egeria* and parrot's feather) that affect fish habitat, and terrestrial plant species that affect river geomorphology (e.g., *Arundo* and saltcedar).

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G9. Focused Conservation Plan: Giant Garter Snake

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the giant garter snake (*Thamnophis gigas*) and its habitat in the SPA for the CVFPP.

The State of California designated the giant garter snake as rare on 27 June 1971, and it was reclassified as threatened on 1 January 1985, pursuant to CESA of 1984 (CDFW 2013). It was federally listed as threatened by USFWS on 20 October 1993 (58 FR 54053). A draft recovery plan for the giant garter snake was published by USFWS in 1999, and a revised draft recovery plan for the species was released for public review in December 2015. In 2006 and 2012, USFWS completed a 5-year review that recommended identifying and protecting suitable habitat, conducting extensive surveys to determine presence/absence and genetic relatedness among populations, examining water quality and toxicology in the giant garter snake's habitat, investigating the long-term response of the species to loss of habitat, and installing culverts beneath roads and bridges to facilitate giant garter snake movement (USFWS 2006, 2012). An updated 5-year review will be released when the revised draft recovery plan is made final. Critical habitat has not been designated.

Status and Trends

Distribution

The giant garter snake is endemic to the valley floor wetlands, marshes, sloughs, ponds, small lakes, low-gradient streams, other waterways and agricultural wetlands, and associated uplands of the Sacramento and San Joaquin Valleys (Fitch 1940; Hansen and Brode 1980; Hansen 2009a; USFWS 2012). Historically, giant garter snakes ranged from Buena Vista Lake, southwest of Bakersfield in Kern County, to Butte County in the north (USFWS 1999); however, it is presumed that they have always been absent from the northern San Joaquin Valley because of the restricted floodplain. Agricultural and flood control activities have extirpated the giant garter snake from the southern third of its historical range (Hansen and Brode 1980; Hansen 1988; CDFG 1992). The known range of the giant garter snake has changed little since the 1993 listing and the 2006 status review; it is restricted to the Central Valley from Fresno County north to the vicinity of Chico in Butte County (USFWS 2012).

Giant garter snakes are year-long residents in suitable habitat throughout the SPA (Figure 1). However, more than 95 percent of the original wetlands in the Central Valley have been lost, and the remaining habitat has been fragmented (Frayer et al. 1989). The revised draft recovery plan for the giant garter snake identifies nine population and recovery units throughout the Central Valley: Butte Basin, Colusa Basin, Sutter Basin, American Basin, Yolo Basin, Cosumnes-Mokelumne Basin, Delta Basin, San Joaquin Basin, and Tulare Basin (USFWS 2015). These population and recovery units overlap with CPAs in the SPA, as shown in Table 1.

Table 1. Distribution of Giant Garter Snake Population and Recovery Units in the SPA

	Upper Sacramento River CPA	Lower Sacramento River CPA	Feather River CPA	Lower San Joaquin River CPA	Upper San Joaquin River CPA
Butte Basin	X		X		
Colusa Basin	X				
Sutter Basin	X		X		
American Basin	X	X			
Yolo Basin		X			
Cosumnes-Mokelumne Basin		X		X	
Delta Basin		X		X	
San Joaquin Basin				X	X
Tulare Basin					X

Key:
CPA = Conservation Planning Area
SPA = Systemwide Planning Area

Currently, most giant garter snakes are found throughout the rice production region of the Sacramento Valley (corresponding to the Feather River and Upper and Lower Sacramento River CPAs. This species uses rice agriculture and associated water conveyance structures (irrigation ditches and canals) in lieu of its natural habitat, which has substantially diminished (Hansen 1988; Wylie et al. 1997, 2000, 2005). In the Upper and Lower San Joaquin River CPAs, water has become less available during spring and summer (the species' active season), partly because there have been fewer rice fields, and water conveyances associated with this crop have been dewatered. The San Joaquin Valley populations of the giant garter snake have shown decreasing population numbers over the last several decades, with little evidence of recruitment (Wylie 1998; Sloan 2004). Table 2 identifies federal, State, and private lands in each of the nine population and recovery units that provide suitable habitat for giant garter snake.

Table 2. Giant Garter Snake Population and Recovery Unit Habitat

Population and Recovery Unit	Total Area (Acres)	Suitable Giant Garter Snake Habitat
Butte Basin	479,118	• Gray Lodge Wildlife Area • Upper Butte Basin Wildlife Area • Butte Sink Wildlife Management Area (incorporating 10,000 acres of USFWS wetland easements) • Sacramento River NWR
Colusa Basin	686,096	• Sacramento NWR • Delevan NWR • Colusa NWR • 5,500 acres of USFWS wetland easements north and south of Delevan NWR • Dolan Ranch Conservation Bank (252 acres) • Ridge Cut Conservation Bank (186 acres)
Sutter Basin	239,810	• Sutter NWR • Sutter Bypass Wildlife Area • Feather River Wildlife Area • Sutter Basin Conservation Bank (429 acres) • Gilsizer Slough South Conservation Bank (379 acres) • Tule Basin Giant Garter Snake Preserve (150 acres)
American Basin	376,104	• Feather River Wildlife Area • Giant garter snake preserves in the Natomas Basin (4,145 acres)
Yolo Basin	410,914	• Yolo Bypass Wildlife Area • Wetland easements in the Yolo Bypass • Jepson Prairie Preserve • Pope Ranch Conservation Bank (390 acres)
Cosumnes-Mokelumne Basin	234,960	• Cosumnes River Preserve
Delta Basin	699,502	• Stone Lakes NWR • Sherman Island Wildlife Area • White Slough Wildlife Area
San Joaquin Basin	800,327	• San Joaquin River NWR • San Luis NWR Complex • Merced NWR • North Grasslands Wildlife Area • Los Banos Wildlife Area • Volta Wildlife Area • Wetlands easements within the Grasslands Ecological Area • Proposed Grasslands Mitigation Bank
Tulare Basin	1,701,841	• Kern NWR • Pixley NWR • Mendota Wildlife Area • Coles Levee Ecosystem Preserve (6,059 acres) • Kern Water Bank HCP Conservation Bank (3,267 acres) • Potential wetlands on private lands

Key:
NWR = National Wildlife Refuge
USFWS = U.S. Fish and Wildlife Service

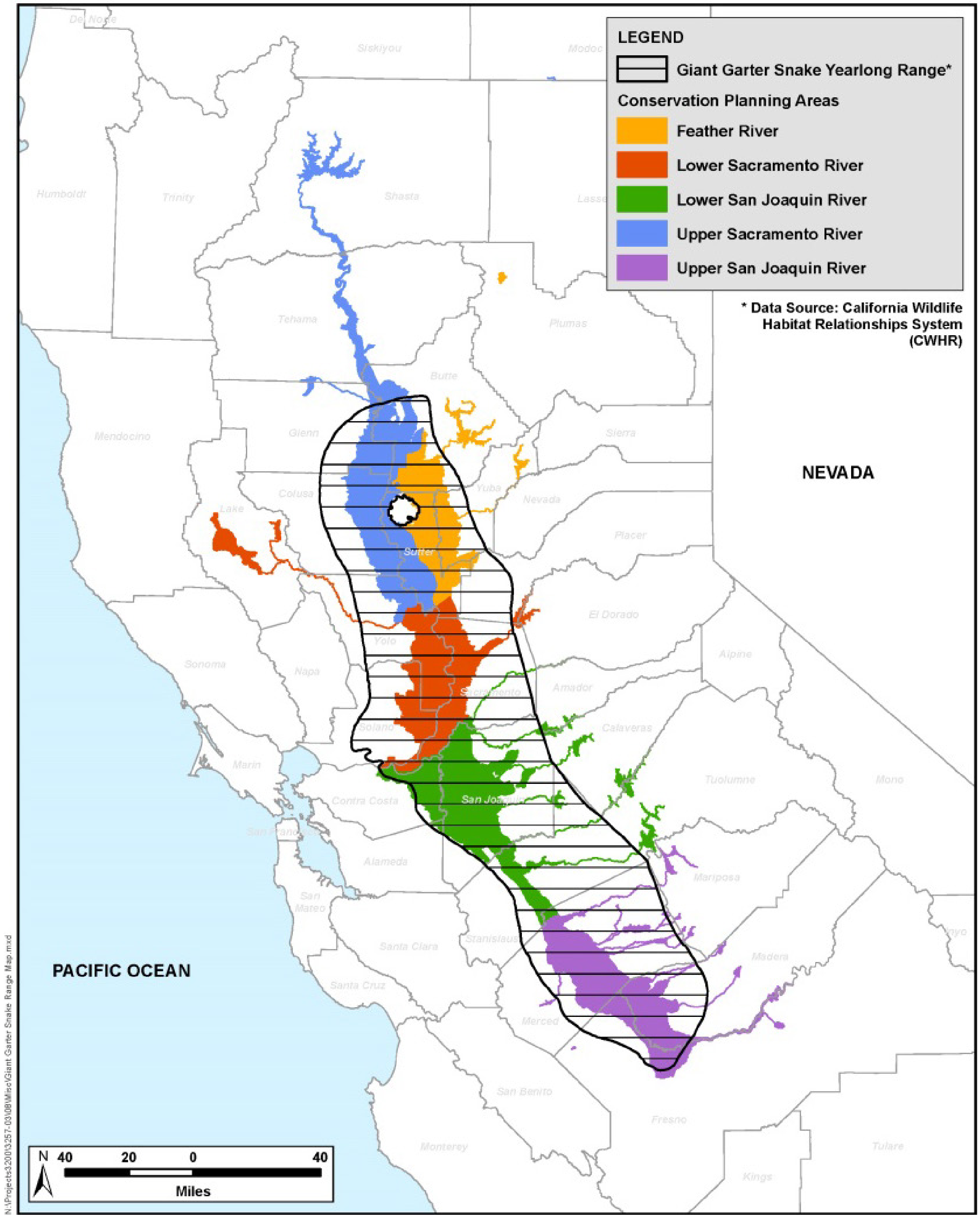

Figure 1. Distribution of the Giant Garter Snake in the SPA

Population Trends

Because giant garter snake populations are sparsely distributed and poorly documented, it is difficult to estimate numbers and evaluate the viability of this species. Much of the existing data is reported as the number of individuals or densities (individuals per unit area) detected during any given survey or monitoring effort.

Thirteen populations were identified in the 1993 listing and in the 1999 recovery plan. Based on two independent genetic studies (Paquin et al. 2006; Engstrom 2010), USFWS's 2012 status review reclassified these populations as representative of the watershed basins in which they occur and, as a result, some groups were combined. The 2012 review also determined that two populations had been extirpated (Yolo Basin-Liberty Farms and Burell and Lanare). There are currently nine populations, as previously described.

The abundance and distribution of giant garter snakes has not changed significantly since the 2006 status review, which likewise had identified very little change since the species was listed in 1993 (USFWS 2012). The populations north of the Delta Basin are believed to be relatively stable compared to the San Joaquin Basin population (USFWS 2012). In the San Joaquin Basin, subpopulations have suffered severe declines and possible extirpations over the last two decades; the alteration of the seasonal water cycle (as a result of incompatible agricultural practices) and predation of young snakes by bullfrogs (*Lithobates catesbeiana*) are likely the primary causes of decline (USFWS 1999; Wylie et al. 2003).

Wylie et al. (2010) performed a meta-analysis of previous mark-recapture studies to determine snake densities in four areas that represent a range of habitats, from rice agriculture (Natomas Basin) to managed seasonal marsh (Colusa NWR and Gilsizer Slough) to managed natural perennial wetland (Badger Creek). Results showed that the highest densities of giant garter snakes were located in natural marsh. Giant garter snake population density in Badger Creek was 8 snakes per hectare (2.47 acres), much greater than estimates of density for wetlands managed for waterfowl and agriculture (Colusa NWR had 0.83 snakes per hectare, Gilsizer Slough had 3.1 snakes per hectare, and Natomas Basin had 1.7 snakes per hectare). Badger Creek is believed to be the most representative of historical habitat conditions (perennial marsh habitat) (Wylie et al. 2010). Another finding of the study was that all four regions were determined to have equal or lower densities of giant garter snakes than the densities reported in the literature for other *Thamnophis* species (e.g., Rossman et al. 1996).

Life History and Ecology

The giant garter snake is sexually dimorphic (females are proportionally larger than males) and one of the largest snakes in the genus *Thamnophis*, reaching an average total length of approximately 64 inches and a weight of 1–1.5 pounds. This species can be distinguished from the common garter snake (*T. sirtalis*) and the western terrestrial garter snake (*T. elegans*) by its color pattern (lack of red lateral markings), scale numbers, and head shape. Coloration may vary individually and geographically among the five CPAs. Snakes from the Feather and Upper and Lower Sacramento River CPAs are typically darker, with a complete dorsal stripe that varies from bright yellow to orange or dull brown. Snakes from the Upper and Lower San Joaquin River CPAs often lack a distinct dorsal stripe, and may exhibit a black, checkered pattern along the back and sides.

Giant garter snakes are strongly associated with aquatic habitats, typically overwintering in small mammal burrows and crevices above prevailing flood elevations and near foraging habitat (Hansen and Hansen 1990). Burrowing mammals benefit giant garter snakes by providing burrows that are necessary for thermoregulation, shedding, and overwintering (Wylie et al. 1996, 1997). Annual activity varies with seasonal weather conditions, but generally giant garter snakes spend the cool winter months in dormancy or in periods of reduced activity, emerging from their overwintering hibernacula from March to early April to begin courtship, which spans into June (Hansen and Brode 1993; Wylie et al. 1997). Sexual maturity is reached at an average age of 3 years for males and 5 years for females (USFWS 1993). Females brood their young internally and give birth to live young from late July through early September; brood size is variable, ranging from 10 to 46 young (average 23) (Hansen and Hansen 1990). Upon birth, the young immediately scatter into dense cover and absorb their yolk sacs, after which they independently forage (USFWS 1999). Giant garter snakes remain active until the onset of cooler fall temperatures (Hansen and Hansen 1990). Typical daily activity consists of emerging from burrows after sunrise, basking to reach active temperatures, and foraging or courting for the remainder of the day (Hansen and Brode 1993).

The diet of giant garter snakes consists predominantly of aquatic prey, such as fish and amphibians. The snakes take advantage of aquatic habitats that trap and concentrate prey such as carp (*Cyprinus carpio*), mosquitofish (*Gambusia affinis*), other small fish, crayfish (*Pacifastacus leniusculus*), and bullfrogs (USFWS 1999, 2012). Known predators include raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), opossums (*Didelphis virginiana*), foxes (*Urocyon cinereoargenteus, Vulpes vulpes*), river otters (*Lontra canadensis*), predatory fish such as largemouth bass (*Micropterus salmoides*) and channel catfish (*Ictalurus* spp.), bullfrogs, hawks (*Buteo* spp.), northern harriers (*Circus cyaneus*), egrets (*Casmerodius albus, Egretta thula*), American bitterns (*Botaurus lentiginosus*), and great blue herons (*Ardea herodias*) (USFWS 1999).

Habitat and Ecological Process Associations

The giant garter snake is endemic to the wetlands of the Sacramento and San Joaquin Valley floors, inhabiting marshes, sloughs, canals, ponds, small lakes, low-gradient streams, rice fields and other agricultural wetlands, and the adjacent uplands (USFWS 2012).

The species' habitat requirements consist of:

- water adequate to provide food and cover during the snake's active season (April through October);

- emergent, herbaceous wetland vegetation, such as cattails (*Typha* spp.) and tule, which provide escape cover and foraging habitat during the active season;
- grassy banks and openings in waterside vegetation, for basking; and
- higher-elevation uplands with burrows, crevices, or other features that provide cover and refuge from floodwaters during the snake's dormant season (November through mid-March) (USFWS 2006).

A habitat suitability model (Halstead et al. 2010) indicated that the presence of giant garter snakes is negatively related to stream density and positively associated with stagnant or slow-moving water bodies with abundant emergent vegetation. Suitable habitat is also positively associated with a dense network of canals in close proximity to rice fields, wetlands, and open water (Halstead et al. 2010). Water conveyance structures and rice fields are now valuable components of giant garter snake habitat because the species' preferred tule marsh habitat is largely absent (Wylie et al. 1997; Halstead et al. 2010). Giant garter snakes generally do not occur in larger rivers or water bodies that support large predatory fishes; nor do they occur in wetlands with sand, gravel, or rock substrates (Hansen 1980; USFWS 1997).

Upland habitats used by giant garter snakes include small mammal burrows along canal banks, low-growing vegetation cover on or adjacent to aquatic habitat, and other areas with underground retreats that are located above flood elevations and may include some sun exposure (USFWS 1999). Upland habitat also provides cover for newborn snakes, and burrows are important habitat features for shedding, thermoregulation, and escape from predators. Riparian woodlands and other woody riparian vegetation are not suitable habitat because they provide excessive shade that reduces the availability of basking sites and have limited prey populations (Hansen 1980).

Perennial wetlands with emergent vegetation offer the best habitat for giant garter snakes; they do not persist in seasonal wetlands managed for waterfowl if there is no aquatic habitat available during the active season (April–October) (USFWS 2012). In the Central Valley, perennial wetlands have been replaced by rice fields and canals (Halstead et al. 2010), and historical habitats have diminished; consequently, giant garter snakes have become increasingly dependent on refuge systems, wildlife management areas, rice fields, and irrigation canals (USFWS 1999, 2006). Although the body condition of snakes is better and their population density is higher in natural wetlands, rice fields are more available and therefore support populations that may not be able to persist without them (Wylie et al. 2010). Wylie et al. (2010) determined that this species will persist in areas dominated by rice fields by foraging in the flooded fields after the plants have emerged, at which time the fields provide suitable cover for the snake and mimic shallow marsh habitat. In California, rice fields are flooded in late April or May, plants emerge in June, and the fields maintain water for most of the active season (until September). The canals that supply the rice fields with water also represent a reliable source of aquatic habitat, serve as movement corridors, and provide refugia for the snake.

Home range sizes and movement patterns vary by habitat quality and connectivity. Median home range estimates vary between 23 acres (range from 10.3 to 203 acres) in a seminative perennial marsh system and 131 acres (range from 3.2 to 2,792 acres) in a managed refuge (USFWS 1999). Giant garter snakes likely move more in poorer-quality habitats or during drier conditions to find prey (Wylie et al. 2000). They tend to be fairly sedentary, but are capable of moving long distances (up to 5 miles) (Wylie et al. 1997). However, long-distance movements put giant garter snakes at greater risk for mortality caused by vehicle strikes and predation (Wylie et al. 2000). Other factors limiting movement include fragmentation of natural wetlands, clearing of emergent and upland vegetation, ground disturbance or heavy equipment activity in and around upland areas such as levees, and rodent control; all of these can result in loss of burrow availability and temporarily contribute to loss of connectivity (LSA Associates 2009). The loss or dewatering of water conveyance structures that support rice fields also influences the species' distribution and movement (USFWS 2012). When dewatered, rice fields and canals lose all or most of their ability to support the species; radio tracking studies revealed that the snakes leave previously occupied rice crops when fallowing is continued for more than one season (Hansen 2008; Wylie et al. 2008; USFWS 2012). Studies on barriers and genetic exchange have shown that structures such as the Natomas Cross Canal and the East Side Canal in the American River Basin have contributed to fragmented habitat, resulting in potentially segregated giant garter snake populations in the Upper Sacramento River CPA (Hansen 2006).

The establishment of conservation banks, which create habitat for the species, may be an essential tool for giant garter snake conservation and recovery. Conservation banks are established to provide mitigation for impacts on giant garter snakes and their habitat. They incorporate a mosaic of wetland, upland, and open space habitat that accommodates the giant garter snake's year-round requirements. Approximately 2,400 acres of habitat have been created in California, with each conservation bank averaging 200 acres (USFWS 2011), and more conservation banks are being actively planned to benefit the species. Trapping efforts have confirmed that giant garter snakes are present in the following conservation banks: Sutter Basin, Gilsizer Slough South, Pope Ranch, and Ridge Cut. Conservation banks and other efforts to incorporate flood control management and wetland restoration (i.e., the Yolo Basin Wetland Project) simultaneously benefit giant garter snakes and other species that rely on a similar habitat mosaic.

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for giant garter snakes within the SPA (Figure 2). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by giant garter snakes within the SPA;
- the specific CPAs within which these habitat conditions occur;

- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Management Issues

Threats and Sensitivities Range-Wide

The primary threat to the giant garter snake is the loss, degradation, and fragmentation of habitat, including the conversion of rice farmland to dry crops and urban development. Conversion of Central Valley wetlands to agricultural and urban uses has already resulted in the loss of 95 percent of historical habitat for this species (Wylie et al. 1997). With increasing water scarcity, farmers are more frequently favoring crops that do not require inundation over water-intensive crops such as rice (USFWS 2012).

Another threat to giant garter snakes is direct mortality resulting from operation and maintenance of flood control facilities and canals: snakes can be killed by activities such as vegetation control (e.g., mowing and burning) and soil excavation and transport, and can be hit by vehicles when the snakes are crossing or basking on roads. Other factors that indirectly or secondarily affect the snake include groundwater pumping that reduces surface flows and water tables, diminishing water quality, introduced predators, nonnative aquatic plants that overtake wetlands and clog channels, vegetation control on floodway facilities and canals that reduces cover and prey availability, and floodway rodent eradication efforts (such as grouting and excavation of burrows and use of rodenticide) that ultimately reduce burrow availability. Finally, climate change could degrade aquatic habitats for giant garter snakes by reducing the availability of water in summer and generally exacerbating water scarcity (USFWS 2012).

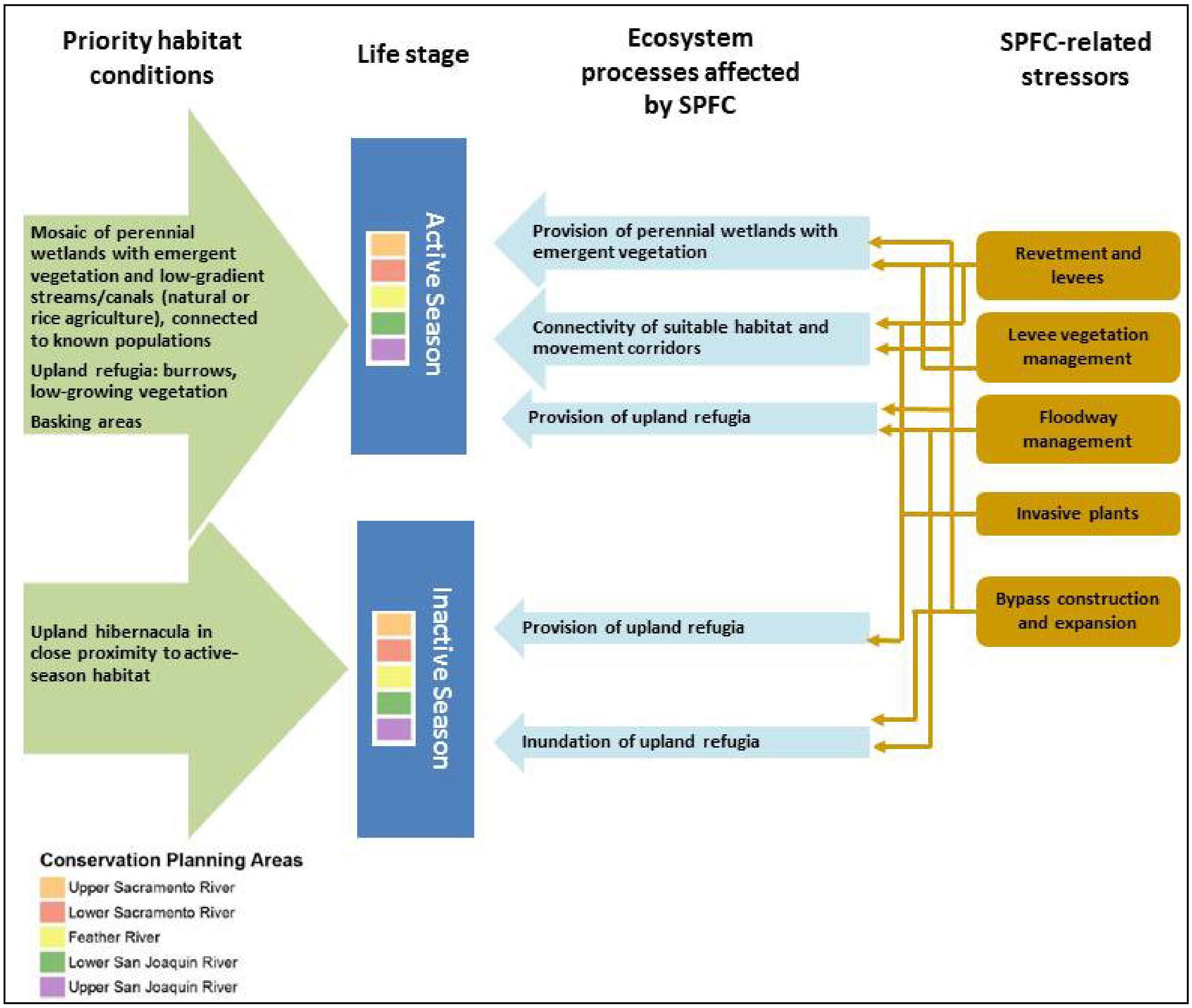

Figure 2. Conceptual Model for Giant Garter Snake within the SPA

Ongoing and Future Impacts

Ongoing and future impacts on the giant garter snake in the SPA include the direct and indirect effects of floodway and agricultural management practices (such as those discussed above), mortality caused by floods, and the effects of climate change.

- Maintenance of aquatic habitats for the purposes of flood control and agriculture may result in indirect impacts on, and direct mortality of, giant garter snakes (Hansen 1988; CDFG 1992; Hansen and Brode 1993). Maintenance activities may fragment and isolate habitats, preventing snake dispersal and colonization of suitable habitat, which is necessary for population growth and gene flow. SPFC operations, maintenance, and improvement activities involving weed eradication, grouting, excavation of rodent burrows, and ground disturbance could destroy underground burrows and retreats, causing direct mortality. The use of pesticides for rodent eradication could secondarily reduce burrow availability over the long term by eliminating species that create burrows. Use of erosion-control measures (plastic microfilament netting) and revetment could degrade aquatic and upland habitats. Giant garter snakes are known to use revetment for thermoregulation and to escape predators; however, revetment installed in conjunction with geotextiles would not be suitable for these purposes (Hansen pers. comm.). Finally, vegetation control practices, such as mowing in and around canals, ditches, and drains, could directly harm giant garter snakes or destroy their habitat (USFWS 2012). Without hydrologic links, the species' status will continue to decline because the snakes will be unable to move among suitable habitats, a limitation that also results in reduced genetic exchange (USFWS 2006).

- Flood events are known to displace giant garter snakes, especially when burrows and overwintering sites become inundated with water. This species is not known to occupy areas that are frequently inundated (e.g., major rivers); however, they are known to occupy the Sutter NWR (outside of the Sutter Bypass), Gilsizer Slough, and the Yolo Bypass in locations where flooding is less frequent during normal water years (Wylie et al. 2005; Hansen 2009b).

- Climate change is predicted to affect giant garter snakes in many ways: increases in air temperature may change behavioral patterns; reduced availability of water in summer is likely to alter habitat; parasites and disease may increase snake injuries and mortalities; the seasonal timing of life history events may be disrupted; and the species' prey base could diminish as prey animals respond to climatic variation (USFWS 2012).

Key Information Gaps or Uncertainties

To better understand giant garter snake ecology, the following additional information is needed: further investigation of the long-term effects of large-scale habitat loss, including the effects of changes in agricultural practices and associated land uses; data on movement corridors and population concentrations, especially in the southern end of the species' range; and more knowledge of the effects of pollutants on the species. These data gaps are discussed below.

- **Habitat loss.** Little is known about the effects of agricultural practices and land use changes on the species' population dynamics and viability (USFWS 2012). The long-term population response of giant garter snakes to large-scale habitat loss, particularly caused by water transfers, fallowing of rice fields, and crop-type conversion, is currently being investigated. The vulnerability of the species to such changes is likely to increase as water becomes scarcer; thus, conservation efforts will require useful data on optimal ways to counteract the effects of agricultural conversion.

- **Population dynamics in the SPA.** The population distribution, habitat use behavior, and activity patterns of giant garter snakes are not well understood, especially in the southern end of their range. The Upper and Lower San Joaquin River CPAs may support limited habitat for the species, so suitable areas may need to be actively managed to maintain any populations that occur there (USFWS 2012). However, management must be supported and informed by better mapping, more robust surveys, and additional data on population dynamics.

- **Pesticides, herbicides, and other environmental pollutants.** Water quality degraded by environmental pollutants likely poses direct and indirect threats to the giant garter snake. For instance, mosquito abatement measures that include spraying herbicides to control water hyacinth in aquatic environments shared by the snake may alter the species' prey base (USFWS 2012). Wylie et al. (2009) evaluated accumulations of trace elements in giant garter snakes and found that mercury concentrations in the tail clips were positively correlated with concentrations in livers and brains, with the most significant correlations occurring in the Natomas Basin population. In this study, tail clipping was shown to be a viable method of collecting nonlethal samples of these bioindicators and contaminant concentrations. Future studies should evaluate how agricultural pesticide and herbicide runoff are adversely affecting the species (USFWS 2012).

Conservation Strategy

Conservation and Recovery Opportunities

The most viable way to support the recovery of giant garter snakes is to increase and sustain suitable habitat and connectivity by encouraging restoration of adjacent habitat and creating large-scale conservation banks. In addition to suitable aquatic habitat, adjacent high-water refugia sites are needed to provide snakes with basking areas, hibernation chambers, and cover from predators and temperature extremes. Management and restoration activities that support the expansion of wetlands and upland transition zones in the SPA will benefit this species. Restoration designs that provide habitat, outside of riverine systems, that includes low-gradient channels with open water, vegetated emergent wetlands, and upland refugia from high-velocity flooding, will be essential for sustaining the long-term viability of giant garter snake populations. As an alternative to conservation banks, the establishment of suitable habitat coupled with flood management agreements that provide beneficial environmental conditions could work to contribute to the recovery of the species, as envisioned for the Yolo Basin Wetland Project. Additionally, supporting the viable continuation of rice agriculture and its infrastructure, along with practices that provide habitat connectivity and minimize stressors on the giant garter snake, will help maintain populations in agricultural areas.

Identified Conservation Needs

1. **Increase suitable habitat:** Habitat loss and degradation are the primary threats to giant garter snakes. This species relies heavily on a mosaic of perennial wetlands, rice fields, associated upland habitat, and associated water conveyance structures lined with vegetation. Such a mosaic is essential to maintaining the habitat connectivity and movement corridors on which the snake relies. Improving habitat in or adjacent to the bypasses, such as by incorporating perennial wetlands that support a suitable prey base,

vegetation for cover from predators, and upland refugia, may provide expansive suitable habitat that mimics historical conditions while also decreasing the giant garter snake's reliance on rice fields and canals. Incorporating habitat that straddles the bypass levees, coupled with habitat enhancement on those levees, would provide upland refugia during high-water events. Continuing to establish conservation banks or other initiatives (e.g., the Yolo Basin Wetland Project) that incorporate this habitat mosaic would be a valuable tool for protecting, conserving, and recovering the species.

2. **Maintain and provide habitat connectivity:** Giant garter snakes can move long distances (up to 5 miles), and travel primarily within aquatic systems. Providing and maintaining connectivity within and between suitable habitat and associated uplands is essential to ensuring the long-term viability of the giant garter snake population. Connectivity is required for movement between foraging and basking areas, uplands, and refugia, and is important for facilitating dispersal to other suitable habitat. Connectivity to overwintering habitat is also essential. Over time, dewatering of corridors, habitat fragmentation, and barriers to connectivity restrict gene flow among snake populations and increase their susceptibility to other impacts. To provide movement corridors, low-flow channels maintained to minimize invasive plants could be incorporated into bypasses that may provide suitable habitat for this species (i.e., the Sutter and Yolo Bypasses). Also, barriers to connectivity could be minimized or removed; these include features such as roads, which not only fragment habitats and block movement, but expose snakes to vehicle strikes, serve as conduits for contaminants and the spread of nonnative species, and change water quality (Fahig 1997; Enge and Wood 2002; Forman et al. 2003). In areas where roads cannot be removed, undercrossings such as appropriately designed culverts could facilitate the movement and dispersal of snakes (County of Sacramento et al. 2010). As previously noted, other barriers include levees and canals that prevent genetic exchange among isolated populations, such as the Natomas Cross Canal and the East Side Canal in the Upper Sacramento River CPA.

3. **Minimize environmental stressors:** Minimizing the effects of environmental stressors is essential for supporting the long-term viability of giant garter snake populations in the SPA. Operations and maintenance activities that occur in wetlands, rice fields, the water conveyance structures that connect them, and associated uplands could degrade or eliminate suitable giant garter snake habitat. Activities that involve dewatering rice fields or water conveyance canals, burrow disturbance or destruction, or mechanical vegetation management could displace, injure, kill, or prevent snake movement across habitat features when they are conducted in or adjacent to suitable habitat during the giant garter snake active season. When conducted during the inactive season (November through mid-March), while snakes are hibernating, activities that disturb or destroy burrows, such as grouting or excavating burrows or inundating habitat, could trap, drown, or otherwise kill giant garter snakes. To discourage or prevent snakes from occupying burrows where they would be exposed to hazards posed by maintenance activities (e.g., annual grouting and excavation), suitable upland habitat could be constructed as alternatives to levees and/or wetland habitat could be sited away from floodway structures and facilities.

Preactivity surveys could determine the presence or absence of snakes in burrows slated for grouting or filling.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the giant garter snake; these are summarized in Table 3 of this section. In many cases, the conservation needs of giant garter snakes can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward 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: Giant garter snakes are not adapted to severe flooding: they are known to occupy the Yolo Bypass during the active season when flooding is unlikely (Hansen 2009b), but they are not known to occupy the Sutter Bypass, which is flooded regularly (Wylie et al. 2005). Giant garter snakes may be displaced during flood events, buried by debris, exposed to predators, and subject to drowning when inundation occurs in upland burrows or overwintering sites (USFWS 2012). Upland or high-ground areas are a required habitat feature for the snakes because they serve as refugia during the active season and as hibernacula during the inactive season. Thus, flooding and eliminating burrows in upland areas represent conflicts between floodwater management needs and giant garter snake survival.

Facility maintenance: Facility maintenance practices have the potential to directly harm giant garter snakes. As stated, giant garter snakes use burrows throughout the year, as temporary refugia from predators and from environmental extremes in the active season, and often as hibernacula in winter. During the inactive season (November through mid-March), giant garter snakes may travel up to approximately 800 feet from aquatic and marsh habitats to hibernate (Hansen 1988; Wylie et al. 1997). Grouting and excavating holes on levees during the active and inactive seasons may trap snakes that are inside their burrows. Facility maintenance activities such as mowing, burning, dragging, disking, minor excavating and backfilling, applying pesticides, and grouting or excavating burrows during the active season (April–October) may also directly injure or kill snakes. Constructing suitable upland habitat in areas that are not subject to frequent maintenance activities or flooding would assist with the recovery of the species while reducing conflicts between snakes in burrows and floodway maintenance practices.

Table 3. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Giant Garter Snake[a]

CVFPP Management Actions	Conservation Need		
	1. Increase Suitable Habitat	**2. Maintain and Provide Habitat Connectivity**	**3. Minimize Environmental Stressors**
Operations, Maintenance, and Floodway Management			
Floodwater storage and reservoir forecasting, operations, and coordination	-	-	-
Facility maintenance	-	-	-
Levee vegetation management	-	-	-
Floodway maintenance			
Modification of floodplain topography	+	+	+
Support of floodplain agriculture	+/-	+/-	+/-
Invasive plant management	+	+	+
Restoration of riparian, SRA, and marsh habitats	+	+	+
Wildlife-friendly agriculture	+	+	+
Structural Improvements			
Levee and revetment removal	+/-	+/-	+/-
Levee relocation	+/-	+/-	+/-
Bypass expansion and construction	+/-	+/-	+/-
Levee construction and improvement			
Flood control structures			

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

Levee vegetation management: Management of vegetation on levees near giant garter snake populations would remove surface cover, and burning or mowing may also kill giant garter snakes. As previously discussed, when possible, it is best to proactively discourage the establishment of burrows on levees to avoid unintended take of the species during maintenance activities such as grouting and excavating holes and burrows. Where habitat occurs on levees and other areas that need to be maintained, vegetation management activities coupled with preactivity surveys could be scheduled for the species' active season to avoid harming dormant snakes, and could be modified to preserve some vegetative cover and reduce the likelihood of directly harming snakes. For example, the height of mower blades could be set at 6 inches or greater from the ground. Also, low-intensity grazing by sheep or goats that would not entirely remove vegetation could be a valuable management tool. Controlled grazing by sheep or goats would have less impact on giant garter snake habitat than cattle grazing (ICF International 2011).

Modification of floodplain topography: Strategically lowering floodway elevations to form marshes and modifying the floodway to achieve greater topographic and hydrologic diversity could create habitat conditions that support giant garter snakes, especially in the Yolo Bypass, Sutter Bypass, and areas near the confluence of the Sacramento and Feather Rivers. Supporting a mosaic of marsh habitat and high-water refugia could create movement corridors, basking sites, and burrowing opportunities in close proximity to foraging sites.

Support of floodplain agriculture: Agricultural lands, in particular rice fields and associated canals and infrastructure, provide essential habitat to giant garter snakes. The abundance of giant garter snakes in the Sacramento Valley compared to the San Joaquin Valley may reflect the availability of alternative habitat provided by rice fields (USFWS 2012). However, rice fields provide lower-quality habitat, with lower densities of giant garter snakes than are found in naturally occurring perennial marsh (Wylie et al. 2010). Nevertheless, conversion of rice fields to other crop types could threaten the giant garter snakes because, unlike rice, other crops do not hold sufficient water for long enough to create a surrogate for temporary wetlands (USFWS 2012).

Invasive plant management: Invasive plant management would generally provide benefits to giant garter snakes. In aquatic areas, invasive plants can form dense patches and diminish open-water marsh, excluding giant garter snakes from previously suitable habitat. Hansen et al. (2010) evaluated the response of giant garter snakes to invasive plant removal in a marsh along Badger Creek in the Cosumnes Preserve, where densely growing water primrose was eliminating open water. After aggressively removing the plants mechanically, then dredging the open area to restore the marsh to its original state, the newly restored habitat appeared to create suitable open-water foraging opportunities and successfully attracted giant garter snakes to the marsh. In uplands, invasive plants such as yellow star-thistle (*Centaurea solstitialis*) and milk thistle (*Silybum marianum*) form dense stands, which could potentially preclude the use of these areas by giant garter snakes. Although invasive plant removal is beneficial, caution must be used, when applying chemical or mechanical removal methods, to avoid disturbing or injuring snakes, or otherwise degrading their habitat conditions or affecting their behavior (USFWS 2012). Also, treatments for yellow star-thistle and milk thistle must be chosen to prevent further propagating the weeds; for example, mowing often results in worse infestations. See Appendix D of the Conservation Strategy (“Vegetation Management Strategy”), for approaches to addressing invasive plants and providing native vegetative cover.

Restoration of riparian, SRA cover, and marsh habitats: Restoration actions that support giant garter snakes would focus on creating, improving, or preserving marsh habitats adjacent to current giant garter snake populations. Marsh habitat could be created or restored in areas such as the Yolo and Sutter Bypasses and near the confluence of the Sacramento and Feather Rivers. Marsh restoration has been shown to successfully provide suitable open-water foraging habitat for this species. Historically, oxbows and backwater areas may have provided suitable habitat; however, river channelization has eliminated the processes that create and sustain these features. See “Levee relocation,” below, for a discussion of how natural processes could be restored to create suitable habitat and indirectly benefit giant garter snakes. In contrast to marsh restoration, establishment of new riparian areas, which typically include SRA, would not contribute suitable habitat for the species. However, riparian areas may provide some connectivity among suitable, occupied habitats.

Wildlife-friendly agriculture: As discussed under "Support of floodplain agriculture," giant garter snakes use rice fields because they act as surrogates for the perennial wetland habitats on which the snake historically relied. Approximately 500,000 acres of rice croplands have been cultivated annually since 1996 (California Rice Commission 2011), with most rice production occurring in the Sacramento Valley. This acreage represents a substantial amount of habitat that could be used, or is being used, by giant garter snakes.

Fallowing of rice fields can have significant and complex impacts on the snake: long-term fallowing may diminish or eliminate habitat, but it is unclear what effects short-term fallowing practices may have (USFWS 2012). Although the giant garter snake population would be adversely affected by fallowing that results in barren fields and dewatering of nearby water conveyance structures (USFWS 2012), the species might benefit from short-term fallowing conducted as part of a crop rotation program that incorporates irrigation, because such a system could improve water quality by flushing contaminants and may promote prey production (Wylie et al. 2002; Hansen 2008).

Agricultural practices such as tilling, grading, harvesting, or mowing may kill or injure giant garter snakes, so the timing of these activities could be considered as part of developing wildlife-friendly farming methods (CDFG 1992). During the active season, giant garter snakes would benefit if water levels were maintained in canals and ditches and if vegetation in these conveyances were managed to facilitate snake movement and dispersal. Also, giant garter snakes have been observed to overwinter near canals in or adjacent to rice fields, making them vulnerable to agricultural management activities (USFWS 2012); therefore, during the species' inactive season, soil disturbance of these areas could be avoided.

Structural Improvements

Levee and revetment removal: Although removing revetment and levees would improve natural geomorphic processes in riverine environments, giant garter snakes would not directly benefit from these actions because their preferred habitat is outside the floodway of large rivers. Levee and revetment removal in smaller stream and channel systems where giant garter snake habitat is present (i.e., Wadsworth Canal and Cherokee Canal) could benefit the species. Levees currently provide high-water refugia for giant garter snakes, but represent hazardous sites for such habitat, because of the risk that snakes will be injured or killed by facility operations and maintenance activities (see "Facility maintenance" for a list of current practices that may be hazardous to the species). Removing levees would therefore create a need and opportunity to provide safer and more suitable alternative upland habitat.

Levee relocation: Relocating levees farther from rivers (i.e., constructing setback levees) is an important approach to creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. In bypasses, setting levees back would create larger floodplains, and wetland and marsh habitat could be restored in these areas to provide foraging habitat for giant garter snakes. In the Yolo and Sutter Bypasses and in areas near the confluence of the Sacramento and Feather Rivers, removing levees and expanding suitable aquatic habitat could create an opportunity to connect existing suitable habitats and provide safe upland refugia, which are important habitat components for giant garter snakes.

Bypass expansion and construction: The expansion of bypasses would add agricultural land and natural vegetation to the floodway and would result in periodic, prolonged inundation of land that was previously isolated from the river system by levees. The duration and amount of inundation of the floodplain may affect giant garter snakes. This species is not known to occupy areas that are frequently inundated (Sutter Bypass) (Wylie et al. 2005), but they are known to occupy the Yolo Bypass where frequent flooding is unlikely (Hansen 2009b). Nevertheless, if appropriate marsh habitat restoration were implemented in the Sutter Bypass, it could provide suitable habitat for the species. Infrequent, low-velocity flooding of new bypass areas could benefit giant garter snakes, especially if they are provided with suitable high-water refugia where snakes and their burrows are not threatened by maintenance activities, as previously discussed. As stated under "Levee relocation," incorporating setback levees in the bypasses would provide opportunities to restore and enhance habitat for the giant garter snake.

Recovery Plan Alignment

The objective of the *Revised Draft Recovery Plan for the Giant Garter Snake* is removal of the species from the federal list of endangered and threatened wildlife; the federal recovery priority number for the giant garter snake is 2C: full species, high degree of threat, high recovery potential (USFWS 1999). Recovery criteria for the giant garter snake are defined for the nine population and recovery units in the Central Valley. The general recovery criteria are as follows:

a. Sufficient habitat is protected to support populations of giant garter snakes.

b. Populations are connected with corridors of suitable habitat.

c. Management plans and best management practices oriented to giant garter snake conservation are developed and implemented (and adaptively updated based on current research).

d. Protected habitat is supplied with a reliable source of clean water during the critical active summer months.

e. Threats due to disease are reduced or removed.

f. Monitoring in recovery units demonstrates stable or increasing populations and evidence that the identified populations and their habitats are viable over a 20-year period including at least one 3-year drought.

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 giant garter snake. Therefore, building on the preceding discussion, this section of the giant garter snake 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 4). 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 marsh is an indicator of progress toward the Conservation Strategy's marsh habitat objective. To measure the contribution of CVFPP actions to conservation of the giant garter snake, requirements would be added to increase the acreage of the perennial wetland habitat required by the species.

Table 4 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of giant garter snakes, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit the giant garter snake may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 4. Measures of Contribution of CVFPP Actions to Conservation of the Giant Garter Snake

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	No	Floodplains on the water side of levees are not typically considered habitat; however, consider including giant garter snake habitat components in floodplains within bypasses, areas on the land side of levees, and in areas where floodplain is added or expanded in channels known to support giant garter snakes. Suitable habitat in bypasses is dependent on the frequency and duration of flooding.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	
	River Meander Potential—total amount (acres)	No	
SRA Cover	SRA Aquatic Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	No	
	Habitat Connectivity—median patch size (acres)	Yes	Consider the potential for riparian habitats to provide connectivity. Although riparian habitat is generally unsuitable for the giant garter snake, low-gradient streams with sparsely vegetated banks may connect suitable habitat for the species.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Create or support marshes that are inundated during the active season, include suitable habitat components (cover, upland refugia, and basking sites), and maintain connectivity to known occupied habitat. Provide paired blocks of habitat composed of two 539-acre blocks of buffered perennial wetlands. The paired blocks should not be separated by more than 5 miles and should be connected by a corridor of aquatic and upland habitat not less than 0.5 mile wide. Paired blocks should be buffered by 0.32 mile of compatible habitat.

Table 4. Measures of Contribution of CVFPP Actions to Conservation of the Giant Garter Snake

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	Increase the extent of rice managed to enhance habitat values for giant garter snakes, especially in the San Joaquin Valley. Provide paired blocks of habitat composed of one block of 539 acres of contiguous buffered perennial wetland and a second block of 1,578 acres of contiguous active rice fields. The paired blocks should not be separated by more than 5 miles and should be connected by a corridor of aquatic and upland habitat not less than 0.5 mile wide. Paired blocks should be buffered by 0.32 mile of compatible habitat.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	No	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	Levee relocation would most benefit the species where it positively affects smaller streams and channels known to support giant garter snakes, or if located near their habitat, with planned connectivity.
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	Target invasive plants for removal in the marshes of the Sutter and Yolo Bypasses and in channels used by giant garter snakes.

Key: EAH = expected annual habitat.

Note:

[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 2 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).

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G10. Focused Conservation Plan: Bank Swallow

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the bank swallow (*Riparia riparia)* and its habitat in the SPA for the CVFPP. Currently, approximately 75 percent of California's bank swallow population occurs along the banks of the Sacramento and Feather Rivers (CDFG 2000), corresponding with the Feather River CPA, the Upper Sacramento River CPA, and to a lesser extent, the Lower Sacramento River CPA.

The bank swallow is a migratory bird species that was listed by the State as a threatened species under CESA in 1989. A recovery plan was published in 1992 in response to the listing (CDFG 1992). The bank swallow is also a focal species in *The Riparian Bird Conservation Plan* (Riparian Habitat Joint Venture [RHJV] 2004) and The Nature Conservancy's program, Linking Biological Response to River Processes (Stillwater Sciences 2007). Recently, the Bank Swallow Technical Advisory Committee (BANS-TAC) developed a *Bank Swallow Conservation Strategy for California* (2013). The bank swallow is not listed under the ESA; however, it is protected by the federal Migratory Bird Treaty Act and CESA (14 CCR 670.5 and California Fish and Game Code Sections 3503, 3503.5 and 3513).

Status and Trends

Distribution

Bank swallows are migratory birds with a Holarctic breeding range: they nest in colonies throughout North America, Europe, and Asia, and winter in South America and Africa (Garrison 1999). In California, bank swallows historically bred along lowland rivers, with some populations occurring along central and southern coastal sites from Santa Barbara County south to San Diego County where alluvial soils exist (Grinnell and Miller 1944). Bank swallow nesting colonies have also been found in artificial sites such as sand quarries, road cuts, and other off-river sites; these types of nesting colonies are uncommon, but have been documented in Siskiyou, Shasta, Lassen, Plumas, San Joaquin, and Inyo Counties (Garrison 1999; BANS-TAC 2013). In 1978, Remsen documented the extirpation of bank swallows from southern California, as well as a declining bank swallow population in the Sacramento Valley. Remsen attributed these losses, in part, to flood control and bank protection projects (Remsen 1978). Statewide, further significant declines were observed after the species was listed in 1989 (see "Population Trends," below).

Currently, approximately 75 percent of California's breeding population of bank swallows is found in the cut banks of the Feather River and Sacramento Rivers, and 90 percent of this population occurs along the stretch of the Sacramento River between Red Bluff (River Mile [RM] 243) and Colusa (RM 143). The Sacramento and Feather Rivers currently support most of the state's breeding population because the relatively unconstrained river reaches meander and contribute to the erosion of banks containing soils suitable for banks swallow burrows (Garrison 1999; Moffatt et al. 2005; Silveira 2008).

The historical and current bank swallow distribution in California shown in Figure 1 was mapped by BANS-TAC (2013).

