U.S. Fish & Wildlife Service

Draft Recovery Plan for the Central California Distinct Population Segment of the California Tiger Salamander (*Ambystoma californiense*)

California tiger salamander at Jepson Prairie, Solano County. Photograph by Adam Clause. Used with permission.

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Region 8
U.S. Fish and Wildlife Service
Sacramento, California

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Regional Director, Pacific Southwest Region, Region 8,
U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXXXXXX

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Literature Citation should read as follows:

U.S. Fish and Wildlife Service. 2015. Draft Recovery Plan for the Central California Distinct Population Segment of the California Tiger Salamander (*Ambystoma californiense*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. v + 53pp.

An electronic copy of this draft recovery plan is available at:
http://www.fws.gov/sacramento/

Acknowledgements

The recovery planning process has benefitted from the advice and assistance of many individuals, agencies, and organizations. We wish to sincerely thank and gratefully acknowledge the assistance from the following individuals and apologize to anyone whose name was inadvertently omitted from this list:

Jeff Alvarez, The Wildlife Project
Joy Albertson, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex
Steve Bobzien, East Bay Regional Park District
Chris Caris, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex
Jackie Charbonneau, Natural Resources Conservation Service, Livermore
Dave Cook, Sonoma County Water Agency
Cat Darst, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office
Steve Detwiler, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office
John Downs, California Department of Fish and Wildlife, Ecosystem Conservation Division
Jeff Drongensen, California Department of Fish and Wildlife, North Central Region
Lisa Ellis, U.S. Fish and Wildlife Service, Pacific Southwest Regional Office
Kim Forest, U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex
Cay Goude, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, retired
Kate Guerena, U.S. Fish and Wildlife Service, San Luis National Wildlife Refuge Complex
Josh Hull, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office
Jarrett Johnson, Western Kentucky University
James Jones, East Bay Municipal Utility District
Diane Kodama, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex
Leslie Koenig, Alameda County Resource Conservation District
Rick Kuyper, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office
Thomas Leeman, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office
Ivette Loredo, U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex
Margaret Mantor, California Department of Fish and Wildlife, State Headquarters, Sacramento
Jacob Martin, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office
Laura Patterson, California Department of Fish and Wildlife, State Headquarters, Sacramento
Angela Picco, U.S. Fish and Wildlife Service, Pacific Southwest Regional Office
Kathleen Pollett, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office
Don Rocha, Santa Clara County Parks
Mary Root, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office
Maureen Ryan, University of Washington
Chris Searcy, University of Toronto
Brad Shaffer, University of California, Los Angeles
Luisa Studen, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office
Eric Tattersall, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office
Peter Trenham, Independent
Julie Vance, California Department of Fish and Wildlife, Central Region
John Vollmar, Vollmar Natural Lands Consulting
Craig Weightman, California Department of Fish and Wildlife, Bay Delta Region
Jeff Wilcox, Sonoma Mountain Ranch Preservation Foundation

Executive Summary

Species Current Status

The Central California Distinct Population Segment (DPS) of the California tiger salamander (*Ambystoma californiense*) (Central California tiger salamander) was listed as threatened on August 8, 2004 (Service 2004). The Service published a final rule designating critical habitat for the Central California tiger salamander on August 23, 2005 (Service 2005). The State of California listed the California tiger salamander throughout its entire range (including the Central California, Santa Barbara, and Sonoma DPSs) as threatened on August 19, 2010 (California Fish and Game Commission 2010). The Central California tiger salamander is restricted to disjunct populations that form a ring along the foothills of the Central Valley and Inner Coast Range from San Luis Obispo, Kern, and Tulare Counties in the south, to Sacramento and Yolo Counties in the north. The recovery priority number for the Central California tiger salamander is 9C. This number indicates that the taxon is a DPS that faces a moderate degree of threat, has a high potential for recovery, and is in conflict with development projects, such as conversion to agriculture or urban development.

Threats

Multiple factors have contributed to population declines of this species, including habitat loss and fragmentation; predation from, and competition with, invasive species; hybridization with non-native barred tiger salamanders (*Ambystoma tigrinum*) (sometimes referred to as *Ambystoma tigrinum mavortium*); mortality from road crossings; contaminants; and small mammal burrow control efforts (Service 2004, 2014). Potential threats include introduction of diseases such as ranaviruses and also climate change (Service 2004, 2014).

Recovery Strategy

The strategy to recover the Central California tiger salamander focuses on alleviating the threat of habitat loss and fragmentation in order to increase population resiliency (ensure each population is sufficiently large to withstand stochastic events), redundancy (ensure a sufficient number of populations to provide a margin of safety for the species to withstand catastrophic events), and representation (conserve the breadth of the genetic makeup of the species to conserve its adaptive capabilities). Recovery of this species can be achieved by addressing the conservation of remaining aquatic and upland habitat that provides essential connectivity, reduces fragmentation, and sufficiently buffers against encroaching development and intensive agricultural land uses. Appropriate management of these areas will also reduce mortality by addressing non-habitat related threats, including those from non-native and hybrid tiger salamanders, other non-native species, disease, and road mortality. Research and monitoring should be undertaken to determine the extent of known threats, identify new threats, and reduce threats to the extent possible.