Population Trends

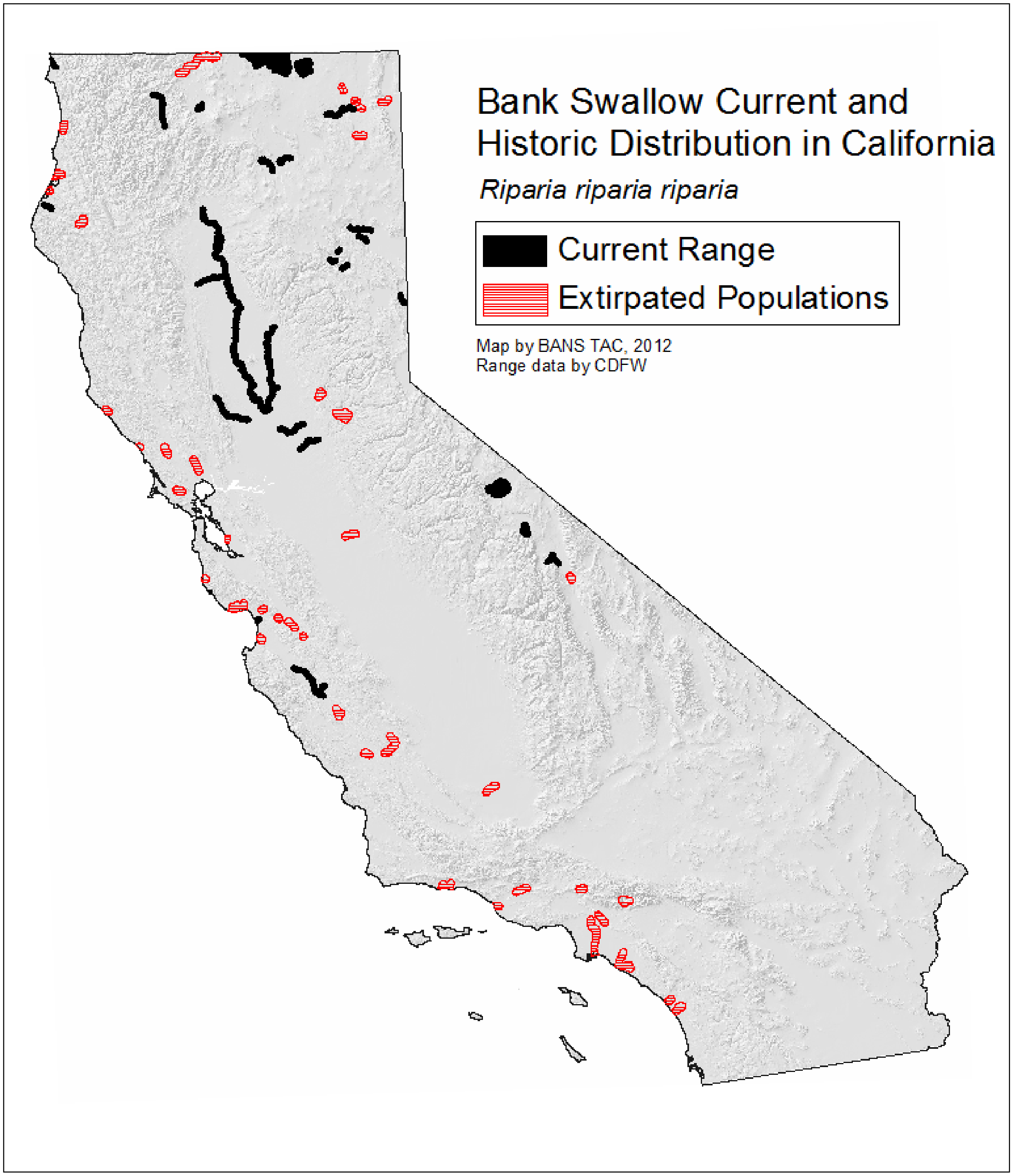
Sacramento River: Bank swallow surveys have been conducted along the Sacramento River between Red Bluff and Colusa in partnership with CDFW since 1986 and with USFWS since 1999 (Laymon et al. 1988; Schlorff 1997; Hight 2000; Garcia et al. 2008; Wright et al. 2011). The number of nesting pairs is difficult to assess directly; most studies use burrow counts and occupancy rates to convert the data to derive a rough estimate of nesting birds. The 1992 recovery plan for the bank swallow documented a 39 percent population decline along the Sacramento River, from approximately 13,000 pairs at the time of listing to a low of 7,525 pairs in 1991 (CDFG 1992). Studies have found that the population of bank swallows using the Sacramento River system has declined since 1986. In 1999, there was a population increase and period of stability; however, the population has not rebounded to the numbers recorded in the late 1980s (BANS-TAC 2013; Garcia et al. 2008).

Two Population Viability Analyses (PVAs) were conducted using the Sacramento River survey data (Buechner 1992; Girvetz 2007). The Girvetz PVA, which incorporated demographic and spatial parameters and corroborated with the Buechner PVA, suggested that there is a 21 percent chance that the Sacramento River bank swallow population will decline to fewer than 2,000 individuals within the next 50 years (i.e., by 2057). Results also suggested that habitat loss caused by placement of rock revetment was responsible for reducing the population's viability by approximately 50 percent (Girvetz 2007).

Feather River: In 1987, CDFW conducted a survey along the Feather River from Verona to Oroville and found 18 colonies with 6,592 burrows; these data were translated to correspond with a population estimate of approximately 2,960 pairs (Laymon et al. 1988). DWR estimated the population to be 1,023 pairs in 2002 and 1,617 pairs in 2003. Since 2008, DWR has conducted annual bank swallow surveys along the Feather River; the resulting annual population estimate reached its lowest value, 824 pairs, in 2010. The most recent estimate for this portion of the Feather River (2012) was 1,133 pairs (BANS-TAC 2013).

Colony Persistence

Garcia (2009) found that all bank swallow colony size classes and lengths of colony activity are important to annual population dynamics and stability. Large colonies may produce more offspring if the nesting habitat is relatively extensive and erosional processes are consistent. However, populations consisting of a few large colonies are at greater risk of population crashes



Source: BANS-TAC 2013; reproduced with permission

Figure 1. Current Bank Swallow Distribution and Extirpated Populations in California

during stochastic environmental events (such as high flows in the nesting season). Small colonies may not be spatially persistent, but they are highly mobile and exhibit the flexibility needed to colonize localized and ephemeral habitat patches that may be exposed periodically. All colony size classes contribute to population stability and growth and should be accommodated by appropriate management actions in order to contribute to the success of the species.

Life History

Bank swallows are medium- to long-distance Holarctic breeding migrants that, in the New World, breed from Alaska and Canada south to the southern United States and northeastern Mexico. These birds winter in Mexico, Central America, the West Indies, and northern South America. They typically leave their winter range in February and begin arriving on the breeding grounds in California in late March to seek suitable nest locations, with most arriving in late April and early May (Garrison 1998). Bank swallows nest in colonies, typically in tall, vertical channel banks with friable soils along streams and lakes, and in coastal areas.

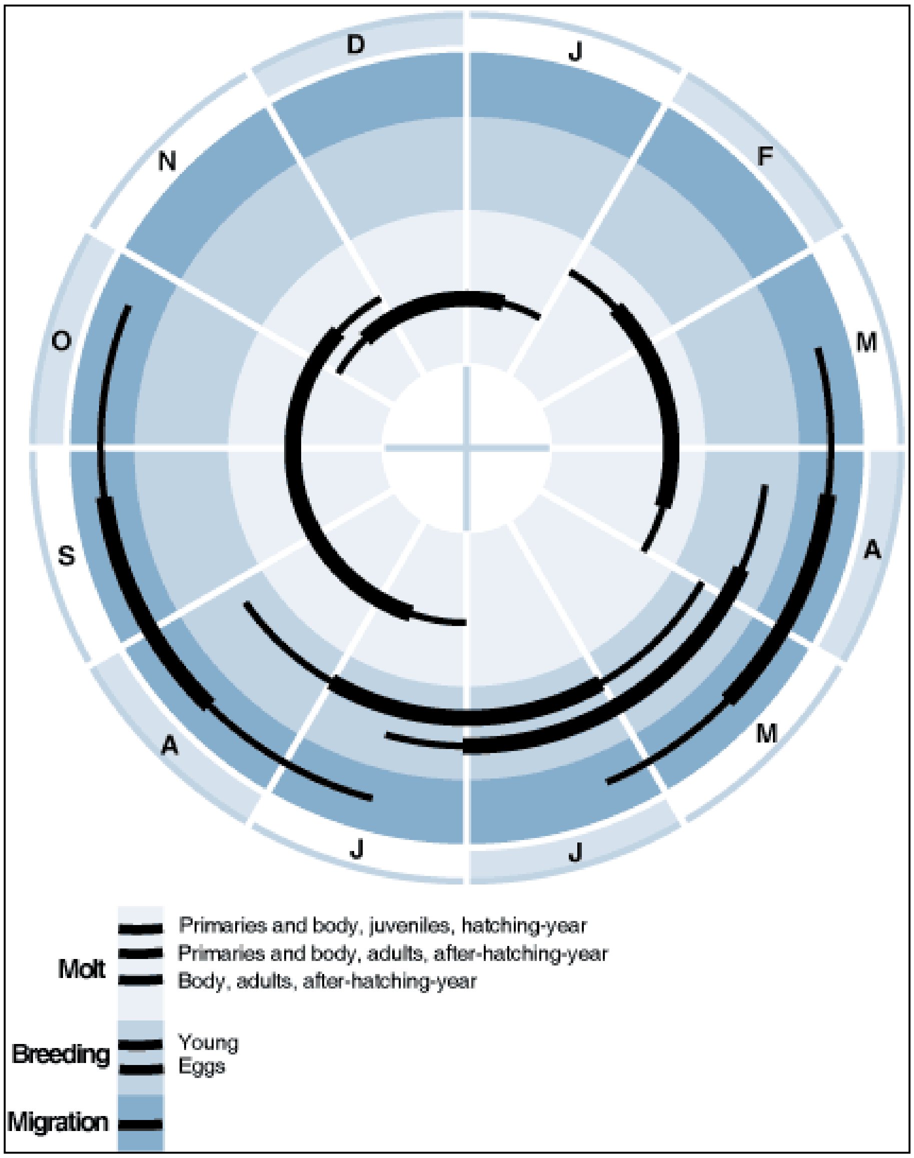
In the Feather River and Upper and Lower Sacramento River CPAs, bank swallows nest in cut channel banks created by lateral channel migration. Recently, colonies have been observed to occur on smaller tributaries (Cache Creek), near the Fremont Weir, and in the San Joaquin Valley (Melcer pers. comm.). Approximately 70 percent of nest sites along the Sacramento and Feather Rivers consist of 10–340 burrows (Schlorff 1997; Garcia 2009), with a typical burrow occupancy rate of 60 percent (Garrison et al. 1987; Wright et al. 2011).

Bank swallows arrive at nesting colony sites in flocks of usually unpaired males and females, with approximately balanced sex ratios of older, experienced birds visiting traditional nesting colony sites (Kuhnen 1985). Flocks arrive separately in different areas with suitable habitat, and pair-formation activities are synchronized within these areas; thus subcolonies are formed (Petersen 1955; Kuhnen 1985). Before beginning to form pair bonds, birds typically spend 2–3 weeks foraging, and males begin to excavate burrows.

Selection of burrow sites is affected by the presence of conspecifics: individuals are more likely to visit areas of high burrow density than areas of low density (Sieber 1980). Burrow excavation takes an average of 4 to 5 days to complete, depending on weather conditions and soil (Sieber 1980; Turner and Rose 1989). Nest building begins immediately after the burrow is completed, taking an additional 1–3 days (Asbirk 1976; Sieber 1980). Bank swallows lay 3–5 eggs, with peak egg-laying occurring between mid-April and mid-May. Egg incubation ranges from 13 to 16 days, and is primarily done by the female. Hatching of the entire brood takes 2–3 days. Nestlings are fed insects until they move out of the burrow, and fledging occurs by mid-July. Bank swallows single-brood in North America, although replacement clutches are produced if nests fail during the early or middle part of breeding season. Colonies are vacant by late July or early August, and migrants are typically observed through mid-September.

Bank swallows usually forage in flight, both individually and in flocks, consuming mainly flying or jumping insects (Beal 1918; Turner and Rose 1989; Garrison 1999). Most insects taken by bank swallows are terrestrial and not dependent on surface water (Garrison 1998), so adjacent natural areas such as grasslands and intact riparian vegetation are important foraging habitat for this species. Bank swallows have been documented using a variety of habitats for foraging, including wetlands, open water, grasslands, riparian woodlands, orchards, agricultural fields, pastures, bogs, shrublands, and upland woodlands (Stoner 1936; Gross 1942; Turner and Rose 1989; CDFG 1992; Garrison 1999). Garcia (2009) reported that bank swallow colonies along the Sacramento River were more strongly associated with native riparian habitats, including herbaceous cover, scrub, and forest, than with orchards.

The *Birds of North America* annual cycle for the bank swallow is shown in Figure 2.



Source: Garrison 1999, in The Birds of North America Online; reproduced with permission

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

Figure 2. Annual Cycle of Breeding, Migration, and Molt of the Bank Swallow

Habitat and Ecological Process Associations

Bank swallow populations rely on breeding habitat that is created by natural river dynamics. Natural riverine meandering processes and annual erosional processes create and expose vertical cut banks that can be colonized by bank swallows. However, suitable bank habitat is ephemeral; over time, most banks eventually slump and collapse, either because of natural sloughing or as a result of human activity or destruction of nest sites.

The renewal of suitable habitat by natural riverine processes is essential to the stability of bank swallow populations. Because of the ephemeral nature of their habitat, individual bank swallows have relatively low nest-site fidelity (Freer 1979), but entire nest colonies may persist in a given area as long as suitable habitat remains. Over time, bank slumping leads to reduced steepness, increased predator access, and more opportunities for vegetation to colonize the bank face; all of these factors gradually make the habitat unsuitable for bank swallows. Also, burrow collapse represents a significant cause of death for young birds (Schlorff 1997). Regular, natural resurfacing of slumped habitat reduces the vegetation encroachment and risk of nest predation posed by the older, slumped banks (Garrison et al. 1989; Garrison 1998). Erosional processes may also be beneficial to bank swallow populations in other ways: ectoparasites that could reduce the reproductive success of swallows (Szép and Møller 1999) may be deterred by regular establishment of new burrows (Moffatt et al. 2005). In sum, bank swallows rely on the continual erosion of bank substrate to renew nesting habitat in which they can excavate burrows.

Erosion of banks is directly affected by river discharge (Buer et al. 1989; Mount 1995), and the timing of high flows is critical to protecting and creating suitable habitat. Moffatt et al. (2005) determined that large increases of discharge to the Sacramento River (and subsequent erosion events) before the nesting season (1 September–31 March) could increase colonization probabilities; however, high flows during the breeding season (1 April–1 August) may cause undercutting that could slough off active colonies (Humphrey and Garrison 1987), and bank-full flows could drown nestlings. Bank-full or near bank-full events have been shown to resurface banks, but colonies can become inundated whenever water surface elevation rises by about 1.6–3.3 feet or more (Melcer pers. comm.). On the Sacramento River, flows in the range of 14,000 to 30,000 cfs have been associated with localized colony collapse and failure. Higher flows (50,000 to 60,000 cfs) can also cause extensive bank erosion. Understanding the effects of flow timing and volume will be useful in managing dam releases to minimize colony loss and to renew habitat in the SPA.

Natural erosion, because it is necessary for renewal of nesting habitat, is also highly associated with colony persistence. Colonies are located on cut banks and bluffs composed of friable soils, which are excavated by bank swallows to create burrows. Garcia (2009) analyzed 9 years of data collected by CDFW along a 100-mile stretch of the Sacramento River in the Upper and Lower Sacramento River CPAs (between Red Bluff and Colusa). The analysis determined that colony numbers and total number of burrows were similarly distributed across the study area: because of erosional patterns, larger, more persistent colonies (8–10 years) tended to be located in the upstream reach, and small and medium-sized colonies tended to be located in the downstream reach (Garcia 2009). Small and medium-sized colonies were the most common size class, and they tended to remained active for 1–2 breeding seasons, echoing Garrison's (1999) results, which indicated that overall colony persistence tends to be 2–3 years.

Bank swallow populations also rely on the foraging habitat provided by grasslands and riparian vegetation adjacent to their breeding habitat. Although bank swallows primarily select their nesting locations based on soil type and bank slope (Garrison 1989), the vegetation communities adjacent to nesting sites play an important role in bank swallow survival because they provide prey resources for swallows and their young during the nesting season. When feeding nestlings, bank swallows are commonly observed foraging within 164–656 feet of nesting colonies (Turner and Rose 1989; Garrison 1998), underscoring the importance of incorporating suitable foraging habitat adjacent to nesting colonies to achieve species conservation.

It has been documented that the majority of bank swallow colonies along the Sacramento River are located next to open areas such as grasslands (Humphrey and Garrison 1987), cultivated crops (e.g., irrigated row crops and dryland grain crops) (Garrison 1998), or native riparian vegetation, including herbaceous cover, scrub, and forest (Garcia 2009). Moffatt et al. (2005) assessed the potential benefits of different restoration strategies for a population of bank swallows along the Sacramento River and determined that direct restoration of nesting habitat through removal of 10 percent of existing rock revetment, combined with restoration of adjacent riparian forest and native grassland habitat, could increase the probability of colonization and may be important for the viability of bank swallow populations.

Available and potentially suitable bank swallow breeding habitat along the Sacramento and Feather Rivers varies because of geomorphic processes and physical constraints such as levees and dams. In Reach 1 of the Sacramento River (Shasta Dam to Red Bluff), there is some river meander, but natural geology limits the meander potential of the river in much of the reach. Reach 2 (Red Bluff to Chico Landing) and Reach 3 (Chico Landing to Colusa) currently provide the largest amount of suitable vertical cut banks in the SPA, in part because some of the levees in these reaches are set back from the river, encouraging natural meander and facilitating erosional processes that create suitable nesting habitat. However, there is also a substantial amount of revetment on private land in these reaches, which limits the maximum potential of these beneficial processes. Compared to Reaches 2 and 3, Reach 4 (Colusa to Verona) currently provides less cut bank habitat for bank swallow colonies, because the river is constrained and revetment is present along the banks. Along the Feather River, the channel is constrained by geological features caused by historical mining: deposition of tailings in and along the river has created an impenetrable layer of debris. Although ephemeral colonies of bank swallows occur along the Feather River, potentially suitable nesting areas are limited by the natural substrate, historical mine tailings, and the presence of revetment on the banks.

Beyond the Sacramento and Feather Rivers, off-river colonies have been documented in San Joaquin County, and it has been suggested that bank swallows could colonize the San Joaquin Valley in response to habitat restoration efforts in that area (BANS-TAC 2013). However, the probability of colonization in the San Joaquin Valley is unknown, because the valley is outside the bank swallow's historical range; also, climate change models have predicted a northward shift in bank swallow distribution in California (Ballard et al. 2008).

Little information exists regarding bank swallow wintering habitat; however, birds have been recorded in grasslands, savannas, open agricultural areas, and freshwater and brackish wetlands in South America (Garrison 1999). These important wintering habitats may be undergoing loss or conversion to less suitable habitat, further contributing to this species' decline.

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for bank swallows within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by bank swallows within the SPA;
- the specific CPAs within which bank swallows breed;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Management Issues

Threats and Sensitivities

Throughout California, bank swallow populations have been negatively affected by direct mortality (e.g., colony collapse), as well as by loss of suitable nesting and foraging habitat caused by land conversion, rock revetment projects, and flood management activities (Remsen 1978; Humphrey and Garrison 1987; CDFG 1992; Schlorff 1997).

Loss of Nesting Habitat and Causes of Direct Mortality. Nesting habitat continues to be lost as a consequence of bank stabilization and revetment projects. The use of revetment to stabilize banks prevents natural meander and erosional processes, reducing available suitable nesting habitat and preventing the renewal of habitat along channel banks. In fact, the destruction of suitable colony sites through the use of rock revetment in bank protection and flood control projects presents the most significant current threat to bank swallows in the SPA (Garrison et al. 1987). Construction of erosion control projects at active nesting sites during the breeding season has also caused direct mortality of adult and nestling birds (Garrison 1991; Schlorff 1995; Garcia et al. 2008). Finally, the timing and magnitude of reservoir releases for flood management and agriculture have negatively affected active bank swallow colonies by inundating nesting sites and triggering bank sloughing (Stillwater Sciences 2007). If alternatives to rock revetment and effective mitigation techniques are not developed, long-term survival and eventual recovery of this species is unlikely (Buechner 1992; CDFG 1992).

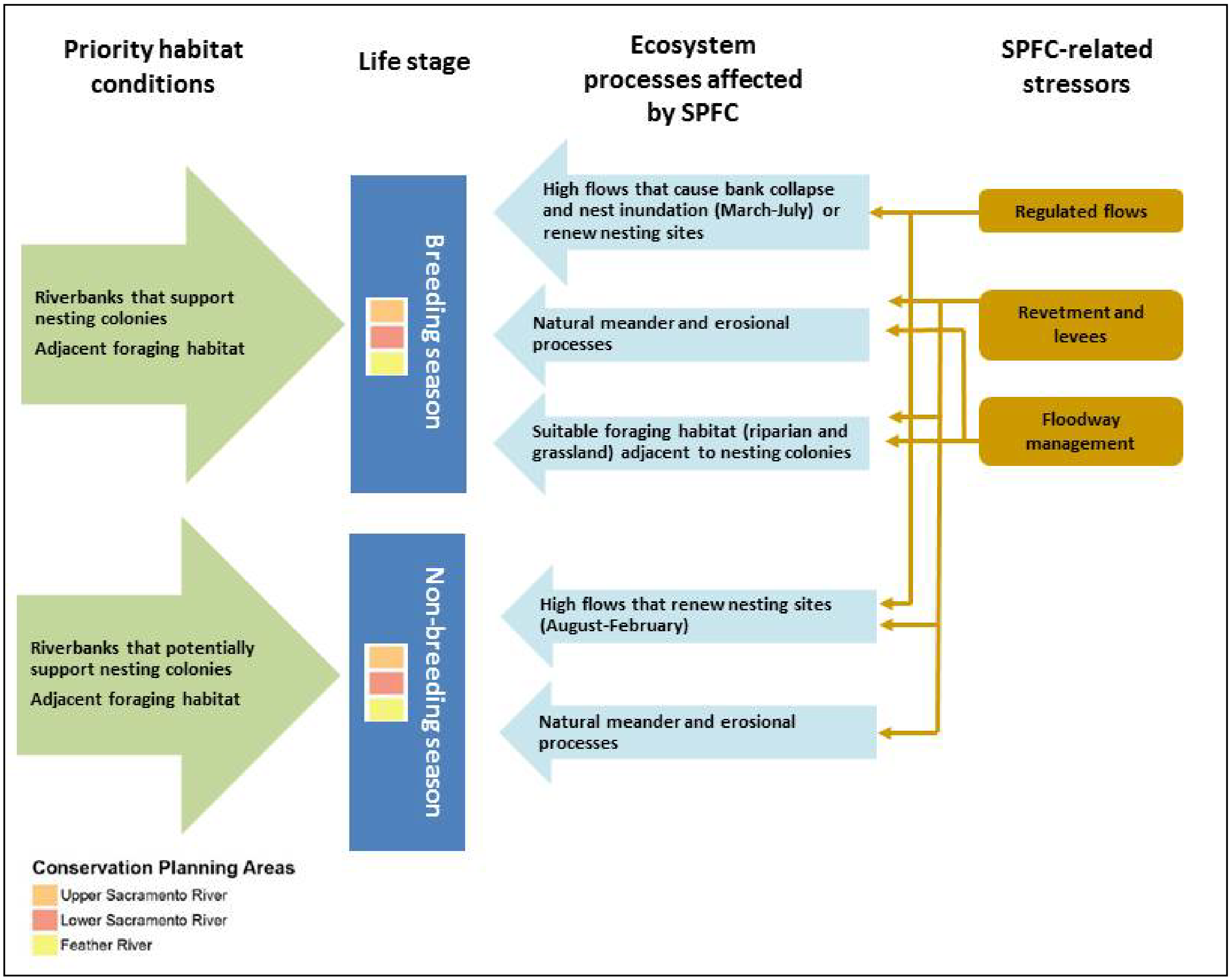


Figure 3. Conceptual Model for Bank Swallow within the SPA

On the Sacramento and Feather Rivers, several ongoing revetment projects have caused a cumulative effect on bank swallow populations and continue to affect the natural river processes on which the species relies (BANS-TAC 2013):

- The Flood Control Act of 1960 authorized the Sacramento River Bank Protection Project (SRBPP), through a partnership between USACE and the Central Valley Flood Protection Board, to use bank stabilization actions to protect the levees and flood control facilities of the Sacramento River Flood Control Project. Between 1960 and 2007, SRBPP was responsible for the installation of 320,500 linear feet (60.7 miles) of rock revetment along banks and levees of the Sacramento River between Verona (RM 80) and Chico Landing (RM 194).

- An additional 10,000 linear feet (1.9 miles) of revetment was placed by DWR during the 2006 Governor’s emergency declaration.

- The federal Flood Control Act of 1958 and Water Resources Development Act of 1976 authorized the Sacramento River, Chico Landing to Red Bluff Project and placed 88,000 linear feet (16.7 miles) of rock revetment between Chico Landing (RM 194) and Red Bluff (RM 245).

- In addition to the large public projects listed above, smaller projects and revetment on private property contribute to the cumulative effect. Installation of revetment by Local Maintaining Agencies and private landowners is difficult to quantify, but to date, more than 44,000 linear feet (8.3 miles) are known to have been rocked along the Sacramento River (BANS-TAC 2013).

- The Feather River has 23,400 linear feet (4.4 miles) of SRBPP revetment between its confluence with the Sacramento River and RM 51, although the total amount of revetment on the Feather River has not been quantified.

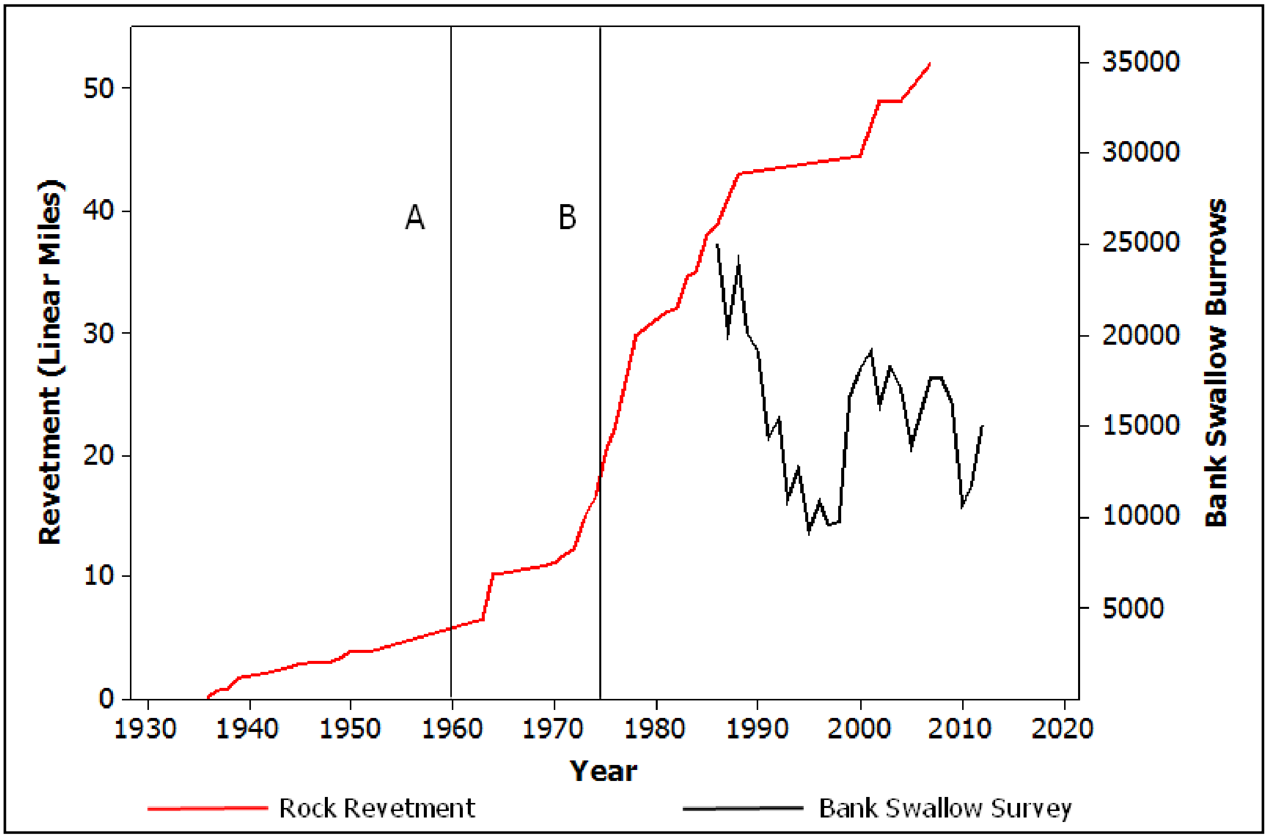
Extensive revetment on both the Sacramento and Feather Rivers not only reduces the amount of nesting habitat for bank swallows, but also negatively affects sediment transport and deposition, vegetation regeneration, and other natural river processes (Table 1 and Figure 4; BANS-TAC 2013).

Table 1. Total Amount of Revetment (Linear Feet) Placed on the Banks of the Sacramento River (between Verona and Red Bluff) and on the Feather River from 1960 to Present

Project Name	Sacramento River			Feather River
	Verona-Colusa	Colusa–Chico Landing	Chico Landing to Red Bluff	
First phase of SRBPP	161,900	9,200		14,000
Second phase of SRBPP	78,650	69,750		9,400
DWR emergency repairs 2005–2006	3,800	6,200		
Chico Landing to Red Bluff			87,915	
Other revetment	162,660	37,700	63,685	40,600
Total (linear feet)	**407,010**	**122,850**	**151,600**	**64,000**

Source: BANS-TAC 2013; used with permission.

Loss of Foraging Habitat. Bank swallows use a variety of foraging habitats, but during nestling development they are dependent on the habitats adjacent to nesting colonies. The majority of bank swallow colonies along the Sacramento River are adjacent to open grasslands (Garrison et al. 1987), cultivated crops (e.g., irrigated row crops and dryland grain crops) (Garrison 1998), and herbaceous, scrub, and forested riparian habitat (Garcia 2009). Moffatt et al. (2005) suggested that colony extinction increases with increased distance to grassland, and related that distance to foraging area requirements. When feeding nestlings, bank swallows are commonly



Source: BANS-TAC 2013; reproduced with permission

Figure 4. Bank Swallow Burrow Counts and Trend (Beginning in 1986) and Cumulative Length of Rock Revetment Placed on the Sacramento River between Colusa and Red Bluff (Approximately 100 Miles of River) from 1935 to Present:
(A) Initial Authorization of SRBPP, Phase 1, 1960
(B) Authorization of SRBPP, Phase 2, 1974

observed foraging within 164–656 feet of nesting colonies (Turner and Rose 1989; Garrison 1998). Where it occurs near waterways and nesting sites throughout the Central Valley, the loss and conversion of natural land cover to less suitable foraging habitat (e.g., orchards) has likely negatively affected bank swallow populations by reducing food resources; however, the magnitude of this effect remains difficult to quantify (Moffatt et al. 2005).

Ongoing and Future Impacts

The primary ongoing threat to bank swallow populations in the Feather River and the Upper and Lower Sacramento River CPAs is loss of nesting habitat. Nesting habitat is being lost as a consequence of flood management activities, such as bank stabilization and reservoir releases, as well as land conversion, other stabilization projects, and mitigation projects that favor other species' habitat at the expense of bank swallow habitat. Bank swallows are also likely to be negatively affected by the consequences of climate change on the species' population, distribution, and viability.

Bank swallow populations continue to be threatened by river and flood management activities, bank stabilization, reservoir releases, and the conversion of natural land cover. All of these activities contribute to the loss of erodible bank and consequently to the loss of potential habitat. Approximately 5,000 linear feet of revetment from the original second phase of SRBPP work remains to be placed; this bank protection is planned to be constructed in 2013–2014 (USACE 2009; Young pers. comm.). As previously described and shown in Table 1, these bank stabilization programs, planned to be implemented in the next 5 years on the Sacramento River, will result in the loss of more than 29 miles of eroding banks (BANS-TAC 2013), further reducing the availability of habitat that is important for the recovery of the bank swallow.

In 2013, the Sutter Buttes Flood Control Agency (SBFCA) began constructing slurry walls and seepage berms to stabilize an approximate 44-mile reach of levee along the Feather River from Thermalito Afterbay to the Sutter Bypass (SBFCA 2012). There are several bank swallow nesting colonies along the west side of this reach of the Feather River. The work could potentially prevent natural fluvial processes from occurring, thus limiting habitat for bank swallows. Additionally, fixing these levees in place may necessitate future placement of revetment, which could result in direct loss of bank swallow habitat. Placing setback levees in areas where bank swallows occur could facilitate natural fluvial processes, and thereby allow for creation and renewal of suitable nesting habitat.

Unauthorized stabilization of eroding banks and placement of rock and rubble continue on private lands throughout the bank swallow's range. The total amount of revetment placed along the Sacramento and Feather Rivers is difficult to quantify, but these actions can displace or eliminate colonies, adding to the cumulative impact on bank swallow nesting habitat.

Lastly, habitat mitigation for impacts on other species has reduced the availability of bank swallow nesting sites. In recent years, mitigation for stabilization and flood management projects has often involved sloping and vegetating eroded banks to enhance SRA habitat for fish. This type of nearshore aquatic habitat mitigation does not restore river processes and has the potential to impair bank swallow recovery.

Climate change may influence the future distribution of bank swallows in the SPA, although the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. Because the population of bank swallows along the Sacramento River is at the extreme southwestern edge of this species' breeding range, it may be susceptible to climate change effects, especially changes in rain and temperature patterns (Girvetz 2010). In two different climate change models, developed by The California Avian Data Center (Ballard et al. 2008), the current range of the bank swallow contracts and shifts northward. Although part of the projected future range of suitable habitat would still overlap the Upper Sacramento River CPA and Feather River CPA, the Lower Sacramento River CPA may no longer provide suitable habitat. The variables that contributed most heavily to the modeled prediction were distance of colony to stream, annual precipitation, and vegetation type. These model results further demonstrate this species' dependence on river and flood system dynamics.

Key Information Gaps or Uncertainties

To better understand bank swallow ecology, the following information is needed: knowledge of the factors currently contributing to population stability; models that quantify the suitability of nesting habitat; data on foraging requirements and patterns; and identification of population stressors outside the SPA. These data gaps are discussed below.

- **Contributors to stability.** It is unclear what factors contributed to the population increase in 1999 and the subsequent period of stability through 2005. Garcia et al. (2008) hypothesize that, from 1960 to 1985, the installation of rock revetment and resultant colony destruction contributed to the decline of the population. Since 1985, there have been fewer active rock revetment projects and presumably more erosional opportunities along the Sacramento River. After 25 years of accumulated and widespread loss of many colony sites, it may have taken more than a decade for the population to rebound in response to improved conditions. However, further analysis of population data is needed to understand the factors contributing to stability and recovery. Future analysis could include examination of population trends using CDFW's 18-year dataset. Garcia's (2009) thesis incorporated only the latter 9 years of these data.

- **Nesting habitat suitability.** It is unclear how populations will respond to changes in their habitats and what criteria can be applied to identify or restore suitable habitat along the Sacramento and Feather Rivers. There is a need to better understand the physical features that define viable bank swallow habitat along the Sacramento River. Broadly, future studies could analyze the complex erosional processes that form and renew the banks where bank swallow colonies persist. Factors that may contribute to desirable erosion patterns may include soil types, summer and winter flows, precipitation, overstory vegetation, and bank parameters (slope, aspect, length, etc.). Some of these variables were examined in Garrison's (1989) Habitat Suitability Index, but were not field-tested to confirm the model's ability to quantify suitable habitat. In addition to incorporating and testing these variables, future modeling would benefit from more detailed mapping of potentially suitable habitat (in particular, soil texture) along the Sacramento and Feather Rivers, even if sites are not in use during the nesting season. Finally, the stage discharge relationship that drives bank sloughing and inundation of colonies is not well understood; future studies could assess this dynamic relationship.

- **Foraging habitat suitability.** Where grasslands are not available near colony sites, agricultural fields could serve as an adequate substitute foraging habitat (Stillwater Sciences 2007); however, higher levels of pesticides in agricultural lands could harm bank swallows or reduce their prey base. Oak woodlands might also provide substitute foraging habitat. Although these alternatives could offer flexibility for conservation efforts, the adequacy of these habitats has not been verified. For example, the number of acres needed to support a colony is not known, nor is the availability of prey for bank swallows in each of these habitat types.

- **Stressors beyond the SPA.** It is unclear to what degree bank swallows are limited by factors encountered in wintering areas and along migratory paths. A focused banding program could provide information about individual movement, site fidelity, and population dynamics. Isotopic feather analysis could help identify important molting areas in the wintering range, allowing diagnosis of stressors on bank swallow populations and thereby informing conservation efforts.

Conservation Strategy

Conservation and Recovery Opportunities

Recovery of bank swallow populations depends on removing revetment and avoiding the placement of new armor on eroding banks. If current flood management activities and rock revetment projects continue, and if new suitable habitat is not created or restored via natural erosional processes, bank swallow populations will most likely continue to decline as suitable nesting and foraging habitat diminishes. Also, the extent and distribution of bank swallow colonies will likely be limited by habitat loss.

Although the persistence of suitable habitat can be cultivated throughout the SPA, the effort to restore and protect nesting sites would focus especially on the 100-mile reach of the Sacramento River from Red Bluff to Colusa (in the Upper Sacramento River CPAs) and the 44-mile stretch of the Feather River West Levee Project area, from Thermalito Afterbay to Yuba City (in the Feather River CPA).

Identified Conservation Needs

1. **Increase and renew suitable nesting habitat:** In the SPA, the Sacramento River serves as the primary breeding center for bank swallows. Conservation efforts along the Sacramento River may have far-reaching beneficial effects on population recovery and dispersal, because birds that fledge from Sacramento River colonies could breed in other locations (Schlorff 1995). By allowing natural erosional processes to occur, channel banks that could support bank swallow colonies could be perpetuated. To this end, the BANS-TAC recommends removing revetment and incorporating setback levees, and provides a preliminary list of areas where this action would be most beneficial to the bank swallow. Some of these recommendations are presented in Table 2.

   To support species recovery throughout the SPA, suitable colony sites could be protected or enhanced even if outside the known range of bank swallows. For example, revetment could be minimized not only in areas currently used by bank swallows but in areas of the San Joaquin Valley that provide suitable habitat. Although there are only four historical records in the San Joaquin Valley (Laymon et al. 1988), the protection of potential habitats in this area could promote colonization in this region and contribute to an increase in the overall breeding population in the SPA.

Table 2. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Bank Swallow[a]

CVFPP Management Actions	Conservation Need		
	1. Increase and Renew Nesting Habitat	2. Increase Amount and Extent of Foraging Habitat	3. Minimize Colony Stressors
Operations, Maintenance, and Floodway Management			
Floodwater storage and reservoir forecasting, operations, and coordination	+/-	+	+
Facility maintenance	-	-	-
Levee vegetation management			
Floodway maintenance			
Modification of floodplain topography			
Support of floodplain agriculture			
Invasive plant management			
Restoration of riparian, SRA, and marsh habitats	+/-	+/-	+/-
Wildlife-friendly agriculture			
Structural Improvements			
Levee and revetment removal	+	+	+
Levee relocation	+		+
Bypass expansion and construction		+	
Levee construction and improvement	-		-
Flood control structures			

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

2. **Increase the amount and extent of suitable foraging habitat:** Bank swallows typically forage above open water and in adjacent wetlands, grasslands, and riparian over-bank vegetation. Most bank swallow colonies are located next to such habitats because they offer ready access to flying insects (Garrison et al. 1987; Humphrey and Garrison 1987; Moffatt et al. 2005). The BANS-TAC recommends that foraging habitat be restored by managing restored floodplains to support open grass and wildflower vegetation, and through management actions that promote new plant growth and reduce invasive plant species. Suitable foraging habitat could be targeted for conservation or enhancement even if located outside the known range of bank swallows (i.e., in the San Joaquin Valley).

3. **<u>Minimize colony stressors:</u>** Minimizing disruptions of established colonies will be essential to allowing bank swallow populations to succeed. Colony stressors to be avoided or minimized include (1) placing revetment on suitable habitat outside the breeding season (1 September–31 March) and thereby preventing colony occupancy; (2) damaging colonies during the breeding season (1 April–1 August) through, for example, revetment projects or dam releases that create high flows and may inundate and erode occupied colonies; and (3) placing revetment along main channels and tributaries historically occupied by this species throughout the SPA. The BANS-TAC recommends that, where impact avoidance is not possible through the use of alternatives, mitigation measures provide a net increase in habitat of comparable value.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the bank swallow; these are summarized in Table 2 at the end of this section. In many cases, the conservation needs of the bank swallow can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward 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: Dam releases during the bank swallow breeding season (1 April–1 August) result in unnatural high-flow events that could contribute to colony collapse. To increase the availability of nesting habitat, resource managers and regulators could work together to develop criteria for beneficial flow regimes. Such regimes would promote annual flows that cause localized bank erosion, meander migration, and channel cutoff during the nonbreeding season (1 September–31 March). Additionally, the BANS-TAC recommends a minimum of one bank-full flood event (also during the nonbreeding season) every 3 years to promote the natural processes that are essential to providing nesting habitat for the bank swallow.

Facility maintenance: Maintenance activities that include manual or mechanical removal of over-bank vegetation could reduce bank swallow foraging habitat. Also, within the range of the bank swallow, placing fill or rock revetment on riverbanks in an effort to constrain lateral channel migration would have negative effects on bank swallow habitats, and could be avoided. Where flows encroach upon the levee system, alternatives to revetment, such as setback levees, could be constructed. This approach would be applicable to many locations on the Feather River and the Sacramento River, such as in the vicinity of the confluence of these rivers, because it could benefit bank swallows by allowing restoration of natural hydrologic and geomorphic processes that are necessary for establishing suitable habitat.

Restoration of riparian, SRA cover, and marsh habitats: Restoring these habitats could have both positive and negative effects on the bank swallow. Increasing the amount of riparian habitat that is hydrologically connected to river channels would not inhibit access to known colony sites or areas where suitable nesting habitat is present. Bank swallows typically forage on insects flying above open water and in adjacent wetlands, grasslands, and over-bank riparian vegetation. Most bank swallow colonies are located next to such open habitats (Garrison et al. 1987; Humphrey and Garrison 1987; Moffatt et al. 2005). Restoring riparian and marsh habitats would also trap fine sediment during high flows, which may become suitable bank substrate in the future. During restoration, use of a planting palate of cottonwood, willows, oaks, and grasses would create beneficial foraging opportunities to bank swallows. However, SRA habitat projects focused on providing habitat for fish could be indirectly detrimental to bank swallows because they would favor sloped, vegetated banks. It is important that this type of SRA restoration not occur on known or potential bank swallow colony sites.

Structural Improvements

Levee and revetment removal: Removing levees and revetment would reduce operations and maintenance costs while creating opportunities to improve the riverine geomorphic and floodplain inundation processes that are important to sustaining habitats in and along the rivers. The Conservation Strategy states that the ecological benefits of levee and revetment removal can be maximized by conducting these activities along salmonid-bearing waterways, at potential bank swallow colony sites, and where removal would contribute to a larger zone of active river meander migration. Encouraging natural erosional processes through levee and revetment removal would benefit bank swallows by providing and maintaining suitable nesting habitat. The BANS-TAC recommends specific amounts and extents of revetment removal to restore habitat and meander potential on the Sacramento River by 2050: (1) remove 100,000 linear feet (19 miles) between Red Bluff and Chico Landing; (2) remove 50,000 linear feet (10 miles) between Chico Landing and Colusa; and (3) remove 130,000 (25 miles) between Colusa and Verona, and possibly construct setback levees in this stretch. Along the Feather River, the BANS-TAC recommendation for revetment removal is 10,000 linear feet (2 miles).

Levee relocation: Improving ecosystem function and restoring natural riverine geomorphology by relocating levees would create opportunities to provide suitable nesting habitat for bank swallows. An expanded floodway, reconnected to the river channel, would allow for river meander, sediment erosion and deposition, and natural ecosystem disturbance processes, all of which could contribute to creating new suitable bank swallow habitat. The BANS-TAC recommends constructing setback levees (and consequently restoring connecting floodplains) on the Sacramento River and Feather River by 2050. The recommendations for the Sacramento River are to (1) restore 4,500 acres of connected floodplain between Chico Landing and Colusa and (2) restore 7,000 acres of connected floodplain between Colusa and Verona. The BANS-

TAC recommendation for the Feather River is to restore 500 acres of connected floodplain. In these reaches, where levees closely follow sinuous river channels, constructing setback levees would not only benefit bank swallows, but could reduce overall maintenance and repair costs and decrease the need for adding revetment to existing levees.

Bypass expansion and construction: Bypass expansion and construction could create a more frequently activated floodplain, helping to restore ecosystems and potentially providing suitable foraging habitat close to bank swallow nesting colonies. Modifications to the Sutter Bypass, particularly in the reach that contains the Feather River, could benefit bank swallows by simultaneously providing nesting and foraging habitat.

Levee construction and improvement: Constructing new levees or improving existing levees could directly or indirectly destroy suitable bank swallow habitat. These activities could be avoided in areas where bank swallows are likely to occur. However, if levees must be constructed in areas where bank swallows nest, the use of revetment, biotechnical bank protection, and nearshore aquatic habitat features could be balanced to best accommodate the needs of both the bank swallow and other species. Incorporating setback levees (as discussed above) would be preferable for areas where known bank swallow colonies are located or have the potential to occur.

Recovery Plan Alignment

This conservation planning document was developed to be consistent with the recovery plan and the BANS-TAC conservation strategy. The goal of the bank swallow recovery plan is to maintain a self-sustaining wild population. The primary objectives are to (1) ensure that the remaining population does not suffer further declines in range or abundance and (2) provide sufficient habitat availability for the species to survive as a member of California's native avifauna (CDFG 1992). Concepts of the recovery plan include impact avoidance, habitat preserves, and a series of setback levees to allow rivers to meander, thereby creating and maintaining nesting habitat.

The BANS-TAC was created to inform and educate government agencies involved in flood management and resource protection. The BANS-TAC has produced a conservation strategy to provide direction for better protecting and recovering the species, as well as for benefiting the many other species dependent on natural river systems. The strategy also discusses the research that is needed to support creation of bank swallow habitat on the Sacramento and Feather Rivers. Specifically, the BANS-TAC's Bank Swallow Conservation Strategy recommends the following conservation actions:

- avoid impacts on individuals, colonies, current and potential habitat, and river processes;
- protect individuals, colonies, current and potential habitat, and river processes;
- restore habitat and river processes; and

- mitigate unavoidable impacts on individuals, colonies, current and potential habitat, and river processes.

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 bank swallow. Therefore, building on the preceding discussion, this section of the bank swallow 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 3). The species-specific measures provide additional detail on geographic location, habitat structure, and other attributes important to conservation of the species. For example, the amount of revetment removed to increase meander potential or natural bank (in miles) is an indicator of progress toward the Conservation Strategy's revetment objective. Requirements would be added to this indicator to reduce the amount of revetment in the flood system and contribute to creating suitable bank swallow habitat.

Table 3 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of bank swallows, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit bank swallows may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the Bank Swallow

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	No	
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	Develop flow criteria that promote formation of bank swallow habitat during the nonbreeding season (1 September–31 March): provide annual flows that cause localized bank erosion and a minimum of one bank-full flood event every 3 years (with the goal of promoting bank erosion, meander migration, and channel cutoff) (BANS-TAC 2013).
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles).	No	Avoid degradation of bank swallow habitat when restoring SRA or near channel vegetation
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	Avoid degradation of bank swallow habitat when restoring SRA or near channel vegetation
Riparian	Habitat Amount—total amount and total amount of active floodplain (acres)	No	
	Habitat Connectivity—median patch size (acres)	No	
Marsh	Habitat Amount—total amount and total amount of active floodplain area (acres)	No	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the Bank Swallow

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	Remove revetment to increase meander along the following portions of the Sacramento River: between Red Bluff and Chico Landing, 19 miles; between Chico Landing and Colusa, 10 miles; and between Colusa and Verona, 25 miles. Remove revetment to increase meander along 2 miles of the Feather River (These are BANS-TAC objectives, to be achieved by 2050.)
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	Along the Sacramento River, Chico Landing to Colusa, restore 4,500 acres of connected floodplain; from Colusa to Verona, restore 7,000 acres. On the Feather River, restore 500 acres of connected floodplain. (These are BANS-TAC objectives, to be achieved by 2050.)
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	No	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G11. Focused Conservation Plan: California Black Rail

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the California black rail (*Laterallus jamaicensis coturniculus*) and its habitat in the SPA for the CVFPP.

The California black rail subspecies was listed by the State as threatened under CESA in 1971 (CDFW 2013). It was designated as fully protected in California prior to its listing under CESA, and retains its fully protected status. California black rails are not listed under the ESA, but the species is on the USFWS Birds of Conservation Concern list, which identifies migratory nongame birds that are likely to become candidates for listing under the ESA if conservation actions are not taken (USFWS 2008).

Status and Trends

Distribution

The historical and current distribution of California black rails is poorly understood because of this species' reclusive behavior and use of densely vegetated marshes. Additionally, black rails are patchily distributed in suitable habitat, and their occupancy in a given marsh is difficult to detect and predict. Labor-intensive call-playback surveys are necessary to determine marsh occupancy and develop density and relative abundance estimates (Spear et al. 1999). Systematic surveys were not attempted until the 1970s (Evens et al. 1991), and those were not conducted range-wide.

California black rails now generally occur in a patchy metapopulation structure, primarily in four broad areas, each with relatively unique habitat associations: (1) fresh and brackish marshes in the Delta; (2) salt and brackish marshes in the San Francisco Bay estuary; (3) seep- and spring-fed marshes at inland sites on the lower Colorado River in southern California and Arizona, and in the Salton Sink, which includes the Imperial and Coachella Valleys; and (4) as recorded recently, in emergent freshwater marshes on the western slopes of the Sierra Nevada foothills, including in Yuba, Nevada, Butte, Placer, and San Joaquin Counties (Evens et al. 1991; Eddleman et al. 1994, Aigner et al. 1995; Richmond et al. 2008; Richmond et al. 2010a). In addition to these main areas, California black rails are known to occur in three disjunct coastal marshes: Tomales Bay, Bolinas Lagoon, and Morro Bay (Evens et al. 1991). Historically, California black rails occupied numerous other outer coastal marshes, but many of these have been lost, fragmented, or degraded by urbanization (Evens et al. 1991).

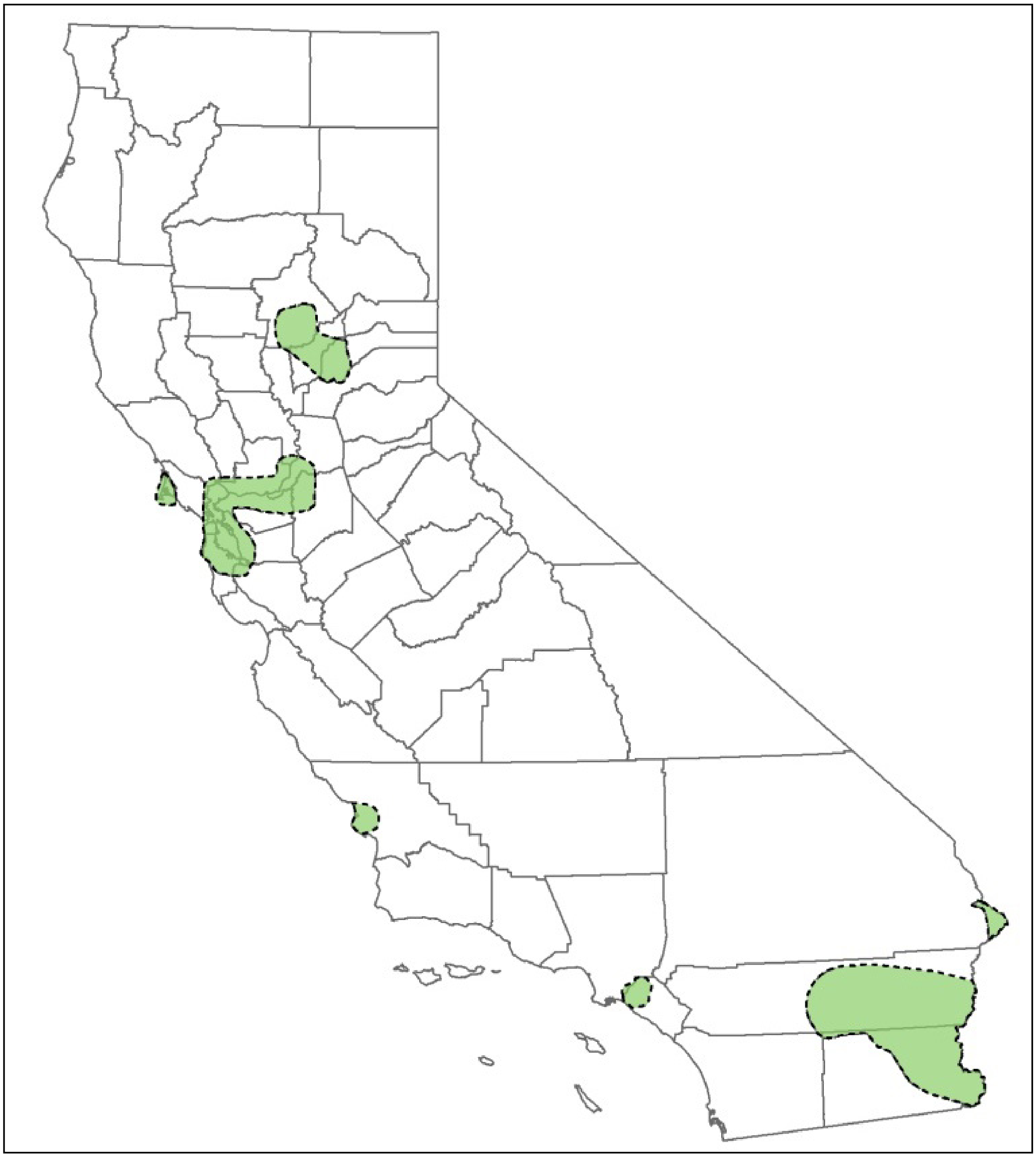
The known distribution of black rails has increased, including their distribution in the Sierra Nevada foothills (Aigner et al. 1995; Richmond et al. 2008, 2010a) and recently in the South San Francisco Bay (Bousman 2013; Hall pers. comm.). However, given that habitat loss has likely resulted in extirpation from portions of the species' former range, the overall distribution of

California black rails has likely decreased while information on its distribution has increased. The current distribution of the California black rail in the state is illustrated in Figure 1.

Within the SPA, California black rails have the potential to occur in the Lower Sacramento and Lower San Joaquin River CPAs. Surveys conducted in the interior Delta by DWR personnel found California black rails in freshwater emergent vegetation and riparian habitats throughout the central Delta, but particularly in association with tidal marsh islands (Tsao et al. 2013). The species has been detected in marshes at the mouth of the Sacramento River, in the vicinity of Sherman Island (CNDDB 2013; eBird 2013), but there are no occurrences north of Sherman Island in the Sacramento River watershed, including in the Yolo Bypass. The Sierra Nevada foothill population occurs farther to the north and northeast, outside the SPA.

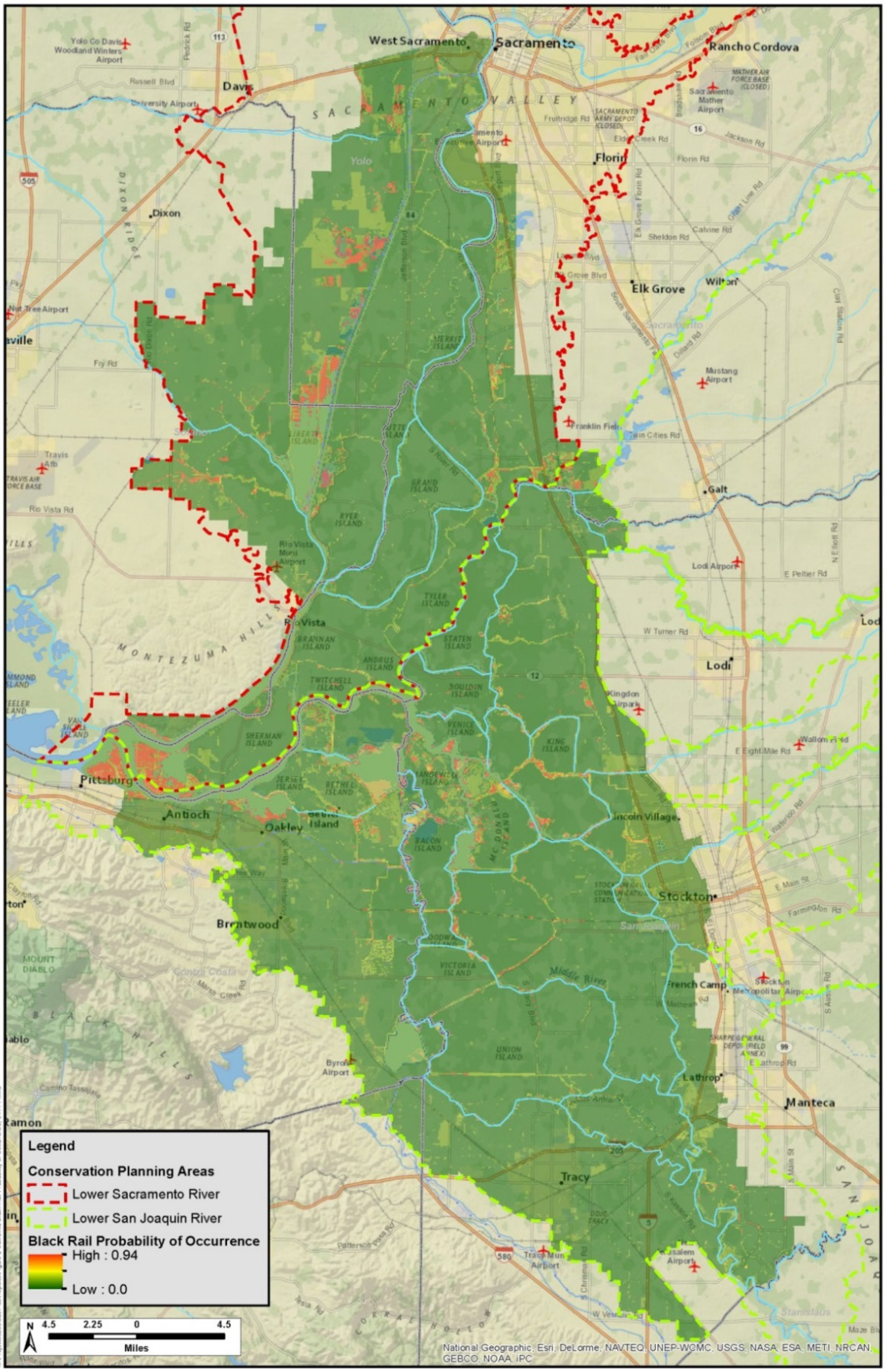
In the Lower San Joaquin River CPA, black rails have been documented in emergent marshes, particularly marsh islands, in Sandmound Slough, White Slough, Disappointment Slough, Whiskey Slough, Tinsely Island, Fourteenmile Slough in the vicinity of Fay Island, Bacon Island, and Middle River as far south as North Victoria Channel (CNDDB 2013; eBird 2013; Tsao et al. 2013). Although black rails had been previously observed in the Delta, these habitats are different from the salt marshes in nearby San Pablo Bay (Tsao et al. 2009a), palustrine emergent wetlands in the Sierra Nevada foothills (Richmond et al. 2008), and emergent freshwater marshes (dominated by common threesquare [*Schoenoplectus pungens*]) in the Salton Sink (Conway and Sulzman 2007), indicating that California black rail distribution is influenced by habitat structure, rather than by plant species composition. This pattern of habitat occupation suggests that black rail distribution in the Lower San Joaquin River and Lower Sacramento River CPAs could be much broader than is currently understood. There are likely areas that have received little or no survey effort where black rails may occur. For instance, there are numerous freshwater marsh habitats, particularly marsh islands such as those in the north Delta that are difficult to access and have not been surveyed for black rails.

Based on habitat-association data collected during California black rail surveys in the central Delta, DWR staff developed a conceptual habitat model for black rails in the Lower San Joaquin River and Lower Sacramento River CPAs (Tsao et al. 2013) (Figures 2 and 3). Marshes with a higher probability of black rail presence include larger marshes with emergent freshwater vegetation and a riparian scrub component (see “Habitat and Ecological Process Associations,” below). Based on these habitat associations, the potential distribution of black rails may extend farther to the north, in areas where rails have not been documented. For instance, there is potentially suitable habitat in freshwater marshes in the vicinity of Cache Slough, Prospect Island, Ryer Island, and Liberty Island, as well as in other marsh island areas of the north and central Delta. Also, marshes in the Yolo and Sutter Bypasses to the north have habitat features that may support black rails. If rails do not occur in these areas now, restoration and management could facilitate colonization of these marshes.



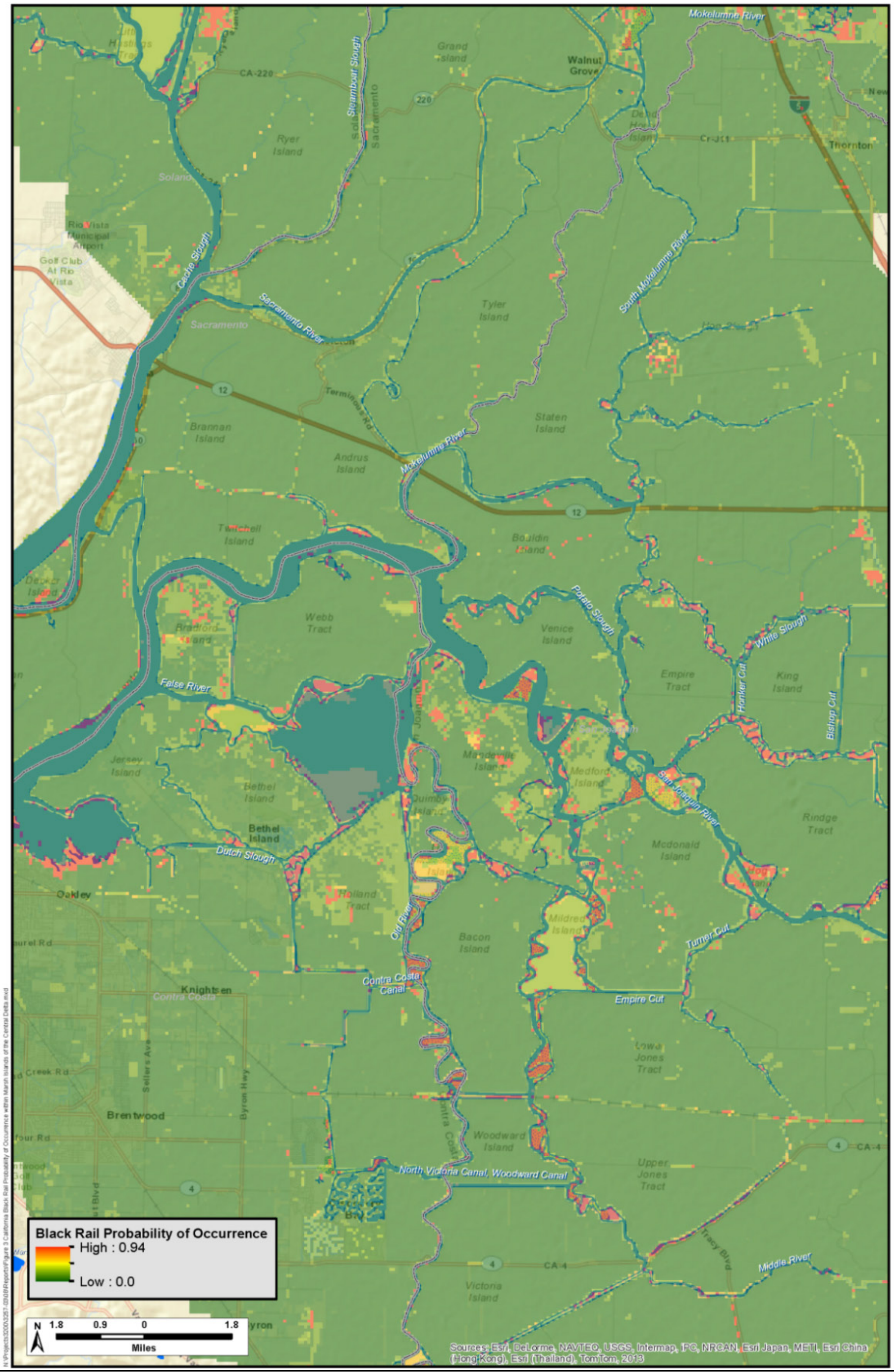
Source: adapted from Girard et al. 2010

Figure 1. Known California Black Rail Distribution in California



Source: Tsao et al. 2013

Figure 2. California Black Rail Probability of Occurrence



Source: Tsao et al. 2013

Figure 3. California Black Rail Probability of Occurrence within Marsh Islands of the Central Delta

Population Trends

California black rails have been extirpated from parts of their former range, particularly in coastal marshes and in the San Francisco Bay estuary, in response to loss and degradation of marsh habitats and an increase in nonnative predators (Evens et al. 1991). The contraction of the species' distribution has likely resulted in an overall population decline. However, historical information on black rail distribution and abundance is lacking. Because there are no historical population estimates, and the species' historical and current distribution and habitat use is poorly understood, population trends are difficult to establish.

Evens et al. (1991) conducted systematic surveys at numerous breeding locations in the species' known range at the time, which included the San Francisco Bay estuary, the Colorado River and Salton Trough, and the outer coastal marshes from Bodega Head to Morro Bay (although most marshes are unoccupied along that portion of the coast). The San Francisco Bay estuary region included the South and Central Bay (i.e., San Francisco Bay proper), San Pablo Bay, and Suisun Bay. The Delta region included tributaries and islands of the Sacramento and San Joaquin Rivers at the head of the estuary; however, Evens et al. (1991) noted that survey effort in the Delta was less than in other parts of the estuary. It was determined that greater than 80 percent of the rail population occurred in the northern portion of the San Francisco Bay estuary, mainly in San Pablo Bay and Suisun Bay. Black rail populations were later estimated at 7,100 individuals in San Pablo Bay, 7,200 in Suisun Bay and the Carquinez Strait, and 289 in outer coastal marshes (Evens and Nur 2002). The Sierra Nevada foothill population has been estimated to be between 734 and 1,466 rails (Richmond et al. 2008). The level of genetic diversity in the Sierra Nevada foothills and San Francisco Bay populations suggests that rails occurred in the foothills region historically, but were just recently discovered, and that the foothills population may be larger, and the San Francisco Bay population smaller, than previously estimated (Girard et al. 2010). Given that our understanding of the species' geographic distribution and habitat use is increasing, population trends will likely emerge as survey efforts for this species continue.

Life History

California black rails are considered nonmigratory (Eddleman et al. 1994; Richmond et al. 2008), and incursions into nonbreeding areas are considered to be made by dispersing juveniles or possibly by relocating adults. Recent observations in the southern portion of the San Francisco Bay (Bousman 2013; Hall pers. comm.) suggest that the species may be recolonizing areas where it had been previously extirpated, or perhaps it had gone undetected until recently. Dispersal patterns and connectivity between black rail populations are largely unknown; however, recent research using molecular markers suggests that the San Francisco Bay estuary and Sierra Nevada foothills populations have diverged from individuals in Imperial Valley, and that there is a greater probability of black rail movement from the Sierra Nevada foothills to the San Francisco Bay than movement from the bay to the foothills (Girard et al. 2010).

The California black rail breeding season typically extends from approximately March through July (Eddleman et al. 1994), although the rail breeding season has been conservatively estimated to occur between 1 February and 30 August (San Joaquin County Habitat Policy Advisory Committee 2000). The timing of pair formation is unknown, but pairs likely form as early as late February, as hypothesized based on calling behavior (Eddleman et al. 1994). Black rails construct cryptic nests in dense marsh vegetation, using dead vegetation from emergent plants near the nest site. Egg-laying peaks around 1 May, and incubation lasts for approximately 17 to 20 days (Eddleman et al. 1994). Clutch size averages six eggs (Eddleman et al. 1994), and both adults may incubate eggs (Flores and Eddleman 1993), but information on black rail nesting behavior is limited. There is evidence that black rails will lay multiple broods in one season (Flores and Eddleman 1993). Chicks are semiprecocial and require parental brooding for several days after they hatch (Eddleman et al. 1994). Black rails are known to molt flight feathers during their prebasic molt after breeding, between 1 July and 31 August (Eddleman et al. 1994).

The diet and foraging behavior of black rails are not well understood because rails inhabit densely vegetated marshes and are difficult to observe. Black rails are primarily insectivores, although they are known to also forage on the seeds of wetland plants (Eddleman et al. 1994). In San Pablo Bay pickleweed salt marshes, California black rails are known to consume low-trophic prey, such as spiders and beetles (Tsao et al. unpublished data, as cited in Tsao et al. 2009b).

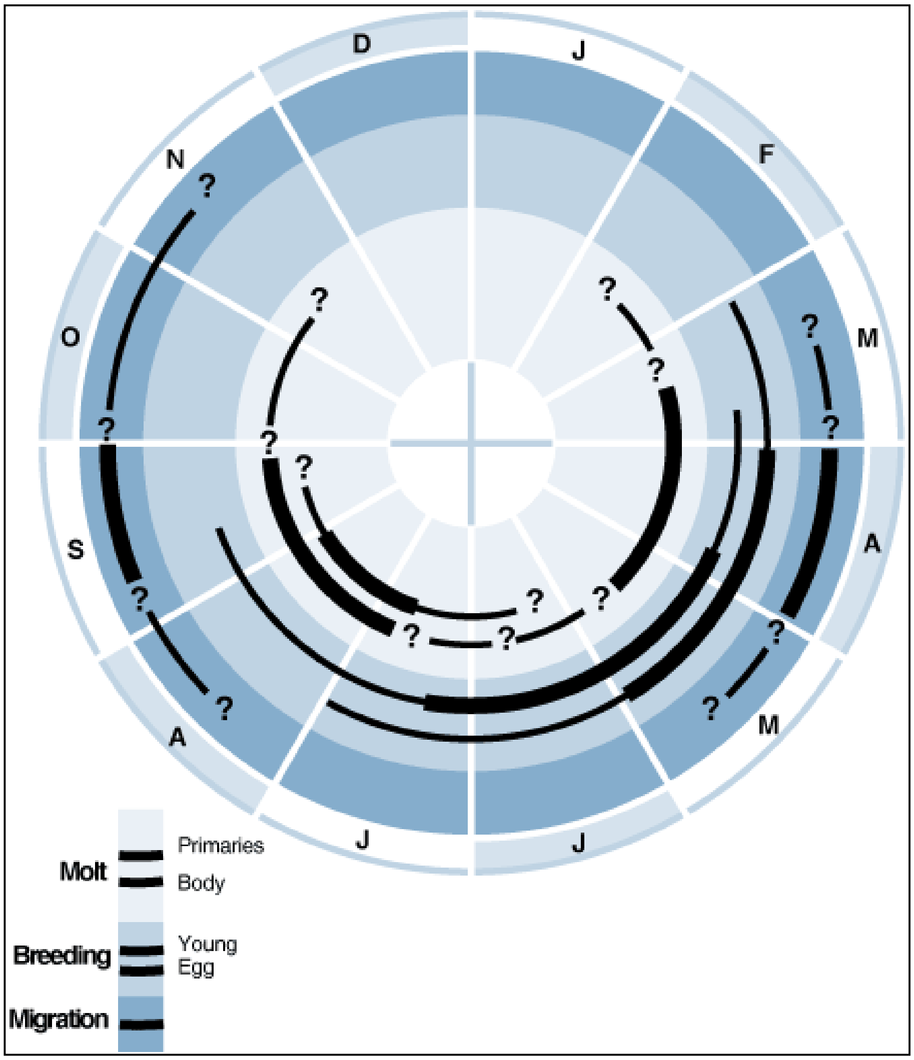
California black rails are vulnerable to predation, particularly when they come out from cover and retreat to higher elevations to escape high water. Species that depredate California black rails include northern harriers (*Circus cyaneus),* great egrets (*Ardea alba*), great blue herons (*A. herodias*), and gulls (*Larus* spp.) (Evens and Page 1986), and mammals such as red foxes (*Vulpes vulpes*), rats (*Rattus* spp.), and domestic cats (*Felis catus*) are also potential black rail predators (Eddleman et al. 1994).

The *Birds of North America* annual cycle for the black rail is shown in Figure 4.

Habitat and Ecological Process Associations

In the interior Delta region, including areas of the Lower San Joaquin River CPA, California black rails inhabit wetlands, particularly marsh islands, with a combination of freshwater emergent wetland vegetation, including California bulrush (*Schoeneoplectus californicus*), common tule (*Schoeneoplectus acutus*), cattail (*Typha latifolia*), and common reed (*Phragmites austrailis*), as well as riparian scrub areas dominated by willows (*Salix* spp.) and red osier dogwood (*Cornus sericea*) (Tsao et al. 2013). These marsh islands are hydrologically connected to the fluvial and tidal processes of the Delta, and are sensitive to changes in water levels because they are confined by levees. Black rails also occur in marshes at the mouth of the Sacramento River in the vicinity of Sherman Island, likely in habitats similar to those observed in the interior Delta. In other regions, black rails inhabit a variety of freshwater marshes, brackish marshes, and salt marshes (Conway and Sulzman 2007; Tsao et al. 2009a; Richmond et al. 2010a; H. T. Harvey & Associates 2011).

Although California black rails use a wide variety of wetland types, they tend to select wetlands that provide dense vegetative cover, shallow water and/or moist soil, and high-water refugia that



Source: Eddleman et al. 1994, in The Birds of North America Online; reproduced with permission

Note: The migration lines denote the migration of eastern black rails in eastern North America.

Figure 4. Annual Cycle of Breeding, Migration, and Molt of the Black Rail

protect them from predation during high tide or high-flow events. Dense vegetation likely allows construction of nests at elevations that protect nests from flooding (Tsao et al. 2009a). Black rails also select breeding areas in high marshes and avoid low marshes (Evens et al. 1991; Tsao et al. 2009a), presumably to avoid higher water levels that may flood nests or preclude foraging. Black rails select shallow water (i.e., <1 inch deep) or moist soil conditions, rather than wetlands with deeper water (Eddleman et al. 1994; Flores and Eddleman 1995; Conway and Sulzman 2007;

Hall pers. comm.), possibly to facilitate foraging given that their small body size prevents them from foraging in deep water and because they likely forage by pecking and gleaning from the substrate (as suggested by bill shape) (Eddleman et al. 1994).

Another important habitat component for California black rails is the presence of high-water refugia in and adjacent to marshes, especially where water levels are variable (Tsao et al. 2009a, 2013). Black rails select freshwater marshes in the Delta that have a mixture of emergent vegetation (e.g., California bulrush, common tule, and cattail) and riparian vegetation (e.g., willows and dogwood), likely because the taller riparian vegetation serves as high-water refugia (Tsao et al. 2013). Numerous avian and mammalian predators have been observed taking black rails when water levels are high, so refuge sites are essential for allowing black rails to escape from high water while avoiding predation (Evens and Page 1986; Eddleman et al. 1994). Conversely, levees, revetment, and walking paths located immediately adjacent to wetlands can expose black rails to predators (Evens et al. 2002). Also, revetment and other artificial structures can provide cover for rats and other potential predators.

California black rail habitat occupancy is also influenced by wetland size. Despite having relatively small home ranges, averaging 1.5 acres (Tsao et al. 2009a), black rails are more likely to occur in larger wetland sites than in smaller sites (Evens and Nur 2002; Spautz et al. 2005; Richmond et al. 2010a; Tsao et al. 2013). For instance, in the interior Delta, the mean wetland size where black rails were detected was 35.73 acres, whereas the mean size for sites with no rail detections was 16.93 acres (Tsao et al. 2013). The preference for larger marshes may be a function of microhabitat selection, because larger wetlands are more likely than smaller wetlands to provide habitat features suitable for foraging, nesting, and evading predators. However, black rails are known to occupy small sites as well: in the Delta, the smallest wetland site with a rail detection was 3.63 acres (Tsao et al. 2013), and rails have been detected in very small wetlands in the Sierra Nevada foothills (Richmond et al. 2010a). Although small wetlands are less likely than larger wetlands to be occupied by black rails, smaller sites may facilitate movement of rails between sites and possibly among populations, and may be important for maintaining genetic diversity (Girard et al. 2010).

Based on the known habitat associations of the California black rail, the species has the potential to occur in a variety of wetland habitats and hydrological regimes. In the Delta, they mainly are associated with island tidal marshes with emergent freshwater vegetation and riparian scrub habitats. They are not known to occur in the northern Delta or upstream in the Sacramento or San Joaquin River watersheds; however, because they use both tidal and nontidal habitats and a variety of vegetation communities, black rails have the potential to occur in habitats in the Lower Sacramento and San Joaquin River CPAs that may be affected by actions related to the SPFC. For instance, if activities in bypasses and managed wetlands allow for shallow water, dense emergent vegetation, and high-water refugia, black rails may colonize these areas.

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for California black rails within the SPA (Figure 5). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by California black rails within the SPA;

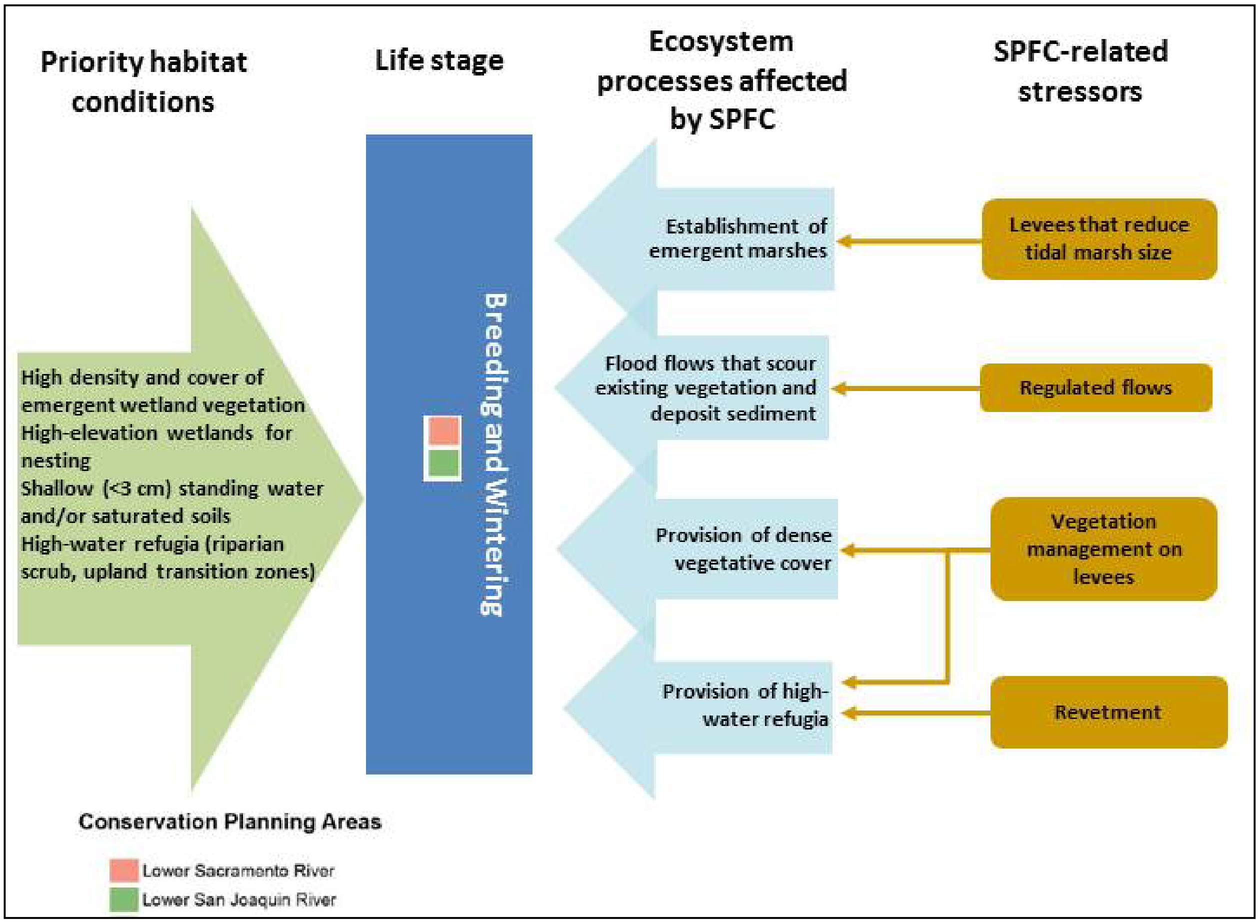


Figure 5. Conceptual Model for California Black Rail within the SPA

- the specific CPAs within which California black rails breed;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Management Issues

Threats and Sensitivities Range-Wide

Habitat loss and degradation are the primary threats to the California black rail (Eddleman et al. 1994). Historically, California black rails may have occurred throughout the Delta region, potentially inhabiting a broad matrix of marshlands and riparian habitats that existed prior to reclamation and flood control activities. Currently, marshes where black rails occur are confined by levees and are at risk from flooding and other environmental stressors. Black rails also likely occurred throughout the San Francisco Bay, but more than 80 percent of historical tidal marshes have been lost (Goals Project 1999), likely resulting in a commensurate loss of the black rail population (Evens et al. 1991). California black rails have also been extirpated from all coastal marshes south of Morro Bay because of a vast reduction in salt marsh habitat (Evens et al. 1991). Black rails in the Colorado River and Salton Trough areas are threatened by loss of habitat and habitat conversion resulting from water management practices (Evens et al. 1991); in Sierra Nevada foothills, replacement of ranchlands with residential development is likely the largest threat to black rails, because irrigation water used in cattle ranching provides black rail habitat in that region (Richmond et al. 2010a). Although black rails can use very small wetlands (Richmond et al. 2010a; Tsao et al. 2013), the species is more likely to be extirpated from small or isolated wetland patches.

High-water and predator refugia are important components of California black rail habitat that have been eliminated or degraded in many areas where black rails occur or previously occurred. This loss subjects rails to increased flood and predation risks, and can preclude wetlands from being occupied. The riverine systems of the Central Valley have undergone a loss of riparian and upland transitional habitat as the rivers have become channelized by flood control levees. In particular, areas with revetment or other bank protection features cannot support the growth of high-water refugia, and facilitate predator access to wetlands.

Concurrently with the reduction in refugia, predator populations have increased dramatically in response to habitat conversion and the increased availability of anthropogenic food sources. For instance, many predators have adapted to developed areas because apex predators have been extirpated and no longer limit populations of mesopredators (i.e., midtrophic-level predators), and because anthropogenic food sources are consistently available in locations such as landfills. Predatory species that regularly use landfills include various species of gulls (Belant et al. 1995; Baxter and Robinson 2007); corvids, such as common ravens (*Corvus corax*) and American crows (*C. brachyrhynchos*) (Stouffer and Caccamise 1991); rats (Marsh and Howard 1969; Sharp 2007); raccoons (*Procyon lotor*) (Totton et al. 2002); and feral cats (Yamane et al. 1997; Hutchins 2003). Anthropogenic food subsidies, favorable habitat conversion, and extirpation of apex predators allows such species to achieve or maintain high populations while continuing to prey on more sensitive species, like black rails. Predation on rare species may have particularly severe population consequences when food subsidies allow predator population numbers to remain high even as their prey populations decline (Sinclair et al. 1988; Andren 1992; Courchamp et al. 2000). Therefore, the predation risk to black rails has been increased dramatically by a combination of refugia loss and an increase in predators that are subsidized by humans.

Habitat- and predation-related stressors are further exacerbated by ongoing sea-level rise. Much of the California black rail habitat in the lower Delta, San Francisco Bay, and outer coastal marshes is confined by levees or development that will prevent the upward migration of marshes as water levels rise. As a result of sea-level rise, the distribution of vegetation suitable for black rails will decrease in the Delta (Tsao et al. 2013). Range shifts by this species are likely to be precluded by an overall lack of suitable habitat at the regional level. Climate change may also disrupt annual weather patterns, potentially causing increased storm intensity that may result in flooding of black rail habitat.

Contaminants may further stress California black rail populations by limiting reproductive success. For example, California black rails in San Francisco Bay are at risk from exposure to methylmercury (the organic form of mercury), which contaminates wetlands in the estuary and may reduce reproductive success in rails (Tsao et al. 2009b). A reduction in the reproductive output of the largest rail population (Evens et al. 1991) would contribute to the cumulative impacts of habitat loss, habitat degradation, predation, and the inability of wetlands to adapt to higher water levels because of surrounding levees and other infrastructure (Tsao et al. 2009b). Wetlands in the Delta and throughout much of the SPA have been contaminated with legacy mercury from gold mining in the Sierra Nevada, and there is potential for black rails and other species in the SPA to be exposed to methylmercury.

Ongoing and Future Impacts

The primary ongoing threats to California black rail populations in the SPA include the potential for flooding of habitats, habitat loss and degradation, increased predation, and an exacerbation of these stressors by climate change.

- Flood events can wash away California black rail nests or young during the breeding season. Flooding could displace black rails from otherwise suitable habitat and increase the risk of predation as rails seek cover in adjacent uplands or attempt to disperse to other areas. Flooding could also scour emergent marsh vegetation, reducing the amount of potential habitat for black rails; however, habitat loss would likely be short term, because marshes would likely recolonize after floods. Although annual precipitation rates are not expected to change significantly because of climate change, more precipitation is expected to fall in the Sierra Nevada as rain rather than snow, thus reducing snowpack and water availability from snowmelt in spring and summer (Cayan et al. 2006). Because black rails occupy marsh islands in the Delta that are subject to flooding, changes in the timing and intensity of rain events or water storage releases could disrupt the annual life cycle of California black rails if flood intensity increases during the breeding season, when higher volumes of water are released in spring due to heavy winter rains. Also, low flows resulting from a reduction in snowpack could create water levels that are insufficient to sustain emergent marshes and riparian vegetation during the dry season.

- In the SPA, ongoing floodway maintenance, weed eradication, and other ground-disturbing activities can physically destroy or degrade nesting substrate and reduce cover used by rails to evade predators. Ground disturbance can also degrade rails' foraging habitat by disrupting soils and reducing prey availability. Finally, the use of revetment and other bank protection measures eliminates potential rail habitat and can facilitate predation.

- Urbanization, agricultural expansion, and other land-conversion practices are increasing the abundance of predators by providing anthropogenic food sources and increasing habitat suitability for predatory species. Also, the presence of infrastructure, such as roadways, facilitates predator access into wetland areas. An increase in predators will exacerbate other stressors on black rails, including the reduction in foraging, nesting, and high-water refugia habitat anticipated to result from development, sea-level rise, and increased flood risk.

- In addition to altering the timing and intensity of storm events, climate change is expected to result in a sea-level rise that could eliminate suitable habitat for California black rails in the Lower San Joaquin and Lower Sacramento River CPAs (Tsao et al. 2013). Sea-level rise in the Delta is of concern because wetlands will not be able to adapt to rising waters, being constrained by levees and other infrastructure. In particular, the marsh islands where black rails have been detected in the Lower San Joaquin River CPA are susceptible to inundation during flood events, including storms and floodwater-storage releases, and flood control levees reduce the potential for marshes to adapt to rising water levels.

Key Information Gaps or Uncertainties

To better understand factors affecting the California black rail population in the SPA, more information is needed on the distribution and population trends of the species in the SPA, its use of habitats in the SPA, and the potential effects of climate change on rail habitats and populations. These data gaps are discussed below.

- **Distribution and population status.** The distribution and population status of California black rails are poorly understood in the Delta and in other portions of the species' range, including the SPA. Recent surveys have yielded valuable information on black rail distribution and habitat occupancy in the central Delta (Tsao et al. 2013), which includes the Lower San Joaquin River CPA. Continuing those surveys in suitable habitat throughout the Lower San Joaquin and Lower Sacramento River CPAs is necessary to better understand the current distribution and population size of this species in the SPA. In particular, suitable marshes in the northern portions of the Delta, including marsh islands in the northern portion of the Lower San Joaquin River CPA and the southern portion of the Lower Sacramento River CPA, have not been systematically surveyed for black rails. Also, potentially suitable marshes occur in the northern portion of the Lower Sacramento River CPA, such as in the vicinity of Liberty Island, Prospect Island, Ryer Island, and farther north, in the Yolo Bypass (Figure 2). Long-term monitoring is also needed to record how the species' distribution shifts in response to habitat changes that result from flood control practices and restoration efforts, and to assess the effects of flooding and sea-level rise.

- **Habitat use in the SPA.** Increasing our understanding of California black rail habitat use in the SPA will facilitate conservation and management of this species. Black rails have been shown to use emergent wetlands with riparian scrub habitats associated with marsh islands in the Lower San Joaquin River CPA, but rails may occupy other marshes as well. In addition to marsh islands in the Lower Sacramento River CPA that have not been surveyed, black rails may occur in marshes in the Yolo Bypass. Additional surveys would therefore expand our understanding of general habitat use by black rails in the SPA. Black rails tend to select larger marshes over smaller sites (Tsao et al. 2013); however, the extent that California black rails rely on smaller wetlands in the SPA and elsewhere as "stepping stones" during local dispersal events and between metapopulations is unknown; thus, the importance of small marshes to black rails in the SPA is unknown. Also, black rail use of nesting, foraging, and high-water refugia microhabitats in the Delta is poorly understood, and could be elucidated through telemetry or other focused studies. More information on habitat use would be useful in understanding the effects of floodway maintenance practices, such as prescribed burning, herbicide use, and mowing, on this species.

- **Climate change.** The extent to which changes in precipitation patterns will result in flooding that could inundate habitat, or in insufficient flows that could result in a loss of emergent wetlands, is unknown. The extent to which sea-level rise will inundate marsh islands or other suitable habitat with little or no adjacent riparian or upland transition areas is also unknown. Modeling the effects of climate change on current and potential black rail habitat will be useful in predicting future black rail distribution in the SPA and will inform where and how wetland restoration efforts may benefit this species.

Conservation Strategy

Conservation and Recovery Opportunities

The most viable way to increase the California black rail population is to create and maintain shallow emergent wetland habitat suitable for black rail foraging and nesting. Coupled with emergent wetlands, adjacent high-water refuge sites (e.g., riparian scrub/upland transition zones) are needed to provide cover for rails when flood events force them out of emergent wetlands. Management and restoration activities that encourage the expansion of emergent wetlands and riparian habitats/upland transition zones in the Lower San Joaquin and Lower Sacramento River CPAs will benefit this species. Restoration designs should consider features that are important for black rails in the unique habitats that they use in the SPA, including marsh islands in the Delta. Restoration designs that include a wide floodplain that allows for larger wetlands to move upslope in response to sea-level rise will be essential for the long-term viability of the black rail population. Also, woody structures that provide high-water refugia for rails, such as willows and dogwood trees, will be a critical feature of wetland restoration designs.

Identified Conservation Needs

1. **Increase amount and quality of emergent wetlands:** Habitat loss and degradation are the primary threats to the California black rail. In the Lower Sacramento and Lower San Joaquin River CPAs, wetlands composed of emergent freshwater vegetation, such as California bulrush, common tule, and cattails, are most likely to support black rails. Black rails generally avoid low marshes with deeper water, and prefer higher-elevation marshes with dense vegetation and shallow water (i.e., <1 inch deep) or moist soils; higher marshes with dense vegetation provide suitable nesting habitat, and shallow water

and wet soils provide foraging substrate for rails. Black rails are more likely to breed in larger wetlands than in smaller sites. Larger, more diverse marshes are more likely to support habitat features that black rails use for foraging, breeding, and as escape cover than smaller marshes, and they are more likely to support multiple breeding pairs. However, small marshes may also be used for breeding and may be important during dispersal between larger marshes; therefore, the size, configuration, and connectivity of marshes should be considered during restoration efforts in the SPA. Restoration and habitat enhancement efforts should focus in and near marshes where black rails have been detected or where future survey efforts detect them. Black rails are known to occur in marsh islands within the Lower San Joaquin River CPA and at the southern extent of Lower Sacramento River CPA, near the mouth of the Sacramento River. However, systematic surveys for black rails have not been conducted throughout the Delta or in areas to the north, and thus black rails may be more widely distributed and may benefit from restoration in other areas. For instance, marsh habitats in the vicinity of Liberty Island and Prospect Island in the Lower Sacramento River CPA have potential to support black rails (Figure 2). In the Lower San Joaquin River CPA, potentially suitable habitat near King Island and along the Middle River could benefit black rails (Figure 3). Although rails have not been detected in these areas, marsh restoration and enhancement may benefit black rails that occur there and have gone undetected, or may allow for colonization to occur.

2. **Increase amount and quality of high-water refugia:** In addition to emergent wetland vegetation, California black rails require refugia to escape from flooding, and to evade predators when rails move from wetlands to higher areas during flood events. In Delta wetlands, black rails select wetlands with a riparian scrub component (e.g., willows and dogwoods), likely because the taller riparian vegetation provides cover when wetlands are flooded (Tsao et al. 2013). In the SPA, flood control levees are generally steep and lack the broad riparian corridor and upland transitional habitat that historically occurred in the Delta and throughout riverine systems in the region. In addition to depriving rails of refugia, levee systems and other development adjacent to wetlands facilitate predation by giving predators easy access into marshes. Creating gently sloping levees with broad riparian and upland transition areas would allow for larger wetlands that contain more high-water and predator refugia and are more adaptable to sea-level rise (see "Minimize environmental stressors," below). In general, reducing the slope of an existing levee would require that the levee be placed farther from the river channel to accommodate riparian vegetation and other transitional habitats in an expanded floodway, while still meeting conveyance and safety needs. A levee setback thus requires available space on the landward side and a wider footprint to accommodate a gentler slope. Therefore, in addition to ecological considerations, the locations of levee setbacks would be evaluated based on engineering, fiscal, and political feasibility. Levee setbacks create more space for river meandering and sediment erosion and deposition, and facilitate riverine disturbance regimes that support diverse riparian and upland transitional habitats that include refugia. Creating refugia is particularly important in the marsh islands of the Delta, where black rails are particularly susceptible to flooding and where levees provide little cover. Creation of high-water refugia would be most effective in marshes where

rails already occur or are most likely to occur, including the lower portions of the Lower San Joaquin River CPA and the Lower Sacramento River CPA, as described above.

3. **Minimize environmental stressors:** Minimizing the effects of environmental stressors will be essential for the long-term viability of California black rail populations in the SPA. Operations and management activities that occur in wetland or riparian areas could degrade or eliminate suitable black rail habitat. When conducted during the breeding season in or adjacent to suitable habitat, activities that involve loud or percussive noise, vibration, or the presence of humans and equipment could lower black rail reproductive success and possibly cause territory abandonment. Therefore, any activities that could result in habitat loss, degradation, or disruption of breeding should occur outside the black rail breeding season (March through July) or after preactivity surveys confirm that black rails are absent from project areas.

   Climate change will exacerbate other stressors, including predation, because of the potential for increased storm intensity and sea-level rise. Maintaining and restoring larger wetlands, with broader riparian and upland transition zones that support high-water refugia and allow for adaptation to sea-level rise, will minimize, to the extent feasible, impacts associated with climate change.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the California black rail; these are summarized in Table 1 of this section. In many cases, the conservation needs of the black rail can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward 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: Dam releases during the California black rail breeding season (approximately 1 March–31 July) may result in unnatural high-flow events that could flood breeding habitats in the lower Delta and contribute to nest failure or loss of young. However, one of the objectives of the Conservation Strategy is to enhance the ecological benefits of overbank flows. To maintain the viability of nesting habitat during the breeding season, flows that could inundate the higher portions of emergent wetland

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the California Black Rail[a]

CVFPP Management Actions	Conservation Need		
	1. Increase Emergent Wetland Habitat	2. Increase High-Water Refugia	3. Minimize Environmental Stressors
Operations, Maintenance, and Floodway Management			
Floodwater storage and reservoir forecasting, operations, and coordination	-	+/-	+/-
Facility maintenance	-	-	-
Levee vegetation management		-	
Floodway maintenance			
Modification of floodplain topography	+	+	+
Support of floodplain agriculture			
Invasive plant management	+	+	+
Restoration of riparian, SRA, and marsh habitats	+	+	+
Wildlife-friendly agriculture			
Structural Improvements			
Levee and revetment removal	+	+	+
Levee relocation	+	+	+
Bypass expansion and construction	+		+
Levee construction and improvement	+	+	+
Flood control structures			

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

vegetation, where black rails are most likely to nest in marshes, could be conducted outside the breeding season to the extent practicable. High flows conducted outside the breeding season are less likely to disrupt breeding activities and force rails to seek refuge in adjacent areas, and thus less likely to expose adults and young to predation. Floodplain inundation outside the breeding season could also benefit black rails, by encouraging recruitment of riparian vegetation (e.g., willows) that provides high-water refugia for black rails (as well as supporting other special-status wildlife species, such as the least Bell's vireo [*Vireo bellii pusillus*]). Other sensitive species, such as slough thistle (*Cirsium crassicaule*), also may benefit from seasonal floodplain inundation and scour. Water managers could consider meeting the conservation needs of multiple species while coordinating the timing of dam releases to minimize the impacts of high flows. As described above, an increase in high-water refugia in the lower Delta, including near the mouth of the Sacramento River (in the Lower Sacramento River CPA) and in the island marshes associated with the downstream portions of the San Joaquin River (in the Lower San Joaquin River CPA) would benefit the species.

Facility maintenance: Maintenance activities that include manual or mechanical removal of vegetation have the potential to disrupt breeding activities if conducted during the California black rail breeding season. Maintenance activities that damage or remove marsh habitat could also result in the direct loss of rail eggs or young, and disturbance caused by activities in or adjacent to breeding sites could lower reproductive success and possibly result in territory abandonment. It is important that facility maintenance activities in or near emergent marsh habitats be conducted outside the breeding season to avoid adversely affecting breeding rails, unless focused (i.e., protocol-level) breeding-season surveys for black rails yield negative results. Maintenance activities in or adjacent to marsh habitat outside the breeding season would not result in the loss of eggs or young, but could reduce habitat suitability for rails (e.g., by removing suitable vegetation) or cause rails to disperse to other areas.

Levee vegetation management: As described under “Facility maintenance,” vegetation removal near emergent marsh habitats should be conducted outside the breeding season. Additionally, vegetation removal on levees could reduce available high-water upland refugia for the black rail.

Modification of floodplain topography: Strategically lowering floodway elevations to form emergent freshwater marsh habitat and modifying the floodway to achieve greater topographic and hydrologic diversity could create habitat conditions that support black rails. Floodplain surfaces could be lowered by excavating benches or swales that allow for more frequent and sustained inundation, which would facilitate marsh formation. Larger marshes with topographic diversity are more likely to provide a matrix of suitable microhabitats that rails need for foraging (shallow water or moist soils), nesting (high density of emergent vegetation in high marsh areas), and high-water refugia (riparian scrub and broad upland transition zones). Modification of floodplain topography would most benefit rails in the Lower Sacramento and San Joaquin River CPAs, particularly in the lowest reaches of the Delta. Black rails could benefit from restoration of floodplains associated with waterways and levees in the vicinity of Liberty Island and Prospect Island (in the Lower Sacramento River CPA), as well as floodways in areas near King Island (in the Lower San Joaquin River CPA), because ostensibly suitable black rail habitat occurs in those areas (Figure 2).

Invasive plant management: Weeds, such as broadleaved pepper weed (*Lepidium latifolium*), could adversely affect emergent wetlands that provide suitable breeding and foraging habitat for California black rails, and reduce the amount of cover available to rails. Weed infestations could also affect riparian habitat that black rails might use for high-water refugia. Managing and controlling invasive plants could minimize this impact, and restoration using native vegetation would create higher-quality black rail habitat in the Lower Sacramento and San Joaquin River CPAs.

Restoration of riparian, SRA cover, and marsh habitat: California black rails would benefit from restoration of emergent marsh and riparian habitats if the amount of foraging, nesting, and high-water refugia habitat for the species is increased. Restoration designs that would most benefit black rails would include larger marshes with topographic diversity that incorporates shallow water or moist soils, dense emergent vegetation, and riparian scrub (e.g., willows and dogwoods) or other high-water refugia vegetation. Larger marshes with topographic diversity are also likely to be more resilient to flood events and sea-level rise, especially if broad upland transition zones are incorporated into restoration designs to allow adaptation to higher water levels. Newly restored marshes can be quickly occupied by California black rails: this species has been observed occupying new marshes within a year (Richmond et al. 2010a). California black rails are more likely to occupy larger marshes; however, extirpation from a given marsh is more likely when marshes are isolated (Richmond et al. 2008, 2010b). Therefore, restoration of black rail habitat should focus on larger marshes that improve connectivity with other nearby marshes, particularly occupied marshes, to facilitate dispersal between sites (Spautz et al. 2005; Richmond et al. 2010b).

Restoration efforts should be concentrated in the Lower Sacramento and San Joaquin River CPAs, where black rails are known to occur and are most likely to occupy new habitats. Historically, marsh and riparian habitats were major components of the Lower San Joaquin and Sacramento Rivers, and black rails may have occupied these habitats before lands were converted to agriculture and other uses. Some examples of locations where restoration of marsh and riparian habitats may benefit rails in the Lower San Joaquin River CPA include project facilities to the east of King Island, where potentially suitable rail habitat occurs (Figure 2). Habitat restoration along project levees on Middle River may also benefit this species because pockets of potentially suitable habitat, although small and isolated, are found there as well. There are no documented rail observations in these areas, but rails have been observed farther to the west and north; thus, marsh and riparian restoration may allow colonization of these sites. Although there have been no known rail detections in the vicinity of Liberty Island, Prospect Island, or other parts of the Yolo Bypass to the north, these areas of the Lower Sacramento River CPA also support potentially suitable vegetation for black rails (Figure 2), and restoration and management of these areas could benefit the species. Lastly, there is some potential for black rails to expand into other CPAs; however, given that black rails do not occur in ostensibly suitable habitats outside their known distribution, those marshes may be used only for dispersal between populations (i.e., between the Sierra Nevada foothills and San Francisco Bay estuary populations), rather than for breeding.