Recovery Goal and Objectives

The goal of this recovery plan is to reduce the threats to the Central California tiger salamander to ensure its long-term viability in the wild and allow for its removal from the list of threatened and endangered species. The recovery objectives of the plan are:

1. Secure self-sustaining populations of Central California tiger salamander throughout the full range of the DPS, ensuring conservation of genetic variability and diverse habitat types (*e.g*., across elevation and precipitation gradients).

2. Ameliorate or eliminate the threats that caused the species to be listed, and any future threats.

3. Restore and conserve a healthy ecosystem supportive of Central California tiger salamander populations.

Recovery Criteria

Delisting criteria are provided in section III-D of this recovery plan. Delisting may be warranted when these recovery criteria have been met in a sufficient number of metapopulation areas such that the Central California tiger salamander is no longer a threatened species. Criteria include measures to ensure protection of aquatic and upland habitat, as well as sufficient funding for management and monitoring of the protected habitat. In some cases, the amount of habitat protection required to meet delisting criteria has already been achieved. For example, metapopulation areas such as in the Bay Area and Central Valley have sufficient amounts of habitat protected to meet or exceed criteria set forth in this Recovery Plan.

Criteria also include measures to ensure that management of these preserved areas reduce mortality by addressing non-habitat related threats, including those from non-native and hybrid tiger salamanders, competition and predation from other non-native species, disease, contaminants, and road mortality.

Actions Needed

Actions needed to recover this species include the following:

1. Maintain current distribution of species
2. Maintain genetic structure across the species range
3. Minimize road mortality
4. Minimize potential for disease introduction
5. Minimize non-native predator populations
6. Ensure management and monitoring of habitat
7. Conduct research

Estimated Date and Cost of Recovery:

Date of recovery: 2067
Cost of recovery: $85,375,000

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I. BACKGROUND

A. Overview

All California tiger salamanders (*Ambystoma californiense*) are federally listed; however, they are listed as three unique entities, or Distinct Population Segments (DPSs): the Sonoma County DPS of California tiger salamander, the Santa Barbara County DPS of California tiger salamander, and the Central California DPS of California tiger salamander. When listing a population as a DPS under the Endangered Species Act of 1973 (Service 1973), as amended (Act), three elements are considered: (1) the discreteness of the population segment in relation to the remainder of the species to which it belongs; (2) the significance of the population segment to the species to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing (Service and National Marine Fisheries Service 1996).

The Central California DPS of the California tiger salamander (Central California tiger salamander) was listed as threatened on August 4, 2004 (Service 2004). The State of California listed the California tiger salamander as a single entity throughout its range as a threatened species in 2010 (California Fish and Game Commission 2010). The Service published a final rule designating critical habitat for the Central California tiger salamander on August 23, 2005 (Service 2005). The first 5-year status review for this species was completed on October 21, 2014 (Service 2014). The recovery priority number for the Central California tiger salamander is 9C. This number indicates that the taxon is a DPS that faces a moderate degree of threat, has a high potential for recovery, and is in conflict with construction or other development projects or other forms of economic activity (Service 1983).

B. Species Description and Taxonomy

The California tiger salamander is a large, stocky, terrestrial salamander with a broad, rounded snout. Total body length of adults range approximately from 6 to 9.5 inches (16 to 24 centimeters) (C. Searcy, pers. comm. 2013a). The coloration of the adults generally consists of random white or yellowish markings against a black body. California tiger salamander larval coloration is variable, with most larvae being pale colored, although larvae can also have a spotted dark grey coloration in clear ponds (Anderson, P. 1968).

The California tiger salamander was described as *Ambystoma californiense* by Gray (1853) from specimens collected in Monterey County (Grinnell and Camp 1917), and the species was recognized as distinct by Storer (1925) and Bishop (1943) and was confirmed with genetic data (Shaffer and McKnight 1996; Irschick and Shaffer 1997). Recent genetic studies also show that there has been little, if any, gene flow between the Central California DPS, the Sonoma County DPS, and the Santa Barbara County DPS for a substantial period of time (Shaffer and Trenham 2002; Shaffer et al. 2004, 2013). In addition, genetic studies have shown that within the Central California DPS there is genetic differentiation between four sub-groups within the Central California tiger salamander range that corresponds with the geographic distribution of those groups. Shaffer et al. (2004, 2013) identified these sub-groups as the following: (1) Southern San Joaquin Valley; (2) Central Valley; (3) Bay Area; and (4) Central Coast Range.

C. Population Trends, Range, and Distribution

Virtually nothing is known concerning the historical abundance of the Central California tiger salamander. We do not have data regarding the absolute number of individuals of this species due to the fact that they spend most of their lives underground and are therefore difficult to observe. The available data suggest that most populations consist of relatively small numbers of breeding adults; breeding populations in the range of a few pairs up to a few dozen pairs are common, and numbers above 100 breeding individuals are rare (CDFG 2010). However, this species exhibits high variation in population numbers (Loredo and Van Vuren 1996; Trenham et al. 2000; C. Searcy, pers. comm, 2012b).