Structural Improvements

Levee and revetment removal: Removing revetment would provide an opportunity to improve natural erosional and geomorphic processes in the riverine environment. These processes could help create emergent marsh and riparian scrub habitats (e.g., by forming meander bends and cutoffs or new floodplain surfaces) if elevations are appropriate for those habitats. Also, existing habitat may be enhanced by restoring natural riverine processes; for instance, natural scouring could support natural regeneration of riparian habitat that provides high-water refugia for rails. These actions would especially benefit California black rails if they create or enhance marsh habitat near existing marshes, thus enhancing connectivity among sites and increasing the probability of occupancy by black rails. Levee and revetment removal would most benefit rails in the Lower Sacramento and San Joaquin River CPAs, particularly in the lowest reaches of the

Delta. In the Lower Sacramento River CPA, areas in the vicinity of Liberty Island and Prospect Island have potential to support black rails, and levee revetment removal in these areas could improve habitat quality for rails, potentially allowing colonization by this species. In the Lower San Joaquin River CPA, levee revetment removal near King Island or along the Middle River could increase the potential for colonization by black rails, because there are small pockets of potentially suitable habitat in those areas.

Levee relocation: Relocating levees farther from rivers (i.e., constructing levee setbacks) is an important approach to creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats. In newly created floodplains, emergent wetland and riparian scrub habitat can be restored to provide habitat for California black rails. As described under "Levee and revetment removal," focusing on larger wetlands that are close to existing marshes, especially those occupied by rails in the Lower Sacramento and San Joaquin River CPAs, will increase the probability that rails will occupy new sites formed by levee relocation. Levee removal in the vicinity of Liberty Island and Ryer Island in the Lower Sacramento River CPA and near King Island and along the Middle River in the Lower San Joaquin River CPA could benefit black rails because potentially suitable habitat exists in those areas.

Bypass expansion and construction: The expansion of bypasses, if constructed in the Lower San Joaquin and Sacramento River CPAs, would add agricultural land and natural vegetation to the floodway and would result in periodic, prolonged inundation of land that was previously isolated from the river system by levees. An expanded, frequently activated floodplain in the bypasses would support restoration of floodplain ecosystems and may provide suitable wetland habitat for black rails, but only if target areas are shallowly flooded and densely vegetated with emergent wetland plant species. Some vegetation in the Yolo Bypass could be suitable for black rails (Figure 2), and additional bypass expansion in the Lower San Joaquin and Sacramento River CPAs could support black rails if suitable vegetation became established. However, bypasses are flooded irregularly, often have high water levels during flooding, and dry out between inundation events. Therefore, unless flooding in bypasses is managed to be more consistent, so that extreme flooding and drying events do not occur, black rails may not colonize areas of otherwise suitable habitat. Nevertheless, appropriately timed releases could benefit the species in some ways, as discussed under "Floodwater storage, operations, and coordination," above.

Levee construction and improvement: New or reconstructed levees could be configured to provide suitable habitat for California black rails. Any new or reconstructed levees that do not incorporate vegetation that functions as high-water refugia could increase predation risk for rails during periods of high water. However, levees can be configured to allow for colonization of emergent wetland habitats and include high-water refugia that would benefit black rails. Beneficial configurations would include a wide floodplain that is shallowly flooded (i.e., <1 inch deep) and gradually sloped to accommodate a wide band of riparian scrub and upland transition area. Wide transition zones would allow marshes to be resilient to sea-level rise and provide refugia during storms. Also, large marshes with topographic diversity are more likely to accommodate habitat features that rails need for foraging, breeding, and refuge, and are more likely to be occupied, particularly if near other occupied marshes. Levee improvements that provide these features would most benefit rails in the Lower Sacramento and San Joaquin River CPAs, where black rails occur. These areas include the vicinities of Liberty Island and Ryer Island in the Lower Sacramento River CPA, and near King Island and along the Middle River in the Lower San Joaquin River CPA.

Recovery Plan Alignment

There is no recovery plan for California black rails; however, this species, along with several other nonlisted marsh species, is addressed in the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (USFWS 2010). California black rails, like all native birds, are also protected under the federal Migratory Bird Treaty Act and by the California Fish and Game Code. The conservation needs of this species in the SPA are addressed in previous sections of this 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 California black rail. Therefore, building on the preceding discussion, this section of the California black rail 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. 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 the contribution of CVFPP actions to conservation of California black rails, requirements would be added to increase the quantity and quality of emergent wetland and high-water refugia habitat, as well as to minimize environmental stressors such as predation pressure and the increased storm intensity and sea-level rise associated with climate change.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of California black rails, and provides additional specificity as necessary to measure this contribution.

Because management actions intended to benefit the California black rail may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the California Black Rail

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	No	Floodplains that are inundated every 2 years are unlikely to support California black rails unless freshwater emergent vegetation forms on the floodplain and refugia are available. Areas with emergent wetland vegetation and shallow water (<1 inch) or moist soils could support black rails. However, infrequent flooding is unlikely to support this habitat.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	
	River Meander Potential—total amount (acres)	No	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	
	Habitat Connectivity—median patch size (acres)	Yes	
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	The average occupied patch size is 35.73 acres. California black rails have not been detected in patches smaller than 16.93 acres.
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	No	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	No	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	No	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G12. Focused Conservation Plan: Greater Sandhill Crane

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the greater sandhill crane (*Grus canadensis tabida*) and its habitat in the SPA for the CVFPP. There are five defined populations of the greater sandhill crane: the Eastern Population, Prairie Population, Rocky Mountain Population, Lower Colorado River Population, and Central Valley Population (Pacific Flyway Council 1997).

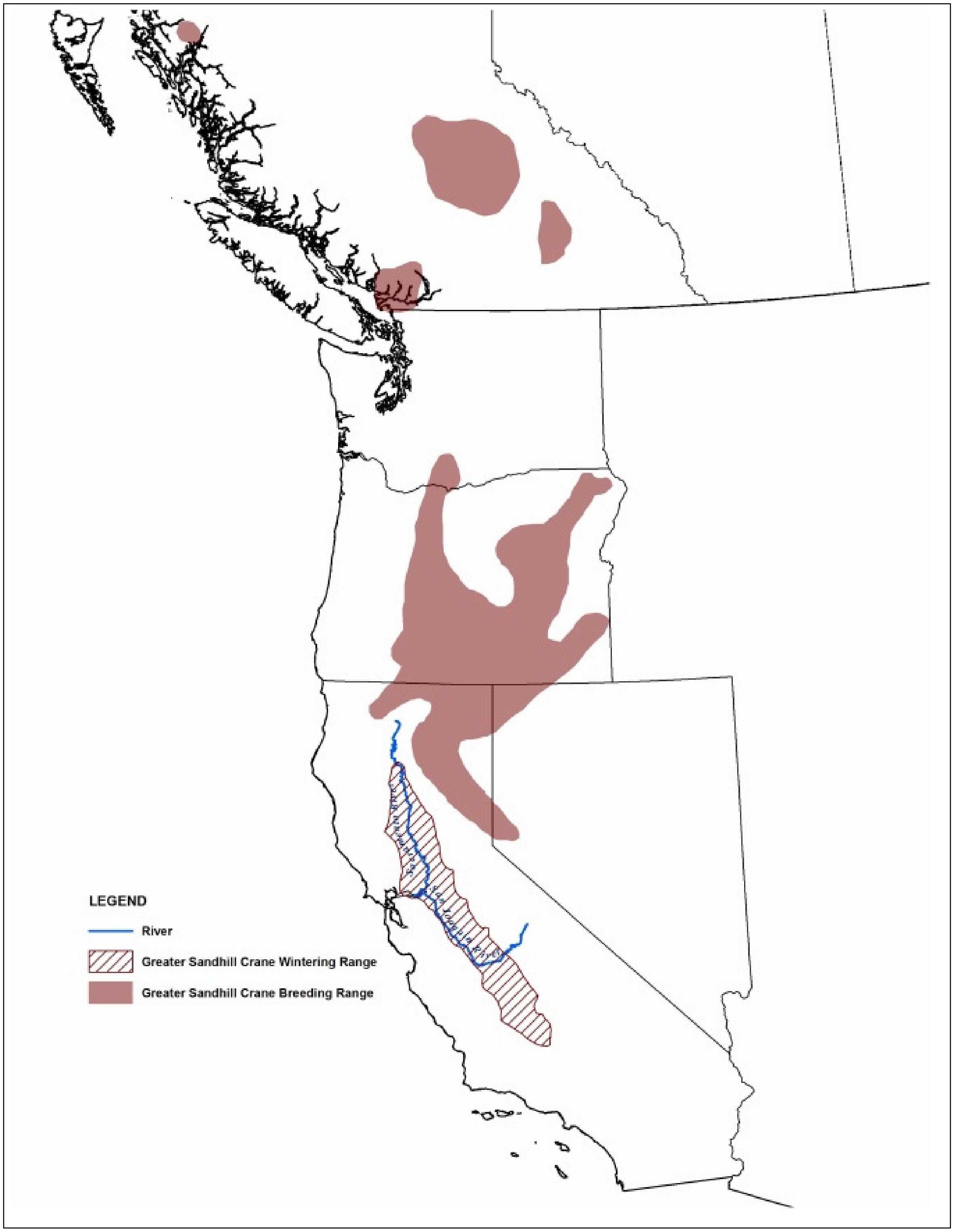
The greater sandhill crane was designated as a threatened species under CESA in 1983 (CDFW 2013). The species was designated as fully protected in California prior to its listing under CESA, and retains its fully protected status. The greater sandhill crane is not federally listed. Like all native birds, greater sandhill cranes are protected under the federal Migratory Bird Treaty Act and by the California Fish and Game Code.

Status and Trends

Distribution

The Central Valley Population of the greater sandhill crane breeds in northeastern California, central and eastern Oregon, southwestern Washington, and southern British Columbia, and winters in the Central Valley and Imperial Valley (Littlefield and Ivey 2000; Littlefield 2002) (Figure 1). Surveys conducted in 1988 within the breeding range found that 67 percent of surveyed pairs were nesting on private lands, and 33 percent were nesting on state and federal lands (CDFG 1994). There are no breeding locations in the SPA; however, the entire Central Valley Population winters in the Central Valley (Littlefield et al. 1994), and greater sandhill cranes use habitats during winter in all of the CPAs, with birds arriving in September and using habitats throughout the Central Valley through March (CDFG 1994; Littlefield and Ivey 2000; CNDDB 2013; eBird 2013). Historical breeding and wintering distributions are not well known, but the Central Valley Population once nested in eastern Siskiyou County, in northeastern Shasta County, and as far south as Honey Lake, in Lassen County (CDFG 1994). Large portions of the Central Valley Population's former breeding range are currently unoccupied. Loss of habitat, along with hunting in the eighteenth and nineteenth centuries, led to extirpation of the greater sandhill crane in many parts of its range (Littlefield and Ivey 2000).

Wintering areas for the Central Valley Population have been identified from the Chico/Butte Basin area south to near Delano in Tulare County. Generally, the majority of the Central Valley Population uses the Butte Basin region in early fall, then moves south to the Delta in late fall and winter (Pogson and Lindstedt 1991). There are no historical records of greater sandhill cranes using the Delta; they likely began using the region after wheat farming began in the 1860s (Littlefield and Ivey 2000). Recent telemetry studies



Source: based on Pogson and Lindstedt 1991, Pacific Flyway Council 1997, and Littlefield and Ivey 2002

Figure 1. Wintering Range and Potential Breeding Range of the Central Valley Population of Greater Sandhill Cranes

indicate that most greater sandhill cranes arrive in the Delta in mid-October, and individuals depart between mid-January and mid-March (Ivey et al. 2011a). Ninety-five percent of winter observations have occurred in the Sacramento Valley, between Butte Sink and the Delta (Pogson and Lindstedt 1991) (Figure 1). Surveys conducted in the early and mid-1980s found that 98 percent of the Central Valley Population's winter range was located on private lands (Pogson and Lindstedt 1991); greater sandhill cranes have likely been using agricultural lands as wintering habitat for more than 100 years (Littlefield and Ivey 2000). Flooding regimes and the availability of roosting sites affect the distribution of wintering sandhill cranes (Ivey et al. 2011a).

Population Trends

In the mid-1980s, Pogson and Lindstedt (1991) estimated the Central Valley Population of "large sandhill cranes" to be 6,000–6,800 individuals. Surveys conducted in the Delta in the mid-1980s recorded a peak of 5,219 greater sandhill cranes in January 1984 (Pogson 1990, as cited in Littlefield and Ivey 2000). The greater sandhill crane Central Valley Population was estimated to be about 8,500 individuals in the early 1990s (Littlefield and Ivey 2000). The overall sandhill crane population estimates conducted in the Delta between mid-December 2007 and early February 2008 resulted in population counts between 20,000 and 27,000 individuals, with the greater sandhill crane population ranging between 2,100 and 6,800 individuals (Ivey et al. 2011a).

It should be noted that the mid-1980s Pogson and Lindstedt (1991) estimate was for "large sandhill cranes," which the researchers considered to be both greater sandhill cranes and Canadian sandhill cranes (*G. c. rowani*), but which excluded lesser sandhill cranes (*G. c. canadensis*); the other studies cited estimated populations of greater sandhill cranes only. Canadian sandhill cranes are considered to be an intermediate-sized subspecies that breeds in boreal forests of North America, with most migrating through the Great Plains and wintering in the Texas Gulf Coast and Mexico; however, some migrate along the Pacific coast and winter in the northern Central Valley with greater sandhill cranes (Tacha et al. 1992; Littlefield and Ivey 2000). There is uncertainty regarding the taxonomic status of the Canadian sandhill crane, because some researchers do not consider it to be a legitimate subspecies (Tacha et al. 1992), and there are no supporting specimens of this subspecies in California (Patten et al. 2003). Therefore, because the intermediate-sized subspecies may be difficult to distinguish in the field, some population estimates of greater sandhill cranes may include Canadian sandhill cranes.

Historically, breeding greater sandhill cranes were common throughout the intermountain west, but by the 1940s there were only 150–200 pairs breeding in Oregon, with five pairs in California, and they were extirpated as a breeder in Washington (Littlefield and Ivey 2000). During surveys conducted in 1988 in Oregon and California breeding grounds, 947 pairs were located in Oregon and 276 were located in California (Littlefield et al. 1994). From 1971 to 1988, breeding pair numbers were stable in Oregon, and in California pairs numbers increased by 52 percent; increases in California were attributed to low densities of predators, the reduced rate of conversion of wetlands to agricultural uses, and above-normal precipitation between 1982 and 1986 (Littlefield et al. 1994). As a result, breeding distributions in California and Oregon are expanding. In Washington, greater sandhill cranes have begun to breed again in small numbers, including in the Conboy Lake NWR and on the Yakama Indian Reservation (Pacific Flyway Council 1997).

Life History

Greater sandhill cranes are the largest of the sandhill crane subspecies, with an average male adult weight of 168 ounces and average female adult weight of 135 ounces (CDFG 1994). Wing cord measurements for adult birds average approximately 22 inches (CDFG 1994). Their coloration is uniformly gray, with contrasting white cheeks and a red crown that extends from the bill to behind the eyes (Tacha et al. 1992).

The life history of sandhill cranes reflects low reproductive output and high parental investment (Littlefield and Ivey 2002), and adult sandhill cranes have high survivorship rates (i.e., greater than 80 percent annual survivorship) (Tacha et al. 1992). Cranes typically mate for life, but will seek another mate if one is lost, and they demonstrate strong nest-site fidelity unless nesting conditions are unfavorable at a previously used site (CDFG 1994). Greater sandhill cranes nest in summer (April–August), constructing a nest over water a few inches deep and laying a one- to three-egg clutch that hatches after an incubation period of about 30 days (Tacha et al. 1992; CDFG 1994). The young can swim, and leave the nest within 24 hours of hatching. They fly at about 2–2.5 months of age, but remain with their parents until about 9–10 months of age (Tacha et al. 1992). Both parents feed and care for the young. After nesting, the parents and young migrate together south in fall to the wintering grounds in the Central Valley, arriving by late September. They move throughout their wintering grounds, following available food resources (Pogson and Lindstedt 1991), then begin migrating northward back to their breeding grounds in late February/early March (Tacha et al. 1992).

Greater sandhill cranes are omnivorous and feed on tubers, seeds, cultivated grains, small vertebrates, and invertebrates found on the surface or subsurface (Tacha et al. 1992). Cultivated grains are a major food item when available (Tacha et al. 1992); however, essential amino acids and calcium are provided by invertebrates such as earthworms, snails, and insects, even though animal matter constitutes a small percentage of the crane’s diet (Reinecke and Krapu 1986). The availability of high-energy resources, in the form of waste grain, allows for the accumulation of lipids used for migration and prenesting activities (Tacha et al. 1992).

Habitat and Ecological Process Associations

Nesting habitat for the greater sandhill crane Central Valley Population consists of wet, open meadows and marshes, mainly in the Great Basin and Cascade Mountains of south-central Oregon and northeastern California (Tacha et al. 1992; Littlefield et al. 1994). Another significant portion of the Central Valley Population nests in British Columbia (Pogson and Lindstedt 1991; Littlefield et al. 1994). Nests are often placed in open habitats consisting of rushes (*Juncus* spp.), sedges (*Carex* spp.), and grasses over shallow water averaging approximately 2 inches deep (CDFG 1994); however, in the Malheur NWR in Oregon, most pairs nest in emergent vegetation, such as hardstem bulrush (*Schoenoplectus acutus*) and cattail (*Typha latifolia*), over water approximately 6 inches deep (CDFG 1994; Littlefield 1995). Predation by common ravens (*Corvus corax*), raccoons (*Procyon lotor*), and coyotes (*Canis latrans*) may result in greater sandhill cranes selecting more concealed nesting sites in the Malheur NWR than is typical in other nesting areas (Littlefield 1995). In a long-term study in the Malheur NWR, most nest predation was associated with coyotes (Littlefield 1995, 2003).

The size of breeding territories varies widely and depends on the quality of available habitat. Territories have been reported to be as small as 17 acres in high-quality habitat in Malheur NWR to as large as 640 acres in low-quality habitat in the Ash Creek Wildlife Area in California (CDFG 1994). The availability of water and foraging areas are the two main components of successful breeding sites (CDFG 1994). Chicks feed primarily in moist meadows on invertebrates, or, if meadows dry out prematurely, in upland sites on grasshoppers and other insects (CDFG 1994). Foraging in grain fields and roosting in shallow water is typical during the postbreeding period and before cranes migrate to wintering areas in the Central Valley (Littlefield 1986; Pacific Flyway Council 1997); foraging areas in Malheur NWR are typically within 3.7 miles of communal roosting sites (Littlefield 1986). Areas in which sandhill cranes roost communally during or before migration to wintering habitat in the Central Valley include Malheur NWR, Lower Klamath NWR, southern Langell Valley (Klamath County), and Modoc NWR when grain crops are available (Littlefield 1986; Pacific Flyway Council 1997).

Wintering habitat for greater sandhill cranes in the Central Valley generally consists of irrigated pastures and croplands, grain fields, small open ponds, wetlands, and floodplains that are open and without visual obstruction (e.g., dense vegetation). Site fidelity and lack of disturbance are the key factors that influence selection of wintering areas by greater sandhill cranes (Littlefield and Ivey 2002). Greater sandhill cranes demonstrate strong fidelity to wintering sites, and move between wintering areas less often than lesser sandhill cranes (Ivey et al. 2011b). In general, cranes concentrate in regions with extensive agricultural land uses, particularly small-grain crops (Littlefield and Ivey 2002). In the Sacramento Valley, greater sandhill cranes feed primarily in harvested rice fields, whereas farther south in the Delta and San Joaquin Valley, they feed more on waste corn. Sandhill cranes throughout the Central Valley also loaf and feed in uncultivated pastures and wetlands (Pacific Flyway Council 1997). Although grain crops are important, wetlands are also important sites for nighttime roosts, as well as for midday loafing and some foraging (Littlefield and Ivey 2002).

Cranes typically leave roosts for agricultural grain fields, where they forage, in early morning. Midday, cranes loaf and may occasionally forage in pastures or shallow wetlands (Littlefield and Ivey 2002), where they may be obtaining other components of their diet, such as amino acids, that are not found in grain foods (Reinecke and Krapu 1986). Most cranes return to grain fields in the afternoon and feed until evening, when they return to roosts (Littlefield and Ivey 2002).

Roosting sites in the Central Valley typically include wetlands or flooded agricultural fields, usually in open areas without dense vegetative cover (Littlefield and Ivey 2002). Greater sandhill cranes roost by congregating in shallowly flooded areas, such as wetlands or fields. In the Sacramento Valley, water depths at roosts range from 3.4 to 6.7 inches, and at a traditional roost in the Delta, water depths ranged from 2 to 4.6 inches (Littlefield and Ivey 2002). Roosting sites in the Central Valley are generally close to foraging sites. In the Delta, most roosts sites are within 2.5 miles of grain fields (Littlefield and Ivey 2002), and the average flight distance between night roosts and foraging sites in the Delta is 1.3 miles (Ivey et al. 2011b). Wintering home ranges of greater sandhill cranes in the Delta average 545 acres (Ivey et al. 2011b).

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for the greater sandhill crane within the SPA (Figure 2). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by greater sandhill cranes within the SPA;
- the specific CPAs in which greater sandhill cranes winter;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that the could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

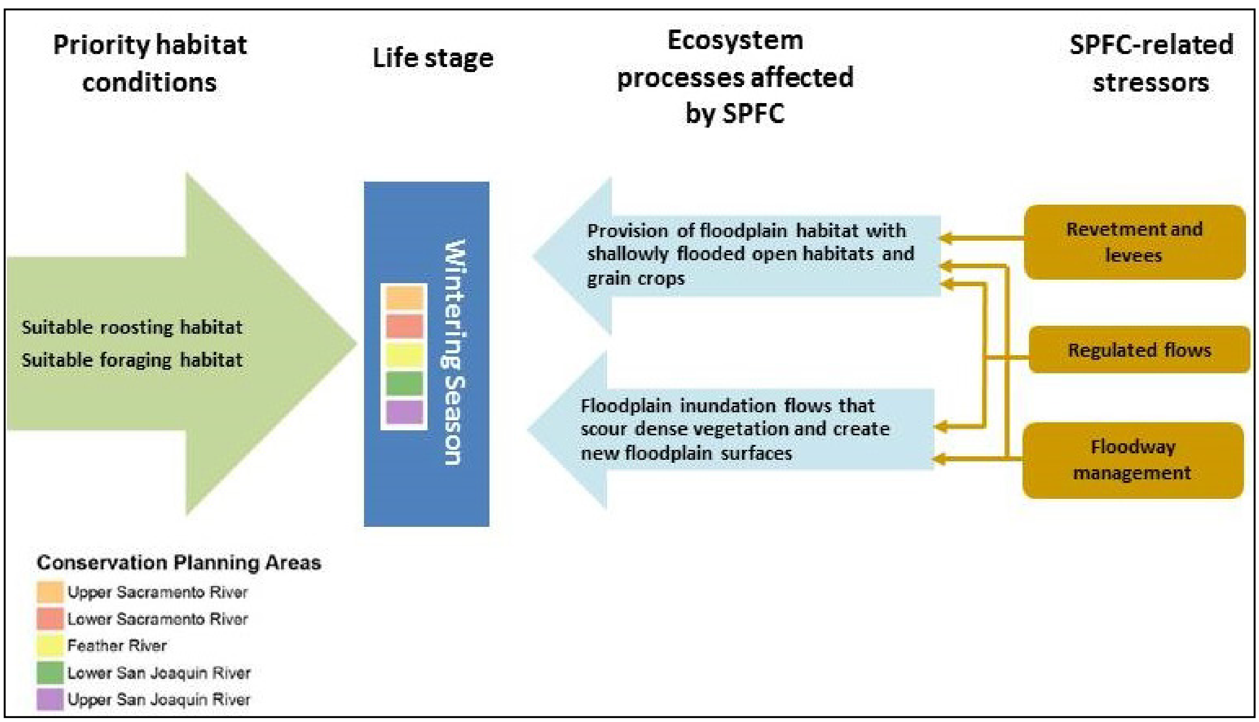


Figure 2. Conceptual Model for Greater Sandhill Crane within the SPA

Management Issues

Threats and Sensitivities Range-Wide

The main threats to the Central Valley Population of greater sandhill cranes are predation of eggs and young, loss of both breeding and wintering habitats, and mortality caused by illegal shooting and accidental collisions with power lines (Pacific Flyway Council 1997).

Declines in numbers of breeding cranes in portions of their range (particularly in the Malheur NWR in Oregon) and loss of breeding habitat were the main reasons the greater sandhill crane was designated by the State of California as a threatened species. Predation on eggs and chicks is a major cause of greater sandhill crane mortality (Littlefield and Ivey 2002). This was demonstrated when predation on young cranes increased after 1972, after the use of toxicants for predator control on public lands was prohibited and predator populations increased (Littlefield and Ivey 2000). In the Malheur NWR, nesting success was lower, fewer young fledged, and recruitment rates were lower in years when there was no predator removal (1972–1981) compared with years during which some predators were removed (1966–1971 and 1982–1989) (Littlefield 2003).

Breeding habitat has been lost as wetlands have been replaced by agriculture or by residential development (Littlefield and Ivey 2002). Drawdown of water for use in irrigation has decreased water levels in crane brooding areas and reduced invertebrate availability. Consequently, the survival rate of young cranes that feed on invertebrates has dropped (Pacific Flyway Council 1997). Suitable breeding habitat may also be threatened by land use practices such as late-season irrigation and pivot irrigation techniques that replace flood irrigation (Littlefield and Ivey 2002). Finally, young cranes are vulnerable to mortality caused by land use activities such as mowing and grazing that occur on private lands where cranes breed (Pacific Flyway Council 1997; Littlefield and Ivey 2002).

In their wintering range, loss of established wintering habitat has adversely affected greater sandhill cranes. Even if adequate grain crops are available in their range, greater sandhill cranes demonstrate strong fidelity to wintering sites and do not readily shift to new foraging areas (Littlefield and Ivey 2000). Therefore, although new wintering habitat may become available, cranes may not easily transition to using those sites. Wintering habitat in the Central Valley is being lost as grain fields and pasturelands are converted to orchards and vineyards. In the northern Central Valley, grain fields (e.g., corn, wheat, and barley) are being converted to orchards, and in the Delta, vineyards are becoming more common, which may result in the loss of grain fields as well as irrigated pastures (Littlefield and Ivey 2002). Wintering habitat has also been lost to urban expansion in the Central Valley (Littlefield 2002; Littlefield and Ivey 2002).

Changes in agricultural practices have also affected wintering habitat and food availability for greater sandhill cranes. Modern farming practices create less waste grain, which greater sandhill cranes consume (Littlefield 2002; Littlefield and Ivey 2002). Specifically, the availability of waste rice, particularly in the northern Central Valley, is influenced by management techniques: disking fields after harvest eliminates access to grains, and burning after harvest reduces the amount of rice available (Littlefield 2002). Also, management of lands for wintering waterfowl may not be compatible with the needs of wintering greater sandhill cranes. Waterfowl efficiently forage for rice and other grains in flooded fields, but sandhill cranes are not adapted to forage on submerged seeds and often avoid flooded grain fields (Littlefield 2002; Littlefield and Ivey 2002).

Market hunting in the eighteenth and nineteenth centuries contributed to the extirpation of sandhill cranes in many parts of their range (Littlefield and Ivey 2000). Market hunting in the Delta in particular supplied San Francisco markets with wild game. The passage of the Migratory Bird Treaty Act halted market hunting for cranes in 1916 (Littlefield and Ivey 2000), and hunting likely is not currently a major cause of mortality for greater sandhill cranes. However, human disturbance, including upland game and waterfowl hunting, can alter greater sandhill crane use of agricultural fields, wetlands, pastures, and other potentially suitable habitat (Littlefield and Ivey 2002). The presence of humans can flush cranes from their roosts or foraging sites, thus increasing energetic demands and forcing cranes to seek other suitable habitats.

Finally, greater sandhill cranes are vulnerable to collisions with power lines, which may be the primary cause of crane mortality after fledging occurs (CDFG 1994). Markers (e.g., orange plastic globes) have been successfully used to prevent cranes from colliding with power lines (CDFG 1994).

Ongoing and Future Impacts

Ongoing impacts on greater sandhill cranes in the SPA include loss or degradation of wintering habitat, reduced food availability, mortality caused by power line collisions, and possibly the effects of climate change.

- Greater sandhill cranes in the Central Valley rely heavily on private lands for foraging and roosting sites, and are therefore vulnerable to changes in land use (CDFG 1994). Development of agricultural lands continues to result in the loss of wintering and staging areas for cranes (Littlefield and Ivey 2002). Additionally, human disturbances (including hunting) near foraging or roosting sites can reduce available habitat for greater sandhill cranes (Littlefield and Ivey 2002).

- Changes in agricultural practices have reduced the amount of food available for greater sandhill cranes. Potential foraging areas are being eliminated by the conversion of grasslands and cereal grain fields to orchards and vineyards in the Central Valley (Pacific Flyway Council 1997; Littlefield 2002). In addition, in the Sacramento Valley, common postharvest agricultural practices, such as burning of harvested rice, flooding, and disking, could reduce the amount of waste seed available to wintering cranes (Littlefield 2002). Also, flooding agricultural fields or grasslands to manage habitat for waterfowl is often incompatible with sandhill crane foraging (Littlefield 2002; Littlefield and Ivey 2002). It is unknown whether the ongoing reduction of available foraging habitat will result in greater sandhill crane population declines.

- Power lines near roosting and feeding sites, particularly in foggy areas, are a cause of mortality for greater sandhill cranes (CDFG 1994).

- Greater sandhill cranes from the Central Valley Population do not appear to be particularly sensitive to the threat of climate change, but their wintering habitat could be threatened by increased flood risk if sea levels rise.

Key Information Gaps or Uncertainties

To contribute to the long-term conservation of greater sandhill cranes, more information is needed about known roosting and foraging locations in the SPA and how management actions can increase the quantity and quality of greater sandhill crane wintering habitat. These information gaps are discussed below.

- **Wintering distribution in the SPA.** Regular monitoring of greater sandhill crane distribution, and documentation of their regularly used foraging and roosting sites in the SPA (especially relative to SPFC levees, other infrastructure, and conservation lands managed by DWR), would inform conservation planning for this species. Understanding greater sandhill crane spatial distribution in the SPA would facilitate restoration and management of habitat in locations that greater sandhill cranes are more likely to use. Regular monitoring would also be necessary to determine whether CVFPP management actions affect greater sandhill crane habitat use, distribution, and population status.

- **Responses to wintering habitat management.** The extent to which greater sandhill cranes would respond to CVFPP management actions is unknown. Greater sandhill cranes have higher site fidelity and smaller home ranges compared to lesser sandhill cranes (Ivey et al. 2011b), so greater sandhill cranes may not readily use new foraging or roosting habitats. Sandhill crane population levels are generally regulated mainly by reproductive success rather than survivorship after fledging; thus, the extent to which increasing habitat quantity and quality on the wintering grounds will result in increased carrying capacity is unknown. Further, the acreage of roosting and foraging habitat needed to increase the carrying capacity of wintering greater sandhill crane habitat in the SPA is not known. Therefore, research and monitoring is needed to determine whether restored or managed sites are used by greater sandhill cranes (e.g., if floodplains are used for roosting), and analysis is required to determine if greater sandhill crane carrying capacity can be increased through enhanced habitat quantity or quality on wintering grounds.

Conservation Strategy

Conservation and Recovery Opportunities

Littlefield and Ivey (2000) suggested that restoring wetlands to mimic the natural hydrological patterns of the region (e.g., flooding during the wet season) would benefit greater sandhill cranes and other wildlife, particularly in the floodplains of the Cosumnes and Mokelumne Rivers, which are located in the southern Lower Sacramento River CPA and the northern Lower San Joaquin River CPA. Throughout the SPA, the timing and duration of inundation at roosting sites likely influences greater sandhill crane distribution in the Central Valley: early (i.e., early September) and late (i.e., through mid-March) flood regimes at roosts would enhance greater sandhill crane habitat (Ivey et al. 2011a). Also, wetland vegetation could be maintained in early seral stages in managed wetlands, and dense stands of emergent vegetation could be discouraged to attract greater sandhill cranes. Because greater sandhill cranes demonstrate fidelity to wintering sites and small home ranges and movements, conservation of wintering habitat near (i.e., within 1.3 miles) existing roosts would increase the probability that cranes use those sites (Ivey et al. 2011b). Also, increasing the amount of potential roosting habitat at the edge of greater sandhill cranes' current winter range would provide foraging access to currently unused agricultural fields, potentially increasing the carrying capacity of the wintering habitat (Ivey et al. 2011b). Opportunities to expand roost sites for greater sandhill cranes may occur in and near the Yolo Bypass, on agricultural lands near existing crane roosts.

Identified Conservation Needs

1. **Increase the amount and extent of roosting habitat:** Greater sandhill cranes exhibit fidelity to roosting sites and restrict their movements around those sites. They roost in shallowly flooded wetlands or agricultural fields that are close (i.e., within 1.3 miles) to foraging habitat. To benefit this species, CVFPP management actions could incorporate flooding regimes that allow for the presence of shallow water when greater sandhill cranes occur in the SPA, including as early as mid-September and as late as early March. Water depths of 2 to 6 inches in wetlands or fields without dense vegetative cover are most likely to attract roosting cranes. Cranes use wetlands and fields that are open and without visual obstructions, such as trees, dense vegetation, or structures (e.g., levees); thus, habitats that are not open are unlikely to be used by cranes. Wetlands and other flooded areas, in addition to providing potential roosting habitat, could also occasionally be used by cranes to forage for prey items that provide dietary components not available in grains. Because greater sandhill cranes can be sensitive to human disturbance near roosts, areas managed as roosting habitat should be relatively devoid of human activities that could cause cranes to flush from roosts during periods when they are most likely to be present (i.e., between September and March).

2. **<u>Increase the amount and extent of foraging habitat:</u>** Greater sandhill cranes forage in irrigated pastures and croplands, grain fields, small open ponds, wetlands, and floodplains. Grain crops are extremely important to greater sandhill cranes in the Central Valley, and some of these crops are being replaced by other crops (e.g., orchards and vineyards) and by development. Modern farming practices may reduce the availability of waste grain near established crane roosts. Also, lands managed for waterfowl are typically less suitable for foraging sandhill cranes, because they are inefficient foragers in deeply flooded areas. Conversion of grain crops is an ongoing practice; it is not known whether a reduction in foraging habitat has affected the winter survival or reproductive success of greater sandhill cranes. However, because greater sandhill cranes restrict their space use around roosting sites, this species would benefit from agricultural practices that involve placing grain fields, particularly rice or corn crops, close (i.e., within 1.3 miles) to suitable greater sandhill crane roosting sites. As with roosting habitat, lands selected to be managed as foraging habitat for cranes should be in open areas (i.e., without visual impediments) and must not be near power lines or sources of frequent human disturbance (CDFG 1994).

3. **<u>Reduce greater sandhill crane mortality:</u>** The carrying capacity of greater sandhill cranes is largely regulated by reproductive success on the breeding grounds. However, adult mortality can occur on the wintering grounds of the Central Valley (particularly through collisions with power lines), limiting population growth. Management actions intended to benefit greater sandhill cranes could negatively affect the species if cranes are attracted to areas where power line collisions could occur. Thus, for potential management actions to positively affect cranes (by increasing foraging and roosting habitat), areas managed to encourage greater sandhill crane roosting must not be located near power lines that may result in collisions, particularly in regions with dense fog. Alternatively, power lines near crane roosts can be fitted with markers, or lines could be buried to prevent collisions. When new CVFPP facilities that require power lines are built, plans for the placement of power lines could take into account the locations of existing and potential crane roosts and foraging sites. In addition, areas managed for greater sandhill cranes should be relatively devoid of human disturbances that could cause cranes to flush from roosts between September and March, when roosting cranes may be present. Flushing from roosts, particularly in foggy conditions, may increase the potential for cranes to collide with power lines.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the greater sandhill crane; these are summarized in Table 1 of this section. In some cases, the conservation needs of the greater sandhill crane can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management,

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Greater Sandhill Crane[a]

CVFPP Management Actions	Conservation Need		
	1. Increase Amount and Extent of Roosting Habitat	2. Increase Amount and Extent of Foraging Habitat	3. Reduce Greater Sandhill Crane Mortality
Operations, Maintenance, and Floodway Management			
Floodwater storage and reservoir forecasting, operations, and coordination	+/-	+/-	+/-
Facility maintenance			
Levee vegetation management			
Floodway maintenance	+/-	+/-	+/-
Modification of floodplain topography	+/-	+/-	+/-
Support of floodplain agriculture	+	+	+/-
Invasive plant management	+	+	+/-
Restoration of riparian, SRA, and marsh habitats	+	+	+/-
Wildlife-friendly agriculture	+	+	+/-
Structural Improvements			
Levee and revetment removal	+	+	+/-
Levee relocation	+/-	+/-	+/-
Bypass expansion and construction	+	+	+/-
Levee construction and improvement			
Flood control structures			

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

and structural improvements. Actions to restore habitat and support agriculture would take into consideration the potential for humans to disturb cranes in those areas, especially near roosting sites where cranes might flush in response to human activity (e.g., maintenance, construction, and hunting). Also, habitat restoration and management would be avoided in locations, especially in foggy areas, with nearby power lines that could result in crane mortality. Power line markers or burial of power lines may be considered in areas where power lines occur but which otherwise represent suitable habitat for greater sandhill cranes.

In some instances, implementation of CVFPP management actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway’s existing capacity for conveying floodflows and/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 toward 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: Dam releases that allow for wetlands and agricultural fields to be shallowly flooded between mid-September and early March could benefit greater sandhill cranes by providing potential roosting habitat. These sites would be most beneficial if potential roosting habitat is flooded to depths of 2 to 6 inches and occurs in close proximity (i.e., within 1.3 miles) of foraging locations. Dam releases that flood potential roosting habitat to unsuitable depths for cranes (i.e., >6 inches) could negatively affect greater sandhill cranes by reducing the amount of roosting habitat available.

Floodway maintenance: Floodway maintenance actions could benefit greater sandhill cranes if maintenance practices, such as livestock grazing, reduce dense vegetation in floodplains, grasslands, or agricultural fields that cranes may use for roosting or foraging. Management practices that restrict dense vegetation in floodways would be most effective in areas that cranes already use or in nearby areas, free of disturbance, where they may expand their distribution.

Maintenance activities that result in human disturbance during the greater sandhill crane wintering period (September through March) could discourage cranes from using otherwise suitable habitat, thus resulting in a negative effect on cranes. Therefore, to the extent feasible, maintenance activities in or near potential roosting or foraging habitat could be scheduled outside the greater sandhill crane wintering period. If the wintering period cannot be avoided, a qualified biologist could conduct preactivity surveys of work areas to identify crane use and thereby prevent disturbance of wintering cranes, in particular the flushing of cranes from roosting sites. The biologist would determine suitable buffer distances for work activities, based on the level of disturbance that would occur. Assessing the level of disturbance would require consideration of how many personnel would be present, the type of equipment that would be used (to assess noise impacts), and the duration of the activity, as well as consideration of topography and other visual barriers that may allow work to be conducted without disturbing cranes.

Modification of floodplain topography: Strategically lowering floodway elevations to form seasonally inundated habitats, and allowing scour to create new floodplain areas and remove dense vegetation, could benefit greater sandhill cranes by creating potential roosting or foraging habitat. Cranes would most likely use wider floodplains, rather than narrow floodplains, because they select open habitats without visual impediments. Floodplain modification would positively affect cranes if the topography resulted in shallowly flooded open areas that cranes could use for roosting or foraging. Floodplain modifications that submerge shallowly flooded areas with deeper water would have a negative effect on cranes, because they are less likely than waterfowl to use deep water. The addition of new inundated floodplains near the edges of currently used roosting and foraging sites would most likely benefit cranes because of the potential to expand their current distribution. Areas where floodplain modification may be beneficial include the

Lower Sacramento and Lower San Joaquin River CPAs, where greater sandhill cranes are known to use the floodplains of the Cosumnes and Mokelumne Rivers.

Support of floodplain agriculture: Floodplain agriculture currently provides important foraging habitat for greater sandhill cranes in the Central Valley. Managing floodways to support grain crops such as rice and corn would provide important foraging resources to greater sandhill cranes, and benefit their population, especially if grain crops are located close to existing or potential roosting areas. Farming practices that produce waste grain would enhance greater sandhill crane foraging opportunities. To ensure that waste grain is available to cranes after harvest, incentive programs could be implemented to encourage farmers to use harvest practices that result in waste grain, such as mulching corn or partial harvests. Incentive programs may include landowner incentive grants, land-lease subsidies, tax exemptions, or enrollment in other land conservation programs. Areas managed for greater sandhill crane foraging would not be flooded, as are areas managed for waterfowl, because cranes tend to forage on dryer land.

Invasive plant management: Removal of invasive plants would benefit cranes if treated areas are located in or adjacent to crane foraging and roosting sites, because cranes generally avoid areas of dense vegetation. Cranes could benefit if removal of invasive plants occurred in open areas, such as floodways or other shallow wetlands that cranes may use for roosting or foraging. However, because cranes favor open habitats without visual obstruction, they are likely to avoid otherwise suitable habitats near levees (i.e., regardless of vegetation management practices, the presence of the levees will likely discourage cranes from using adjacent habitat). Thus, removing invasive plants on levees or in other areas where there are visual obstructions (other than dense vegetation) is unlikely to create new, open habitats that cranes would use.

Restoration of riparian, shaded riverine aquatic (SRA) cover, and marsh habitats: Restored marsh habitats could provide important nighttime roosting habitat and may occasionally be used for foraging. Greater sandhill cranes are more likely to use marshes that are shallowly inundated, open (without dense vegetation), and free from frequent human disturbance. Cranes would most likely prefer large, wide marshes over smaller marshes, because they select open areas and avoid spaces with vegetation or structures that impede their view. Restored marshes would benefit greater sandhill cranes in areas that could expand the current distribution of cranes, such as near currently used roosting and foraging sites.

Support of wildlife-friendly agriculture: Incorporating wildlife-friendly agricultural practices would increase the habitat value of agricultural lands for greater sandhill cranes. The most important agricultural practice providing habitat for greater sandhill cranes is cultivation of grain crops, such as corn or rice, near existing or potential roosting sites. Agricultural practices that create waste grain after harvest would benefit this species; therefore, farming practices that destroy waste grain or make grain unavailable could be avoided in areas managed for cranes. For instance, disking or burning rice fields after harvest makes most waste grain unavailable to sandhill cranes. Also, inundating grain fields makes waste grain largely unavailable to sandhill cranes; thus, flooding of grain fields should be avoided when wintering cranes are present. Long-term habitat value for greater sandhill cranes could be achieved by supporting wildlife-friendly agriculture through landowner incentive grants, land-lease subsidies, tax exemptions, conservation easements, or management of conserved areas.

Structural Improvements

Levee and revetment removal: Removing revetment would reduce operations and maintenance costs while reconnecting rivers with floodplain habitats and allowing for more natural riverine geomorphic processes. These processes could help create seasonally inundated floodplain habitats that are beneficial to greater sandhill cranes. Removal of levees and revetment would be most beneficial if combined with other habitat restoration projects, or near habitats currently used by greater sandhill cranes, that allow for the expansion of greater sandhill crane wintering habitat, especially in the Lower Sacramento and San Joaquin River CPAs.

Levee relocation: As described above, under "Levee and revetment removal," relocating levees (i.e., constructing levee setbacks) and thereby reconnecting rivers to floodplains would expand potential greater sandhill crane roosting habitat. Levee relocations that support agriculture within expanded floodways would be most beneficial to greater sandhill cranes, especially if floodways include roosting sites in close proximity to foraging areas. As described in "Support of wildlife-friendly agriculture," agriculture that results in waste grain in floodplains that are not flooded after harvest would most benefit cranes. Although levee relocation could be beneficial, any levees that are relocated to existing greater sandhill crane foraging or roosting sites would reduce available habitat for cranes in the given area, resulting in a negative effect.

Bypass expansion and construction: Construction of new bypasses or expansion of existing bypasses would establish new seasonal floodplains that could provide greater sandhill crane roosting habitat. New or expanded bypasses that include agricultural lands would also enhance foraging opportunities for greater sandhill cranes. Because greater sandhill cranes have small home ranges, bypasses that include both roosting and foraging habitat are more likely to support cranes than bypasses with only one habitat component, because cranes are more likely to use foraging areas that are close to roosting sites. Agriculture that results in waste grain would increase potential greater sandhill crane foraging habitat. As described in "Support of floodplain agriculture," incentive programs to encourage farmers to grow crops that result in waste grain could be implemented.

Recovery Plan Alignment

CDFW does not have a statewide recovery plan for the greater sandhill crane.

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 greater sandhill crane. Therefore, building on the preceding discussion, this section of the greater sandhill crane 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. The species-specific measures provide additional detail on geographic location, habitat structure, and other attributes important to conserving the species. For example, the acreage of marsh restoration is an indicator of progress toward the Conservation Strategy's marsh habitat objective. To measure the contribution of CVFPP actions to the conservation of greater sandhill cranes, requirements would be added to increase acreage that makes a positive contribution to the marsh habitat that the species requires for roosting. Additional specificity would be would be added to these targets to increase the quantity and quality of roosting and foraging habitat for greater sandhill cranes in the SPA.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of greater sandhill cranes, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit greater sandhill cranes may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Greater Sandhill Crane[a]

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	Shallowly inundated (<6 inches) are most likely to be used by greater sandhill cranes for roosting and occasionally for foraging. Floodplains near potential foraging areas and near the edges of currently used roosting sites may expand their current distribution; these areas may include the Lower Sacramento and Lower San Joaquin River CPAs, where greater sandhill cranes are known to use the floodplains of the Cosumnes and Mokelumne Rivers.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	
	River Meander Potential—total amount (acres)	No	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Greater Sandhill Crane[a]

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	No	
	Habitat Connectivity—median patch size (acres)	No	
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Increase open, shallowly flooded (2–6 inches) marsh habitats located near foraging sites to benefit greater sandhill cranes.
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	Yes	Promote the cultivation of grain crops, such as corn or rice, near existing or potential roosting sites. Avoid inundation of grain crops after harvest to minimize loss of food supply.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	No	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	During invasive plant removal, create open areas suitable for greater sandhill crane foraging or roosting.

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G13. Focused Conservation Plan: Least Bell's Vireo

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the least Bell's vireo (*Vireo bellii pusillus*) and its habitat in the SPA for the CVFPP.

The least Bell's vireo, a small, Neotropical migratory songbird, is one of four subspecies of Bell's vireo recognized by the American Ornithologists' Union (1957). It is the westernmost subspecies, breeding entirely within California and northern Baja California. Historically, it was a common to locally abundant subspecies in California (Grinnell and Miller 1944), and riparian habitats in the Central Valley once supported 60–80 percent of the population (Franzreb 1989). The least Bell's vireo was listed as endangered by the California Fish and Game Commission, pursuant to CESA, on 2 October 1980, and was federally listed as endangered by USFWS on 2 May 1986 (51 FR 16474), because of a sharp decline in its population and reduction of its range. Critical habitat was designated in 1994, and a recovery plan was subsequently published in 1998. By the time the species was listed as endangered, it had been extirpated from most of its historical range. The least Bell's vireo is a focal species in *The Riparian Bird Conservation Plan* (RHJV 2004).

No nesting pairs had been confirmed to occur in the five CPAs in the last 50 years until 2005, when one pair successfully bred (two nestlings were observed) in the Lower San Joaquin River CPA on a 3-year-old riparian restoration site in the San Joaquin River NWR in Stanislaus County (Wood et al. 2006). The male, color banded in 2005, returned to the San Joaquin River NWR in 2006 with a mate and successfully fledged at least two more young in a restored riparian area approximately 330 feet from the 2005 nest site (Howell et al. 2010). In 2007, a female least Bell's vireo built a nest and laid four eggs, but none hatched (Howell et al. 2010). Additional recent records of breeding and territorial males in northern California indicate that the least Bell's vireo may be in the early stages of recolonizing its former range in this portion of the state.

Status and Trends

Distribution

The least Bell's vireo is a small, Neotropical migratory songbird that is sparsely distributed along waterways in southern California and northern Baja California, Mexico (Brown 1993). In California, the least Bell's vireo was historically distributed throughout much of the state, including the Central Valley, the central and southern Coast Ranges, local areas of the eastern Sierra Nevada, and the southwestern portion of the state (Franzreb et al. 1994; Kus 2002).

The species was once purported to be common to locally abundant throughout its range (Grinnell and Miller 1944). However, riparian habitat in California is estimated to have declined by up to 98 percent since European contact (RHJV 2004), and this extensive habitat destruction, exacerbated by the population pressure of parasitism by brown-headed cowbirds (*Molothrus ater*), caused precipitous population declines (Kus et al. 2010). Specifically, large-scale conversion of riparian areas has resulted in a substantial reduction of Bell's vireo habitat in the west, while habitat fragmentation and conversion of adjacent uplands to agriculture and grazing have increased cowbird parasitism rates. Habitat fragmentation also isolates subpopulations, which then become more susceptible to extirpation (Kus et al. 2010). As a result of this effect, the species has been extirpated from most of its former range, becoming restricted primarily to a few small, remnant populations in riparian drainages in counties south of Santa Barbara (excluding Imperial County). The greatest abundance of least Bell's vireos occurs in San Diego County (Franzreb et al. 1994).

Recently, the least Bell's vireo has been documented to occur in the Lower San Joaquin River CPA, on a riparian restoration site in the San Joaquin River NWR. Given that the least Bell's vireo depends on early successional riparian habitat, if similar restoration projects are implemented throughout the SPA, they may provide suitable habitat that will facilitate the species' expansion into its historical range. It should be noted that large-scale riparian restoration efforts are occurring in other NWRs, on State lands, at various land trusts, and on private lands throughout the Central Valley. Figure 1 illustrates the historical range, current range, and recent breeding location of least Bell's vireos in California.