Historically, Central California tiger salamanders were endemic to the San Joaquin-Sacramento River valleys, bordering foothills, and coastal valleys of Central California (Stebbins 1985; Shaffer et al. 2013). Although the historical distribution of Central California tiger salamanders is not known in detail, their current distribution suggests that they may have been continuously distributed along the low-elevation grassland-oak woodland plant communities of the valleys and foothills (Shaffer et al. 1993; Shaffer et al. 2013). The species is known from sites on the Central Valley floor near sea level, up to a maximum elevation of roughly 3,940 feet (1,200 meters) in the Coast Ranges and 1,640 feet (500 meters) in the Sierra Nevada foothills (Shaffer et al. 2013). The higher elevation sites in the Sierra Nevada foothills are found in the southern San Joaquin Valley (CNDDB 2015). The higher elevation sites in the Bay Area occur in the Ohlone Wilderness, Alameda County (CNDDB 2015).

The Central California tiger salamander occurs in the following counties: Alameda, Amador, Calaveras, Contra Costa, Fresno, Kern, Kings, Madera, Mariposa, Merced, Monterey, Sacramento, San Benito, San Mateo, San Joaquin, San Luis Obispo, Santa Clara, Santa Cruz, Stanislaus, Solano, Tulare, Tuolumne, and Yolo (See Figure 1).

D. Life History and Ecology

Life Cycle

The California tiger salamander has an obligate biphasic life cycle where it utilizes both aquatic and terrestrial habitat (Shaffer et al. 2004). Although salamander larvae develop in the vernal pools and ponds in which they were born, once a metamorph leaves its natal pond and enters a burrow, it will then spend the vast majority of its life underground (Trenham et al. 2001). Adult Central California tiger salamanders engage in mass migrations during a few rainy nights per year, typically from November through April, although migrating adults have been observed as early as October and as late as May (Hansen and Tremper 1993; Loredo and Van Vuren 1996; Petranka 1998; Trenham et al. 2000). During these rain events, adults leave their underground burrows and return to breeding ponds to mate and will then return to their underground burrows. Males typically arrive before the females and generally remain in the ponds longer than females (Loredo and Van Vuren 1996; Trenham et al. 2000).

Females lay their eggs in the water, attaching their eggs to twigs, grass stems, or other vegetation or debris (Storer 1925; Twitty 1941; Anderson, P. 1968). The amount of time necessary for hatching is likely related to water temperature, with eggs hatching quicker in colder water temperatures (Anderson, P. 1968). Reported hatching time for eggs ranges from 10 to 28 days (Anderson, P. 1968; Petranka 1998; C. Searcy, pers. comm., 2012a). The larval stage of the Central California tiger salamander usually lasts 3 to 6 months, with metamorphosis beginning in late spring or early summer (Petranka 1998). Once metamorphosis occurs, juveniles typically depart their natal ponds at night and enter into terrestrial habitat in search of underground burrows (Petranka 1998). Peak periods for metamorphs to leave their natal ponds have been reported from May to July (C. Searcy, pers. comm., 2012a; Loredo and Van Vuren 1996; Trenham et al. 2000). In rare instances, larvae have been reported to overwinter in ponds (Alvarez 2004).

Central California tiger salamanders are infrequent breeders and lifetime reproductive success is low (Trenham et al. 2000; Trenham 2001). Trenham et al. (2000) reported that, while individuals may survive for more than 10 years, many breed only once, and mortality of individuals exceeded 50 percent during the first summer. In addition, less than 5 percent of marked metamorphs survived to become breeding adults (Trenham et al. 2000).

Little is known about the behavior of California tiger salamanders while they are underground because they are difficult to observe. However, most evidence suggests that Central California tiger salamanders remain active in their underground dwellings (Semonsen 1998; Trenham 2001; Van Hattem 2004).

Diet

California tiger salamander larvae typically feed on invertebrate prey. J. Anderson (1968) studied a Central California tiger salamander population in Santa Cruz County and reported that larvae fed on zooplankton, small crustaceans, snails, and aquatic insects until they grew large enough to switch to larger prey. Water fleas (Order Cladocera) were reported as the most common prey item for larvae, occurring in 93.7 percent of Central California tiger salamander stomachs. Once large enough, the Central California tiger salamander larvae preferentially consumed the tadpoles of Pacific chorus frogs and California red-legged frogs, which were the largest food items available to them (J. Anderson, 1968). In another study, P. Anderson (1968) reported that Central California tiger salamander larvae consumed aquatic insects (including rotifer eggs, water fleas, and mosquito larvae), crustaceans (*branchinecta*), algae, Pacific chorus frog tadpoles, and smaller Central California tiger salamander larvae. Feaver (1971) reported that Central California tiger salamander larvae predated on western spadefoot toad larvae. Less is known about what Central California tiger salamanders eat while underground, but Van Hattem (2004) anecdotally reported on a Central California tiger salamander eating a moth while being observed with a camera underground. Stomach contents of several sub-adults from San Luis Obispo County included spiders, earthworms, and insects (water boatmen) (Hansen and Tremper 1993). Gastric lavage (commonly referred to as stomach pumping) was used to examine the stomach contents of adult California tiger salamanders at Jepson Prairie, Solano County, and 17 invertebrate species were detected. The most common types of prey were *Tipula*, *Carabidae*, *Noctuidae* (larva), and *Collembola* (C. Searcy, pers. comm., 2012a).

Metapopulation Structure, Migration and Dispersal

The California tiger salamander has a metapopulation structure. A metapopulation is a set of local populations or breeding sites within an area, where dispersal from one local population or breeding site to other areas containing suitable habitat is possible, but not routine. Central California tiger salamanders appear to have high site fidelity, returning to their natal pond as adults; and after breeding, they commonly return to the same terrestrial habitat areas (Orloff 2007 and 2011). However, some salamanders disperse to new breeding ponds (Trenham 2001; Wang et al. 2009).

Migration is defined as movements, primarily by resident adults, toward and away from aquatic breeding sites (Semlitsch 2008). For the adult residents using a breeding pond, migrations are reoccurring events (often, but not always annually), round-trip, and intrapopulational (within populations). Dispersal is defined as unidirectional movements that are interpopulational (between different populations) in scale, are ultimately greater in distance than for migrating adults, and may occur only once in a lifetime (Semlitsch 2008). For dispersing juveniles, movement occurs from natal sites to future breeding sites that are not the pond of birth and not part of the local population. For dispersing adults, movements occur out of the local population and/or between metapopulations. A local population can be either one pond or clusters of ponds in close proximity occupied by one breeding group.

Central California tiger salamanders have been reported to migrate up to 1.3 miles (2.2 kilometers) between breeding ponds and upland habitat (Orloff 2007). Searcy and Shaffer (2011) estimated average migration distance to be 1,844 feet (562 meters), and they estimated that Central California tiger salamanders are physiologically capable of migrating up to 1.5 miles (2.4 kilometers) each breeding season. In addition, Searcy and Shaffer (2011) estimated that 95 percent of the population occurred within 1.16 miles (1.86 kilometers) of the breeding pond. Trenham et al. (2001) observed a substantial number of California tiger salamanders dispersing between ponds separated by up to 2,200 feet (670 meters).

Fluctuations in Population Size and Gaps in Breeding

There have been multiple studies on breeding Central California tiger salamander populations, most of which have shown large amounts of fluctuation in numbers of breeding adults as well as numbers of larvae produced. In Monterey County, Trenham et al. (2000) found the number of breeding adults visiting a pond varied from 57 to 244 individuals. In Contra Costa County, Loredo and Van Vuren (1996) reported numbers of juveniles produced within a single pond ranging from over 1,000 metamorphs in one year to only three metamorphs 2 years later. In Solano County, metamorph production ranged from a high of 3,115 in one year to zero 2 years later (C. Searcy, pers. comm., 2012b). Breeding pools in Alameda and Contra Costa counties show similar trends, with salamander larvae being detected in breeding pools one year but not the next (Bobzien and DiDonato 2007). Alvarez (pers. comm., 2012) surveyed 90 ponds in Contra Costa County for 9 years and reported that only one pond had breeding observed every year, and the most breeding observed in a single year was in 44 ponds. The average gap in breeding observed in the 90 ponds was 3 years.

The environmental factors that play a role in this fluctuation are not entirely understood, but likely are related to climatic conditions, including the timing of rainfall events, amount of rainfall, or unseasonably high temperatures. Other factors may include predator/prey assemblages, with environmental conditions favoring species that predate on or compete with Central California tiger salamander larvae (Bobzien and DiDonato 2007).

E. Habitat Characteristics/Ecosystem

The Central California tiger salamander primarily inhabits annual grasslands and open woodlands (Stebbins 1985; Shaffer et al. 2013). The Central California tiger salamander requires upland habitat that is occupied by small burrowing mammals such as California ground squirrel (*Otospermophilus beecheyi*) and Botta's pocket gopher (*Thommomys bottae*) that create underground burrow systems utilized by the salamanders throughout the year (Shaffer et al. 1993; Seymour and Westphal 1994; Loredo et al. 1996; Pittman 2005). Upland habitats surrounding known Central California tiger salamander breeding pools are usually dominated by grassland, oak savanna, or oak woodland (CNDDB 2015). Large tracts of upland habitat, preferably with multiple breeding ponds, are necessary for the Central California tiger salamander to persist.

Although California tiger salamanders are adapted to breeding in natural vernal pools and ponds, they now frequently use livestock ponds and other modified ephemeral and permanent ponds. In fact, the Service issued a 4(d) rule concurrent with the listing rule that identified sustainable ranching, including the provision of stock ponds and managed grazing, as a practice that is compatible with and often beneficial for California tiger salamanders (Service 2004). Breeding ponds, whether natural or man-made, must have a long enough ponding duration for adult Central California tiger salamanders to breed and also pond water long enough for larvae to mature into juveniles capable of dispersing from the aquatic breeding site to suitable terrestrial habitat. Optimum breeding habitat is ephemeral and dries down before August or September, which prevents bullfrogs (*Rana catesbeiana*) or non-native fish species from establishing breeding populations (Service 2005). California tiger salamanders can be found in permanent ponds; permanent ponds used by California tiger salamanders are usually free of predatory fish or breeding bullfrog populations (Shaffer et al. 1993; Fisher and Shaffer 1996). This species is not known to breed in streams or rivers; however breeding populations have been reported in ditches that contain seasonal wetlands (D. Cook, in literature, 2009; Seymour and Westphal 1994) and in slow-moving swales and creeks situated near other suitable breeding habitat (Alvarez et al. 2013). In addition, Central California tiger salamander larvae have been documented in sewage treatment ponds in Calaveras County (EBMUD 2013).