Population Trends

The least Bell's vireo population declined dramatically between 1930 and 1985. This decline has been attributed to the fragmentation of suitable habitat caused by the loss and degradation of riparian habitat in the species' breeding range (Smith 1977; Wilbur 1981) and to nest parasitism by the brown-headed cowbird (Grinnell and Miller 1944; Franzreb 1989). The California breeding population was estimated to be 300 pairs at its low point in the early 1980s (Kus 2002). Since the species was listed, recovery efforts, including riparian habitat restoration and cowbird management in core population areas, have resulted in increases in least Bell's vireo populations in some areas of southern California. In 1996, the population estimate in California was 1,300 pairs, and by 2004, the estimate rose to 2,500 pairs (USFWS 1998; Kus and Whitfield 2005). The species appears to be recolonizing its range, which may be attributed to riparian restoration or to an increasing population that will naturally disperse into suitable early successional habitats provided by restoration efforts. A pair of least Bell's vireos was confirmed to be breeding in the San Joaquin River NWR in Stanislaus County in 2005, 2006, and 2007; however, no least Bell's vireos were detected on the refuge in 2008 or 2009 (Howell et al. 2010; Dettling et al. 2012). A pair was documented attempting to nest along Llagas Creek in Santa Clara County in 1997 (Rottenborn 2007). Also, small numbers of singing individuals have recently been detected in other portions of the species' historical range, including San Luis Obispo, Tulare, Merced, Yolo, Sacramento, and Santa Clara Counties (Kus 2002; Padley 2010).

Source: Howell et al. 2010; reproduced with permission. Historical distribution based on Grinnell and Miller (1944); CWHR = California Wildlife Habitat Relationships

Figure 1. Current and Historic Least Bell's Vireo Distributions in California and Locations of 2005–2007 Breeding Records

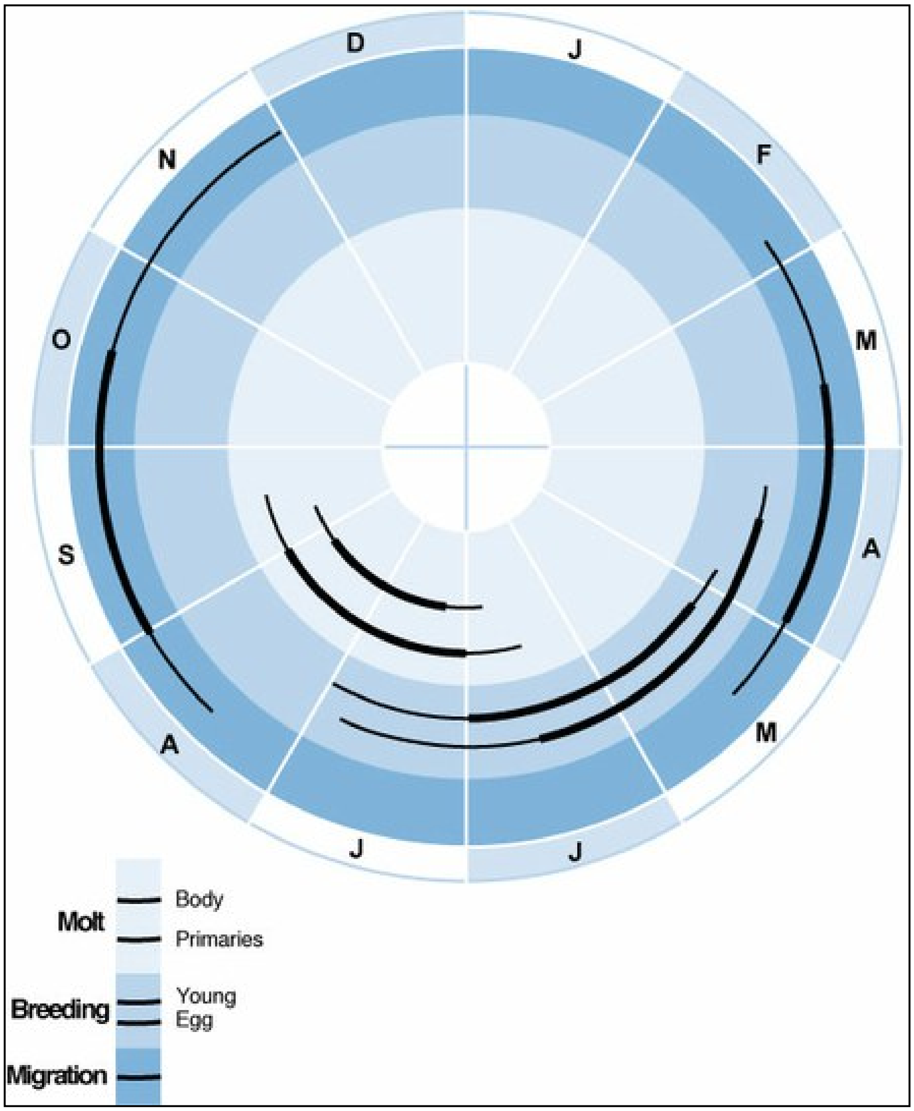
As noted, in addition to habitat loss, brood parasitism by the brown-headed cowbird has been linked to the least Bell's vireo population decline (Franzreb 1989; Kus 1999, 2002). Brood parasitism rates vary across populations, averaging between 30 and 50 percent (Brown 1993), but have been as high as 80 percent (Jones 1985). In a long-term study of brood parasitism rates in three populations of least Bell's vireos in San Diego County, rates of parasitism were more than 37 percent (Kus 2002), and parasitism accounted for between 58 and 71 percent of the variability in seasonal productivity (Kus and Whitfield 2005). Least Bell's vireo populations become unstable when brood parasitism rates reach 30 to 48 percent, and rates above 48 percent will lead to extinction in a short time (Laymon 1987). Cowbird management has been successfully implemented as a strategy to reduce brood parasitism rates (Griffith and Griffith 2000; Famolaro 2006). However, restoring and maintaining suitable habitat and the riverine processes that renew early successional habitat may be a more sustainable method for maximizing breeding opportunities, because the dense habitat that the least Bell's vireo prefers provides a buffer from brown-headed cowbirds (Sharp and Kus 2006).

Life History

Least Bell's vireos arrive on their breeding grounds in California from mid-March to early April and begin departing to their wintering grounds in Mexico in late July; some (primarily birds of the year) may remain on the breeding grounds until late September (Garrett and Dunn 1981; Salata 1983). In southern California, territory sizes range from 0.5 to 7.5 acres but average between 1.5 and 2.5 acres (USFWS 1998). Least Bell's vireos exhibit high breeding-site fidelity, returning to the same territory (even nesting in the same shrub) over multiple years (Kus 2002). Females select suitable trees or shrubs with dense cover, and the pair constructs a cup-shaped nest approximately 3–6 feet off the ground using leaves, bark, willow catkins, spider webs, and other materials (Bent 1950; Barlow 1962). Nests tend to be placed in forked branches of willows (*Salix* spp.) and mule fat (*Baccharis glutinosa*), but a variety of other riparian trees and shrubs are also used.

Least Bell's vireos forage by gleaning insects from vegetation closely associated with their breeding habitat. Their diet consists of a variety of insects and arachnids, including beetles, grasshoppers, moths, and particularly caterpillars and spiders (Chapin 1925; Brown 1993). Least Bell's vireos preferentially forage in mid-level vegetative strata (10–20 feet high), but they will forage at all levels of the riparian canopy (Grinnell and Miller 1944; Miner 1989). They may also forage in upland vegetation adjacent to riparian corridors, particularly later in the season (Gray and Greaves 1981; Salata 1983).

The Birds of North America annual cycle for the least Bell's vireo is shown in Figure 2 below.



Source: Kus et al. 2010, in The Birds of North America Online; reproduced with permission

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

Figure 2. Annual Cycle of Breeding, Molt, and Migration in Bell's Vireo; Breeding Data from Grand Canyon, Arizona

Habitat and Ecological Process Associations

The least Bell's vireo is characterized as a riparian-obligate breeder (Kus 1998), using dense thickets of early successional willow shrubs and other low bushes along perennial or ephemeral streams (Franzreb et al. 1994; Kus et al. 2010). Early successional to mid-seral riparian forests with a dense understory provide important nesting habitat for this endangered bird (Howell et al. 2010). A plant community consisting of low-growing willows, coyote bush (*Baccharis pilularis*), and California rose (*Rosa californica*), with an understory of mugwort (*Artemesia douglasiana*), gumplant (*Grindelia camporum* var. *camporum*), California blackberry (*Rubus ursinus*), and beardless wild rye (*Elymus triticoides*), has been demonstrated to provide highly suitable habitat structure and offers nest concealment and protection from predators (Dettling et al. 2012). Ideal least Bell's vireo nesting habitat includes a wide (greater than 800 feet) riparian corridor with dense shrub growth extending vertically from 2–10 feet, few trees greater than approximately 3.2 inches in diameter at breast height (dbh) forming the canopy, and an open canopy (Kus 2002; Sharp and Kus 2006; Kus et al. 2010).

Early successional habitats are highly ephemeral, productive communities and require periodic disturbance to renew and maintain the vegetative structural components and species composition that the least Bell's vireo prefers. 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 early successional plant communities. As these natural processes continue, they generate new floodplain surfaces and create a mosaic of vegetation that supports the highly suitable nesting habitat on which the least Bell's vireo relies.

Brown-headed cowbirds prefer to forage on grain and insects in open grasslands, in agricultural areas, and near livestock (Goguen and Mathews 1999; Chace et al. 2005), but they lay their eggs in the nests of other bird species. Some studies have shown that parasitism rates decrease rapidly with distance from food sources (Verner and Ritter 1983; Uyehara et al. 2000). Nest parasitism of the least Bell's vireo occurs in areas where open land borders the riparian habitat where vireos nest. Much of the riparian habitat throughout the range of the least Bell's vireo has been fragmented, providing opportunities for the brown-headed cowbird to locate the nests of their host species. The ideal dense nesting habitat described above conceals and protects vireo nests from the brown-headed cowbird. Nests in large willows have been found to have a lower probability of parasitism than those placed in other plant species, especially when there was also a dense understory component (Sharp and Kus 2006). Scrub habitats adjacent to riparian corridors are equally important to vireos because they also provide vegetative buffers that protect and conceal nests from brown-headed cowbirds.

Range expansion depends on successful reproduction in occupied habitat and dispersal to suitable unoccupied habitat. Successful breeding and dispersal of young birds in southern California, coupled with riparian restoration efforts, is attributed to the species' recent dispersal into its historical breeding range, including the Central Valley (Kus and Beck 1998; USFWS 1998; Kus and Whitfield 2005; Dettling et al. 2012). Dispersal distances in California have been shown to be between 150 and approximately 230 miles, which is not an unusual range, given that maximum dispersal distances for several species of passerines are reported to be approximately 250 miles (Greaves and Labinger 1997; Sutherland et al. 2000; Dettling et al. 2012). 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 recovery of the least Bell's vireo population.

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for least Bell's vireo within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by least Bell's vireos within the SPA;
- the specific CPAs within which the least Bell's vireo may breed under suitable habitat conditions;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

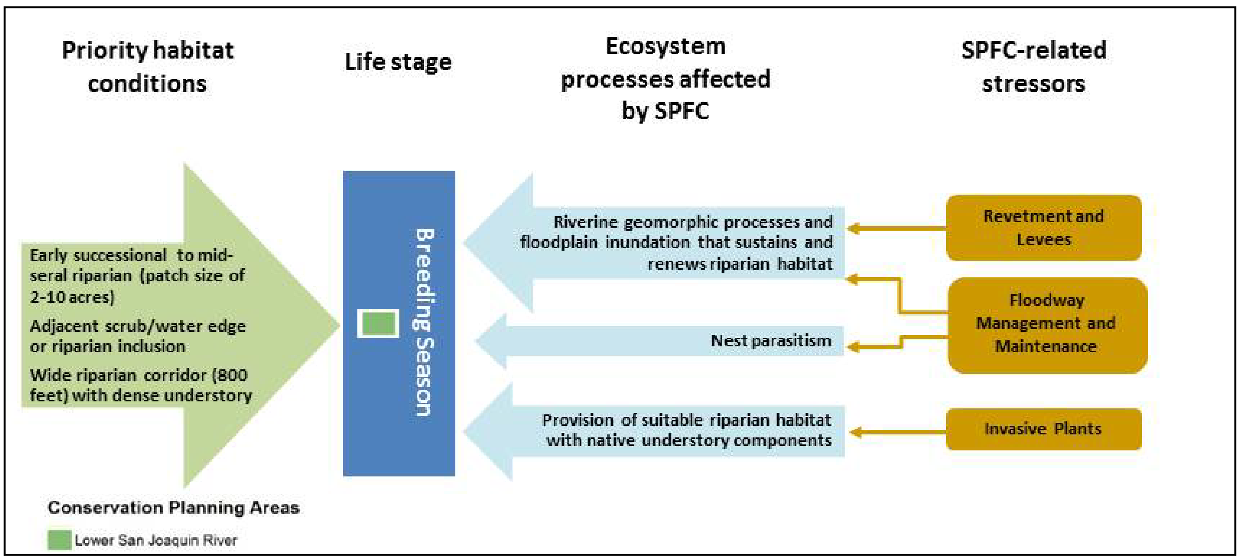


Figure 3. Conceptual Model for Least Bell's Vireo within the SPA

To further understand the habitat requirements of the least Bell's vireo, the California Wildlife Habitat Relationships (CWHR) System created a Level II model prototype for the species (Laudenslayer and Parisi 2007). The model results indicated that the presence of water (rivers, streams) enhances habitat suitability, with valley foothill riparian and desert riparian habitat being the most suitable for the species. The following required attributes of suitable habitat patches were also identified:

- **Patch size:** 2 acres is the threshold for low suitability, and a patch size of 10 acres or more is considered to be highly suitable.

- **Edge:** A tree/water edge or shrub/water edge is necessary. The species is found in shrubby habitats, often along stream courses, both perennial and intermittent.

- **Food:** Invertebrates, especially terrestrial insects, are essential. This species also consumes fruit.

- **Spatial habitat requirements for persistence of population:**

  - Lowest suitability = 200 acres, if suitable patches cover at least 75 percent of area, are at least of minimum suitable size (2 acres), and are a maximum of approximately 100 feet apart.

  - Highest suitability = greater than 500 acres, if suitable patches cover at least 75 percent of area, are at least of minimum suitable size (2 acres), and are less than approximately 16.5 feet apart.

Management Issues

Threats and Sensitivities Range-Wide

The population decline of least Bell's vireos is largely a function of loss and degradation of early successional to mid-seral riparian habitat throughout the species' range, the alteration and loss of river processes that renew and maintain these habitats, brood parasitism by brown-headed cowbirds, and the habitat effects caused by invasive, exotic vegetation. Riparian habitat in California is estimated to have declined by up to 98 percent since European contact (RHJV 2004). Levees, dams, and other flood control structures prevent natural disturbances and the subsequent development of early successional vegetation, leading to riparian forests with dense canopies and open understories, which represent unsuitable breeding habitat for this species. Also, if suitable nesting habitat is surrounded by agricultural land or developed areas, brown-headed cowbirds can become more abundant and consequently lower the breeding success of riparian-breeding avian species, including the least Bell's vireo. Minimizing the availability of brown-headed cowbird food sources, especially near suitable least Bell's vireo habitat, could be another tool to reduce parasitism rates.

Ongoing and Future Impacts

The most important ongoing and likely future issues for sustaining viable breeding populations of least Bell's vireos in the Central Valley are the continued loss of suitable habitat, the lack of river processes that sustain early successional habitat, nest parasitism by brown-headed cowbirds, and climate change. As discussed in "Population Trends," least Bell's vireo populations continue to fluctuate and may be rebounding from the estimated historical low, but they may be experiencing an overall decline from historical estimates because of brood parasitism by the brown-headed cowbird; if parasitism rates increase, the least Bell's vireo will be threatened with extinction. Climate change may also influence the future distribution of least Bell's vireos in the SPA, although the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. In two different climate change models developed by the California Avian Data Center (Ballard et al. 2008), the current range of least Bell's vireo grows northward, following the rivers of the Central Valley and expanding into the tributaries associated with the Upper and Lower Sacramento and San Joaquin River CPAs. This predicted range recolonization further illustrates this species' dependence on riparian systems and emphasizes the need to secure and restore suitable breeding habitat that it can use in the future.

Key Information Gaps or Uncertainties

To better understand factors affecting the least Bell's vireo population, more information on local population trends and migratory routes, including stopover sites and wintering locations, is needed.

- **Regional population trends.** Understanding population trends at a regional level (i.e., in areas of California where least Bell's vireos are currently breeding) will enable researchers to identify sites of population increases or declines and determine relative contributions of habitat loss and degradation, cowbird parasitism, and other factors that influence the population. Understanding these dynamics will be the key to identifying and prioritizing sites for conservation and management of this species. Currently, suitable habitat occurs in the San Joaquin River NWR, at Kern River Preserve, and at Caswell Memorial State Park. In the Sacramento Valley, areas of potential least Bell's vireo habitat include the Cosumnes River Preserve, Bobelaine Sanctuary, Butte Sink, and Big Chico Creek to the mouth of Pine Creek and the Sacramento River (USFWS 1998).

- **Migration and wintering grounds.** Very little information exists regarding the wintering range and migratory routes of this species (American Ornithologists' Union 1998). Recorded observations of wintering least Bell's vireos have occurred between Baja California Sur to Mexico and Central America. Understanding conditions in the wintering grounds and identifying key stopover locations will help identify the habitats and threats that this species may encounter during migration.

Conservation Strategy

Conservation and Recovery Opportunities

The most viable ways to support recovery of the least Bell's vireo are to encourage natural riverine processes that promote early successional habitat and implement riparian habitat restoration to increase and sustain suitable nesting habitat throughout the SPA, while reducing occurrences of brood parasitism by the brown-headed cowbird. Creating suitable breeding habitat patches and connecting those patches to existing or new suitable habitat would increase opportunities for least Bell's vireo to recolonize the margins of waterways in the SPA (part of the species' historical range). Given the recent successful breeding events associated with riparian restoration in the Lower San Joaquin River CPA, restoration efforts appropriate for this species would be beneficial throughout the SPA. Furthermore, connecting riparian habitat and increasing cottonwood-willow habitat between riparian forest patches may be beneficial to many other bird species, including special-status species (e.g., western yellow-billed cuckoo and willow flycatcher) (Kleinschmidt Associates 2008). Improving ecosystem function and restoring natural riverine geomorphology by implementing appropriate management actions would create the disturbance regimes necessary to create and maintain this suitable habitat. Additionally, cowbird management could be used as a tool to prevent nest parasitism in areas where least Bell's vireo populations are monitored and low productivity is documented. Currently, such management may not be feasible in the Central Valley because least Bell's vireo breeding attempts are too limited; however, if the species begins to recolonize historical habitat and more information pertaining to cowbird management is acquired, it could become practicable. All such conservation and restoration initiatives could incorporate the vegetative and structural components identified in the "Conceptual Model" section.

Identified Conservation Needs

1. **Increase and sustain nesting habitat:** The least Bell's vireo 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 and sustain nesting habitat. Decommissioning levees may also contribute to geomorphic processes that create early successional habitat. This suitable habitat must be situated along streams or rivers, with a minimum patch size of 2 acres. Riparian restoration 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 riparian restoration efforts.

2. **Reduce nest parasitism:** Brood parasitism by brown-headed cowbirds lowers the breeding success of the least Bell's vireo. Sustaining dense, early successional habitat with a dense understory may naturally minimize nest parasitism rates. Incorporating scrub habitat next to suitable breeding habitat also provides a protective buffer from brown-headed cowbirds (lowering the rate of brood parasitism) while creating foraging opportunities for the least Bell's vireo. Lastly, minimizing brown-headed cowbird food sources, especially in areas close to least Bell's vireo habitat, may also reduce parasitism rates. Conducting surveys for brown-headed cowbirds in areas where breeding populations of least Bell's vireos occur would inform targeted conservation efforts. To ensure that the least Bell's vireo has the opportunity to successfully breed and disperse, removal of brown-headed cowbirds may be needed, but should not be the primary management method.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the least Bell's vireo; these are summarized in Table 1 of this section. In many cases, the conservation needs of the least Bell's vireo can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Operations, Maintenance, and Floodway Management

Modification of floodplain topography: Lowering floodplain elevations would provide more frequent and sustained inundation, which may allow the growth of additional riparian vegetation (i.e., more suitable vireo habitat) along channel margins. As the least Bell's vireo population expands, this growth could benefit the species if it occurs in areas next to known nesting habitat or areas that may support nesting habitat, such as in the southern part of the Sacramento–San Joaquin River Delta (near Paradise Cut) and near the confluence of the Feather and Sacramento Rivers.

Support of floodplain agriculture: Agricultural lands provide habitat for the brown-headed cowbird. Least Bell's vireo territories bordering on agricultural areas have been shown to be significantly less successful in producing young than territories bordering on coastal sage scrub, grassland, and chaparral (Regional Environmental Consultants 1989). As least Bell's vireos recolonize the SPA in response to conservation and restoration actions, providing scrub habitat or other vegetative buffers from agricultural lands will be important for protecting and concealing nests from brown-headed cowbirds.

Invasive plant management: New weed infestations could negatively affect the early successional riparian habitat on which the least Bell's vireo relies during the breeding season. Managing and controlling invasive plants could minimize this impact. Additionally, using a planting palette of suitable understory plants in riparian restoration projects could provide nest concealment and protection from predators. Native forbs and grasses should be incorporated into restoration designs, because they have been shown to reduce invasive species colonization in newly planted sites (McClain et al. 2011; Moore et al. 2011; Tjarks 2012).

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Least Bell's Vireo[a]

CVFPP 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		
Facility maintenance		
Levee vegetation management		
Floodway maintenance		
Modification of floodplain topography	+	
Support of floodplain agriculture		-
Invasive plant management	+	+
Restoration of riparian, SRA, and marsh habitats	+	+
Wildlife-friendly agriculture		-
Structural Improvements		
Levee and revetment removal	+	
Levee relocation	+	
Bypass expansion and construction	+	-
Levee construction and improvement	-	
Flood control structures		

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

Restoration of riparian, SRA cover, and marsh habitats: Riparian restoration in core least Bell's vireo population areas has been shown to be important and effective in facilitating increases of this species' population in southern California (USFWS 1998) and in supporting recent colonization of parts of its historical range (Kus 2002; Rottenborn 2007; Padley 2010). 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 would create nesting and foraging habitat for the least Bell's vireo (USFWS 2005); this diversified habitat would also provide corridors that accommodate other riparian-obligate species.

Wildlife-friendly agriculture. Wildlife-friendly agriculture is an important conservation tool for benefiting many target species, but expanses of open habitat are preferred by the brown-headed cowbird. Establishing agricultural lands next to known least Bell's vireo breeding locations may inadvertently lead to nest parasitism by cowbirds.

Structural 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 the rivers. Encouraging river meander and natural erosional processes that deposit soils and facilitate early successional riparian habitat establishment would benefit the least Bell's vireo by providing and maintaining suitable nesting habitat.

Levee relocation: As discussed above, improving ecosystem function and restoring natural riverine geomorphology by relocating levees would create opportunities to establish and sustain early successional habitat. Specifically, an expanded floodway, reconnected to the river channel, would allow for river meander, sediment erosion and deposition, and natural ecosystem disturbance processes, all of which could contribute to creating new suitable habitat and renewing early successional habitat that is important for sustaining populations of the least Bell's vireo. Also, 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. Habitat connectivity has been shown to be an important factor in conservation of the Bell's vireo (Laudenslayer and Parisi 2007).

Bypass expansion and construction: The expansion of bypasses would add agricultural land and natural vegetation to the floodway and would result in 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 least Bell's vireo. However, the expansion of 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 least Bell's vireo. Potential areas where bypass expansion could benefit the least Bell's vireo include the Yolo Bypass in the vicinity of Putah Creek and the area near Paradise Cut.

Levee construction and improvement: New or reconstructed levees could restrict the floodway, preventing natural geomorphic processes from creating and sustaining the early successional riparian habitat that the least Bell's vireo relies on as nesting habitat. New levees should not be constructed adjacent to rivers and near areas that have the potential to support suitable nesting habitat.

Recovery Plan Alignment

The draft recovery plan for least Bell's vireo (USFWS 1998) lists the following criteria, which constitute recovery goals for the species:

- Reclassification to threatened may be considered when Criterion 1 has been met for a period of 5 consecutive years:

   - **Criterion 1.** Stable or increasing least Bell's vireo populations/metapopulations, each consisting of several hundred or more breeding pairs, are protected and managed at the following sites: Tijuana River, Dalzura Creek/Jamul Creek/Otay River, Sweetwater River, San Diego River, San Luis Rey River, Camp Pendleton/Santa Margarita River, an Orange County/Los Angeles County metapopulation, Santa Clara River, Santa Inez River, and an Anzo Borrego Desert metapopulation.

- Delisting may be considered when the species meets the criterion for downlisting (i.e., Criterion 1) and the following criteria have been met for 5 consecutive years:
   - **Criterion 2.** Stable or increasing least Bell's vireo populations/metapopulations, each consisting of several hundred or more breeding pairs, have become established and are protected and managed at the following sites: Salinas River, a San Joaquin Valley metapopulation, and a Sacramento Valley metapopulation.
   - **Criterion 3.** Threats are reduced or eliminated so that least Bell's vireo populations/metapopulations listed above are capable of persisting without significant human intervention, or perpetual endowments are secured for cowbird trapping and exotic plant control in riparian habitat occupied by least Bell's vireo.

This focused conservation plan was developed to be consistent with the recovery plan for least Bell's vireo.

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 least Bell's vireo. Therefore, building on the preceding discussion, this section of the least Bell's vireo 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 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 conservation of the least Bell's vireo, requirements would be added to increase acreage that makes a positive contribution to the early successional riparian habitat that the species requires for nesting.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of least Bell's vireos, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit least Bell's vireos may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Least Bell's Vireo

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	Yes	
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	
	River Meander Potential—total amount (acres)	Yes	A water edge in favored nesting habitat is essential.
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Wide riparian corridors with the following attributes are essential: wider than 800 feet, presence of dense thickets of early successional riparian habitat (willows and other low shrubs 2–10 feet tall, few open-canopied trees greater than 3.2 inches dbh, and a dense understory [mugwort, etc.]), and presence of a water edge.
	Habitat Connectivity—median patch size (acres)	Yes	Provide 2–10 acres: 2 acres is the threshold for low suitability; 10 acres is considered highly suitable. A tree/water edge or shrub/water edge is also essential.
Marsh	Habitat Amount—total amount and total amount on active floodplain area (acres)	No	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Least Bell's Vireo

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	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	No	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G14. Focused Conservation Plan: Swainson's Hawk

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the Swainson's hawk (*Buteo swainsoni*) and its habitat in the SPA for the CVFPP.

The Swainson's hawk is a migratory raptor that was listed by the State as a threatened species under CESA in 1983. Its population had declined in response to the loss of nesting habitat (Schlorff and Bloom 1984) and foraging habitat, precipitated by development and the conversion of land uses to agricultural uses considered unsuitable for the species (England et al. 1995). The Swainson's Hawk Technical Advisory Committee, a conglomeration of Swainson's hawk experts including agency, consulting, and nongovernmental organization personnel, was established in 1989 to address management, research, and land use issues affecting the species. The Swainson's hawk is also a focal species in *The Riparian Bird Conservation Plan* (RHJV 2004). The Swainson's hawk is not federally listed; however, between 1982 and 1994, it was a candidate for listing as endangered or threatened five times.

Swainson's hawks garner considerable conservation attention and frequently are a prominent regulatory concern under the California Environmental Quality Act (CEQA) because of their preference for nesting and foraging in open, lowland habitats that often are the focus of development (and where there is consequently potential for direct impacts and habitat loss). For this reason, CDFW and others have promulgated standards for quantifying and mitigating risks to Swainson's hawks from various development activities (CDFG 1994; Yolo County HCP/NCCP Joint Powers Agency [YC HCP/NCCP JPA] 2002; California Energy Commission [CEC] and CDFG 2010).

Status and Trends

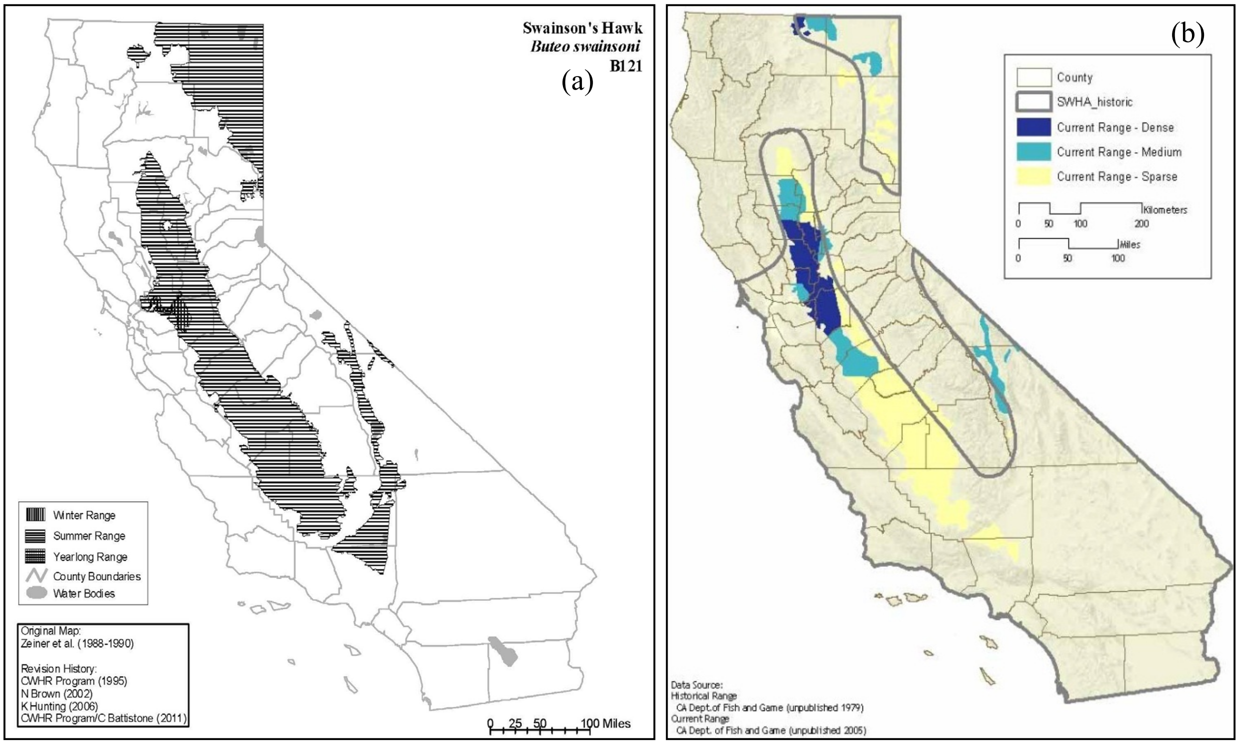
Historical Distribution

Since the early 1900s, the range of nesting Swainson's hawks in California has contracted substantially (Bloom 1980; Anderson et al. 2007). Once prevalent across lowland habitats throughout much of the state, the species is now extirpated from the Southern Transverse Ranges and central Coast Ranges, and its nesting distribution is greatly reduced in many other areas where it was once prevalent. The most substantial decline involved extirpation from the coastal region of southern California, where Swainson's hawks were once considered an abundant breeding species (Sharp 1902).

Current Distribution

Swainson's hawks occur in all five CPAs. An estimated 95 percent of the state's Swainson's hawk population is currently located in the Central Valley (Anderson et al. 2007). Within the Central Valley, approximately 85 percent of the area's population occurs in the southern Sacramento–northern San Joaquin Valley region of Yolo, San Joaquin, and Sacramento Counties

(Estep 1989; CDFG 1993; Anderson et al. 2007). In this region, Swainson's hawks nest primarily in riparian forest or suitable isolated trees and forage in adjacent agricultural and grassland habitats. Outside of the Central Valley, only a handful of nest sites are located in the southern half of the state; these sites are found primarily in Antelope Valley and Owens Valley. In northeast California, Butte Valley supports a population of Swainson's hawks considered to be part of the Great Basin population. Figure 1 illustrates the historical and current range of Swainson's hawks in California, as portrayed by CDFW's CWHR System.



Source: (a) CWHR System and (b) Anderson et al. (2007)

Figure 1. Historical and Current Distribution Maps for Swainson's Hawks in California

Population Trends

Since the Swainson's hawk was listed as threatened in California, researchers have undertaken a variety of efforts to:

- understand the reasons for the species' decline and document the nesting population size and range in the state (e.g., see Estep 1989, 2008; Woodbridge 1998; Anderson et al. 2007; and Gifford et al. 2012);
- determine patterns of use and the relative importance of nesting and foraging habitats on population dynamics (e.g., see Schlorff and Bloom 1984, Estep 1989, Smallwood 1995, Swolgaard et al. 2008, and Briggs et al. 2011);
- evaluate the genetic characteristics of California Swainson's hawks (Hull et al. 2008);

- document the migratory habits and winter-range characteristics of selected populations (Woodbridge et al. 1995); and,
- develop the *Conservation Strategy for Swainson's Hawk in California* (Bradbury 2009).

These research efforts have contributed valuable insight into Swainson's hawk population dynamics and have informed conservation efforts for this species. Over the last 70 years, population estimates and trends have been assessed using a variety of methods, such as inventorying breeding pairs, monitoring active nests, and documenting territories. Bloom (1980) inventoried nesting Swainson's hawks on public and private lands across California and concluded that the statewide population had declined by as much as 90 percent since the early 1900s, from an estimated historical population of 4,000–17,000 breeding pairs down to an estimated 375 pairs in 1979. Grinnell and Miller (1944) reported evidence of declines as early as the 1940s. A statewide survey conducted in 1988 recorded 320 active territories, with 75 percent of territories located in the Central Valley and 24 percent in the Great Basin of northeastern California, and estimated the statewide population at 550 breeding pairs (CDFG 1988). Anderson et al. (2007) conducted a statewide assessment in 2005–2006 and estimated the population to be 1,770–2,393 pairs, with the majority located in the Sacramento Valley and San Joaquin County. From these studies, it is apparent that the population size of Swainson's hawks in the Central Valley increased substantially after the species was listed by the State as threatened in 1983.

In an effort to update nest records in the CNDDB, Gifford et al. (2012) conducted a nest monitoring study in 2002, 2003, and 2009 in portions of the Sacramento Valley and Sacramento–San Joaquin River Delta. They used a stratified sampling design with replacement to select a set of survey blocks for each survey year, meaning that some blocks may or may not have been surveyed more than once in the multi-year study. The study documented 593, 1,008, and 941 nests, respectively, with 60 percent of nests occurring on the valley floor in the four counties surrounding the Delta (San Joaquin, Sacramento, Solano, and Yolo). Spatial analysis of nest-location data revealed that active nests tended to be clumped, suggesting that there are spatial differences in habitat parameters or differential preferences within this habitat (e.g., clumping of nests in a given area may facilitate predator detection and deterrence). The increase in Swainson's hawks in the Central Valley suggests that the conservation efforts identified in the species' conservation strategy (Bradbury 2009) initiated by State listing of the species have been effective.

The recent increasing trend may also reflect a combination of continuing, successful adjustment by the hawks to using agricultural fields as primary foraging habitats, as well as a positive response to reduced mortality on wintering grounds (Goldstein et al. 1999a; Briggs 2007). On a range-wide basis, substantial concern arose in the mid-1990s after tens of thousands of Swainson's hawks were found dead on wintering grounds in Argentina, poisoned by monocrotophos, a highly toxic organophosphate insecticide that local farmers were using to control grasshoppers, the hawks' primary prey in this area (Woodbridge et al. 1995; Goldstein et al. 1996, 1999b). International outcry over this finding led to an immediate reduction in use of this harmful pesticide, and the Argentine government ultimately banned its use in 2000 (Woodbridge 2001), which substantially reduced the winter mortality rate of Swainson's hawks

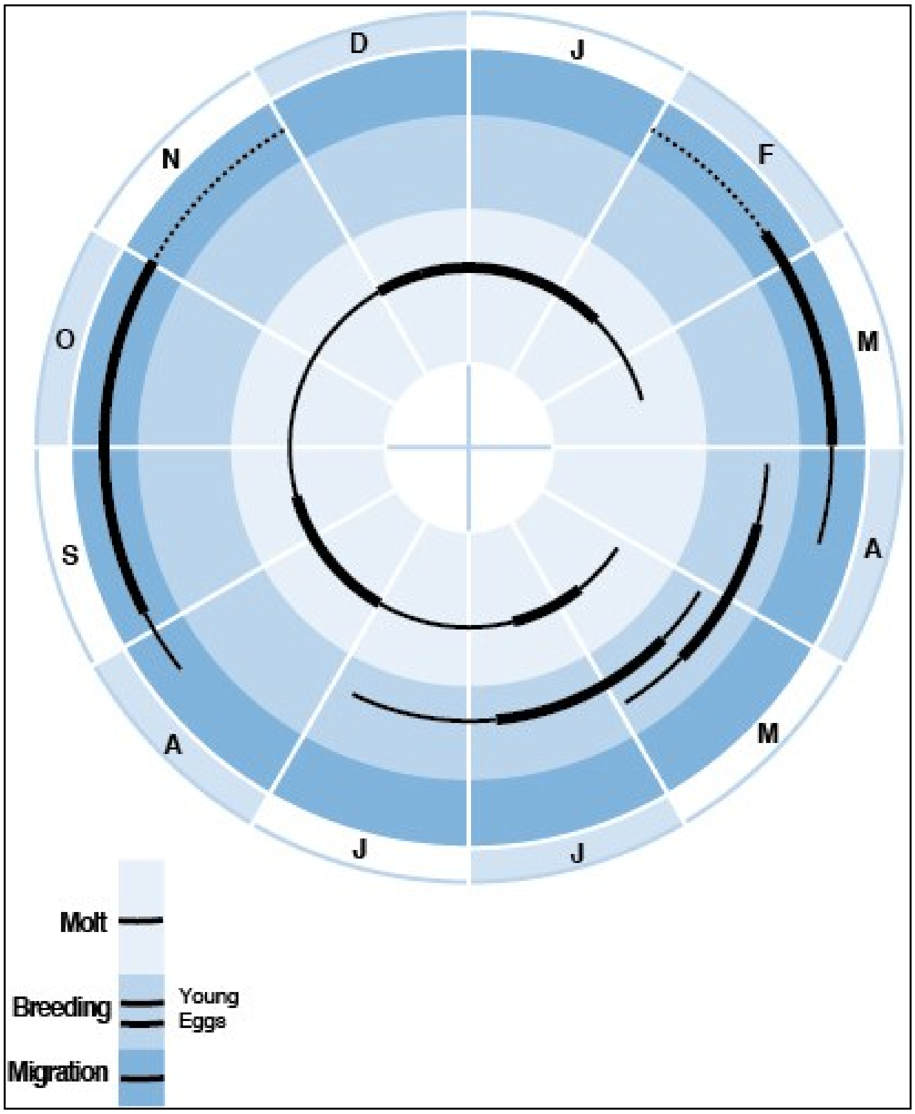
(Goldstein et al. 1999a). This source of mortality may have affected 1–5 percent of the species' total population (Goldstein et al. 1996, 1999b). Subsequent analyses of the long-term dataset from the Butte Valley, California, population demonstrated a strong decreasing trend in adult survival from 1979 through 1996, followed by an increasing trend after the use of monocrotophos was limited (Briggs 2007). Thus, it appears that management actions on the wintering grounds have had demonstrable effects on Swainson's hawks, including birds breeding in California.

Life History

The Swainson's hawk is a migratory raptor that breeds in Alaska, Canada, the United States, and northern Mexico. The hawks arrive on breeding grounds in the Central Valley from early March into mid-April. Nest building and reconstruction of old nests begins immediately upon arrival, with egg laying beginning in mid- to late April. The brooding period continues through early to mid-July, when the young begin to fledge (England et al. 1997). In mid-August, Swainson's hawks begin to congregate in large communal groups, staging for fall migration in suitable foraging habitats. Swainson's hawks typically leave their breeding grounds to head south for the winter from mid-August through mid-October, with the majority located south of the United States by mid-October (Woodbridge et al. 1995; Fuller et al. 1998; Hoffman and Smith 2003; Kochert et al. 2011). Most Swainson's hawks are highly migratory, wintering in the pampas region of central Argentina (Bildstein 2006; Sarasola et al. 2008); however, recent satellite tracking revealed that the Central Valley population winters in western Mexico and central South America, although the proportions of birds that winter at particular locations is currently unknown (Bradbury 2009). Also, small numbers of individuals have been documented wintering in the SPA in the last 30 years (Herzog 1996; eBird 2013). The annual cycle of the species is shown in Figure 2 to illustrate the timing of breeding, migration, and molt activity of the Swainson's hawk in its North American range. There is some variation to the timing of these events for the population of Swainson's hawks that occur in the SPA; these are discussed in further detail below.

Reproductive Period

Timing: As described above, migrant Swainson's hawks typically return to their Central Valley breeding grounds from early March through mid-April. They begin courtship and nest building immediately upon arrival (Bechard et al. 2010). Usually, eggs are laid between mid-April and mid-May, with two to four eggs in a typical clutch. The incubation period averages 34–35 days, and nestlings typically fledge in 38–46 days (Bechard et al. 2010). Most clutches are completed by mid-April, hatching typically begins in mid- to late May, and fledging typically occurs in the first three weeks of July (Estep 1989; Bradbury pers. comm.). As is true for most raptors, the female takes primary responsibility for incubating and brooding the young, while the male provisions the family and patrols the nesting territory. The adult female remains at the nest most of the time until the chicks reach about 9–10 days of age and are able to thermoregulate on their own, at which point both adults may provision the young. However, the female typically remains close to the nest until the young fledge while the male continues to provide the vast majority of



Source: Bechard et al. 2010, in The Birds of North America Online; reproduced with permission

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

Figure 2. Annual Cycle of Breeding, Migration, and Molt of the Swainson's Hawk

the food. Fledglings typically remain dependent on their parents and stay within 0.62–1.24 miles of the nesting area for an additional 3–4 weeks before joining communal groups for staging prior to migration (Estep 1989).

Nesting: Swainson's hawks build stick nests in a wide variety of trees, ranging from moderate-stature junipers (*Juniperus* spp.), willows (*Salix* spp.), and valley oaks (*Quercus lobata*) to tall cottonwoods (*Populus fremontii*), sycamores (*Platanus racemosa*), black walnut (*Juglans californica*), and many types of nonnative trees (*Eucalyptus* sp., etc.) in residential and agricultural environments (Bloom 1980; Estep 1989; Bechard et al. 2010). In the SPA, Swainson's hawks typically nest in mature, dense-canopied cottonwoods, willows, and valley oaks associated with riparian forest habitat and in isolated trees next to agricultural and grassland habitat.

Like most raptors, Swainson's hawks show a high degree of interannual fidelity to established breeding territories, which often contain multiple alternative nest sites. They may reuse individual nests repeatedly among years, or reconstruct new nests when needed (Fitzner 1980; Woodbridge 1991; Bechard et al. 2010; Smith and Slater 2010). It has been shown that suitable nesting habitat must be directly associated with suitable foraging habitat (Estep 1989).

Territory size: The amount and extent of available foraging habitat influences territory size. A radio tracking study revealed that the Swainson's hawk nesting home-range size in the Central Valley typically average 10.7 square miles, but can vary from 1 to 34 square miles across the study area, with larger home ranges containing expanses of croplands unsuitable for foraging, and smaller home ranges situated near alfalfa, fallow fields, and dryland pasture (Estep 1989; Babcock 1995; Woodbridge 1991). The wide variation in home-range sizes that has been documented indicates that several factors (e.g., distribution of high-quality foraging habitat and crop mowing or harvesting schedules) influence the species' foraging range considerably (Woodbridge 1998). The foraging range of individual pairs may also vary within a season as crops mature and prey availability changes as a result. Breeding adults may travel as far as 19 miles from their nests to provision their young; however, they do not nest in regions with unsuitable foraging habitat (Estep 1989; Woodbridge 1991; Babcock 1993, 1995).

Foraging: In the SPA, breeding Swainson's hawks feed their young small mammals, such as meadow voles (*Microtus pennsylvanicus*), California ground squirrels (*Spermophilus beecheyi*), valley pocket gophers (*Thomomys bottae*), black rats (*Rattus rattus*), and various mouse species, as well as a variety of small to medium-sized birds, snakes, lizards, toads, and various insects, including grasshoppers and odonates (Estep 1989). Otherwise, Swainson's hawks are highly insectivorous; with grasshoppers composing more than 90 percent of the diet of nonbreeding and wintering birds (Snyder and Wiley 1976; Woodbridge et al. 1995). Foraging Swainson's hawks spend most of their time on the wing, circle-soaring and coursing low over fields in search of prey, or taking insects from the air. They also employ other hunting techniques (Bechard et al. 2010); they are well known for following agricultural equipment and taking a variety of prey disturbed by plowing, mowing, and harvesting activities (Estep 1989). Swainson's hawks also frequently hunt from perches, large rocks, and on the ground near small mammal burrows, although this behavior is not well documented in the Central Valley.

Habitat and Ecological Process Associations

Historically in California, cottonwoods, oaks, sycamores, and willows supported more than 95 percent of Swainson's hawk nests, and most such nests were associated with riparian corridors (Bloom 1980). Although the Swainson's hawk is not an obligate riparian species because its relationship with riparian habitats is variable; riparian woodlands are a key nesting habitat for the species in the Central Valley (Schlorff and Bloom 1984; Estep 1989). In the Central Valley, riparian and valley oak woodlands represent key nesting habitat for Swainson's hawks because they frequently provide suitable nesting substrates adjacent to suitable foraging habitat; however, isolated mature native and nonnative trees interspersed within agricultural landscapes and small woodlots are also used where preferred foraging habitat is available (Estep 1989, 2007; Woodbridge 1991; England et al. 1995; LSA Associates, Inc. 2007).

Foraging preference studies have revealed that Swainson's hawks primarily depend on a mosaic of suitable foraging habitat in proximity to suitable nesting habitat. Importantly, the close association between nesting and foraging habitats means that most nest sites and home ranges are located on or around privately owned lands, making Swainson's hawks particularly susceptible to changes in agricultural activity and development patterns (Estep 1989; LSA Associates, Inc. 2007). The patterns and seasonal stages of crop maturity, irrigation, and crop harvest influence prey availability, which in turn influences habitat use.

Swainson's hawks differentially use foraging habitat in the SPA based on native grassland vegetative structure and the timing of agricultural management practices that change the vegetative structure of crops. Smallwood (1995) investigated habitat use in the Sacramento Valley and demonstrated the apparent preference of Swainson's hawks for breeding in riparian habitat (due to the presence of suitably sized trees) and for foraging in grassland, in alfalfa stands more than 2 years old during irrigation and mowing periods, and in annual field crops during harvest periods. Estep (2008) evaluated the distribution of nesting Swainson's hawks in Yolo County and determined that roughly half of nest sites were in riparian woodlands and that nesting territories were positively associated with irrigated croplands and alfalfa, but negatively associated with uncultivated grasslands, rice fields, orchards, and vineyards. Bechard (1982) showed that increasing vegetative cover reduces prey availability and results in a reduction of Swainson's hawk use. Consistent with this finding, alfalfa and irrigated pasture were found to provide consistently higher prey accessibility throughout the breeding season than other cover types because these types of agricultural use provide little cover and force prey to move to more exposed field borders during flood irrigation (Estep 2009). Estep (1989) radio-tagged 12 Swainson's hawks and evaluated their foraging preference in agricultural habitats; these preferences were ranked in the following order in terms of their relative importance (greatest to least): alfalfa fields, disked fields, fallow fields, dryland pasture, beet crops, tomato crops, irrigated pasture, grain crops, other row crops, and other agricultural crops. Orchards and vineyards generally have low value as Swainson's hawk foraging habitat because the height and density of the vegetation prevents the hawks' access to the ground and the bare ground underneath orchards generally support low rodent populations (Estep 1989, 2009). Estep (1989) notes that the Swainson's hawks' preference for disked fields was somewhat misleading because, although these fields provided a readily available and easily obtainable food source (insects) for foraging male Swainson's hawks during the incubation and nestling period, this foraging behavior contributed only a very small percentage of the overall dietary biomass. Nevertheless, this evaluation indicates that Swainson's hawks rely heavily on riparian features and associated agricultural habitats in the SPA that meet the vegetative and management conditions that increase prey abundance and accessibility.

The amount and diversity of suitable foraging habitat within several miles of Swainson's hawk nests affects reproductive success and adult survival. A fundamental concept in wildlife management is that suitable habitat allows for higher reproductive success relative to less suitable habitat (Lack 1966), and that the amount of available foraging area around a nest site increases the potential that parents can provide for their young (Lack 1954). Viable Swainson's hawk populations depend on nesting habitat that is buffered from excessive human disturbance (although some birds are very tolerant of such disturbance, even when nesting) and surrounded by diverse mixes and extents of high-quality "natural" and agricultural foraging habitats, located within several miles of the nesting areas. Given the effects of variation in crop and vegetation phenology on prey availability and accessibility, a mix of suitable foraging habitat allows adult hawks to access nearby sources of accessible prey throughout the breeding season. Woodbridge (1991) found that nest sites situated more than about 0.8 miles from alfalfa fields showed significantly less reproductive success than closer nests. In a study conducted in Butte Valley, it was shown that increasing distance from a nest to agriculture was negatively correlated with adult survival, and the amount of agriculture within a territory was positively correlated with survival (Briggs et al. 2011).

The availability of suitable foraging habitat is also important during migration staging and stopovers. Before autumn migration, Swainson's hawks need habitats capable of supporting late summer/early fall aggregations of recently independent juveniles and other hawks seeking rich prey resources. Such habitats may include extensive agricultural areas where late-season harvesting and plowing is in progress (Johnson et al. 1987).