F. Critical Habitat

On September 22, 2005, the Service designated approximately 199,109 acres (80,576 hectares) of critical habitat for the Central California tiger salamander. The critical habitat is comprised of 31 units and located within 19 California counties (Service 2005) (Figure 2). The areas designated as critical habitat for the Central California tiger salamander provide needed aquatic and upland refugia habitats for adult salamanders to maintain and sustain extant occurrences of the species throughout their geographic and genetic ranges and provide those habitat components essential for the conservation of the species (Service 2005).

G. Reasons for Listing and Current Threats

In determining whether to list, delist, or reclassify a species under section 4(a) of the Act, we evaluate the threats to the species based on the five categories outlined in section 4(a)(1) of the Act: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. The following is a summary of factors that supported listing of the Central California tiger salamander (Service 2004) and that were addressed in the 5-year status review for the species (Service 2014). For more detailed information about each of these threats, please refer to the final rule to list the species and the 5-year review (Service 2014).

Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The loss, degradation, and fragmentation of habitat as the result of human activities are the primary threats to the Central California tiger salamander (Service 2004, 2014). Aquatic and upland habitat available to Central California tiger salamanders has been degraded and reduced in area through agricultural conversion, urbanization, road construction, and other projects (Service 2014). Central California tiger salamander populations occur in scattered and increasingly isolated breeding sites, reducing opportunities for inter-pond dispersal. The following sections summarize the greatest threats to the species through the destruction, modification, or curtailment of the Central California tiger salamander's habitat or range.

<u>Habitat Loss</u>

Habitat destruction through grading or other habitat modifications reduces the available feeding, breeding, and sheltering opportunities required for California tiger salamander survival and reproduction and thus lowers the carrying capacity of the landscape. Large areas of upland habitat have been converted to high intensity human uses, which are unsuitable for salamanders because they lack the aquatic and upland habitat necessary for the salamander. Grading and leveling or deep-ripping operations associated with urban and agricultural conversion of uplands have destroyed upland and breeding habitat and caused direct injury and mortality to larvae, juveniles, and adults occupying the habitat. The Service (2003) determined that there was a 20.7 percent loss of known Central California tiger salamander occurrences as of 2002 as a result of habitat loss and degradation. Habitat loss has continued to occur since the time of listing (Service 2014). A detailed description of the threats of agricultural conversion and urban development to the Central California tiger salamander can be found in the 5-year review (Service 2014).

Habitat Fragmentation

California tiger salamanders require a large amount of barrier-free landscape for successful migration and dispersal (Shaffer et al. 1993; Loredo et al. 1996). Habitat fragmentation reduces population connectivity needed for dispersal and migration, results in isolation of metapopulations, and makes them more vulnerable to stochastic effects because they are unlikely to become recolonized if extirpated (Shaffer et al. 1993). Urbanization and conversion to intensive agriculture can create permanent barriers that can isolate California tiger salamanders and prevent them from moving to new breeding habitat, or it can prevent them from returning to their breeding ponds or underground burrow sites. Roads and highways also create permanent physical obstacles and increase habitat fragmentation. For example, Highway 580 from Pleasanton to Tracy and Highway 680 from Pleasanton to Milpitas have created an unpassable barrier for California tiger salamanders from the western edge of San Joaquin County, through Alameda County, to the eastern edge of Contra Costa County. These road barriers have isolated several metapopulations found in this area (S. Bobzien, in literature, 2003).

Habitat Alteration

Habitat adjacent to urban and intensive agriculture land uses can be altered by pond modifications that favor exotic predators (*i.e.*, breeding ponds are converted from ephemeral to perennial); ground squirrel eradication actions; increases in contaminants; increases in domestic pets, such as house cats and dogs, which may predate on salamanders; and, increases in native species, such as raccoons, that may become artificially abundant in association with urban development. Some less intensive agricultural uses (such as irrigated pasture) may still provide areas for California tiger salamanders to persist; however, even less intensive forms of agricultural use often lead to the alteration of wetlands and upland habitat which will result in less favorable conditions for California tiger salamanders. For example, irrigated pasture decreases abundance of burrowing mammals such as ground squirrels (Marsh 1994), thereby reducing the amount of available burrows for Central California tiger salamanders.

Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for commercial, recreational, scientific, or educational purposes was not known to be a factor in the 2004 final listing rule (Service 2004) and does not appear to be a threat at this time.

Factor C: Disease or Predation

Disease

Ranaviruses are pathogens in a group of viruses in the family Iridoviridae, which are known to infect amphibians, reptiles, and fishes. Ranaviruses such as ATV (*Ambystoma tigrinum* virus), have caused tiger salamander die-offs throughout western North America (Jancovich et al. 2001, 2003, 2005). At this time, pathogen outbreaks have not been documented in Central California tiger salamander populations; however, viral pathogens such as ATV have been shown to be lethal to Central California tiger salamanders in experimental conditions (Picco et al. 2007). Diseases, such as ATV and other ranaviruses, are considered a potential threat because non-native tiger salamanders carrying these diseases can easily be brought into California for use as fish bait, and many of these non-native tiger salamanders are known carriers of ATV (Picco et al. 2007). Although California currently prohibits the use of tiger salamanders for fishing bait, it is difficult to enforce such regulations. If a Central California tiger salamander population is infected with one of these diseases, it could quickly spread to an entire metapopulation since some individuals may not die, becoming carriers of the disease and dispersing to other ponds where they will infect other individuals (Service 2002, 2007).