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for Swainson's hawks within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by Swainson's hawks within the SPA;
- the specific CPAs within which the Swainson's hawk breeds;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Management Issues

Threats and Sensitivities Range-Wide

Conversion and fragmentation of favored agricultural habitats to other, less favorable crop types and land uses, especially urban uses, are now considered the primary threats to the sustainability and recovery of Swainson's hawk populations in California (Bradbury 2009) and elsewhere. Distribution of Swainson's hawks is also constrained by the limited availability of trees close to otherwise suitable agricultural land: historically, as small-scale agriculture gave way to large industrial farms, the distribution of scattered trees and small woodlots near fields used for foraging declined (Olendorff and Stoddart 1974). Finally, widespread historical and, in some

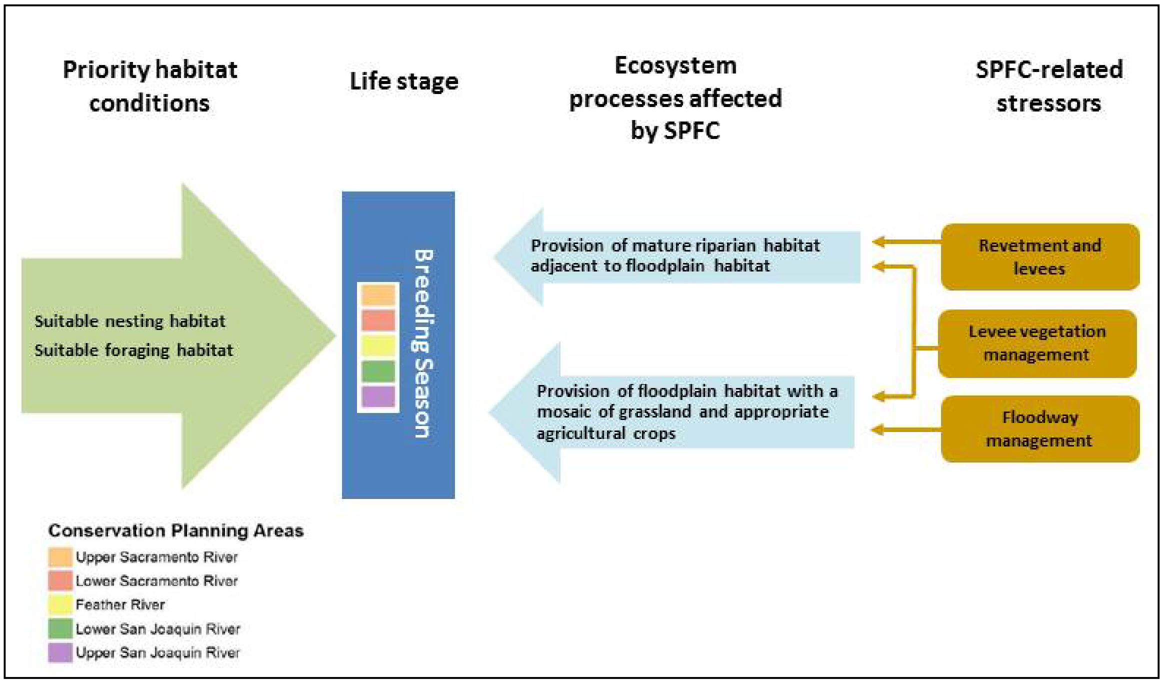


Figure 3. Conceptual Model for Swainson's Hawk within the SPA

cases, on-going loss of riparian woodland constrains the availability of optimal nesting habitat in California (Bradbury 2009). Although grasslands provide moderately suitable habitat year-round, implementing a management strategy that incorporates a more diverse landscape matrix of suitable crops may provide higher foraging value while also providing opportunities to optimize agricultural productivity (Estep 2009).

Another threat to the species is the effect of human disturbance on reproductive success. If a nesting site is disturbed early in the breeding season, the parents may abandon the nest. In agricultural and urban landscapes, Swainson's hawks tend to be relatively tolerant of regular or continual human activities around their nest sites but, especially early in the nesting cycle, they may abandon a nesting attempt if confronted with unusually loud or irregular noises and activities (Bechard et al. 2010).

Regionally, the Swainson's hawk population is also threatened by direct natural and anthropogenic causes of mortality. An assessment based on 538 Swainson's hawk band recovery reports from throughout their breeding, wintering, and migratory range revealed that many young birds likely died of starvation. However, about 23 percent of fatalities were caused by vehicle collisions, 2 percent by electrocutions, and a handful by collisions with fences (Houston and Schmutz 1995). To date in California, a few Swainson's hawks have been documented at wind-energy facilities in the Montezuma Hills Wind Resource Area of Solano County (Point Impact Analysis, LLC 2011; Johnston et al. 2012) and at the Altamont Pass Wind Resource Area in Contra Costa and Alameda Counties (Howell 1997; Altamont Pass Avian Monitoring Team

2008). Elsewhere, susceptibility to wind-turbine collisions has been demonstrated in Alberta (Brown and Hamilton 2004) and at several facilities in Oregon and Washington (Gritski et al. 2009; Jeffrey et al. 2009; Johnson and Erickson 2010). Although direct fatalities generally are not expected at solar facilities, displacement of hawks caused by conversion of foraging and nesting habitat to other uses is a common concern in areas developed or proposed for solar development in the Central Valley and Antelope Valley (e.g., see CEC and CDFG 2010). Lastly, as discussed under "Population Trends," pest management practices and other human activities may threaten Swainson's hawks on their wintering grounds.

Ongoing and Future Impacts

Ongoing impacts on Swainson's hawk populations in the SPA include loss of preferred nesting habitat, conversion of suitable foraging habitat to less favorable crops, fragmentation of foraging habitat as a result of urban expansion, and the indirect effects of climate change. Also, the development of utility-scale renewable energy may affect the species by converting habitat and creating collision risks for raptors.

- Swainson's hawks nest in mature trees along riparian corridors and valley oak woodlands in proximity to favored foraging habitat. Over the past 150 years, the Central Valley has lost more than 98 percent of its riparian habitat (Smith 1977; Katibah 1984). Natural recruitment of favored nest-tree species, such as cottonwood and willow, requires an active floodplain. If natural recruitment of these trees is limited, suitable nesting habitat will continue to be lost as mature trees reach the end of their life cycle. Some CVFPP actions, such as levee vegetation management and placement of revetment could contribute to the loss of riparian habitat or prevent natural recruitment of nest trees, and thus may negatively affect this species.

- The extent and amount of suitable foraging habitat for Swainson's hawks will continue to be adversely affected by the conversion of hayfields, pastures, fallow fields, and low-stature row crops to less favorable crops (e.g., vineyards, orchards, and rice fields). In addition, foraging habitat is likely to become further fragmented by development projects.

- Climate change will affect habitat throughout the SPA, although the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. Total annual precipitation is not expected to change substantially; however, more precipitation is expected to fall in the Sierra Nevada as rain rather than snow, reducing the availability of water from snowmelt in spring and summer (Cayan et al. 2006). Reductions in water availability for crops could cause changes in vegetation structure, which may affect prey resources for Swainson's hawks.

Key Information Gaps or Uncertainties

To better understand Swainson's hawk ecology, the following information is needed: a more thorough quantification of migratory routes, insight into potential threats associated with those routes, and an investigation of the effects of rodenticide on local population dynamics in the SPA. Uncertainties related to the use of rodenticide are directly relevant to the flood system and operation and maintenance of the SPFC. These data gaps are discussed below.

- **Migration routes.** Recent satellite tracking of about a dozen hawks suggested that the migration ecology of Swainson's hawks breeding in the middle Central Valley is unique within the species: many, but not all, such hawks migrate to southwestern Mexico, instead of Argentina, to overwinter (Bradbury 2009). In addition, a genetic study suggested possible recent differentiation of this population from a more widespread "Great Basin" type (Hull et al. 2008). Additional satellite tracking of more than 30 birds from the middle Central Valley was initiated in 2011, and will yield valuable new data on the prevalence of this unusual migratory behavior in the Central Valley subpopulation (Estep pers. comm.). However, this research needs to be expanded to include birds from throughout the range of the Central California population to further confirm the extent of unusual migration behavior among this apparently distinct population. Results from this research will elucidate migratory behavior as well as the timing and extent of habitat use throughout the region, which will better inform conservation planning initiatives.

- **High-resolution data.** CDFW and others have promulgated standards and established guidelines for quantifying and mitigating the risks posed by various development activities to Swainson's hawks (CDFG 1994; YC HCP/NCCP JPA 2002; CEC and CDFG 2010). For example, guidance documents specify the dimensions of appropriate buffer zones to protect hawk nests from disturbance, as well as mitigation ratios to be used when compensating for habitat loss. The current formula for determining how much compensatory habitat mitigation is needed to offset projected losses of nesting and foraging habitat is based on limited data from conventional radio tracking studies conducted in the middle Central Valley (Estep 1989; Babcock 1995) and Butte Valley, CA (Woodbridge 1991). The additional satellite tracking study now underway, using high-resolution Global Positioning System (GPS) transmitters, will greatly enhance insight about the home-range dynamics and patterns of habitat use of the middle Central Valley population. In turn, this knowledge will facilitate refined projections of how Swainson's hawks are likely to respond to new development pressures and how managers can best maintain landscapes that sustain viable and productive nesting populations. Finally, GPS tracking studies need to be expanded throughout the range of the Central California population to ensure that conservation strategies and habitat mitigation formulas are effectively tailored to account for region-specific conditions.

- **Toxins.** Rodenticides, typically Chlorophacinone and Diphacinone, are used at bait stations along the levee system to control ground squirrel populations. These toxins may have direct and indirect effects on adult Swainson's hawks and their nestlings. If Swainson's hawks eat sick or dead ground squirrels or other small mammals that may have consumed rodenticides, the toxin could move through the food chain and harm Swainson's hawks (Bradbury pers. comm.). Further investigation of the role of ground squirrels and nontarget small mammals in the Swainson's hawk diet is required to clarify the extent and nature of this potential threat and provide a basis for establishing pest control techniques that support Swainson's hawk conservation.

Conservation Strategy

Conservation and Recovery Opportunities

The most viable way to increase the Swainson's hawk population is to create and maintain contiguous arrays of nesting habitat, buffered from excessive human disturbance and closely surrounded (within several miles) by diverse mixes and extents of high-quality "natural" and agricultural foraging habitats. Mosaics of foraging habitats must include dynamic arrays of suitable crop types, pastures, and/or grasslands that, throughout the breeding season, give adult hawks access to nearby foraging areas rich in accessible prey. Given the effects of variation in crop and vegetation phenology, maturity, and harvest practices on prey availability and accessibility, conscientious planning will be required to achieve consistently suitable habitat mosaics.

Identified Conservation Needs

1. **Increase and renew suitable nesting habitat:** Riparian habitats consisting of mature cottonwoods, sycamores, oaks, and willows provide high-quality nesting habitat that is important to the success and survival of breeding Swainson's hawks. Maintaining a contiguous corridor of self-sustaining riparian habitat along rivers is essential for continued Swainson's hawk nesting success. Implementation of the CVFPP and the Conservation Strategy could increase and sustain this nesting habitat by constructing set-back levees that would provide more active floodplains and riparian habitat. Larger, more contiguous areas of riparian habitat also provide a buffer to nest trees. In renewing populations of riparian habitat, it will be important to maintain a variety of age and size classes so that, as current nest trees die off, younger trees mature into suitable replacements. Furthermore, this nesting habitat must be situated next to suitable foraging habitat that provides important prey resources during the breeding season.

2. **Increase the amount and extent of suitable foraging habitat:** Swainson's hawks require foraging habitat that supports high densities of accessible prey during the breeding season; such habitat includes the natural lands and specific crop types previously discussed. Because foraging habitat suitability changes seasonally with shifts in vegetative structure, crop maturity, and crop management practices (irrigation, mowing), it is essential to provide a mosaic of foraging habitat to ensure adequate prey accessibility. Floodplains that support such a mosaic situated close to suitable nesting habitat will contribute to the success and survival of Swainson's hawks in the SPA.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the Swainson's hawk; these are summarized in Table 1 of this section. In many cases, the conservation needs of the Swainson's hawk can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/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 toward adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Operations, Maintenance, and Floodway Management

Facility maintenance: The use of rodenticide at bait stations on SPFC levees may have direct and indirect negative effects on adult Swainson's hawks and their nestlings, and could decrease the populations of important prey resources, such as voles and other small mammals. Because an estimated 95 percent of the state's Swainson's hawk population is currently located in the Central Valley, the use of rodenticide in the SPA has the potential to alter the population structure of the species. The use of bait stations (especially on the water side of levees) to control ground squirrels has not been found to have a substantial effect on Swainson's hawk populations, but the rodenticide may move through the food chain, affecting adults and nestlings via their consumption of sick or dead prey (Bradbury pers. comm.). To avoid redistribution and secondary poisoning effects, spilled bait could be cleaned up immediately and carcass retrieval surveys could be conducted. These removal efforts will help researchers better understand the extent to which target and nontarget species are being affected by rodenticide while also removing them from the food chain. These rodenticide minimization activities would contribute to the provision of suitable foraging habitat for Swainson's hawk by reducing unnecessary and potentially harmful toxins in the food chain, especially in close proximity to nest sites.

Levee vegetation management: Removal of vegetation from levees could have negative effects on nesting habitat. Although vegetation management that fully or partially complies with USACE levee vegetation policy would not result in direct loss of active Swainson's hawk nests, long-term indirect effects may occur, including loss of habitat corridors. It will be important to establish replacement plantings that will mature into suitable nesting habitat for Swainson's hawks. These replacement plantings can be situated near existing suitable habitat and planned well in advance of vegetation loss to provide a diverse mixture of trees composed of varying ages and structures.

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Swainson's Hawk[a]

CVFPP Management Actions	Conservation Need	
	1. Increase and Renew Nesting Habitat	2. Increase Amount and Extent of Foraging Habitat
Operations, Maintenance, and Floodway Management		
Floodwater storage and reservoir forecasting, operations, and coordination		
Facility maintenance	–	–
Levee vegetation management	–	
Floodway maintenance		+
Modification of floodplain topography		
Support of floodplain agriculture		+
Invasive plant management		
Restoration of riparian, SRA, and marsh habitats	+	
Wildlife-friendly agriculture		+
Structural Improvements		
Levee and revetment removal	+/–	+
Levee relocation	+	+
Bypass expansion and construction		+
Levee construction and improvement		
Flood control structures		

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

Floodway maintenance: Floodway maintenance actions could be implemented in a way to sustain the existing mosaic of floodplain habitats. To provide additional conservation benefits, maintenance practices could be changed at selected locations to facilitate the restoration of riparian habitat, or to otherwise yield ecological benefits to Swainson's hawks. For example, native vegetation could be planted after sediment is removed, and planting berms could be used to expand habitat. Plantings would provide potential nesting and roosting habitat adjacent to the mosaic of floodplain habitats, which would provide the required habitat diversity supporting a diverse assemblage of prey.

Support of floodplain agriculture: Floodplain agriculture currently provides important foraging habitat for Swainson's hawks in the Central Valley. Managing floodways to maintain the compatibility of flood management with agriculture would minimize fragmentation of agricultural parcels, retaining parcels of sufficient size to support continued efficient agricultural production as well as Swainson's hawk foraging habitat (assuming that the crop types are compatible with Swainson's hawk foraging needs). As discussed in previous sections, Estep (1989) ranked the relative importance of various crop types to foraging preference. In decreasing order of importance, these crop types are: alfalfa fields, disked fields, fallow fields, dryland pasture, beet crops, tomato crops, irrigated pasture, grain crops, other row crops, and other agricultural crops.

Restoration of riparian, SRA cover, and marsh habitats: Riparian habitat could be targeted at selected locations within the floodway, benefiting Swainson's hawks by providing nesting substrate (trees). The benefits of riparian restoration would be greatest in areas where restoration expands or connects existing habitat patches, especially where gaps in this connectivity occur, such as near the confluence of the Feather and Sacramento Rivers. Marsh restoration may secondarily benefit Swainson's hawks by providing habitat for mammalian prey species (voles, etc.).

Support of wildlife-friendly agriculture: Incorporating wildlife-friendly agriculture would increase the habitat value of existing agricultural land to Swainson's hawks. Especially important to Swainson's hawks would be the cultivation of crops, such as alfalfa, that have a high habitat value for the species. The value of specific crop types is discussed above (see "Support of floodplain agriculture"). Long-term benefits to the Swainson's hawk could be realized by supporting wildlife-friendly agriculture through landowner incentive grants, conservation easements, or management of conserved areas. Swainson's hawks occur throughout the SPA; however, wildlife-friendly agriculture should be given priority in the areas where gaps in nesting and foraging habitat continuity occur, such as near the confluence of the Feather and Sacramento Rivers. Existing grasslands also provide high quality foraging habitat. Supporting wildlife-friendly agriculture should not result in the conversion of this grassland habitat to agricultural habitat.

Structural Improvements

Levee and revetment removal: Removing revetment would reduce operation and maintenance costs while providing an opportunity to improve natural erosional and geomorphic processes in the riverine environment. These processes would encourage the recruitment of suitable nesting trees and increase or improve suitable foraging habitat for Swainson's hawks. This type of natural recruitment continually provides a tree community consisting of various age classes, ensuring that there will be suitable nesting substrate in the future.

Levee relocation: Relocating levees farther from rivers (i.e., constructing setback levees) is an important approach to creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats while often still supporting agriculture within expanded floodways. These natural river processes allow for the recruitment of nesting habitat while still retaining foraging habitat. Constructing setback levees could also decrease the need for adding revetment on existing levees, further encouraging recruitment of suitable nesting trees adjacent to suitable foraging habitat. Effective setback levees could be constructed in areas near the Sutter Bypass, Sacramento Weir and Bypass, and the Sutter Bypass. Where vegetation is planted as part of levee construction or improvement, cottonwoods, oaks, and willows could be included in the planting palette to provide suitable nesting substrate for Swainson's hawks.

Bypass expansion and construction: The expansion of bypasses would add agricultural land and natural vegetation to the floodway and would result in periodic, prolonged inundation of land that was previously isolated from the river system by levees. An expanded, frequently activated floodplain in the bypasses would support restoration of floodplain ecosystems and may provide suitable foraging habitat for Swainson's hawks. Potential areas where bypass expansion could benefit Swainson's hawks include the land near the Sutter and the upper Yolo Bypasses and near the confluence of the Sacramento and Feather Rivers.

Recovery Plan Alignment

CDFW does not have a statewide recovery plan for Swainson's hawks. The species is included in the California Wildlife Action Plan, which identifies known threats. The conservation needs of this species in the SPA are addressed in previous sections of this conservation plan. If CDFW produces a statewide recovery plan for Swainson's hawk, it is likely to include the main components of this plan. The adaptive management component of the Conservation Strategy would facilitate alignment with the statewide plan, should it be created, as needed.

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 Swainson's hawk. Therefore, building on the preceding discussion, this section of the Swainson's hawk 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 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 conservation of Swainson's hawks, requirements would be added to increase acreage that makes a positive contribution to areas adjacent to suitable foraging habitat, expanding the mosaic of foraging and nesting habitat needed by the species. Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of Swainson's hawks, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit Swainson's hawk may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objective for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Swainson's Hawk

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain —total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	No	
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	
	River Meander Potential—total amount (acres)	No	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount of active floodplain (acres)	Yes	Suitable nest trees in riparian habitat include cottonwood, willow, valley oak, and sycamore.
	Habitat Connectivity—median patch size (acres)	Yes	Situate suitable nest trees adjacent to suitable foraging habitat, such as grasslands and wildlife-friendly agriculture. Woodbridge (1991) found that nest sites situated more than about 0.8 miles from alfalfa fields showed significantly less reproductive success than closer nests.
Marsh	Habitat Amount—total amount and total amount of active floodplain area (acres)	No	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	Yes	Suitable foraging habitat includes grassland and agricultural crops such as alfalfa and irrigated pasture; unsuitable crops include orchards, vineyards, and rice fields.
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	No	

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Swainson's Hawk

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)	No	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced(acres)	No	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G15. Focused Conservation Plan: Western Yellow-Billed Cuckoo

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), a Neotropical migratory bird, and its habitat in the SPA for the CVFPP. This subspecies was once considered to be common throughout riparian habitats in the SPA. Currently, the western yellow-billed cuckoo ("cuckoo") breeds in the Feather River and Upper Sacramento River CPAs, but under suitable habitat conditions and if the population increases and recolonizes its range, it has the potential to breed in riparian habitat throughout the SPA.

In 2001, USFWS determined that the western population of the yellow-billed cuckoo represents a DPS (USFWS 2001). At the same time, the western yellow-billed cuckoo became a candidate for listing under the ESA (66 FR 38611–38626), but the listing was determined to be "warranted but precluded by higher priority listings"; therefore, this taxon did not receive statutory protection under the ESA (USFWS 2002). On 3 October 2013, USFWS proposed to list the western yellow-billed cuckoo as a threatened species (78 FR 61622–61666, USFWS 2013), and on 2 October 2014, an announcement was made that a final determination would be effective on 3 November 2014, designating the species as threatened (79 FR 59991–60038; USFWS 2014a). On 15 August 2014, USFWS had proposed to designate critical habitat for the western distinct population segment of the yellow-billed cuckoo, in advance of the October listing determination (77 FR 69993–70060; USFWS 2014b). Proposed critical habitat in the SPA consists of 35,418 acres along a 69-mile-long contiguous segment of the Sacramento River and 1,090 acres along a 7-mile-long contiguous segment of the Sutter Bypass. This species was listed by the State as threatened in 1971 and as endangered in 1988 under CESA (CDFG 1998). The cuckoo is also a focal species in *The Riparian Bird Conservation Plan* (RHJV 2004). A recovery plan for this species has not been published; however, USFWS has organized a multiagency group that is developing a range-wide conservation assessment and strategy for the cuckoo (75 FR 69222–69294; USFWS 2010).

Status and Trends

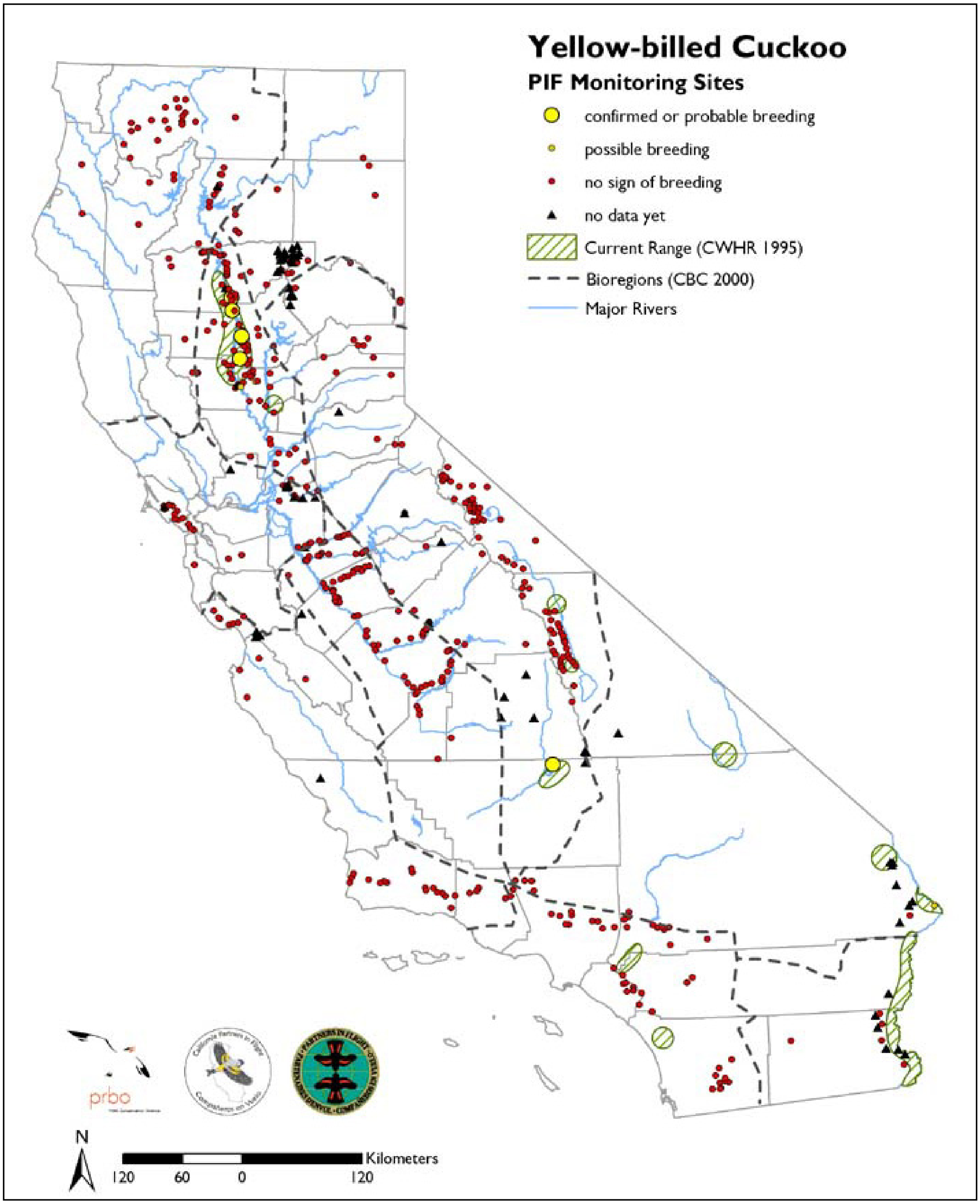
Distribution

The yellow-billed cuckoo is a riparian-obligate species found throughout the United States. There are two recognized subspecies: the western subspecies occurs west of the Rocky Mountains and is the focus of this conservation plan, and the eastern subspecies (*Coccyzus americanus americanus*) occurs east of the Rocky Mountains (American Ornithologists' Union 1957). Historically, the western yellow-billed cuckoo range extended from southern British Columbia to the Rio Grande River in northern Mexico, and east to the Rocky Mountains (Bent 1940). Currently, the only known breeding populations of western yellow-billed cuckoo occur in several disjunct locations in Arizona (Groschupf 1987), California (Laymon and Halterman 1989), Colorado (Kingery 1998), Idaho (Dobkin 1994), New Mexico (Howe 1986), Utah (Walters 1983) and Wyoming (Bennett and Keinath 2003). This subspecies was once common in riparian habitat throughout California (Grinnell and Miller 1944), but the population has declined over the last 100 years following extensive loss of riparian habitat. In California's Central Valley, approximately 98 percent of riparian habitat has been lost or altered over the last 150 years (Smith 1977; Katibah 1984). Currently in California, cuckoos are consistently found in only a few isolated areas: the Sacramento Valley (between Red Bluff and Colusa), the Feather River (between Gridley and Nicolaus), the South Fork of the Kern River, and in several Lower Colorado River Multi-Species Conservation Program (LCR MSCP) restoration sites on the California side of the lower Colorado River (Gaines and Laymon 1984; Laymon and Halterman 1989; Laymon 1998; Halterman et al. 2001; Dettling and Seavy 2012). The Upper Sacramento River CPA is believed to have one of the largest cuckoo populations in California (Halterman et al. 2001), and riparian vegetation has increased by almost 5,000 acres since 1996 due to restoration efforts in this area (Golet et al. 2008). Gaines and Laymon (1984) suggested that many large patches along the Sacramento River in Tehama County and along the Feather River appeared to be unoccupied but apparently represent suitable habitat. Follow-up surveys were conducted in 1987 and 1999, and between one and six individuals were found along the Feather River between Oroville and Nicolaus (Laymon and Halterman 1989; Halterman et al. 2001).

Cuckoos are long-distance migrants, likely following the Pacific slope of Mexico and Central America to their wintering grounds in northwest South America (Hughes 1999). The map shown in Figure 1 illustrates the California Partners in Flight (CalPIF) monitoring sites, breeding status, and current range of the cuckoo in California (RHJV 2004).

Population Trends

Historically, the cuckoo was considered common, and its distribution extended throughout the SPA (Belding 1890). Statewide, the historical population was estimated at approximately 15,000 breeding pairs (Hughes 1999); however, it is believed that the predevelopment population in California was much higher, given that large tracts of floodplain habitat had already been removed when estimates were first made, and because the cuckoo's elusive behavior makes it difficult to detect (Gaines 1974). Grinnell and Miller (1944) noted declines in the population in the 1940s. The first statewide survey was conducted in 1977, when the population was estimated at 122–163 pairs (Gaines and Laymon 1984), and the statewide estimate was 100 pairs in 2000 (Halterman et al. 2001). The Sacramento population was estimated to be 96 pairs in 1973 (Gaines 1974), and 60 pairs in 1977 (Gaines and Laymon 1984). The total number of pairs fluctuated between 23 and 35 pairs between 1987 and 1990 (Halterman 1991), and in 2000, only 40 pairs were detected (Halterman et al. 2001). When the majority of potentially suitable habitat on the Sacramento River was surveyed in 2010, only 18 individuals were detected (Dettling and Howell 2011). In 2012, only seven to nine cuckoos were detected along the Sacramento River, and no cuckoos were detected along the Feather River (Dettling and Seavy 2012). In 2013, CDFW detected five yellow-billed cuckoos in the Upper Butte Basin Wildlife Area, along Little Dry Creek and Butte Creek.



Source: RHJV 2004

Figure 1. CalPIF Monitoring Sites, Breeding Status, and Current Range of the Cuckoo in California

Estimating yellow-billed cuckoo populations is fraught with difficulties. Cuckoos are present in the United States for only a few months of the year, they have large home ranges, they vocalize infrequently, and their nests are difficult to locate. During an average protocol-level, call-playback survey, yellow-billed cuckoos respond between 50 and 80 percent of the time (Halterman 2009; McNeil et al. 2011). All of these factors complicate estimation of the most basic population parameters. Survey methods and data interpretation have changed through the years, rendering a direct comparison of numbers difficult; however, there can be little doubt that cuckoo populations in the Central Valley have declined dramatically over the last 50 years. This decline has been attributed to the loss, fragmentation, and degradation of riparian forests in California, which are effects of agricultural and urban expansion (USFWS 2001) and inundation by reservoirs and flood control activities, such as channelization (Halterman et al. 2009).

Life History and Ecology

Western yellow-billed cuckoos are long-distance Neotropical migrants that spend the winter in Central and South America (Hughes 1999). They begin arriving in the SPA as early as late May, but mid-June is more typical (Franzreb and Laymon 1993). Nesting occurs between June and August, with the peak occurring from mid-July to early August (Bent 1940; Howe 1986). It is suggested that the species is restricted to breeding during the midsummer period in response to a seasonal peak in large insect abundance—the onset of breeding may be correlated with the abundance of the local food supply (Nolan and Thompson 1975; Rosenberg et al. 1982). To accommodate this restriction, young develop very rapidly, with a breeding cycle of 17 days from egg laying to fledging. Cuckoos in the western United States eat a wide variety of prey items, including large arthropods such as cicadas, katydids, grasshoppers, and caterpillars, and also small lizards and spiders (Laymon et al. 1997; Halterman 2009). Food resources vary from year to year and significantly affect reproductive success (Laymon et al. 1997). Little is known about cuckoo breeding-site fidelity, but a study on the San Pedro and lower Colorado Rivers indicated that some individuals return to the same breeding sites each year (Halterman 2009; McNeil et al. 2011).

Cuckoos breed in large blocks of riparian habitat, particularly riparian woodlands with cottonwoods (*Populus fremontii*) and willows (*Salix* spp.) (USFWS 2001). Pairs may frequently visit prospective nest sites together before selecting a nest location and initiating nest building (Hamilton and Hamilton 1965). Both adults build the nest, incubate the eggs, and brood and feed the young. Clutch size in western North America is typically 2–4 eggs (Laymon et al. 1997; Halterman 2009). The nest is usually a flimsy stick platform with variable amounts of lining, and is constructed in less than a day, with additional material added to the nest as incubation proceeds (Hughes 1999; Halterman 2009). Nests are typically well concealed in dense vegetation within approximately 30 feet of the ground (Laymon 1980; Laymon et al. 1997) and placed in locations where they are protected from prevailing winds or rain by thick overhanging branches (Preble 1957; Potter 1980); several nest sites found on the Sacramento River were draped with wild grape (Gaines and Laymon 1984; Laymon 1998). The pale bluish-green eggs are incubated from 9 to 11 days (Hughes 1999), and young cuckoos fledge 5–8 days after hatching. Males incubate the eggs at night, and the pair alternates incubation duties during the day (Payne 2005; Halterman 2009). Males also care for the young after fledging, and the young may continue to be dependent on adults until they are 28–32 days old (Halterman et al. 2009). The cuckoos typically migrate out of California from mid-August to early September, although they have been observed as late as mid-September (Halterman 2009). In years of high food abundance, successful double and triple brooding has been observed (Halterman 1991; Laymon et al. 1997; Halterman 2009).

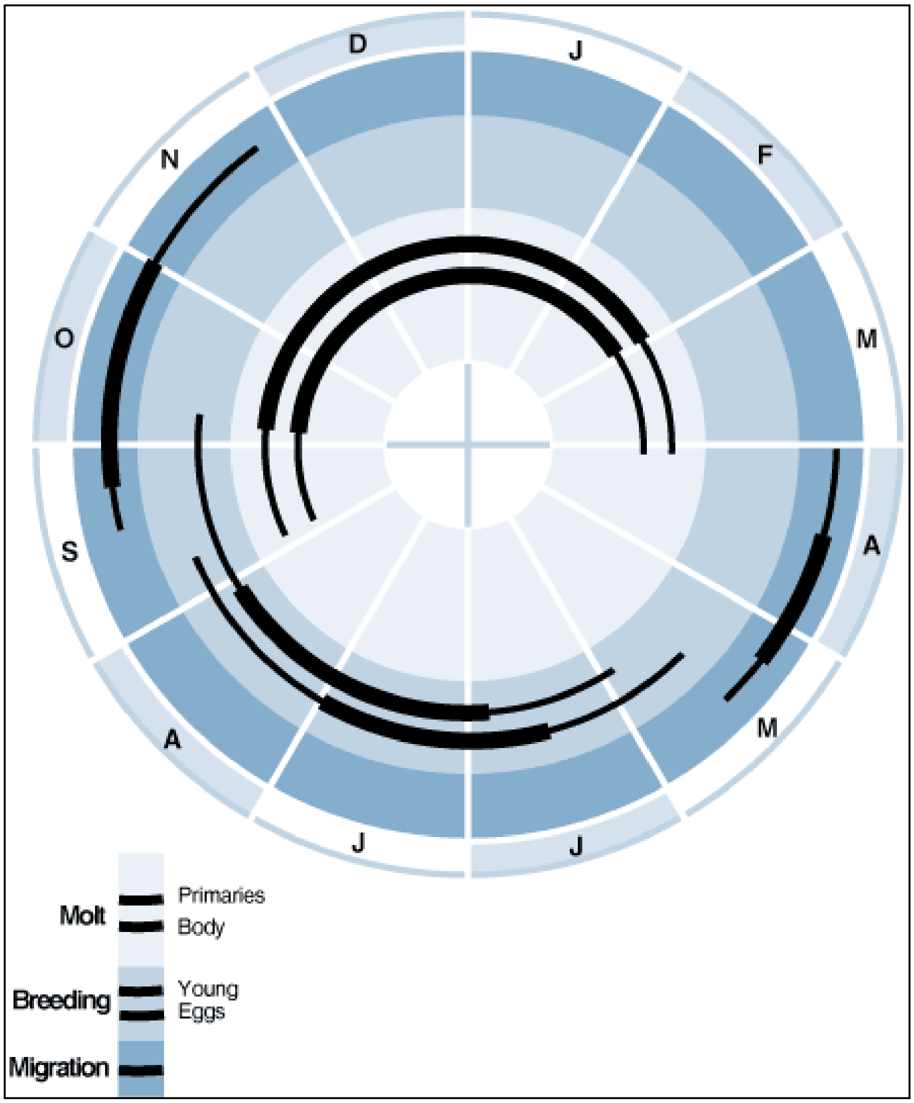
Cuckoos rarely nest in orchards, but nests have been documented in prune, English walnut, and almond orchards (Laymon 1998), and the direct effect of pesticide poisoning in these areas continues to be a concern. Foraging typically occurs in riparian vegetation, adjacent streams, and to a lesser extent, orchards adjacent to breeding areas. The distribution of cuckoos at 74 sites along the Sacramento River was not correlated with surrounding land use (dry rangeland, irrigated agriculture, and orchards) (Halterman 1991). During the breeding season, foraging areas of nesting pairs may overlap (Laymon 1980). Nest sites with a dense canopy (averaging 98.6 percent at the nest) and a large patch size (greater than 50 acres) are typically required by the species (Laymon 1998). A dense understory that provides nest protection and concealment is also required.

Limited information is available about home range and territory size. Cuckoo home range sizes are currently understood to be highly variable, averaging between 67 acres on the lower Colorado River and 95 acres on the San Pedro River (Halterman 2009; McNeil et al. 2011). Territory size on the South Fork Kern River ranged from 20–100 acres (Laymon and Halterman 1985), but territories along the Colorado River were as small as 10 acres (Laymon and Halterman 1989). In California, Halterman (1991) found that patch size, type and quality of habitat, and prey abundance largely determine the sizes of territories.

The *Birds of North America* annual cycle for the yellow-billed cuckoo is shown in Figure 2.

Habitat and Ecological Process Associations

The cuckoo is a riparian-obligate species that primarily breeds in cottonwood-willow forests, but other tree species such as white alder (*Alnus rhombifolia*) and box elder (*Acer negundo*) are also important habitat components, especially along the Sacramento River (Laymon 1998), because they provide foraging habitat, particularly as a source of insect prey. Invasive plant species such as saltcedar (*Tamarix* sp.) and giant reed (*Arundo donax*) have contributed to the degradation of cottonwood-willow habitat, a reduction of adequate vegetative structure required by nesting cuckoos, and a reduction in the food supply, particularly insect populations (Frandsen and Jackson 1994; Dudley and Collins 1995). Cuckoos may forage in saltcedar, but they rarely use it as a nesting substrate (Rosenberg et al. 1991). More information is needed to determine how cuckoos are using saltcedar-dominated patches (Halterman 2009). There are other exotic plant species along the Sacramento River, such as domestic fig (*Ficus* sp.) that do not provide suitable nesting structure for the cuckoo. Removing invasive or exotic species may provide opportunities for native species to reestablish and, as they mature, provide suitable foraging and nesting habitat for the cuckoo.



Source: Hughes 1999, in The Birds of North America Online; reproduced with permission

Note: Thick lines show peak activity; thin lines, off-peak; northern and western populations arrive and breed 2–8 weeks later, and depart for wintering grounds 2–4 weeks earlier.

Figure 2. Annual Cycle of Breeding, Migration, and Molt by Yellow-Billed Cuckoos in the Central United States

All studies indicate that there is a highly significant association between cuckoos and expansive stands of cottonwood-willow forests, especially where a river is allowed to meander and willows and cottonwoods can regenerate on point bars and streambanks (Greco 2008). Continuing habitat succession is important to sustaining breeding populations (Laymon 1998). Meandering streams that allow for continual erosion and deposition create habitat for rapidly growing willow stands, which represent preferred nesting habitat. Pioneer (early successional) riparian forests in the floodplain develop rapidly and are subject to frequent cycles of flooding, erosion, and deposition (Vaghti and Greco 2007). The Sacramento River cuckoo population occupies a highly dynamic mosaic of patches that are created, renewed, and shifted in response to geomorphic channel processes and vegetation succession over decadal timescales (Greco 2013). As pioneer forests mature into larger trees and shrubs (mid-seral habitat), and natural hydrologic and geomorphic processes continue, the resulting lateral channel migration creates a dynamic vegetation community composed of various age classes that provide patches of nesting and foraging habitat that is critical for the cuckoo. Channelized streams or leveed systems that do not support these natural processes to occur allow for the development of late-successional riparian vegetation, which does not provide optimal habitat for cuckoos (Greco 2008). The Sacramento River channel migration potential has been diminished by dam construction and the placement of revetment; this has resulted in a 79 percent decrease in channel migration potential from pre-dam conditions (Fremier 2007).

Several factors influence habitat occupancy. Gaines (1974) described suitable habitat as consisting of at least 25 acres (at least 330 feet wide and approximately 1,000 feet long) located within 300 feet of surface water and dominated by a cottonwood-willow forest with a humid microclimate. Laymon and Halterman (1989) further classified cottonwood-willow patch sizes into suitability classes and revised Gaines's patch size suitability estimates:

- Optimum—greater than 200 acres (and greater than 1,950 feet wide)
- Suitable—between 101 and 200 acres (between 650 and 1,949 feet wide)
- Marginal—between 50 and 100 acres (between 325 and 650 feet wide)
- Unsuitable—less than 50 acres (or less than 325 feet wide)

Halterman (1991) found that the best predictors of cuckoo occupancy and nesting density were (1) patch size, (2) proximity to other occupied patches, (3) presence of young riparian vegetation (one indication of patch age), and (4) presence of woody vegetation (typically less than 30 feet tall). Greco (1999) found that riparian habitat on the Sacramento River was suitable for occupancy within 9 years of establishment and remained suitable for up to 30 years, after which suitability declined. These results further imply that channel meander migration plays a significant role in maintaining the heterogeneity of forest structure and riparian landscape mosaics on the Sacramento River (Greco 1999). The same can likely be said of the San Joaquin Valley, where potentially suitable habitat will vary based on river flow and flooding events. Patches may be occupied for only a few years because of factors such as local climatic conditions and prey availability (Johnson et al. 2008; Girvetz and Greco 2009).

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for western yellow-billed cuckoos within the SPA (Figure 3). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by cuckoos within the SPA;
- the specific CPAs within which the cuckoo is known to or expected to breed under suitable habitat conditions;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

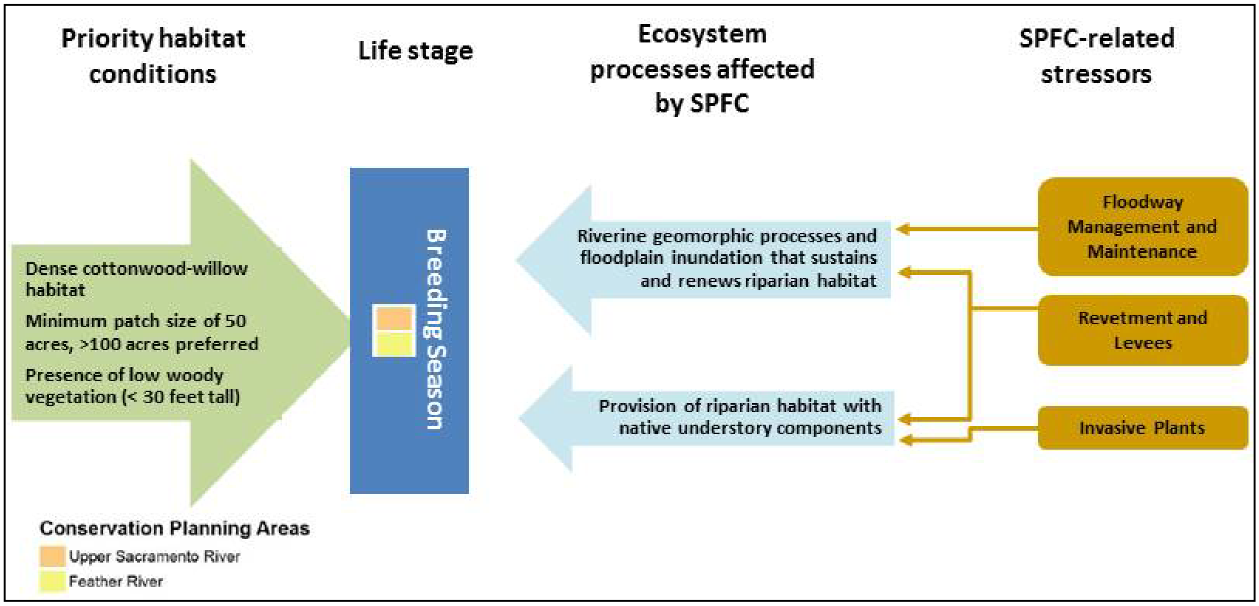


Figure 3. Conceptual Model for Western Yellow-Billed Cuckoo within the SPA

Management Issues

Threats and Sensitivities Range-Wide

The Sacramento Valley population must remain viable if the cuckoo population in California is to recover and avoid extirpation (Dettling and Howell 2011). Habitat fragmentation and availability of suitable habitat may be limiting factors for breeding populations of cuckoos along the Sacramento River. Historically, most of the land along the Sacramento River was covered by riparian forests, although portions of it supported grasslands, wetlands, and gravel bars (Gibson 1975). However, the historical landscape has been fragmented, reducing the area’s ability to sustain cuckoo populations and leading to local extirpations and the loss of suitable patches of habitat that are used as dispersal corridors (USFWS 2001). Nesting cuckoos are sensitive to habitat fragmentation because it reduces patch size (Hughes 1999) and increases the risk of predation of eggs and nestlings by other birds, snakes, and mammals (Nolan 1963; Nolan and Thompson 1975; Launer et al. 1990).

Riparian habitat in the Upper Sacramento River CPA has fluctuated over time. Greco (2013) quantified changes in riparian habitat along a 79-mile stretch of the Sacramento River (from Colusa to Red Bluff) and found that total riparian area declined by 16 percent over a 35-year period (between 1952 and 1987), and that subpatches (portions of riparian forest patches that are most important to cuckoos) declined by 11 percent during the same period. This reduction represents a decline from approximately 17,500 acres of riparian habitat in 1952 to 14,655 acres by 1987 (Greco 2013). In 2001, it was estimated that only 13.5 percent of the land within about 1.25 miles of the Sacramento River supports riparian habitat, and the majority of that land (71.8 percent) is privately owned (Dettling and Howell 2011). This reduction in the total extent of riparian land cover and the lack of natural geomorphic processes (i.e., channel migration) that promote vegetation recruitment exemplify the negative ecosystem consequences of bank revetment (Greco 2013).

Restoration efforts along the Sacramento River since 1989 have restored approximately 6,200 acres of riparian habitat (Golet et al. 2008), and this number continues to increase as federal, State, and nongovernmental organizations acquire habitat and implement restoration projects. Although the amount of riparian habitat that has been restored over recent years is impressive, the acreage represents only a fraction of the extent of historical riparian forests, and total available habitat for the cuckoo along the Sacramento River is still limited (Greco 2013). Connecting suitable patches of riparian forest would provide nesting habitat and could create dispersal corridors that facilitate recolonization of the cuckoo's historical range within the SPA. In the near term, promoting habitat connectivity in areas adjacent to known cuckoo populations (Feather River and Upper Sacramento River CPAs) would be the most beneficial. Achieving the long-term sustainability and viability of the cuckoo population along the Sacramento River will require process-based restoration (Greco 2008); in other words, encouraging channel meander dynamics and channel cut-offs that continually renew the floodplain and support natural recruitment of cottonwood-willow communities will be critical (Greco 2013).

Ongoing and Future Impacts

The primary ongoing threat to the viability of the cuckoo population is the loss of suitable nesting habitat. The cuckoo is sensitive to habitat fragmentation and degradation of riparian forests. In California, cuckoos are absent where vegetation is sparse, water is more than 300 feet away, and vegetation patch size is less than 50 acres (Gaines 1974; Laymon and Halterman 1989). Climate change may also influence the future distribution of cuckoos in the SPA, although the rate of climate change is uncertain. Climate change models predict increased warming in the Central Valley through this century. In two different climate change models developed by The California Avian Data Center (Ballard et al. 2008), the current range of the cuckoo expands northward, following the rivers of the Central Valley and expanding into all five CPAs and their tributaries (i.e., the Feather River and the Upper and Lower Sacramento and San Joaquin River CPAs and their tributaries). Given that cuckoos rely on wide, vegetated floodplains for suitable nesting habitat, it is unclear to what extent they could occupy the narrower floodplains encountered in the tributaries, as predicted by the model. Based on the first two variables identified by the model as being important predictors, such a shift may occur because of changes in the seasonality of precipitation and the associated changes to vegetation under the new precipitation regime. This predicted range recolonization further illustrates the species' dependence on riparian systems and emphasizes the need to secure and restore suitable breeding habitat that it can use in the future. Additionally, in response to the potential impacts of a changing precipitation regime, managing appropriately timed water releases that support riparian forest regeneration and succession could be considered as a conservation tool to develop early successional habitat in the SPA.

Key Information Gaps or Uncertainties

To better understand cuckoo ecology, additional information is needed regarding the species' life history, population sizes, and distribution throughout the West; to what extent pesticides and West Nile virus are affecting the population; and the challenges facing the species on migratory routes and on wintering grounds.

- **Life history, population size, and distribution.** Significant data gaps obscure our understanding of the life history (e.g., fecundity, mating, population structure, and site fidelity) of the western yellow-billed cuckoo. Contributions to the ongoing census of western populations must continue to determine the locations of remnant populations and understand the habitat dynamics associated with these populations (Laymon 1980). Protocol-level surveys to further understand habitat use, population dynamics, and probability of occurrence in the SPA, especially along the Feather, Sacramento, and San Joaquin Rivers, are needed to properly assess impacts and inform targeted restoration. The diet of cuckoos is well known; however, the processes that affect prey populations are not understood, yet are likely to be critical to influencing nest-site selection by the cuckoo. It is also unclear how prey availability affects cuckoo productivity and survival. Many of the cuckoo's preferred prey items winter underground in uplands and may influence the distribution of the cuckoo during insect emergence (i.e., cuckoos may also rely on upland habitat for these prey resources). The Yellow-Billed Cuckoo Working Group was formed in 2008 and is currently working on addressing these types of data gaps. Any annual survey or data collection efforts that contribute to filling these data gaps would benefit from coordinating with the working group to facilitate the development of a conservation plan and guide the management of the species.

- **Pesticides.** Pesticides may affect cuckoo behavior or cause their death, either by being directly contacted or by contaminating cuckoo prey items, but the extent to which pesticides affect cuckoo populations is unknown. Laymon (1980) documented that sublethal poisoning of young birds had been caused by pesticides sprayed on active nests in orchards. Pesticides may contaminate preferred prey items, particularly lepidopteran larvae, as well as some prey items associated with runoff from agricultural land (Laymon and Halterman 1987). Pesticide and herbicide use in agricultural lands adjacent to habitat may also have indirect effects by reducing insect abundance, thus limiting the cuckoo's prey base.

- **West Nile virus.** The National Wildlife Health Center of the U.S. Geological Survey (USGS) has identified the yellow-billed cuckoo as a species that may be affected by West Nile virus (USGS 2003). How the virus is affecting cuckoos is currently unknown.

- **Migration routes and wintering grounds.** Habitat and ecological requirements of the cuckoo along migratory routes and wintering grounds in Central and South America are poorly understood. To positively affect populations in the SPA, it is important to understand the challenges that cuckoos encounter during migration, the habitats they use during migration and on wintering grounds, and the factors that influence the timing of colonization of newly created habitat patches. Because many of their prey species winter underground in riparian and upland habitat, the emergence of prey insects may influence cuckoo distribution in these habitats during migration.

Conservation Strategy

Conservation and Recovery Opportunities

Because cuckoos require relatively large and wide riparian forests with specific structural requirements, and because this habitat is limited throughout the cuckoo's former range in California, the most viable way to support recovery of the western yellow-billed cuckoo is to encourage natural riverine processes that promote, sustain, and renew riparian forests and to implement riparian restoration to increase and sustain suitable nesting habitat throughout the SPA. Creating suitable patches of breeding habitat and connecting those patches to existing or newly established suitable habitat would increase opportunities for the cuckoo to recolonize the riparian forests of the SPA (part of the species' historical range). Restoring natural riverine geomorphologic processes on a broad river floodplain by implementing appropriate management actions would create the disturbance regimes necessary for establishing and maintaining this suitable habitat and provide the space required for the habitat to evolve over time. These conservation efforts could first be implemented adjacent to existing populations (Feather River and Upper Sacramento River CPAs) and then expanded to include other portions of the SPA where feasible.