A chytrid fungus (*Batrachochytrium dedrobatidis*) has been linked to native amphibian declines in California as well as many amphibian species worldwide (Fellers et al. 2001; Garner et al. 2006). Padgett-Flohr (2008) found that California tiger salamanders infected in the laboratory with chytrid fungus did not die or exhibit clinical signs of disease, but they did remain infected with the fungus. Infected salamanders exhibited mostly normal behavior; however, infected California tiger salamanders sloughed (*i.e.*, molted) whole skins more frequently than uninfected salamanders which may help prevent effects from the fungus but also requires use of additional energy by the salamander. However, to date, chytrid fungus has not been found to be responsible for California tiger salamander mortality in the laboratory or the field, and we do not have evidence of negative effects on California tiger salamanders.

Predation

At the time of listing, bullfrogs were considered a threat to Central California tiger salamanders and are presently still considered a threat. Bullfrogs have been documented to predate upon Central California tiger salamanders (Anderson, P. 1968) and have eliminated some Central California tiger salamander populations (Shaffer et al. 1993). Although bullfrogs are unable to establish permanent breeding populations in unaltered vernal pools and seasonal ponds, dispersing immature bullfrogs take up residence in vernal pools and other ephemeral wetlands during winter and spring (Seymour and Westphal 1994) and may predate on Central California tiger salamander larvae and migrating adults.

The Service determined that introductions of non-native fish species into California tiger salamander breeding habitat was a threat to the persistence of the species (Service 2004), and they are still considered a threat at this time. Many non-native fish species are introduced by landowners to perennial wetland features for sport fishing or other reasons, thereby lowering the habitat suitability of the wetland for California tiger salamander use. The introduction of fish species, such as largemouth bass (*Micropterus salmoides*) and blue gill (*Lepomis macrochirus*), and non-native crayfish species (*Pacifastacus*, *Orconectes*, and *Procambarus* spp.) has likely eliminated salamanders from those sites (Shaffer et al. 1993; Jennings and Hayes 1994).

Introduction of mosquitofish was considered a threat to California tiger salamanders at the time of listing, and it is still considered a threat at this time. Mosquitofish will predate on California tiger salamanders (Leyse and Lawler 2000), and introductions of mosquitofish to a wetland can eliminate an entire cohort of developing California tiger salamander embryos or larvae (Shaffer et al. 1993; Jennings and Hayes 1994; Loredo-Prendeville et al. 1994). Leyse and Lawler (2000) observed that mosquitofish reduced survival of Central California tiger salamander larvae in simulated perennial ponds. Salamander larvae that survived in ponds with mosquitofish were smaller, took longer to reach metamorphosis, and had injuries such as shortened tails (Leyse and Lawler 2000). In addition, both California tiger salamanders and mosquitofish feed on invertebrates, and it is possible that large numbers of mosquitofish may out-compete Central California tiger salamander larvae for food (Graf and Allen-Diaz 1993).

At the time of listing, predation by hybrid tiger salamanders was not addressed (Service 2004); however, larger hybrid tiger salamanders will predate on the smaller Central California tiger salamanders. Ryan et al. (2009) reported that hybrid salamanders were observed predating on native California tiger salamanders, and all cannibalism observed was unidirectional, with hybrids always predating on native California tiger salamanders. In addition, the non-native tiger salamander has kin recognition and is more likely to preferentially consume less related individuals (Pfennig et al. 1999). Therefore, non-native and hybrid tiger salamanders may be more likely to cannibalize on pure California tiger salamanders than on more similarly related hybrid salamanders. At this time the Service believes that predation by hybrid tiger salamanders is a threat to all native California tiger salamanders where they co-occur; however, it is unknown to what degree this affects California tiger salamander populations.

Factor D: Inadequacy of Existing Regulatory Mechanisms

In the final rule to list the Central California tiger salamander as threatened (Service 2004), we concluded that Federal, State, and local laws have not been sufficient to prevent past and ongoing losses of the Central California tiger salamander and its habitat. The regulatory mechanisms that protect the Central California tiger salamander include Federal protections such as the National Environmental Policy Act, Clean Water Act, and the Endangered Species Act. State laws include the California Endangered Species Act, California Environmental Quality Act, and the Natural Community Conservation Planning Act. For an analysis of regulatory mechanisms that provide protection to the Central California tiger salamander, see Service (2014). If all other threat factors have been ameliorated, we believe that Factor D does not constitute a threat to the Central California tiger salamander.

Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

The listing rule (Service 2004) identified several other factors that may also cause direct or indirect adverse effects to Central California tiger salamanders or their habitat, including road mortality, hybridization with non-native tiger salamanders, contaminants, mosquito control efforts, and livestock grazing. The Service now also considers climate change a potential threat to the species. A discussion of these threats follows.