Identified Conservation Needs

1. **Increase and sustain nesting habitat:** The western yellow-billed cuckoo is a riparian obligate, dependent on dense and structurally complex habitat, such as cottonwood-willow forest that is close to water and of sufficient extent and width. Cuckoos are also therefore dependent on the natural hydrologic and geomorphic processes that create and sustain their nesting habitat. Creating setback levees to connect rivers to their floodplains and facilitating natural flood processes that lead to relatively continuous, dynamic riparian successional stages will provide opportunities to renew and sustain nesting habitat throughout the SPA, especially in the Feather and Upper Sacramento River CPAs. Establishment of natural processes on a sufficiently large floodplain to support large riparian forests would limit the need for additional restoration or management efforts.

This suitable habitat must be situated along streams or rivers, with a minimum patch size of 50 acres, although larger patches (i.e., more than 100 acres) are preferred. These patches must be adjacent to or connected to additional nesting habitat in order to support viable populations of yellow-billed cuckoos. Riparian restoration in core population areas, especially in the Upper Sacramento and Feather River CPAs, would provide habitat connectivity important to increasing the species' numbers and facilitating recolonization of the SPA. Removing exotic vegetation would also improve opportunities to establish native vegetation, limiting the spread of undesirable species that do not provide nesting habitat in the SPA and enhancing riparian restoration efforts.

2. **Restore riverine geomorphic processes:** Linked with increasing the extent of riparian forest, the restoration of riverine geomorphic processes would contribute to providing a mosaic of suitable habitat that would sustain cuckoo populations in the SPA, especially in the Feather and Upper Sacramento River CPAs. Riverine geomorphic processes result in disturbances that create, sustain, and renew the early successional to mid-seral habitat that is preferred by the cuckoo. Lateral channel migration creates a dynamic vegetation community composed of various age classes that provide patches of nesting and foraging habitat that is critical for the cuckoo.

3. **Manage invasive and exotic plants:** Cuckoos are highly dependent on cottonwood-willow habitat for adequate nesting structure and prey resources. Invasive plant species such as saltcedar and giant reed have contributed to the degradation of cottonwood-willow habitat by reducing the availability of adequate vegetative structure required by nesting cuckoos and by reducing the food supply, particularly insects (Frandsen and Jackson 1994; Dudley and Collins 1995). Removal of invasive and exotic species, combined with establishment of native plant species within the SPA, would create opportunities to provide suitable nesting and foraging habitat for the cuckoo.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the western yellow-billed cuckoo; these are summarized in Table 1 of this section. In many cases, the conservation needs of the cuckoo can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/or revetment removal at a site that

Table 1. Summary of CVFPP Management Actions that Address Identified Conservation Needs of the Western Yellow-Billed Cuckoo

CVFPP Management Actions	Conservation Need		
	1. Increase and Sustain Nesting Habitat	2. Restore Riverine Geomorphic Processes	3. Manage Invasive and Exotic Plants
Operations, Maintenance, and Floodway Management			
Floodwater storage and reservoir forecasting, operations, and coordination	+	+	+
Facility maintenance			
Levee vegetation management	-		+
Floodway maintenance	-		+
Modification of floodplain topography	+	+	
Support of floodplain agriculture			
Invasive plant management	+		+
Restoration of riparian, SRA, and marsh habitats	+		
Wildlife-friendly agriculture			
Structural Improvements			
Levee and revetment removal	+	+	
Levee relocation	+	+	
Bypass expansion and construction			
Levee construction and improvement			
Flood control structures			

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

may depend on levee relocation to allow for bank erosion. Wherever feasible, conservation objectives and indicators will inform management actions toward 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 provide flow releases that seasonally inundate floodplains, scour existing vegetation, create new floodplain, and promote natural erosional and depositional processes that facilitate the establishment of early successional riparian vegetation, all of which would benefit the western yellow-billed cuckoo.

Levee vegetation management: On the whole, levee vegetation management may negatively affect habitat for the cuckoo by fragmenting patches of suitable habitat. The vegetation on levees is often next to or near cottonwood-willow habitat that may provide continuity and connectivity among patches of suitable habitat used by the cuckoo. Within the levee VMZ, implementation of the 2012 CVFPP has involved managing levee vegetation, including woody vegetation, for visibility and accessibility. Levee vegetation above or outside the VMZ would also be significantly trimmed or removed, reducing inputs of terrestrial insects and habitat connectivity, thereby reducing food availability and habitat patch size.

Floodway maintenance: Current floodway maintenance activities are similar to levee maintenance activities, but also include removing sediment, debris, and other flow obstructions, such as by clearing vegetation in the bypasses. This type of vegetation clearing could reduce the patch sizes of suitable habitat required by the cuckoo. Certain tree types, such as willows and alders, may benefit cuckoos and still allow for floodwaters to move through bypasses; management practices could be altered to allow for such beneficial trees to be left in place. Maintenance practices could be changed in areas where the cuckoo is known to breed (Upper Sacramento and Feather River CPAs) to facilitate the restoration of riparian habitat. Lastly, increasing the size of the floodway by setting back levees could reduce the need to remove vegetation and other materials that are a part of cuckoo habitat.

Modification of floodplain topography: Lowering floodplain elevations would support natural hydraulic processes and allow more frequent and sustained inundation, which in some locations may allow the growth of additional riparian vegetation (i.e., more suitable cuckoo habitat) on point bars and river banks.

Invasive plant management: Existing and new weed infestations could negatively affect the riparian habitat that the cuckoo uses for breeding and foraging. Managing and controlling invasive plants throughout the SPA could minimize this impact. Additionally, using a planting palette of suitable understory plants in riparian restoration projects could provide nest concealment and protection from predators.

Restoration of riparian, SRA cover, and marsh habitats: Riparian restoration in core cuckoo population areas could be important and effective in facilitating increases of this species' population and in creating critical dispersal corridors. Providing corridors and large contiguous tracts of suitable breeding habitat throughout the SPA would maximize opportunities for this species to expand. The following guidelines should be observed to maximize habitat patch quality: optimum habitat is >200 acres (and >1,950 feet wide); suitable habitat is 101–200 acres (and 660–1,949 feet wide); marginal habitat is 50–100 acres (and 325–650 feet wide); patches <50 acres or narrower than 325 feet are considered unsuitable. The RHJV (2004) recommends restoring a total of 20,450 acres of suitable habitat in the SPA that can sustain 11 subpopulations (25 pairs per subpopulation). The recommended totals per location are as follows: 9,150 acres across six locations along the Sacramento River; 1,900 acres along the Feather River; 1,900 acres along the Stanislaus River; 2,500 acres along the Cosumnes River; 2,500 acres along the Merced River; and 2,500 acres along the Mendota Canal.

Structural Improvements

Levee and revetment removal: Removing levees and revetment would create opportunities to improve the riverine geomorphic and floodplain inundation processes important to sustaining habitats along the rivers. Encouraging river meander and natural erosional and depositional processes would facilitate the establishment of early successional riparian vegetation and would thereby benefit the cuckoo by providing and maintaining suitable nesting habitat. The section of the Sacramento River from River Mile 144 to River Mile 245 has the greatest potential to maintain large patches of suitable habitat because this section contains setback levees, and about half of the eroding banks and point bars still function naturally (Greco 2013). Levee removal and relocation, setback levees, and revetment removal throughout the SPA, especially in areas adjacent to existing cuckoo habitat in the Feather and Upper Sacramento River CPAs and near the confluence of these two rivers, could increase the potential for creating, reconnecting, sustaining, and renewing suitable habitat.

Levee relocation: As discussed above, improving ecosystem function and restoring natural riverine geomorphology by relocating levees would create opportunities to establish and sustain suitable breeding and foraging habitat. Specifically, an expanded floodway, reconnected to the river channel, would allow for river meander, sediment erosion and deposition, and other natural ecosystem disturbance processes, all of which could contribute to creating, renewing, and connecting suitable habitat important for sustaining populations of the cuckoo.

Recovery Plan Alignment

Currently, there is no formal recovery plan for the western yellow-billed cuckoo; it is expected to be forthcoming.

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 western yellow-billed cuckoo. Therefore, building on the preceding discussion, this section of the western yellow-billed cuckoo 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 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 conservation of the cuckoo, requirements would be added to increase acreage that makes a positive contribution to the riparian habitat that the species requires for nesting and foraging.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of cuckoos, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit the cuckoo may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Western Yellow-Billed Cuckoo[a]

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain and total amount of expected annual inundated floodplain habitat[a]	No	
Riverine Geomorphic Processes	Natural Bank—total length (miles)	Yes	
	River Meander Potential—total amount (acres)	Yes	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	
	Habitat Connectivity—median patch size (acres)	Yes	Provide habitat and promote connectivity using the following guidelines for habitat patch quality to the extent feasible: optimum habitat is >200 acres (and >1,950 feet wide); suitable habitat is 101–200 acres (and 660–1,949 feet wide); marginal habitat is 50–100 acres (and 325–650 feet wide); patches <50 acres or narrower than 325 feet are considered unsuitable. The RHJV (2004) recommends restoring a total of 20,450 acres of suitable habitat in the SPA that can sustain 11 subpopulations (25 pairs per subpopulation). The recommended totals per

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Western Yellow-Billed Cuckoo[a]

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
			location are as follows: Sacramento River—9,150 acres across six locations; Feather River—1,900 acres; Stanislaus River—1,900 acres; Cosumnes River—2,500 acres; Merced River—2,500 acres; and Mendota Canal—2,500 acres.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	No	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	Yes	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	Yes	The Sacramento River from River Mile 144 to River Mile 245 has the greatest potential to maintain large patches of suitable habitat because of the presence of functioning eroding banks and setback levees (Greco 2013). Reconnecting floodplains in the Feather River and Upper Sacramento River CPAs may facilitate the establishment and renewal of early successional habitat.
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	Yes	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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G16. Focused Conservation Plan: Riparian Brush Rabbit

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the riparian brush rabbit (*Sylvilagus bachmani riparius*) and its habitat in the SPA for the CVFPP.

The riparian brush rabbit is a subspecies of the brush rabbit (*S. bachmani*) (Orr 1935). It is one of thirteen subspecies of *S. bachmani*, eight of which occur in California (Hall 1981). It is distinguished from other members of *S. bachmani* by its unique skull morphology: the sides of the rostrum are noticeably convex when viewed from above, instead of straight or concave (Orr 1940). This small cottontail was listed as endangered under the ESA on 23 February 2000 (65 FR 8881) by USFWS. It was designated as an endangered species under CESA in 1994 (CDFW 2013). Population declines have been attributed to the loss, fragmentation, and degradation of riparian habitat (USFWS 2000). The current known range of the riparian brush rabbit consists of Caswell Memorial State Park (Caswell SP), in Stanislaus County; the San Joaquin River National Wildlife Refuge (NWR); and a few sites on private land in the southern Sacramento–San Joaquin River Delta (South Delta), near Lathrop. These three population groups are located in the Lower San Joaquin River CPA.

Status and Trends

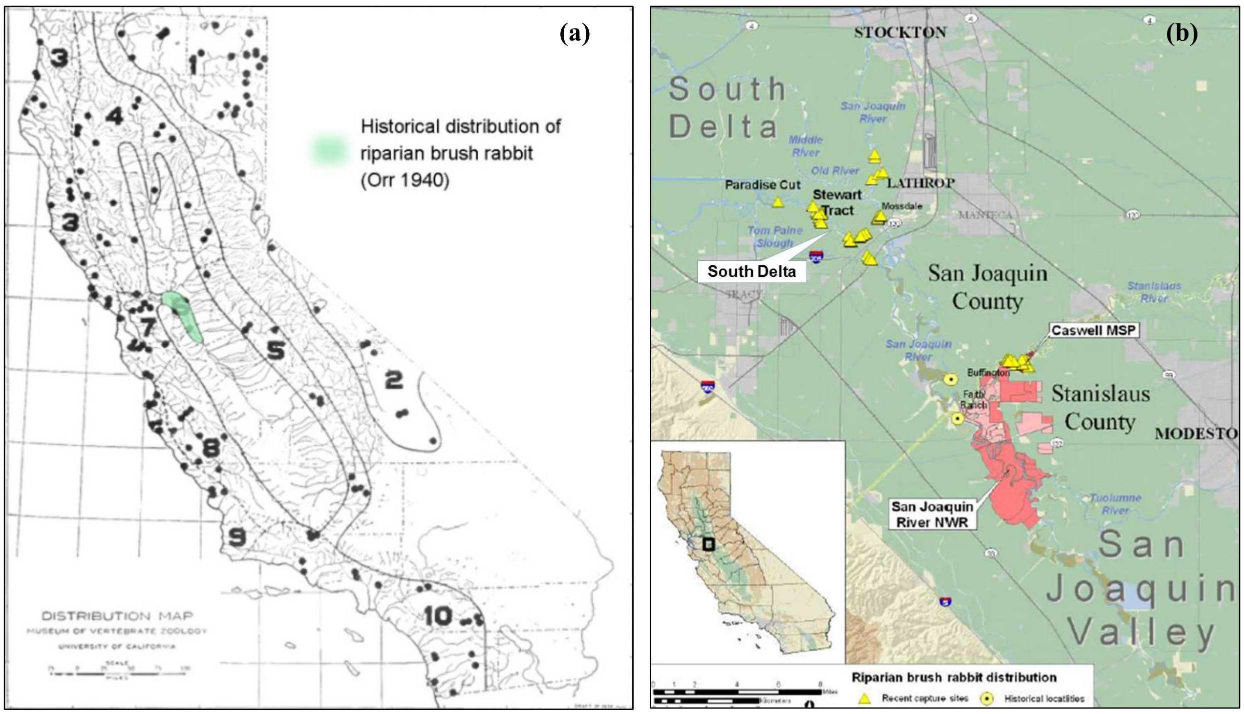
Distribution

The brush rabbit ranges along the Pacific coast, from southwestern Washington south through California to the tip of Baja California Sur, Mexico (Chapman 1974). It occurs throughout most of California, except in the high Sierra Nevada, southeastern deserts, and much of the Central Valley. The riparian brush rabbit is endemic to the San Joaquin Valley of California. Records of its historical range are limited to the documentation of a few captures near the type locality in Vernalis, San Joaquin County. At the time of its description by Orr (1935), the subspecies had likely been extirpated from much of its historical range (USFWS 2000); however, Orr (1940) believed that riparian brush rabbits occupied river bottomlands along the San Joaquin River from the Delta region in the north to Stanislaus County in the south (Orr 1940) (Figure 1a). By the 1970s, the riparian brush rabbit was thought to be limited to a single population at Caswell SP (Williams and Basey 1986). Extensive surveys along the Stanislaus, San Joaquin, and Tuolumne Rivers in 1985 and 1986 failed to discover any evidence of riparian brush rabbits outside of Caswell SP (Williams and Basey 1986). Surveys along the San Joaquin River did not extend north of Caswell SP, so the South Delta was not included in Williams and Basey's search.

In 1998, the California State University, Stanislaus, Endangered Species Recovery Program (ESRP)[1] discovered a new population of riparian brush rabbits on private lands near Lathrop

1 ESRP is a cooperative research program on biodiversity conservation in central California, administered by California State University, Stanislaus. ESRP's mission is to facilitate endangered species recovery and resolve conservation conflicts through scientifically based recovery planning and implementation.

(Williams et al. 2002a; Williams and Hamilton 2002). Rabbits captured from this population were used as breeders in a captive breeding program initiated by USFWS in 2001. In 2002, captive-bred rabbits were used to establish a new population in San Joaquin County at the San Joaquin River NWR. The present distribution of this subspecies therefore includes three isolated population centers, located at Caswell SP, the San Joaquin River NWR, and private land in the South Delta near Paradise Cut, the city of Lathrop, and Mossdale (Figure 1b).



Source: (a) Orr 1940; (b) Lloyd et al. 2011

Figure 1. (a) Historical Range of the Riparian Brush Rabbit: "Nuttall cottontail (*Sylvilagiis nuttallii*) and brush rabbit—1. *Sylvilagus n. nutallii* 2. *S. n. grangeri 3. S. b. ubericolor*; 4. *S. b. tehamae*; 5. *S. b. mariposae*; 6. *S. b. riparius*; 7. *S. b. macrohinus*; 8. *S. b. virgulli*; 9. *S. b. bachmani*; 10. *S. b. cinerascens*"
(b) Current Distribution of Riparian Brush Rabbit

Population Trends

In 2003, CDFW described riparian brush rabbit populations as stable or increasing (CDFG 2003). The recently established population in the San Joaquin River NWR was reported as robust throughout the refuge by 2010 (Lloyd et al. 2011). Population monitoring in the South Delta has not been possible, because access to private lands for this purpose has not been granted (Williams et al. 2002a). The South Delta population is thought to consist of, at most, a few hundred individuals scattered among highly fragmented parcels (Williams et al. 2008). Despite the promising reports above, the small size and isolation of the three extant populations leave them extremely vulnerable to extirpation. Potential threats to the subspecies include disease, habitat loss, and increased predation associated with urban development, genetic risks, and environmental stochasticity (USFWS 2000). Populations at both Caswell SP and the San Joaquin

River NWR have undergone precipitous declines following flooding events. As few as 20 individuals may have survived the 1986 floods in Caswell SP (Williams 1988). Similarly, flooding in the San Joaquin River NWR resulted in the deaths of 91 percent (23 of 25) of radio-collared brush rabbits in 2006 (Lloyd et al. 2011). Reports of survival following the severe flooding of 2011 are not available; however, the increased availability of high-water refugia following restoration work, coupled with rescue efforts, may have increased survival in 2011 (Prose 2011). Biologists from River Partners observed several riparian brush rabbits on elevated, brush-covered mounds ("bunny mounds") during flooding (River Partners 2011).

Life History

Information regarding the life history of the riparian brush rabbit is limited; however, the riparian brush rabbit is a subspecies of the brush rabbit, which has been more extensively studied. The following text draws on sources of information concerning both the species and the subspecies.

Movements and territories: Brush rabbits are most active in the early evening and early morning (Pearson 1959; Chapman 1974). They do not hibernate, migrate, or exhibit any other seasonal movement. Their home ranges are smaller than those of other members of the genus *Sylvilagus* and typically conform to the size and shape of available habitat (Chapman 1971). Like most small mammals, male riparian brush rabbits have larger home ranges (0.24 acres) than females (0.06 acres) (Basey 1990). Hamilton (2010) found a similar disparity between males and females in captive-bred riparian brush rabbits, but recorded much larger home ranges (3.8–5.2 acres). The discrepancy in home range size could be due to differences in the subspecies studied, or could reflect behavioral differences caused by translocation, small population size, or disturbance (wildfire) in Hamilton's study. Some overlap has been observed at the edges of female home ranges, but core areas did not coincide (Larson 1993).

Dispersal is poorly understood in this species. Brush rabbits rarely venture far from cover, and typically cross between patches of brush where the distance between patches is shortest (Chapman 1971). At the time of listing, it was thought that dispersal was limited by the availability and connectivity of brushy cover. Subsequent study by Hamilton (2010) indicated that translocated riparian brush rabbits move longer distances than previously hypothesized. Hamilton postulated that these movements reflected exploratory behavior by naïve rabbits, or could indicate that release sites were saturated, causing the rabbits to travel farther before settling.

Nesting and breeding: The reproductive season of brush rabbits typically lasts from January to June (Orr 1940; Mossman 1955). Peak breeding of riparian brush rabbits coincides with months with higher precipitation (Hamilton 2010), but there are few accounts of riparian brush rabbit reproduction in the wild. In captive riparian brush rabbits, pregnancies were recorded as early as late December and as late as July and August (Williams et al. 2002b), a much longer breeding season than recorded in wild populations of this or other brush rabbit subspecies. A peak in the numbers of newly trapped and marked young occurred in May and August, with young averaging 29 days old at first capture (Williams et al. 2002b).

Gestation in brush rabbits lasts 27 ± 3 days, with an average litter size of three to six young. Females may produce as many as six litters in a year, but three is typical (Mossman 1955; Chapman 1974). Although female brush rabbits may produce as many as 16 young in a single year, only one in six brush rabbits survives to the next breeding season (Mossman 1955; Chapman and Harman 1972). In one study, captive riparian brush rabbit females produced up to three or four litters each per year, with an average of 2.9 young per pregnancy surviving the first few weeks after birth (Williams et al. 2002b). Furthermore, captive riparian brush rabbits have produced an average of only 5.3 young per year, although this estimate was calculated from young surviving to first capture rather than from a count of embryos (Williams et al. 2008). This rate is much lower than Chapman and Harman's (1972) estimate of 16 young per year.

Riparian brush rabbits kept in fenced enclosures (of 1.2–1.4 acres) exhibited a polygynous mating system, with one male dominating reproduction in each pen. Some females mated promiscuously, with more than one sire identified for their litters (Williams et al. 2008). The mating system of wild brush rabbits has not been reported. It is probably similar to that of the captive rabbits, given that polygyny and promiscuity are common among lagomorphs (Cowan and Bell 1986).

Female brush rabbits give birth in a well-concealed nest lined with fur and dried grass. Nests are built in a shallow cavity or burrow and are covered by a plug of dried grass (Orr 1940; Chapman 1974). The young stay in the nest for about 2 weeks and are nursed only at night (Chapman 1974). Young rabbits reach maturity in 4–5 months (Orr 1940). Williams et al. (2008) observed a number of captive females reproducing in the same breeding season in which they had been born. However, neither Mossman (1955) nor Chapman and Harman (1972) believed that brush rabbits reproduced in the spring of their birth, and such early reproduction may not occur in the wild.

Foraging and food resources: Brush rabbits can subsist on a wide variety of plants. Grasses and other herbaceous vegetation are the most important part of the brush rabbit's diet when they are available (Orr 1940). Brush rabbits prefer new green grass and cow clover (*Trifolium wormskioldii*) above all other food (Orr 1940). They also prefer Mediterranean barley (*Hordeum murinum*), soft chess (*Bromus hordeaceous*), and wild oat (*Avena fatua*) when they are available, but will feed on a variety of forbs, sedges, shoots, and leaves (Orr 1940). Shrubs like blackberry (*Rubus ursinus*), wild rose (*Rosa californica*), and marsh baccharis (*Baccharis douglasii)* are also consumed, especially during fall and winter months when grass is scarce (Orr 1940; USFWS 1998).

Habitat and Ecological Process Associations

Williams measured the population density of riparian brush rabbits in Caswell SP at 0.7 to 3.5 rabbits per acre in 1988, and obtained similar results in 1993 (1.2 ± 0.5 rabbits per acre). This density likely reflects Caswell SP's carrying capacity (Williams 1993); much lower densities were observed after the major flood events of 1986 and 1997 (USFWS 1998).

As its name implies, the riparian brush rabbit is found along riparian corridors with dense, brushy habitats. Such brush typically consists of short to medium-height shrubs and forbs with dense cover from approximately ground height up to 6 feet. Previous studies have suggested that brush rabbits prefer larger shrub clumps, and will not occupy shrub clumps smaller than 0.11 acres (Chapman 1971). Riparian brush rabbits have since been captured in areas vegetated by grasses and weeds (Williams and Hamilton 2002), and movements documented by Hamilton (2010) clearly indicate that brush rabbits will move through less brushy areas when dispersing.

Brush rabbits prefer areas with a mix of low and tall shrubs, small trees, and open patches of grass and herbaceous plants. Structures that provide cover, such as woody debris or dense thickets of California blackberry, California wild rose, coyote brush (*Baccharis pilularis*), golden currant (*Ribes aureum*), or marsh baccharis are also associated with high riparian brush rabbit use (Williams 1988). Hamilton (2010) found riparian brush rabbits in areas with a secondary canopy and herbaceous cover, but the rabbits were more common where a shrub layer was also present. They were absent from areas with a high canopy. Such habitats may provide insufficient cover for the rabbits; Williams (1986) found a negative correlation between canopy cover and understory cover. Riparian brush rabbits are also absent from areas that show evidence of frequent flooding or flooding greater than 5 feet in depth (Williams 1986).

Although less frequently occupied, areas that provide refuge from floodwaters are critically important to riparian brush rabbits. Between 1980 and 2000, four major floods occurred in Caswell SP. Populations of riparian brush rabbits remained depressed for several years after severe flooding that fully inundated the park in 1997 and 2006. Rabbits have been observed stranded in trees and snags during flooding (William 1988; Lloyd et al. 2011), but such refugia offer little to no food and leave the animals vulnerable to predation. Also, Caswell SP and the San Joaquin River NWR are closely surrounded by levees and, until recently, these levees provided the only refuges from flooding. However, levees as refugia are far from ideal, because they are frequently distant from areas occupied by brush rabbits and offer little or no cover (Williams 1986). To improve conditions for rabbits, efforts are being made to build brush-covered mounds (called "bunny mounds" by park officials) and to revegetate retired levees in the San Joaquin River NWR (Lloyd et al. 2011). It is still unclear what placement or vegetative characteristics will most benefit brush rabbits (Hamilton 2010); nonetheless, rabbits were observed using the mounds during floods in 2011 (Lloyd et al. 2011).

Kelly et al. (2011) summarized the primary habitat requirements of the riparian brush rabbit:

- Large patches of dense brush, preferably of riparian species like blackberry, wild rose, or willow (*Salix* sp.), but other dense shrub species are also suitable
- Ecotonal edges of dense brush to open patches of grass and forbs
- Live or dead scaffolding vegetation that can withstand flooding
- Either an open tree canopy or no canopy

- High-ground refugia from flood events

Restoration of riverine geomorphic processes and an ecologically functional floodplain will help establish new riparian vegetation and sustain the existing dense, brushy habitat preferred by riparian brush rabbits.

Orr (1940) conducted behavioral observations of brush rabbits. Brush rabbits prefer to forage in or near cover. When foraging in the open, rabbits usually remain close to cover and in the shade. Most feeding occurs in the early morning and around sunset. Feeding continues late into the night when a full moon is visible. Weather conditions alter feeding times, with fog and light rain delaying morning feeding and curtailing feeding in the evening. Rabbits typically remain in shelter or seek shelter during heavy rainfall. Brush rabbits also spend a great deal of time sunning themselves in the late morning and early afternoon. Sunning is most common following rain or fog and is typically done near or just inside brushy cover.

Many birds, mammals, and snakes prey on brush rabbits. Known predators of riparian brush rabbits include red-tailed hawks (*Buteo jamaicensis*), Swainson's hawks (*B. swainsoni*), red-shouldered hawks (*B. lineatus*), owls, feral cats (*Felis catus*), gray foxes (*Urocyon cinereoargenteus*), coyotes (*Canis latrans*), bobcats (*lynx rufus*), spotted skunks (*Spilogale gracilis*), striped skunks (*Mephitis mephitis*), and dogs (*Canis lupus familiaris*) (USFWS 1998; Williams et al. 2002a). Scrub jays (*Aphelocoma californica*), weasels (*Mustela frenata*), gopher snakes (*Pituophis catenifer*), and rattlesnakes (*Crotalus oreganus*) have also been observed taking young brush rabbits (Orr 1940). Black rats (*Rattus rattus*) also depredate nestling riparian brush rabbits, and are believed to be an extreme threat to the subspecies (Williams et al. 2002a).

Predator species are similar for all three population groups of riparian brush rabbits; however, the relative impact of individual predator species varies by area. In Caswell SP, feral cats are particularly numerous and pose a significant threat to riparian brush rabbits. Control efforts are sporadic, and new cats are regularly abandoned at the park (Williams et al. 2002a). In the South Delta, predation is exacerbated by the proximity of occupied habitat to residential properties, public roads, and waterways (Kelly et al. 2011). Increased urban development in the South Delta is expected to lead to increased predation of riparian brush rabbits by domestic cats and dogs, and by black rats (City of Lathrop 2004). In the San Joaquin River NWR, predation accounted for the greatest percentage (24.5 percent) of known-cause mortality in translocated riparian brush rabbits (Hamilton 2010). In most cases, the predator was not identified. Predation is the highest cause of mortality in other lagomorph species (see, for example, Moriarty et al. 2000, Chapman and Litvaitis 2003), so high predation rates are not unexpected.

Riparian brush rabbits are commonly associated with riparian woodrats (*Neotoma fuscipes riparia*), black rats, western gray squirrels (*Sciurus griseus*), American opossums (*Didelphis virginiana*), and striped skunks, although their specific habitat associations and uses vary (USFWS 1998). Runways used by rabbits are also frequented by multiple mammal, bird, and snake species (Pearson 1959).

The final listing rule identified desert cottontails (*Sylvilagus audubonii*) as potential competitors of riparian brush rabbits (USFWS 2000). Small numbers of desert cottontails have been observed in Caswell SP (Williams and Basey 1986; Cook 1992), but subsequent surveys failed to detect them, and it is unlikely that any permanent population occurs there (Williams 1993). Similarly, comparatively few desert cottontails have been captured during trapping efforts in the South Delta (Williams and Hamilton 2002). Given their scarcity, desert cottontails are unlikely to be significant competitors with riparian brush rabbits in Caswell SP and the South Delta in normal years. Desert cottontails are common in the San Joaquin River NWR (USFWS 2006), but no reports on their interactions with riparian brush rabbits there are available.

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for riparian brush rabbits within the SPA (Figure 2). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by riparian brush rabbits within the SPA;
- the specific CPAs within which riparian brush rabbits occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

Management Issues

Threats and Sensitivities Range-Wide

The extensive loss, degradation, and fragmentation of riparian habitat throughout the Central Valley have confined the riparian brush rabbit to just three extant population groups (USFWS 2000). The small size and isolation of these populations leave them extremely vulnerable to increased genetic risks, disease, demographic stochasticity, environmental stochasticity (in particular floods), predation, human recreational activities, urban development, and climate change.

The Caswell SP population of riparian brush rabbits has recently experienced multiple drastic population reductions, declining to fewer than 25 individuals at least four times since the 1970s (Williams 1988; Williams et al. 2002a; USFWS 2006; Hamilton 2010). The South Delta metapopulation may have experienced similar reductions in the past 30 years as a consequence of flooding (Williams et al. 2002a); however, no data are available for this area from before the late 1990s. In addition, the isolation of the Paradise Cut/Lathrop and Caswell SP populations precludes natural gene flow between them. Indeed, a recent genetic analysis found that the two

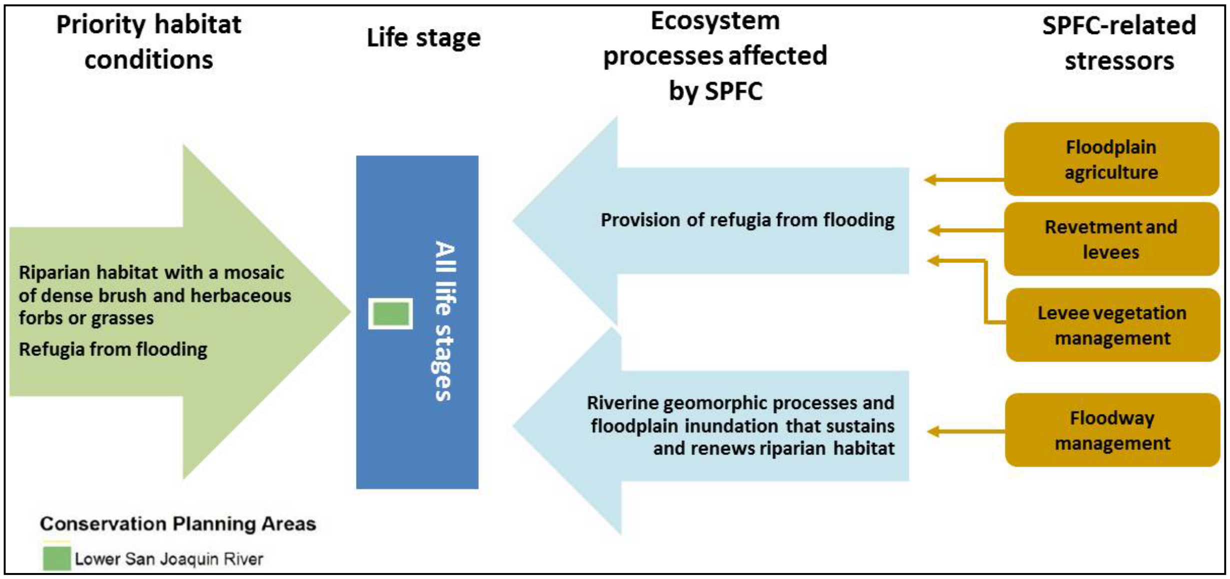


Figure 2. Conceptual Model for Riparian Brush Rabbit within the SPA

population groups were genetically distinct (Constable et al. 2011). Because the San Joaquin River NWR population was founded by individuals trapped in the South Delta, it too faces the genetic risks posed by small population size and loss of genetic diversity. However, efforts to trap breeders from multiple, spatially distant sites may mitigate some of the genetic risks faced by the captive-bred population in the San Joaquin River NWR. Nonetheless, all three populations are at risk of inbreeding depression and disease outbreaks exacerbated by loss of genetic diversity (USFWS 1998; Williams et al. 2002a).

Brush rabbits are susceptible to several diseases. In captive riparian brush rabbits, roundworms (*Baylisascaris* sp.) were most commonly implicated in disease-related mortality; necrotizing typhlitis and intestinal lymphoma were also implicated in rabbit fatalities (Williams et al. 2008). Several other diseases are common in California rabbit species and could occur in riparian brush rabbits. Williams (1988) listed the following: tularemia, plague, myxomatosis, silverwater, California encephalitis, equine encephalitis, listeriosis, Q-fever, and brucellosis. The remaining small, genetically depauperate populations of riparian brush rabbits could be quickly extirpated by an outbreak of epidemic disease (Williams 1988; USFWS 1998).

All three population groups of riparian brush rabbits also remain extremely vulnerable to natural disturbances. Flooding is a major threat to the remaining populations. Although riparian brush rabbits have been found in trees and tall shrubs during floods, it is doubtful they can survive in trees for long. Rabbits trapped in this manner are highly susceptible to predation, hypothermia, and starvation. Also, little refuge is available to brush rabbits fleeing rising waters, because agricultural fields abut the riparian corridors occupied by all three populations. As noted above, severe and long-lasting population declines were observed in Caswell SP after flooding in both 1997 and 2006. Revegetation of retired levees and construction of high mounds in the San Joaquin River NWR has provided functional refuge from floodwaters (Lloyd et al. 2011), but unvegetated levees do not provide suitable flood refugia. Also, where active levees provide emergency refugia for the rabbits, the subspecies' habitat needs may conflict with federal requirements for levee maintenance. Biologists rescued rabbits trapped in trees and tall shrubs during flooding in 2011 (Prose 2011), so continued construction of high-water refugia and planting of scaffolding vegetation is likely warranted. Incorporating scaffolding vegetation into habitat restoration programs could provide tall and dense vegetation that persists after flood events to maintain cover.

Wildfires can reduce riparian brush rabbit populations by causing both direct mortality and habitat loss. A history of fire suppression has allowed Caswell SP to develop thick, overgrown vegetation with accumulated dead wood and a deep layer of litter (Williams et al. 2002a). Such heavy fuel loads increase the likelihood of catastrophic fires in both Caswell SP and the San Joaquin River NWR. In 2004, a wildfire destroyed important habitat occupied by riparian brush rabbits in the San Joaquin River NWR (Phillips et al. 2005; Kelly et al. 2011).

Predation may also contribute to low population levels all three population centers (Williams et al. 2002a). As previously discussed, several avian, mammalian, and reptilian predators take riparian brush rabbits. Of particular concern are the large numbers of feral cats and black rats in Caswell SP (Williams et al. 2002a). These animals likely depredate rabbits in other populations as well. They may be of particular concern in the South Delta, because this population is closely associated with both agricultural and urban development.

The South Delta population is likely subject to the same risks that threaten the Caswell SP and San Joaquin River NWR populations, but faces the additional risk of urban development. Occupied habitat is highly fragmented, and patches are typically small and narrow (Williams and Hamilton 2002). These conditions exacerbate flood and fire risks in the South Delta. Furthermore, much of the private land occupied by brush rabbits is slated for development in the near future. In addition, activities like vegetation control along stream channels, on levees, and along railroads could eliminate habitat and high-water refugia in the South Delta (Williams et al. 2002).

Ongoing and Future Impacts

Ongoing impacts on riparian brush rabbit populations in the SPA include the effects of urban and agricultural expansion and human activities, flooding, and climate change.

- Although increased urban and agricultural development is not expected to directly reduce riparian brush rabbit habitat for the two populations on protected State and federal lands, development near Caswell SP and the San Joaquin River NWR may increase threats to brush rabbits from nonnative predators, particularly black rats and feral cats. Also, increased development nearby could further limit riparian brush rabbit access to nearby high-water refugia and dispersal to new habitat. In addition, both agricultural and urban development are associated with increases in the use of rodenticide, which would directly harm riparian brush rabbits if deployed in areas where they forage, and especially in areas used as high-water refugia. In the South Delta, nearly all riparian brush rabbits occur on private land. Encroaching urban development in the South Delta is an ongoing threat to this small, scattered population; however, other conservation planning efforts in the Delta may seek to contribute to the recovery of this population. Lastly, those responsible for flood maintenance in San Joaquin County periodically clear vegetation from levees and stream channels, reducing habitat for riparian brush rabbits (Williams 2002a).

- Flooding remains a major threat to riparian brush rabbits. Severe floods periodically inundate nearly all habitats available to the rabbits (Williams 1986). Vegetated high-water refugia in surrounding lands have been largely eliminated by agricultural land uses. Although levees provide elevated land that may act as refugia, they are not ideal because they are not vegetated and therefore do not provide adequate cover, and are often located far from areas occupied by rabbits (Williams 1986). Construction of bunny mounds in the San Joaquin River NWR has provided high-quality refugia for riparian brush rabbits, but more such refugia are needed throughout the riparian brush rabbit's range to minimize the effects of flooding.

- Climate change will affect habitat throughout the SPA, although its influence on the remaining populations of riparian brush rabbits is uncertain. Despite this uncertainty, riparian brush rabbits are vulnerable to environmental change of any kind because of their small population size, isolation, low genetic diversity, and inability to disperse to new habitats. Although total annual precipitation is not predicted to change substantially, less precipitation is expected to fall as snow in the Sierra Nevada. This change is expected to increase winter flooding, and also reduce the availability of water from snowmelt during spring and summer months (Cayan et al. 2006). Increased diversion of water from riparian streams to irrigated crops could alter vegetation structure along riparian corridors, which would reduce habitat for riparian brush rabbits. In addition, climate change is expected to increase the occurrence and severity of flooding (Miller et al. 2003; Fissekis 2008; Dettinger et al. 2009). The risks of flooding to riparian brush rabbits are detailed above (see "Threats and Sensitivities Range-Wide"). Finally, wildfires are expected to become more frequent in California (Cayan et al. 2006). Along the Stanislaus River, fire hazards would be exacerbated by increased water diversion, accumulations of dead brush, and diversion-induced drought. Frequent wildfires pose the risk of essential habitat loss for, and direct mortality of, riparian brush rabbits.

Key Information Gaps or Uncertainties

To better understand riparian brush rabbit ecology, the following information is needed: a more thorough quantification of population sizes and trends in the South Delta, Caswell SP, and lands in and adjacent to the San Joaquin River NWR; further examination of the taxonomy and genetic relationships of the Caswell SP population and the South Delta population group; greater insight into the habitat requirements and habitat uses of the subspecies in all population groups; data on the most effective size and locations of bunny mounds as high-water refugia; and a greater understanding of the subspecies' community ecology. These data gaps are discussed below.

- **Population status.** Little is known about the South Delta population of riparian brush rabbits. This lack of information is largely the result of researchers' limited access to the private land where the rabbits live. A greater understanding of the size, connectivity, and genetics of the South Delta population would be beneficial, especially because these rabbits were used to breed animals for release in the San Joaquin River NWR and would likely serve as the source for future captive breeding efforts. Also needed is a better understanding of the status and sustainability of riparian brush rabbit population groups in Caswell SP and the lands in and adjacent to the San Joaquin River NWR.

- **Taxonomy and genetics.** Little research has been conducted on the genetics of the riparian brush rabbit. Although the study by Constable et al. (2011) indicated that the South Delta and Caswell SP groups are remarkably distinct genetically, analysis of additional markers would help clarify the extent of genetic differentiation between the two population groups and help guide future population recovery efforts. Additional genetic analyses would also help clarify the evolutionary history of this endangered subspecies.

- **Habitat use and requirements.** Studies concerning the habitat preferences and requirements of riparian brush rabbits have thus far been limited to the population at Caswell SP. Hamilton (2010) notes that her study of habitat use occurred when populations were depressed after flooding in 2006, so sample sizes were too low to fully understand the riparian brush rabbit's habitat associations. To understand habitat use in the subspecies as a whole, studies outside of Caswell SP are needed. In addition, future studies would best contribute to conservation efforts by providing analyses of topography, the connectivity of habitat patches, distances between habitats and trails and other recreational facilities, and the optimal and actual proximities of habitats to high-water refugia.

- **Refugia.** Brush rabbits have been observed using bunny mounds constructed in the San Joaquin River NWR. Further study into the best placement of these mounds and the utility of brush planted there is needed to optimize future conservation efforts that incorporate high-water refugia. Understanding the ideal spatial configuration and vegetation species composition of this habitat mosaic will provide guidance for incorporating bunny mounds into restoration initiatives.

- **Community ecology.** Little is known about the community ecology of riparian brush rabbits. Further study of the predators, competitors, and commensals of riparian brush rabbits is needed. Of special concern are the effects of feral cats and black rats on brush rabbit survival and reproductive success. More information is also needed on the occurrence of desert cottontails near brush rabbit populations, and on the interactions between these two species.

Conservation Strategy

Conservation and Recovery Opportunities

The most viable way to increase riparian brush rabbit populations is to create and maintain contiguous areas of high-quality riparian habitat, buffered from excessive human disturbance, with sufficient high-water refugia. Given the limited distribution of the subspecies, the greatest benefit to brush rabbits would be to protect, restore, and add riparian habitat in and adjacent to Caswell SP and the San Joaquin River NWR. There are limited opportunities to improve habitat in the South Delta, because the South Delta population occurs almost exclusively on private land. However, preserving and expanding occupied riparian habitat in the South Delta would reduce the threat of impending development in this area, and would allow for habitat restoration. Also, expanding the San Joaquin River NWR could greatly increase riparian habitat and potentially restore connectivity between the Caswell SP and the San Joaquin River NWR populations (USFWS 2012); such plans could have measurable positive effects on riparian brush rabbits soon after implementation.

Identified Conservation Needs

1. **Protect and expand occupied habitat.** Continued protection of existing habitat occupied by known populations of riparian brush rabbits is the highest priority for this subspecies. Also, protection of the genetically distinct population at Caswell SP is important to the preservation of the subspecies. Implementation of the CVFPP and Conservation Strategy could increase and sustain suitable habitat by prioritizing restoration projects near Lathrop, Paradise Cut, Caswell SP, and the San Joaquin River NWR, and by enhancing hydrologic processes that support the long-term viability of these areas. Patchy riparian woodlands with a mix of dense brush, an open or absent tree canopy, and patches of open grass and herbaceous cover are required to support riparian brush rabbits. In renewing riparian areas, it will be important to maintain a patchy structure by leaving open areas in addition to planting shrubs, vines, and trees. Restoration of riverine geomorphic processes would support the establishment and maintenance of a mosaic of riparian habitats.

2. **Increase and restore high-water refugia.** Populations of riparian brush rabbits need habitat in which to take refuge from seasonal floods. The Kelly et al. study (2011) recommended construction of high-ground habitat (on mounds or berms) to provide wildlife with refuge from short- and long-duration flood events. At minimum, shrubs and herbaceous plants that provide both cover and forage, such as coyote brush, California rose, and beardless wild rye (*Leymus triticoides*) should be planted on refugia. Ongoing efforts to build mounds and revegetate retired levees in and near the San Joaquin River NWR will provide useful information on the best placement and vegetation types for these structures.

3. **Establish new populations.** Existing populations of riparian brush rabbits are vulnerable to extirpation by several factors (see “Threats and Sensitivities Range-Wide”). Establishing new populations is therefore critical to the long-term viability of this subspecies. Because the riparian brush rabbit has limited dispersal capabilities, translocation of captive-bred rabbits will be necessary to establish populations in newly restored habitat within the rabbit’s historical range. Williams et al. (2008) successfully established a new population of riparian brush rabbits at the San Joaquin River NWR. Their methods could be used to create additional populations once suitable habitat is

restored. As part of breeding and translocation efforts, genetic studies should be conducted to ensure that these efforts maintain or increase genetic diversity.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the riparian brush rabbit; these are summarized in Table 1 of this section. In many cases, the conservation needs of the riparian brush rabbit can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements to facilities. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/or revetment removal at a site that may depend on levee relocation to allow for bank erosion.

The impacts of CVFPP management actions on riparian brush rabbits are location specific. In short, any actions that remove habitat in or adjacent to Caswell SP, the Stanislaus River between Caswell SP and the San Joaquin River, the San Joaquin River near its confluence with the Stanislaus River, the San Joaquin River near its confluence with the Tuolumne River, the San Joaquin River near Paradise Cut, the San Joaquin River near Lathrop, or in the San Joaquin River NWR, or that increase the frequency, duration, or severity of flooding in those areas, would be highly detrimental to riparian brush rabbits. Wherever feasible, conservation objectives and indicators will inform management actions toward adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on native species and ecosystems.

Operations, Maintenance, and Floodway Management

Facility maintenance: Rodenticides used in facility maintenance would have direct negative effects on riparian brush rabbits if applied in or near areas they occupy. Although riparian brush rabbits are unlikely to occupy levees, they do seek shelter and food on levees during floods, and will consume treated bait meant for ground squirrels (USFWS 1998). Levees near dense riparian areas in and around Caswell SP, the San Joaquin River NWR, Paradise Cut, and occupied habitat in Lathrop and Mossdale are most likely to attract riparian brush rabbits fleeing floodwaters. The California Department of Pesticide Regulation (CDPR) (2002) has published guidelines on the application of rodenticides near riparian brush rabbit habitat. Specifically, a 50-foot clearing is required between the edge of riparian brush and any bait station or broadcast baiting site. Modified bait stations (with an inverted T design) can be placed closer to riparian habitat if the stations are capped at night (CDPR 2002).

Table 1. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Riparian Brush Rabbit[a]

CVFPP Management Actions	Conservation Need		
	1. Protect and Expand Existing Habitat	2. Increase and Restore High-Water Refugia	3. Establish New Populations
Operations, Maintenance, and Floodway Management			
Floodwater storage and reservoir forecasting, operations, and coordination			
Facility maintenance	-	-	
Levee vegetation management	-	-	
Floodway maintenance	+/-	+	
Modification of floodplain topography	+/-	+/-	
Support of floodplain agriculture	-	-	
Invasive plant management	-		
Restoration of riparian, SRA, and marsh habitats	+	+	+
Wildlife-friendly agriculture			
Structural Improvements			
Levee and revetment removal	+	+	
Levee relocation	+	+	
Bypass expansion and construction			
Levee construction and improvement	-		
Flood control structures			

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

Levee vegetation management: Levee vegetation is managed to increase visibility for inspections. This practice typically results in low or no ground cover and removal of brush and low tree branches. Removal of vegetation might cause direct mortality of riparian brush rabbits, and the loss of potential shelter and forage above high-water lines could indirectly harm rabbit populations (e.g., by increasing the vulnerability of rabbits to predation). In the South Delta, occupied habitat is typically narrow and isolated. These conditions exacerbate the risks of vegetation removal to riparian brush rabbits in this area. Maintaining shrubby habitat along the east bank of the San Joaquin River near the Lathrop is critically important to maintaining the current range of riparian brush rabbits.

Some cover for rabbits could be maintained in the VMZ by planting levees with native grasses such as beardless wild rye (Kelly et al. 2011). Cooperation with local levee districts in areas where riparian brush rabbits occur could result in some compromises regarding the management of levee vegetation, particularly outside of VMZs. If vegetation removal is planned where riparian brush rabbits may be affected, it will be important to first establish accessible and suitable replacement plantings. In addition, suitable flood-refuge habitat (e.g., densely vegetated bunny mounds) should be established.

Floodway maintenance: Floodway maintenance actions could be implemented in a way that provides conservation benefits to riparian brush rabbits. Maintenance practices could be changed at selected locations to retain brush and herbaceous forbs. Management practices could also be altered to facilitate the restoration of riparian habitat, or to otherwise yield ecological benefits to riparian brush rabbits. For example, native vegetation could be planted after sediment is removed, and planting berms could be used to provide high-water refugia.

Modification of floodplain topography: Modification of floodplain topography could increase the frequency and duration of flooding. This would increase direct mortality of rabbits and eliminate high-water refugia if it occurs near Caswell SP, occupied South Delta habitat, the San Joaquin River NWR, or other occupied habitat. However, topographic modifications could also promote the establishment and maintenance of riparian vegetation, increasing the amount and connectivity of habitat for riparian brush rabbits. Alternatively, floodplain topography could be modified to create higher-elevation areas that serve as high-water refugia, which could reduce rabbit mortality resulting from floods.

Support of floodplain agriculture: Assuming that no new agricultural areas would be created, support of floodplain agriculture is not expected to have additional negative effects on populations of riparian brush rabbits. However, any action decreasing the amount of natural or ruderal vegetation near the remaining populations of riparian brush rabbits could result in new adverse effects on the subspecies. An increase in agricultural land use near Paradise Cut, Lathrop, Caswell SP, or the San Joaquin River NWR could also increase populations of black rats and feral cats in and near rabbit habitats, thus increasing the risk of predation. Finally, certain rodenticides, other pesticides, and other chemicals used in agriculture, if applied in any amounts near the remaining riparian brush rabbit populations, could harm the subspecies. Agricultural activities farther from occupied habitats would have no impact on the riparian brush rabbit.

Invasive plant management: Treatment of invasive plants, which may include herbicide use, could adversely affect riparian brush rabbits if it occurs in occupied habitat or in adjacent foraging habitat. Habitat may be removed or degraded, the rabbits' reproductive efforts could be disrupted, or the invasive plant treatments could kill or injure rabbits (USFWS 2000).

Restoration of riparian, SRA cover, and marsh habitats: As stated above, creation and restoration of high-quality riparian habitat, buffered from human disturbance and closely associated with high-water refugia, represent the best way to conserve riparian brush rabbit populations. Given the subspecies' limited distribution, the greatest benefit would be realized by restoring and expanding riparian habitat in and adjacent to Paradise Cut, Lathrop, Caswell SP, and the San Joaquin River NWR, and facilitating connectivity among the populations.