Mortality from Road Crossings

Mortality from road crossings was determined to be a threat at the time of listing (Service 2004). This is still considered a threat at this time, although the extent of this threat is not known. Because California tiger salamanders migrate en masse and frequently cross roadways that occur between breeding and nonbreeding areas, they are more susceptible to road mortality (G. Fellers, in literature, 2012). Dead and wounded California tiger salamanders are likely removed from roads quickly by scavengers, making detection far less likely (Shaffer et al. 1993). In addition, salamanders that are crushed by vehicles are not easily identifiable. Despite this difficulty in making detections, Central California tiger salamanders have been reported to be killed by vehicular traffic while crossing roads (Twitty1941; Barry and Shaffer 1994; Launer and Fee 1996; CCPWD 2009; C. Caris, pers. comm., 2014). The CNDDB (2015) reports 27 occurrences of Central California tiger salamanders that are threatened by vehicular traffic and road mortality. Of these 27 occurrences, 18 have reported observations of Central California tiger salamanders that were struck by vehicles. The majority of these occurrences are reported in Alameda County (13), and other occurrences are reported in Contra Costa, Mariposa, Merced, Santa Cruz, Santa Clara, San Benito, San Joaquin, and Stanislaus Counties.

Hybridization with Non-native Tiger Salamanders

At the time of listing in 2004, the Service determined that hybridization between Central California tiger salamanders and non-native barred tiger salamanders posed a significant threat to the Central California tiger salamander. Non-native tiger salamanders can have negative effects on California tiger salamander populations through hybridization, resulting in genetic loss of pure native salamanders (Shaffer et al. 1993; Riley et al. 2003; Fitzpatrick and Shaffer 2007). Central California tiger salamanders in the Salinas Valley, in particular, are threatened by hybridization with non-native tiger salamanders. There was a large-scale introduction of barred tiger salamanders approximately 60 years ago in the Salinas Valley in support of the bass-bait industry. These introduced salamanders began breeding with Central California tiger salamanders (Riley et al. 2003). The invasion has spread from the original source populations out across the Salinas Valley and coast range portion of the range of the species (Fitzpatrick and Shaffer 2007). In general, hybridization seems to decrease in populations the further they are from the introduction sites in the Salinas Valley. Breeding populations in Monterey and San Benito Counties are also threatened with hybridization (Fitzpatrick and Shaffer 2007; Fitzpatrick et al. 2010). Hybrids have also been reported in multiple ponds in the Altamont Pass area (S. Wenner, pers. comm. 2015). Additionally, barred tiger salamanders were introduced to two ponds near the North Fork Pacheco Creek in Santa Clara County in the early 1980s (J. Smith pers. comm. 2010a, as cited in ICF International 2010). Non-native tiger salamanders were likely also introduced to ponds in Merced County (Fitzpatrick and Shaffer 2007). Figure 4 in Appendix A shows the location of known hybrid and non-native populations.

The areas where hybrids are known to occur are roughly the same as at the time of listing. Currently, the distribution of introduced tiger salamander genes is largely confined to within 7.5 miles (12 kilometers) of introduction sites, and most populations are essentially pure Central California tiger salamanders by approximately 22 to 29 miles (35 to 47 kilometers) north of the introduction sites (Fitzpatrick and Shaffer 2007; Shaffer et al. 2013). Fitzpatrick and Shaffer

(2007) conjecture that the hybrid swarm may have remained contained within the Salinas Valley during this time because of its relative high amount of perennial breeding ponds that contain non-native tiger salamanders compared to other areas to the north that have more natural seasonal pools and native Central California tiger salamanders. Fitzpatrick and Shaffer (2007) point out that the two areas of the Salinas watershed with pure or nearly pure native tiger salamanders (Fort Ord and Peachtree Valley) have high concentrations of natural seasonal pools.

Fitzpatrick et al. (2009, 2010) identified genetic markers that have been labelled as "superinvasive" (SI) because the markers become fixed in the population within ponds almost instantaneously. The SI markers become fixed in the population, which represents a loss of the alternate native genes. However, it is unknown what trait(s) is reflected through these SI markers (*i.e.*, what effects do these SI markers have on Central California tiger salamander appearances or behaviors?), and whether this threatens the persistence of the Central California tiger salamander. Preliminary data suggest that the SI markers act in concert to affect aspects of larval growth and body size at metamorphosis (Johnson et al. 2010b), but it appears that pure Central California tiger salamanders and salamanders with only SI markers behave ecologically similarly (Searcy et al. 2014). These SI markers appear to extend from the Salinas Valley introduction sites north to Alameda County, with only the far-northern portion of Alameda County being free of SI markers (Shaffer et al. 2013). In addition, SI markers have been detected in Olcott Lake, in Solano County (Shaffer et al. 2013).