Specifically, riparian brush rabbits require large patches of riparian scrub and forest with dense understories, interspersed with open patches of grasses and herbaceous forbs. In addition to planting appropriate vegetation (see "Habitat and Ecological Process Associations"), restoration of riverine geomorphic processes will be an important tool in establishing new and maintaining existing riparian habitat. Enhancement of disjunct habitat patches to achieve patch connectivity would benefit the subspecies by supporting naturally occurring and reintroduced populations of brush rabbits.

Structural Improvements

Levee and revetment removal: Removing revetment would provide an opportunity to improve natural erosional and geomorphic processes in the riverine environment. These processes would facilitate the recruitment of native trees and shrubs, and thus increase or improve suitable habitat for riparian brush rabbits. Removal of revetment and levees around Caswell SP would also reduce the frequency of severe floods that fully inundate the park's riparian habitat. Riparian brush rabbits would benefit most if retired levees or revetments are left in place to provide additional flood refugia. This beneficial result could be achieved by breaching the levee/revetment in several places and establishing vegetation suitable to riparian brush rabbits on the remaining structures.

Levee relocation: Relocating levees farther from rivers (i.e., creating setback levees) is an important approach to increasing space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats, while often still supporting agriculture within expanded floodways. Relocating levees in the areas around Caswell SP and the San Joaquin River NWR could reduce the depth, duration, velocity, or extent of flooding, thus reducing rabbit mortality caused by floods while providing additional riparian habitat. Constructing setback levees could also decrease the need for adding revetment on existing levees, further supporting the development of suitable vegetation adjacent to occupied habitat. Retaining and revegetating old, breached levees could also provide additional flood refugia for riparian brush rabbits.

Levee construction and improvement: If new or higher levees were constructed near Caswell SP or the San Joaquin River NWR, the increase in flood capacity and potential for more severe flooding would have adverse effects on riparian brush rabbit populations because habitat would be flooded more frequently, causing direct mortality of rabbits. It is critical that construction of new levees and levee improvements affecting these areas be avoided to the extent feasible. Where vegetation is planted as part of levee construction or improvement projects, blackberry, California rose, or other dense-canopied shrubs could be included in the planting palette outside of VMZs, and beardless wild rye could be used inside or outside VMZs to provide suitable brush rabbit habitat.

Recovery Plan Alignment

CDFW is currently preparing a statewide recovery plan for riparian brush rabbits. The species is included in the USFWS's 1998 *Recovery Plan for Upland Species of the San Joaquin Valley,* *California.* This document identifies known threats to riparian brush rabbits, but does not include any of the requirements that will be listed in a statewide recovery 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 riparian brush rabbit. Therefore, building on the preceding discussion, this section of the riparian brush rabbit 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. The species-specific measures provide additional detail on geographic location, habitat structure, and other attributes important to conserving 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 conservation of the riparian brush rabbit, requirements would be added to increase suitable riparian habitat acreage adjacent to existing populations, to restore connectivity between populations, allow population expansion, and provide refugia from flooding.

Table 2 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of the riparian brush rabbit, and provides additional specificity as necessary to measure this contribution.

Because management actions intended to benefit riparian brush rabbits may simultaneously affect the conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA's objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 2. Measures of Contribution of CVFPP Actions to Conservation of the Riparian Brush Rabbit

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain and total amount of expected annual inundated floodplain habitat[a]	No	Increasing flooding of riparian brush rabbit habitat without providing high-quality refugia from floodwaters could lead to the extirpation of the subspecies in the South Delta, Caswell SP, and the San Joaquin River NWR.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	
	River Meander Potential—total amount (acres)	No	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Provide habitat that abuts Caswell SP, the San Joaquin River NWR, Paradise Cut, or the Lathrop area, or that is of sufficient size to support a reintroduced population of brush rabbits to the extent feasible. Suitable habitat would include large patches of dense brush, ecotonal edges of dense brush to open patches of grass and forbs, and refugia from flooding.
	Habitat Connectivity—median patch size (acres)	Yes	Restore habitat connectivity among riparian areas in Caswell SP, the San Joaquin River NWR, and the South Delta to the extent feasible.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	No	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	No	
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	No	
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	No	

Key: EAH = expected annual habitat.

Note:

[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 2 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).

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G17. Focused Conservation Plan: Riparian (San Joaquin Valley) Woodrat

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Conservation Status

This conservation plan addresses needs and opportunities for conserving the riparian (San Joaquin Valley) woodrat (*Neotoma fuscipes riparia*) and its habitat in the SPA for the CVFPP.

The riparian woodrat is a medium-sized rodent that was federally listed as endangered under the ESA in 2000 (USFWS 2000). It has also been designated as a Species of Special Concern by CDFW (Williams 1986). Population declines have been attributed to the loss, fragmentation, and degradation of riparian habitat throughout the Central Valley (USFWS 2000). The range of the riparian woodrat is restricted to riparian habitat within Caswell SP in Stanislaus County and to a few sites in the San Joaquin River NWR. Both of these locations are in the Lower San Joaquin River CPA.

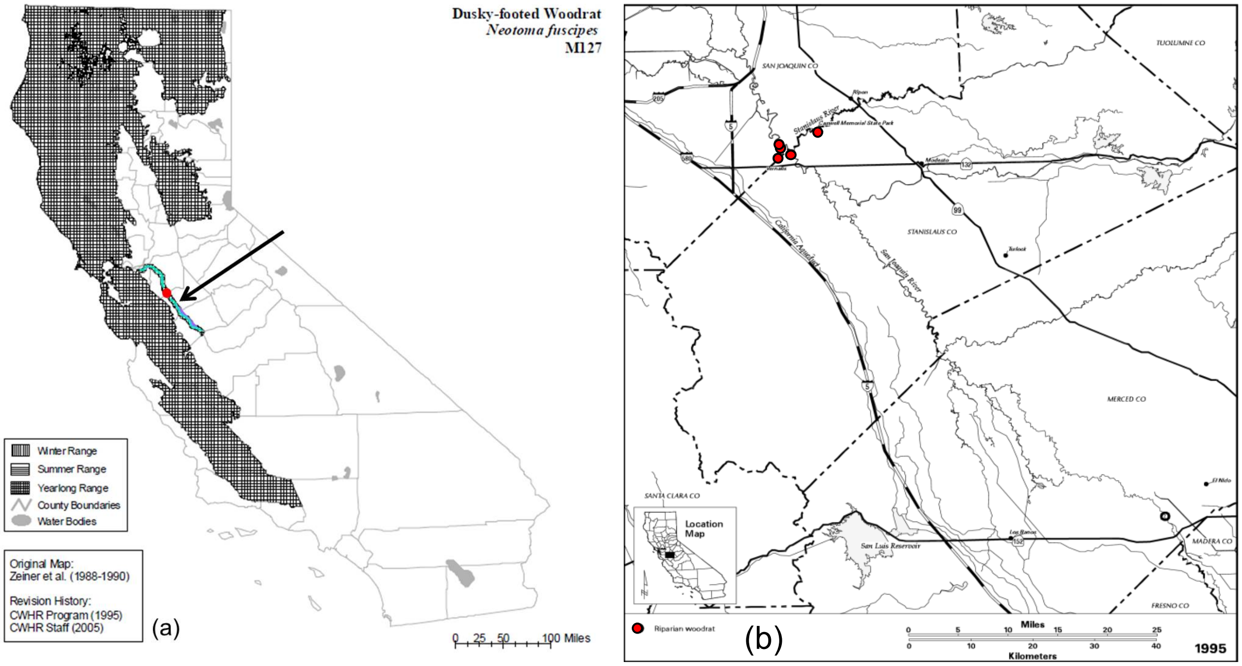
Since the time of listing, a genetic research study has been implemented to clarify the species' classification; these results will be included in the next USFWS 5-year review. In 2002, *N. fuscipes* was split into two species: the dusky-footed woodrat (*N. fuscipes*) and the big-eared woodrat (*N. macrotis*) (Matocq 2002). Matocq et al.'s (2012) data indicate that riparian woodrats are more closely allied with *N. fuscipes* than with *N. macrotis*. Genetic analysis, however, has revealed that the Caswell SP and San Joaquin River NWR woodrats are genetically distinct from other dusky-footed woodrat populations, likely because of recent isolation and repeated population reductions (Matocq et al. 2012).

Status and Trends

Distribution

The dusky-footed woodrat ranges from northwestern Oregon south through northern and central California (Figure 1). The species' range was once thought to extend south to northern Baja California, Mexico; however, recent genetic research indicates that animals in the southern part of the range constitute a separate species, the big-eared woodrat (Matocq 2002).

The riparian woodrat is endemic to the San Joaquin Valley of California. The true extent of its historical range is difficult to determine, because much of its riparian habitat had already been destroyed by the time Hooper (1938) described the subspecies (Williams 1986). Hooper's specimens were collected in Stanislaus County, but he speculated that riparian woodrats occupied river bottomlands north through Contra Costa County and as far south as southern Merced County. Indeed, riparian woodrats were likely abundant throughout the extensive riparian forests of the San Joaquin Valley (Williams 1986; Matocq et al. 2012).



Sources: (a) CDFW 2013; (b) USFWS 1998.

Note: The red dots denote the area currently occupied by the riparian woodrat, and its historical range is thought to include the blue lozenge indicated by the arrow on map (a).

Figure 1. Current Distribution of the Dusky-Footed Woodrat and Capture Locations for the Riparian Woodrat

The current distribution of riparian woodrats is largely restricted to Caswell SP, located along the Stanislaus River (Figure 1). In 1993, this population was estimated to comprise 437 individuals occupying the 225 acres of suitable habitat in Caswell SP (Williams 1993). In 2003, riparian woodrats were discovered in the San Joaquin River NWR, located 5 miles south of Caswell SP (USFWS 2011). Between 2003 and 2011, 34 riparian woodrats were captured during trapping for riparian brush rabbits (*Sylvilagus bachmani riparius*) in the San Joaquin River NWR (USFWS 2012a).

Population Trends

Only two studies have estimated population size for riparian woodrats. Cook (1992) estimated that 637 animals occupied 252 acres of suitable habitat at Caswell SP. The following year, Williams resurveyed the area and estimated that 437 animals occupied 225 acres of suitable habitat. These two estimates did not significantly differ (Williams 1993). Subsequent trapping efforts were not intended to estimate population size (USFWS 2012a). A small number of riparian woodrats have since been captured in the San Joaquin River NWR (USFWS 2011; Matocq et al. 2012). Lower trapping success suggests that fewer animals occupy the San Joaquin River NWR compared to Caswell SP, although no systematic population study has been conducted (USFWS 2011, 2012a). Flooding events in 1997 and 2006 likely reduced woodrat numbers in both Caswell SP and the San Joaquin River NWR—fewer woodrats were captured after flooding (USFWS 2011; Matocq et al. 2012). The long-term impacts of these events remain unknown because no systematic population surveys of the riparian woodrat have been conducted since Williams's 1993 study.

Life History

Information regarding the life history of the riparian woodrat is limited; however, as previously mentioned, the riparian woodrat is a subspecies of the dusky-footed woodrat, which has been studied extensively. The following text draws on both sources of information. When referring to general information about *N. fuscipes,* the term "dusky-footed woodrat" or "woodrat" is used. When information specific to riparian woodrats is known, the term "riparian woodrat" is used. Life history information specific to the riparian subspecies is relatively scarce.

Houses/Lodges: Dusky-footed woodrats typically build mounded stick and leaf houses, also called lodges, that range in size from 3 to 8 feet across at the base and as high as 8 feet tall (English 1923). They tend to live in colonies of three to fifteen or more houses (Kelly 1990). Woodrat houses that are built at ground level usually have many openings. Paths from these ground-level openings frequently connect with adjacent houses, and passageways sometimes penetrate the soil, especially if the house is built on a slope (Gander 1928). Woodrats typically remain in the vicinity of their houses and use such paths when being pursued by predators (Parks 1922; Gander 1928). Competition for houses is constant and intense (Linsdale and Tevis 1951), and the availability of houses or nest-building materials may limit population densities. When radio-collared animals died, Innes et al. (2009) found that their houses were occupied by other woodrats within a few days.

Dusky-footed woodrats can also build aerial nests in many species of trees (Carraway and Verts 1991; Johnston and Cezniak 2004; Innes et al. 2008) and in logs, anthropogenic structures (Johnston 2009), and cavities (H. T. Harvey & Associates 2008). In some areas, as many as 61 percent of *N. fuscipes* nests were constructed in cavities, rock crevices, or ground holes with few or no sticks (Fargo and Laudenslayer 1999). These nests are typically more cryptic and harder to locate than traditional woodrat stick lodges (Fargo and Laudenslayer 1999).

Among riparian woodrats, terrestrial houses appear to be less common than among most other dusky-footed woodrat subspecies. Terrestrial houses are relatively rare at Caswell SP, and none has been found in the San Joaquin River NWR despite intensive searches (Kelly et al. 2009; USFWS 2011). Riparian woodrats are known to build nests on or in a variety of alternative substrates, including trees, rocks, tree cavities, and anthropogenic structures (USFWS 2011).

Movements and territories: The dusky-footed woodrat is mostly nocturnal, and although its activity may decline on moonlit or rainy nights, it is active year-round (Brylski et al. 2008). Dusky-footed woodrats do not hibernate, migrate, or exhibit any other seasonal movement. Their home ranges are approximately 0.5 acres, but depend on the gender of the woodrat. Cranford (1977) reported that females' home ranges averaged about 0.48 acres and males' averaged 0.57 acres. The home ranges of males, which are larger than those of females, can overlap three or four female home ranges (Kelly 1990; Innes et al. 2009). Lynch et al. (1994) reported average home ranges of 0.88 acres (n=4) for females and 1.10 acres for a male during a radio-telemetry study conducted in oak woodlands bounded by an intermittent stream. There was considerable overlap in the home ranges, with a core area of 0.19 acres that included portions of the home ranges of all five collared individuals. Innes et al. (2009) found that, although foraging areas are often shared among both same-sex and opposite-sex neighboring woodrats, the core areas immediately surrounding woodrat houses did not typically overlap those of same-sex neighbors. No study of riparian woodrat movements or home ranges has been published.

Nesting and breeding: The riparian woodrat typically breeds between February and April, but can reproduce at any time of year when conditions are favorable (USFWS 2011). Female dusky-footed woodrats produce one litter per year (Vestal 1938). Wood (1935) reported that gestation lasts about 1 month, and litter size ranges from one to four offspring. Kelly (1990) reported that, during a 3-year period, the percentage of dusky-footed woodrat females in reproductive condition in December was correlated with the abundance of acorns from coast live oaks (*Quercus agrifolia*) and valley oaks (*Q. lobata*). Whether riparian woodrats respond to acorn mast or food resources in a similar manner is not known; however, it is likely that acorns are important to the riparian subspecies, given the consistent findings that acorns make up a key part of the diet of other subspecies of *N. fuscipes*.

There has been considerable research effort to understand the breeding systems of dusky-footed woodrats. In a northern Sierra Nevada population, Innes et al. (2009) found that females typically shared their core area and houses with one male, but males shared their home ranges with many females. Innes et al. (2009), therefore, suggested that this species is polygynous (i.e., that each male mates with more than one female). This suggestion is supported by the fact that dusky-footed woodrats are known to maintain near-exclusive use of their houses and the immediately adjacent areas against same-sex conspecifics (Carraway and Verts 1991). However, McEachern (2005) noted evidence of both monogamous and promiscuous breeding. Subsequent genetic studies of both dusky-footed and big-eared woodrats demonstrated multiple parentages within a litter, indicating that the polygyny was flexible and the breeding system was more accurately termed promiscuous (Matocq 2004; McEachern et al. 2009). The mating system of the riparian woodrat has not been studied, but is likely similar to that of its closest relatives.

Social behavior: Similarly, there have been efforts to understand the social relations of dusky-footed woodrats within houses and within groups of houses. Each house is typically occupied by a single adult, although Lynch et al. (1994) noted females and subadults occupying the same house on occasion. McEachern et al. (2007) studied dusky-footed woodrats in two populations in northern California, and found that woodrat populations were organized into neighborhoods of closely related females. These studies suggest a social structure in which female offspring stay relatively close to their mothers, and males disperse longer distances. The social behavior of riparian woodrats has not been studied, nor has the social behavior of woodrats using alternative nesting structures.

Cunningham (2005) examined dispersal and house inheritance in dusky-footed woodrats, both in the field and in the laboratory. This study showed that female adults, after weaning their young, bequeath the natal house to the young and settle nearby. Cunningham (2005) stated that such bequeathal behavior was particularly common in dense populations. Moreover, if the adult female's house was subsequently destroyed (experimentally), the female was welcomed back into the natal house by her offspring. Conversely, if the natal house containing the offspring was destroyed, the mother prevented the young from joining her in her new house. Cunningham's thesis includes theoretical discussions of parental investment, parent/offspring conflict, and dispersal mechanisms. She noted that territorial divisions among family members after dispersal were flexible and only mildly aggressive. Also, when houses were experimentally dismantled, in most cases the woodrats readily rebuilt them. However, in one case, an individual prevented the reconstruction of its sibling's house by continually removing sticks. No information on riparian woodrat dispersal or house inheritance is available.

Foraging and food resources: Whereas the foraging habits of riparian woodrats have not been described, the foraging habits of other subspecies of *N. fuscipes* occurring within 100 miles of occupied riparian woodrat habitat have been studied extensively. These studies are useful to indicate the likely foraging habits of the riparian woodrat. Dusky-footed woodrats forage on the ground, in bushes, and in trees (Innes et al. 2007; Brylski et al. 2008). They feed mainly on the fruits, acorns, and leaves of woody plants, especially valley oak, maple (*Acer macrophyllum*), coffeeberry (*Rhamnus california)*, white alder (*Alnus rhombifolia*), and elderberry (*Sambucussp.*) when available (Linsdale and Tevis 1951). Parts of other woody plants, including sometimes the cambium layer, are also eaten. English (1923) listed 37 plant and fungus species eaten by the dusky-footed woodrat; forms ingested include fungi, flowers, grasses, fern fronds, and acorns. Poison oak (*Toxicodendron diversilobum*) is also commonly eaten and used in dusky-footed woodrat nests (Johnston and Cezniak 2004).

Dusky-footed woodrats drink water, but they may be able to satisfy water requirements by consuming leafy vegetation and fungi (Brylski et al. 2008). They consumed 1.48 fluid ounces of water per day in the laboratory when maintained at 68–73.4ºF and 50–80 percent relative humidity (Carraway and Verts 1991). Carpenter (1966, as cited in Carraway and Verts 1991) reported that the minimum daily requirement for water was 10.2 percent of body mass at 50–80 percent humidity. When deprived of water, woodrats cannot maintain body mass and will die within 4–16 days (Carraway and Verts 1991). The urine-concentrating abilities of these animals are correlated with the variable amounts of water present in plants throughout the year (Stallone 1979).

Habitat and Ecological Process Associations

Population density in dusky-footed woodrats varies temporally and by region. Estimates for the riparian subspecies range from 1.8 to 2.5 woodrats per acre (Cook 1992; Williams 1993). Macrohabitat characteristics are important for dusky-footed woodrats, and woodrat abundance is correlated with vegetation density (Forsman et al. 1984, 1991; Carey et al. 1999; Sakai and Noon 1993, as cited in Innes et al. 2009). Kelly (1990) found that dusky-footed woodrat densities on the Hastings Natural History Reservation (Monterey County), varied with habitat and resources, with the highest densities of woodrats found in riparian and oak woodland habitats. Innes et al. (2007) found that dusky-footed woodrat density was correlated with the density of large oaks, likely because large oaks provide food resources. Additionally, the location of woodrat houses was correlated with large stumps, steep slopes, and a lack of bare ground (Innes et al. 2007).

No studies have been conducted on the habitat associations or requirements of the riparian woodrat. However, at Caswell SP, they occur in areas with a valley oak–dominated overstory and dense shrub understory composed of California blackberry (*Rubus ursinus*), willow (*Salix* sp.), California rose (*Rosa californica*), golden currant (*Ribes aureum*) or other shrub species (USFWS 2011). Riparian woodrats were absent from open areas and open-canopy woodlands that lacked a significant understory (Williams 1993). Dusky-footed woodrats also require shade canopy for their nests. Woodrats abandoned their nests in oak woodland habitat near Menlo Park when coast live oak tree canopies were trimmed to the point that woodrat nests were exposed to full sunlight for several hours in the day (Johnston pers. obs.).

USFWS (2011) identified several important components of riparian woodrat habitat:

- A tree canopy, preferably composed of valley oaks, but alternatively of cottonwoods (*Populus fremontii*), sycamores (*Platanus racemosa*), willows, or other large trees
- Large patches of dense understory brush connected to the canopy by a midstory of vines or native shrubs or trees
- A complex, three-dimensional habitat structure for nesting and nest building
- High-water refugia planted with dense riparian brush to provide both forage and shelter for woodrats

In central California, acorn mast may be largely responsible for local fluctuations in dusky-footed woodrat population densities (Kelly 1990). Woodrats cache acorns and, in some areas, a low-mast year for one species of oak may be compensated for by acorns from other oaks, providing woodrats with a more stable food supply. However, only one oak species (valley oak) occurs at Caswell SP and in the San Joaquin River NWR, so riparian woodrats could be more vulnerable to starvation in low-mast years if alternative food supplies (listed above under "Foraging and food resources") are not available.

Although less frequently occupied, areas that provide refuge from floodwaters are critically important to riparian woodrats. The woodrats' historical habitat occurred on wide floodplains with an undulating topography that provided refuge from shallow, slow-moving floodwaters. Construction of levees near Caswell SP and the San Joaquin River NWR has significantly narrowed the floodplain, resulting in deeper and faster floodflows. Expansion of agriculture adjacent to the parks has removed the brush and undulating topography that once provided high-water refugia during flood events. Caswell SP and the San Joaquin River NWR are located within the active floodplain and are vulnerable to complete inundation approximately every 5 years (USFWS 2012a). High-water refugia are now primarily limited to tall trees and levees within Caswell SP and the San Joaquin River NWR. Restoration efforts within the San Joaquin River NWR have increased the availability of high-water refugia, both through revegetation of retired levees and construction of vegetated mounds (Lloyd et al. 2011). It is not known whether these structures are used by woodrats. Restoration of a wider floodplain and natural topography near Caswell SP and the San Joaquin River NWR would reduce risks to woodrats associated with flooding. However, it is important that such efforts avoid destruction of existing riparian habitat in these areas.

Woodrats preferentially build their houses in areas that are comparatively higher in humidity (Linsdale 1957) and shaded by overstory vegetation (Johnston and Cezniak 2004). The inside temperatures of the houses are less variable than ambient temperatures and provide relief from extremes of both heat and cold (Thies et al. 1996). Each house contains three or four sleeping nests that are constructed of shredded grass, leaves, and other miscellaneous materials (Gander 1928). California bay (*Umbellularia californica*) foliage has been found in sleeping nests, where it may repel nest-borne ectoparasites (Hemmes et al. 2002). In most houses, sleeping nests are located in an outer part of the house without an external opening (Gander 1928). Woodrats also store food in their houses in large central chambers (also referred to as large rooms). Some plant foods likely detoxify as they dry inside the woodrat houses (Atsatt and Ingram 1983). The central food storage chambers are connected by passageways to external openings in the mound (Carraway and Verts 1991).

Many birds, mammals, and snakes prey on dusky-footed woodrats. Predators of the riparian woodrat include feral cats (*Felis catus*), feral dogs (*Canis familiaris*), long-tailed weasels (*Mustela frenata*), coyotes (*Canis latrans*), gray foxes (*Urocyon cinereoargenteus*), bobcats (*Lynx rufus*), minks (*Neovison vison*), raccoons (*Procyon lotor*), and various raptors and snakes (USFWS 2011). Black rats (*Rattus rattus*) may also compete with woodrats for resources, or prey on woodrat young. Research by Kelly et al. (2009) suggests that the presence of black rats reduces reproductive success in riparian woodrats. The study found that, in areas of high black rat densities, riparian woodrat reproductive success was lower than in areas where black rats had been systematically removed.

Whitford and Steinberger (2010) considered dusky-footed woodrats an engineer keystone species because similar habitats without woodrats had lower biodiversity indices than areas with woodrats and their houses. When woodrat houses were removed in a central California study, the density of *Peromyscus truei* was reduced slightly, and the population of *P. californicus* declined by 50 percent for 2 years (Cranford 1982). As woodrats repopulated the area and rebuilt nests, the population densities of *P. truei* and *P. californicus* also increased (Cranford 1982). It is not clear whether woodrats that use alternative nesting structures play the same key role within their ecosystem.

The nests of dusky-footed woodrats provide food and habitat for many commensal invertebrate and vertebrate species. Carraway and Verts (1991) listed commensal vertebrates that use dusky-footed woodrat nests (Table 1).

Table 1. Animals Commensal with Dusky-Footed Woodrat

Mammals[a]	Amphibians and Reptiles[a]	Insects and Other Arthropods[b]
Ornate shrew (*Sorex ornatus*)	Western fence lizard (*Sceloporus occidentalis*)	Ashley and Bohnsack (1974, as cited in Carraway and Verts 1991) collected 109,558 arthropods, representing 100 species, from 72 dusky-footed woodrat nests.
Desert shrew (*Notiosorex crawfordi*)	Southern alligator lizard (*Elgaria multicarinata*)	
Brush rabbit (*Sylvilagus bachmani*)	Northern alligator lizard (*E. coerulea*)	
California mouse (*Peromyscus californicus*)	Northwestern garter snake (*Thamnophis ordinoides*)	
Cactus mouse (*P. eremicus*)	Racer (*Coluber constrictor*)	
White-footed mouse (*P. maniculatus*)	Striped racer (*Masticophis lateralis*)	
Piñon mouse (*P. truei*)	Gopher snake (*Pituophis catenifer*)	
Western harvest mouse (*Reithrodontomys megalotis*)	Ensatina (*Ensatina eschscholtzii*)	
	Slender salamander (*Batrachoseps attenuatus*)	
	California newt (*Taricha torosa*)	

Notes:
[a] Carraway and Verts (1991) detailed the mammals, amphibians, and reptiles commensal with dusky-footed woodrats.
[b] The Ashley and Bohnsack (1974) study is cited in Carraway and Verts (1991) as the authoritative work on insects and arthropods commensal with San Francisco dusky-footed woodrats.

Conceptual Models

A conceptual model has been designed to assist in developing a targeted conservation strategy for riparian woodrats within the SPA (Figure 2). It is not intended to be a comprehensive model of all ecological processes, stressors, and other factors that could be relevant for this species; rather, it specifically depicts:

- habitat conditions required by riparian woodrats within the SPA;
- the specific CPAs within which riparian woodrats occur;
- key ecosystem processes of riverine systems within the SPA, and thus potentially affected by actions that could be implemented as part of the CVFPP and Conservation Strategy; and
- stressors related to SPFC facilities and their operation and maintenance.

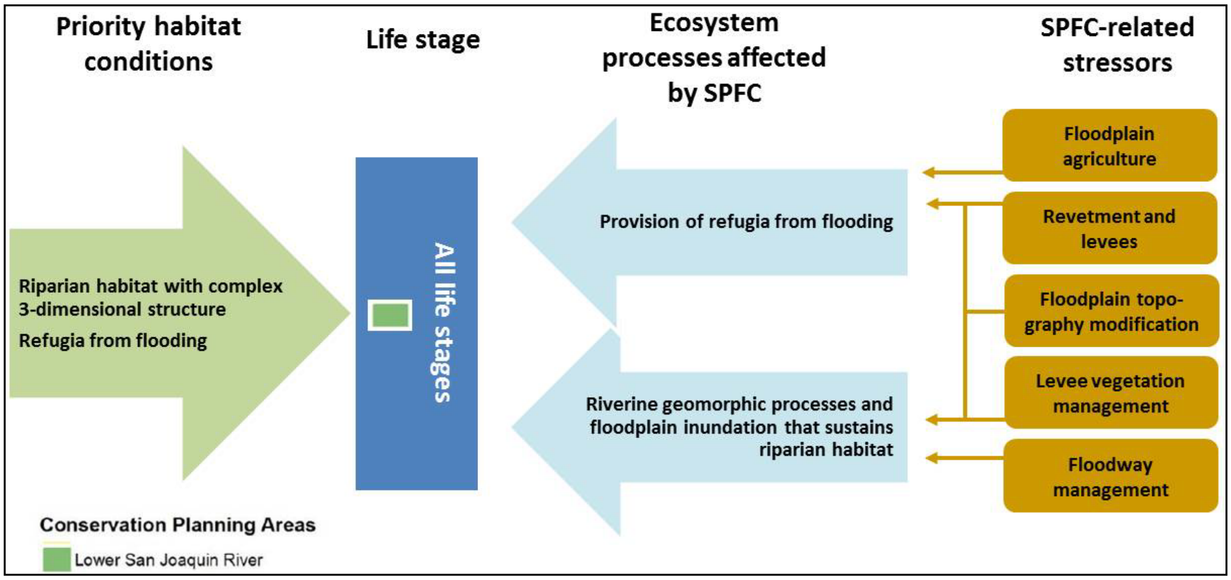


Figure 2. Conceptual Model for Riparian Woodrat within the SPA

Management Issues

Threats and Sensitivities Range-Wide

The population size of riparian woodrats is small primarily because of the extensive loss, degradation, and fragmentation of riparian habitat that has occurred throughout the subspecies' historical range (USFWS 2000). The small size and isolation of riparian woodrats leave them increasingly vulnerable to genetic risks, demographic stochasticity, and environmental stochasticity.

Riparian woodrats remain extremely vulnerable to natural disturbances. Wildfires can result in direct mortality and habitat loss. In 2004, a wildfire destroyed important habitat occupied by riparian woodrats in the San Joaquin River NWR (USFWS 2011, 2012a). The effects of the fire on the woodrat population were not assessed. Flooding is also a major threat to riparian woodrats. Major flooding occurred along the San Joaquin and Stanislaus Rivers in 1997 and 2006, and is suspected to have reduced riparian woodrat numbers. Although riparian woodrats are highly arboreal and can climb into the canopy, little refuge from rising water is available to them, because agricultural fields abut the riparian corridors in both locations. Trapping efforts at Caswell SP following the 1997 flood resulted in only eight captures, compared to 57 captures from a comparable trapping effort in 1993 (Matocq et al. 2012). Likewise, USFWS (2011) reported a sharp decline in successful trapping of riparian woodrats after flooding in the San Joaquin River NWR. USFWS captured only three riparian woodrats in the 5 years following the 2006 flood. Wildfires and floods can also destroy woodrat houses. Loss of houses can negatively affect population viability, because the houses are essential for survival and are often passed down to subsequent generations (Cunningham 2005).

Exotic species may also adversely affect riparian woodrats, by competing with them for resources or by preying on adult woodrats and their young. Black rats and feral cats have been documented at Caswell SP and in the San Joaquin River NWR. Predation of dusky-footed woodrats by feral cats has been documented in other habitats (Hubbs 1951; Kelly 1990), so it is likely that cats prey on riparian woodrats where they co-occur.

Ongoing and Future Impacts

Ongoing impacts on riparian woodrats in the SPA include urban and agricultural expansion, lack of high-water refugia during flood events, and climate change.

- Although increased urban and agricultural development is not expected to directly reduce riparian woodrat habitat (because all the animals reside on protected state and federal lands), development near Caswell SP and the San Joaquin River NWR may increase threats to riparian woodrats from invasive exotics and predators, in particular black rats and feral cats. Also, increased development could further limit riparian woodrat access to nearby high-water refugia, prevent habitat connectivity, and prevent recolonization of the historical range. Finally, increased development would result in increased use of chemicals, including rodenticides that could cause direct mortality, illness, or reduced reproductive success in nearby riparian woodrat populations.

- Flooding remains a major threat to riparian woodrats. The levees near Caswell SP have isolated most of the Stanislaus River's natural floodplain from the river, and as a result, the floodplain that remains connected to the river (the active floodplain) now conveys deeper and faster floodflows. The park is located within the remaining active floodplain and is now vulnerable to complete inundation by high-velocity flows during major storms or larger flow releases from New Melones Dam (USFWS 2000). High-water refugia in surrounding lands have also been largely eliminated by agricultural expansion.

- Climate change will affect habitat throughout the SPA, although its influence on riparian woodrats is uncertain. Despite this uncertainty, riparian woodrats are vulnerable to environmental change of any kind because of their small population size, isolation, low genetic diversity, and inability to disperse to new habitats. Although total annual precipitation is not predicted to change substantially, less precipitation is expected to fall as snow in the Sierra Nevada. This change is expected to reduce the availability of water from snowmelt during spring and summer months (Cayan et al. 2006). Increased diversion of water from riparian streams to irrigated crops could alter vegetation structure along riparian corridors, which would reduce habitat for riparian woodrats. In addition, climate change is expected to increase the occurrence and severity of flooding (Miller et al. 2003; Fissekis 2008; Dettinger et al. 2009). The risks of flooding to riparian woodrats are detailed above (under "Threats and Sensitivities Range-Wide"). Finally, wildfires are expected to become more frequent in California (Cayan et al. 2006). Along the Stanislaus River, fire hazards would be exacerbated by increased water diversion, accumulations of brush, and diversion-induced drought. Frequent wildfires pose the risk of substantial habitat loss for riparian woodrats.

Key Information Gaps or Uncertainties

To better understand riparian woodrat ecology, the following information is needed: basic life history information specific to the riparian woodrat, a more thorough quantification of population sizes and trends in Caswell SP and the San Joaquin River NWR, insight into the habitat requirements specific to this subspecies, and a greater understanding of the community ecology and taxonomy of riparian woodrats. These data gaps are discussed below.

- **Life history.** Basic information on this subspecies is sorely lacking. To date, there has been no examination of the riparian woodrat's diet, house use and construction, reproduction, or demography, to identify a few topics in need of study. Such information is needed to determine population viability and the potential response of riparian woodrats to management activities.

- **Population status**. Only two studies have quantified riparian woodrat population size, and both have focused on woodrats occurring in Caswell SP. Although the literature suggests that the subspecies has declined in response to specific natural disturbances, the status and viability of the riparian woodrat is currently unknown. California State University students have occasionally observed riparian woodrats on private land along the San Joaquin and Tuolumne Rivers (Williams 1986). A systematic survey for riparian woodrats in both Caswell SP and the San Joaquin River NWR, as well as on private lands nearby, is greatly needed.

- **Habitat requirements.** Little information is available on the habitat requirements of the riparian woodrat. For instance, terrestrial houses are less common among riparian woodrats than among other woodrat subspecies (Kelly et al. 2009), but little is known about their preferences for and use of alternative structures for denning and nesting. The importance of a complex riparian woodland with a midstory connecting the canopy and understory is well established; however, how space is used within this habitat is largely unknown.

- **Community ecology.** Research by Kelly et al. (2009) suggested that black rats adversely affect riparian woodrat reproductive success. No other studies have been conducted on the interactions of riparian woodrats with other organisms in the riparian community. A greater understanding of predators, competitors, and commensals would help target management efforts to conserve riparian woodrats.

- **Taxonomy.** The taxonomy of the riparian woodrat is not fully understood. Additional genetic studies are warranted to definitively determine the species affinity of the riparian woodrat.

Conservation Strategy

Conservation and Recovery Opportunities

The most viable way to increase riparian woodrat populations is to create and maintain contiguous areas of high-quality riparian habitat, buffered from excessive human disturbance and closely associated with high-water refugia. Given the limited distribution of the subspecies, the greatest benefit to woodrats would be realized by restoring and adding riparian habitat in and adjacent to Caswell SP and the San Joaquin River NWR. Ongoing riparian restoration activities in the San Joaquin River NWR are expected to create habitat for the riparian woodrat. Plans to expand the refuge could greatly increase habitat and potentially restore connectivity between the Caswell SP and San Joaquin River NWR (USFWS 2012b); however, such plans are in preliminary stages, and it is doubtful that they will have measurable effects on riparian woodrats in the near future because it will take several years for these plans to be implemented and for habitat and connectivity to increase. Therefore, opportunities exist to continue and expand current restoration and land acquisition efforts in areas occupied by riparian woodrats. Improving ecosystem function and restoring natural riverine geomorphology by implementing appropriate management actions would also create the disturbance regimes necessary to establish and maintain suitable habitat.

Identified Conservation Needs

1. **Protect and expand occupied habitat:** Continued protection of existing habitat occupied by riparian woodrats is the highest priority for this subspecies. Implementation of the CVFPP and the Conservation Strategy could increase and sustain suitable habitat by prioritizing restoration projects near Caswell SP and the San Joaquin River NWR, and by enhancing hydrologic processes that support the long-term viability of these areas. Riparian woodlands with a complex canopy, midstory, and understory are required to support riparian woodrats. In renewing riparian areas, it will be important to maintain complex structure by planting native shrubs and vines in addition to trees. Plant species important to riparian woodrats are listed above, under “Habitat and Ecological Process Associations.” Where warranted, buffer habitat should be established to protect desirable habitat from disturbance. Because information on riparian woodrat habitat use is limited, additional research should be conducted to inform restoration efforts. Without more studies on habitat use, it is difficult to evaluate some of the species’ conservation needs.

2. **Increase and restore high-water refugia:** Riparian woodrats require habitat in which to take refuge from seasonal flooding. USFWS (2011) recommended construction of high-ground habitat (on mounds or berms) to provide woodrats with refuge from short- and long-duration flood events.

Integration of Conservation and Restoration in Flood Management

CVFPP management actions have the potential to provide a positive, negative, or neutral contribution to the identified conservation needs of the riparian woodrat; these contributions are summarized in Table 2 at the end of this section. In many cases, the conservation needs of the riparian woodrat can be positively addressed by implementing management actions that integrate conservation/restoration elements with SPFC operation and maintenance, floodway management, and structural improvements. In some instances, implementation of these actions would be dependent on operations, maintenance, and floodway management actions and structural improvements (as described in the following section) to resolve constraints such as the floodway's existing capacity for conveying floodflows and/or revetment removal at a site that may depend on levee relocation to allow for bank erosion. However, the impacts of CVFPP management actions on riparian woodrats are highly location specific. Any actions that remove habitat in or adjacent to Caswell SP or the San Joaquin River NWR or that increase the frequency, duration, or severity of flooding in those areas would be highly detrimental to riparian woodrats. Wherever feasible, conservation objectives and indicators will inform management actions toward adaptive, responsive, and sustainable implementation that avoids and minimizes impacts on species and ecosystems.

Operations, Maintenance, and Floodway Management

Facility maintenance: Rodenticides used in facility maintenance would have direct negative effects on riparian woodrats if applied in or near areas they occupy. Although riparian woodrats are unlikely to occupy levees, they may seek shelter and food on levees during flood events. Levees near dense riparian areas in and around Caswell SP and the San Joaquin River NWR are most likely to attract riparian woodrats fleeing floodwaters. The California Department of Pesticide Regulation (2002) has published guidelines on the application of rodenticides near riparian woodrat habitat. These guidelines should be distributed to facility managers and maintenance crews and strictly enforced. Use of rodenticides on levees where riparian woodrats may seek shelter from flooding should be prohibited.

Levee vegetation management: Removal of vegetation from levees could indirectly harm riparian woodrats if plants providing forage or high-water refugia are removed in areas close to woodrat populations. In addition, the removal of overstory canopy vegetation could cause direct loss of riparian woodrats. If vegetation is removed where woodrats may be affected, it will be important to establish replacement plantings nearby, above flood levels, that will mature into trees and shrubs that provide suitable shade canopy and refuge habitat for riparian woodrats. Brush-covered mounds built in the San Joaquin River NWR have been successfully used by riparian brush rabbits seeking shelter during 2011 flooding (Lloyd et al. 2011), and it is expected that woodrats would also benefit from this type of refugia.

Table 2. Summary of CVFPP Management Actions That Contribute to Identified Conservation Needs of the Riparian Woodrat[a]

CVFPP Management Actions	Conservation Need	
	1. Protect and Expand Existing Habitat	2. Increase and Restore High-Water Refugia
Operations, Maintenance, and Floodway Management		
Floodwater storage and reservoir forecasting, operations, and coordination		
Facility maintenance	-	-
Levee vegetation management		-
Floodway maintenance	+/-	+/-
Modification of floodplain topography	+/-	+/-
Support of floodplain agriculture	-	-
Invasive plant management		
Restoration of riparian, SRA, and marsh habitats	+	+
Wildlife-friendly agriculture		
Structural Improvements		
Levee and revetment removal	+	
Levee relocation	+	
Bypass expansion and construction		
Levee construction and improvement	-	-
Flood control structures		

Note:
[a] CVFPP management actions are designated as having the potential to provide a positive (+), negative (–), or neutral (blank) contribution to the identified conservation needs of the species.

Floodway maintenance: Floodway maintenance actions could be implemented in a way that provides conservation benefits to riparian woodrats. Riparian woodrats would benefit from maintenance that allows for riparian forest midstory and canopy vegetation at selected locations, and retains occupied woodrat houses. Management practices could also be altered to facilitate the restoration of riparian habitat, or to otherwise yield ecological benefits to riparian woodrats. For example, native vegetation could be planted after sediment is removed, and planting berms could be used to provide high-water refugia. However, floodway maintenance actions will either not benefit or have negative effects on riparian woodrats if vegetation is removed without retaining appropriate riparian woodrat habitat features.

Modification of floodplain topography: Modification of floodplain topography could increase the frequency, depth, and duration of flooding. This would increase direct mortality of riparian woodrats, destroy woodrat houses, and eliminate high-water refugia if it occurs near Caswell SP or the San Joaquin River NWR. However, topographic modifications could promote the establishment and maintenance of riparian vegetation, increasing the amount and connectivity of habitat for riparian woodrats. Alternatively, floodplain topography could be modified to create higher-elevation areas that serve as high-water refugia, which could reduce the mortality and destruction of houses resulting from floods.

Support of floodplain agriculture: Assuming that no new agricultural areas would be created, support of floodplain agriculture is not expected to have a negative effect on riparian woodrats. However, any action decreasing the amount of natural or ruderal vegetation near Caswell SP or the San Joaquin River NWR could adversely affect the riparian woodrat. An increase in agricultural land use near Caswell SP or the San Joaquin River NWR could also increase populations of black rats and feral cats in and near woodrat habitats. Finally, rodenticides, pesticides, and other chemicals used in agriculture, if applied in greater amounts near occupied riparian woodrat habitat, could harm these woodrats. However, agricultural activities farther from Caswell SP and the San Joaquin River NWR would have no impact on riparian woodrats.

Restoration of riparian, SRA cover, and marsh habitats: As stated above, creation and restoration of high-quality riparian habitat, buffered from human disturbance and closely associated with high-water refugia, represent the best way to conserve the riparian woodrat. Given the subspecies' limited distribution, the greatest benefit would be realized by restoring and expanding riparian habitat in and adjacent to Caswell SP and the San Joaquin River NWR, and facilitating connectivity between the two occupied habitats. Restoration near these two areas could include additional structure for nesting habitat (e.g., oak logs), plants providing dense cover (e.g., poison oak and California blackberry), and plants that offer food and canopy cover (e.g., valley oak). It will be important to protect riparian woodrat nests during restoration activities.

Since becoming a California Species of Special Concern, mitigation success for the dusky-footed woodrat has been mixed (Johnston 2009). Because woodrats are territorial and resource-limited (Carraway and Verts 1991), mitigation practices without a strong habitat restoration component typically fail (Johnston 2009). H. T. Harvey & Associates (2013) provides an example of a successful riparian restoration project that restored a population of the San Francisco dusky-footed woodrat.

Structural Improvements

Levee and revetment removal: Removing revetment would provide an opportunity to improve natural erosional and geomorphic processes in the riverine environment. These processes would encourage the recruitment of native trees and shrubs and increase or improve suitable habitat for riparian woodrats. Also, removal of levees around Caswell SP could reduce the frequency with which the area is fully inundated. In lieu of complete levee removal, riparian woodrats would benefit if levees were breached in several places and the remnants of the levee were planted with suitable habitat for riparian woodrats. This technique has been used successfully for riparian brush rabbits in the San Joaquin River NWR (Lloyd et al. 2011).

Levee relocation: Relocating levees farther from rivers (i.e., constructing setback levees) is an important approach to creating space for river meanders, reconnecting floodplains, allowing transport and deposition of sediment, supporting natural ecosystem disturbance processes, and increasing the diversity of riverine and floodplain habitats while often still supporting agriculture within expanded floodways. Relocating levees in the areas around Caswell SP and the San Joaquin River NWR could reduce the severity of flooding, thus reducing woodrat mortality caused by seasonal floods. Constructing setback levees could also decrease the need for adding revetment on existing levees, further encouraging recruitment of suitable vegetation adjacent to occupied habitat. Where vegetation is planted as part of levee construction or improvement, oaks, Fremont cottonwoods, sycamores, box elders (*Acer negundo*), and black walnuts (*Juglans* sp.) could be included in the planting palette to provide suitable woodrat habitat.

Levee construction and improvement: If new or higher levees were constructed near Caswell SP or the San Joaquin River NWR, the increase in flood capacity and potential for more severe flooding would have adverse effects on riparian woodrats because habitat would be flooded more frequently, causing direct mortality of woodrats and destruction of their houses. It is critical that construction of new levees and levee improvements be avoided in these areas.

Recovery Plan Alignment

The riparian woodrat is included in the USFWS's 1998 *Recovery Plan for Upland Species of the San Joaquin Valley, California*, which identifies known threats. Long-term conservation goals of the recovery plan call for three or more populations of riparian woodrats numbering 5,000 or more adults in total, with no fewer than 400 individuals in any given population. To achieve this goal, USFWS (1998, 2012b) proposes several conservation priorities:

1. Expand the San Joaquin River NWR, with an emphasis on establishing connectivity with Caswell SP. Restore riparian habitat within these areas.

2. Conduct or fund a genetic study to clarify the taxonomy and phylogenetic relationships of the Caswell SP and San Joaquin River NWR woodrats.

3. Assess the fire fuel load at Caswell SP to determine the risk to riparian woodrats of catastrophic wildfire within the park. If necessary, reduce fuel loads while accounting for the habitat requirements of riparian woodrats (e.g., their use of woody debris as shelter).

4. Survey all riparian areas along the San Joaquin River and its major tributaries, as well as the South Delta, for suitable riparian woodrat habitat. In areas where suitable habitat is found, surveys for riparian woodrats should be conducted. Unoccupied habitat should be assessed to determine its suitability for reintroduction efforts.

5. Manage or eradicate populations of black rats in Caswell SP and the San Joaquin River NWR. These efforts should rely primarily on live trapping and should avoid the use of rodenticides. If possible, research into the competitive relationship between black rats and riparian woodrats should be incorporated into management or eradication efforts.

6. Examine the habitat preferences of riparian woodrats, with an emphasis on nest structures in the San Joaquin River NWR, because traditional stick lodges have not been observed there.

Many of these priorities are addressed in previous sections of this conservation plan, including surveying riparian areas and populations, restoring riparian habitat, and supporting connectivity among habitats (priorities 1 and 4). Also, Matocq et al. (2012) recently published a genetic study of the riparian woodrat, although further genetic analyses are warranted (priority 2). No information is available regarding efforts to reduce fuel loads in Caswell or manage black rat populations (priorities 3 and 5). General habitat requirements have been identified for the species, but formal habitat association research has not been completed (priority 6).

Translocation of riparian woodrats to suitable habitat (priority 4) has not yet been addressed. Successful translocation depends on the availability of suitable habitat and a robust source population. The San Joaquin River NWR is a clear first target for translocation, because suitable habitat already exists, and augmentation of the woodrats occurring there may help establish a stable population. However, surveys of the Caswell SP population must occur first to determine if it is large enough to support translocation efforts. If conditions become favorable, translocation could be implemented as part of the adaptive management component of the Conservation Strategy.

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 riparian woodrat. Therefore, building on the preceding discussion, this section of the riparian woodrat 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. The species-specific measures provide additional detail on geographic location, habitat structure, and other attributes important to conserving the species. For example, acreage of riparian restoration is an indicator of progress toward the Conservation Strategy’s riparian habitat objective. To contribute to conservation of riparian woodrat, important attributes of restored riparian habitat are the number and density of plants that provide food, cover, and nesting habitat for the riparian woodrat, because these three elements are necessary for suitable habitat.

Table 3 lists the process, habitat, and stressor targets of the Conservation Strategy, identifies those used to measure the contribution to conservation of the riparian woodrat, and provides additional specificity as necessary to measure this contribution. Because management actions intended to benefit riparian woodrats may simultaneously affect conservation of other species in the SPA, these measures of contribution have been incorporated into each CPA’s objectives for the conservation of target species, which are provided in Section 3.0 of the Conservation Strategy. The target species objectives cover multiple species and reflect the interrelated nature of CVFPP flood management and conservation actions.

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the Riparian Woodrat

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Inundated Floodplain	Inundated Floodplain—total amount (acres, EAH units) with sustained spring and 50-percent frequently activated floodplain, and total amount of expected annual inundated floodplain habitat[a]	No	Inundation may have negative effects unless riparian woodrats have developed arboreal nests, access to food and cover in closed canopy situations, and access to high-water refugia. Inundation may also have negative effects if it destroys stick lodges.
Riverine Geomorphic Processes	Natural Bank—total length (miles)	No	
	River Meander Potential—total amount (acres)	No	
SRA Cover	SRA Cover and Bank and Vegetation Attributes of SRA Cover—total length (miles)	No	
	Total Length and % of Bank Affected by Flood Projects that Incorporate SRA Attributes	No	
Riparian	Habitat Amount—total amount and total amount on active floodplain (acres)	Yes	Habitat amount is defined as the habitat occupied by riparian woodrats. Suitable habitat would include an understory connected to the canopy by a midstory and refugia from flooding.
	Habitat Connectivity—median patch size (acres)	Yes	Restore connectivity among occupied riparian areas within and between Caswell SP and the San Joaquin River NWR to the extent feasible.
Marsh	Habitat Amount—total amount and total amount on active floodplain (acres)	No	
Floodplain Agriculture	Habitat Amount—total amount (acres) of floodplain agriculture providing habitat for target species	No	
Revetment	Revetment Removed to Increase Meander Potential and/or Natural Bank—total length (miles)	No	May have negative effect if riparian woodrats have built nests in bank stabilization projects containing large boulders that create rocky talus slopes.
Levees	Levees Relocated to Reconnect Floodplain or Improved to Eliminate Hydraulic Constraints on Restoration—total length (miles)	No	

Table 3. Measures of Contribution of CVFPP Actions to Conservation of the Riparian Woodrat

Target	Indicator	Selected as Measure of Contribution	Additional Specificity
Fish Passage Barriers	Fish Passage Barriers—modified or removed	No	
Invasive Plants	Invasive Plant–Dominated Vegetation—total area reduced (acres)	No	

Key: EAH = expected annual habitat.
Note:
[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 2 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).

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