Effects of Ponding Duration on Native California Tiger Salamander and Hybrids

Natural vernal pools and ephemeral wetlands with short ponding durations (*i.e.*, approximately 3 months) favor reproductive success for native California tiger salamanders, and similarly, non-native genes are favored in permanent ponds (Riley et al. 2003; Fitzpatrick and Shaffer 2004; Johnson et al. 2013). Most breeding sites that are currently available are perennial, which favors non-native salamanders (Riley et al. 2003; Johnson et al. 2013). Perennial ponds tend to be larger and may have more consistent breeding and recruitment across years, which may also give the non-native tiger salamanders an advantage on a landscape scale because they are able to have a much higher reproductive success rate when compared to the native California tiger salamander (Fitzpatrick and Shaffer 2004). In addition, non-native barred tiger salamanders and their hybrids can opportunistically forgo metamorphosis in perennial ponds and reproduce as sexually mature paedomorphs (adult salamander with larval characteristics such as gills) (Collins et al. 1988). Perennial ponds in areas where California tiger salamanders and non-native tiger salamander hybrids occur often contain paedomorphic tiger salamanders and the paedomorphs have an advantage over the native California tiger salamander because they breed earlier, they are larger in size, females produce more eggs (Rose and Armentrout 1976; Fizpatrick and Shaffer 2004), and paedomorphs will cannibalize other tiger salamanders (Rose and Armentrout 1976; Collins et al. 1988).

<u>Contaminants</u>

Contaminants were considered a threat to Central California tiger salamanders at the time of listing (Service 2004), and contaminants are still considered a threat at this time. Literature suggests that contaminants have played a role in global amphibian declines (Alford and Richards

1999; Blaustein and Kiesecker 2002). Amphibians in general are extremely sensitive to contaminants due to their highly permeable skin which can rapidly absorb pollutant substances (Blaustein and Wake 1990). Sources of chemical pollution that may adversely affect Central California tiger salamanders include hydrocarbon and other contaminants from oil production and road runoff, the application of chemicals for agricultural production and urban/suburban landscape maintenance, increased nitrogen levels in aquatic habitats, and rodent and vector control programs (Service 2004).

There has been very little research on the effects of contaminants on California tiger salamanders. Currently, the sensitivity of the Central California tiger salamander to pesticides, heavy metals, air pollutants, and other contaminants is largely unknown. Strong evidence has shown that pesticide application on properties adjacent to Central California tiger salamander populations in Salinas Valley contributed to larval die-offs (Ryan et al. 2012). Even if pesticides don't cause direct mortality, they can have an indirect effect on salamanders. For example, exposure to pesticides has been shown to slow *Ambystoma* species' larval growth (Larson et al. 1998), increase susceptibility to viral infections (Forson and Storfer 2006a, b; Kerby and Storfer 2009), and increase susceptibility to predation (Verrell 2000).

Methods of mosquito control include the application of chemicals such as methoprene, which disrupts the molting process in insect larvae. The use of methoprene and other insecticides will likely have an indirect adverse effect on California tiger salamanders by reducing the availability of prey species. The Service is not aware of research on the direct effects of methoprene on California tiger salamanders. Research has shown that it may not affect amphibians at low concentrations (Ankley et al. 1998; Degitz et al. 2003). We are unable to determine the level of threat posed by the use of mosquito abatement chemicals at this time. However, we believe the use of mosquito abatement chemicals is a potential threat to the species that requires further monitoring and analysis.

Livestock Grazing

Livestock grazing was listed as a potential threat to the species at the time of listing (2004). The Service (2004) stated that livestock grazing is for the most part compatible with the continued successful use of rangelands by the California tiger salamander, provided the grazed areas do not also have intensive burrowing rodent control efforts. As such, the 4(d) rule issued with the final listing rule exempts existing routine ranching activities from prohibitions under section 9 of the Endangered Species Act (Service 2004). Low to moderate levels of cattle grazing do not appear to have an effect on the population dynamics of California ground squirrels, including both the density or the spatial distribution of active burrow entrances within colonies of California ground squirrels (Fehmi et al. 2005). In fact, livestock management can be used as a tool to improve habitat for the Central California tiger salamander. For example, taller grass, or grass with significant thatch build-up, may make dispersal more difficult for migrating California tiger salamanders. In addition, taller grass heights resulting from a lack of grazing have been associated with declines in ground squirrel populations (EDAW 2008; Ford et al. 2013).

Climate Change

Climate change was not considered a threat to California tiger salamanders at the time of listing. However, climate change is considered a potential threat at this time. Climate simulations predict that average annual temperatures in California will rise (Field et al. 1999; Cayan et al. 2008), there will be increases in winter precipitation (particularly in the mountains), and more precipitation will fall as rain than snow (Field et al. 1999). These climate simulation studies offer statewide averages and generalizations, but because of the diversity of California's landscape, it is unknown at this time how climate change will affect local areas; and the effects of climate change are likely to vary greatly from one place to another (Field et al. 1999). While it appears reasonable to assume that California tiger salamanders may be affected by factors resulting from climate change, we lack sufficient certainty about how and how soon climate change will affect the species. The distribution of the Central California tiger salamander spans a considerable range in climatic conditions, and we do not know yet how the various sub-populations of the Central California tiger salamander might differ in their responses to climate change.

Because California experiences highly variable annual rainfall events and droughts, California tiger salamanders have adapted a life history strategy to deal with these inconsistent environmental conditions. For example, given the sensitivity of California tiger salamander breeding success to rainfall amounts and timing, different breeding habitats may serve as sources in different years, buffering the metapopulation against climatic variability (Cook et al. 2005). However, despite these life history strategies, climate change could result in even more erratic weather patterns that California tiger salamanders cannot adapt to quickly enough. If a drought occurs, ponds may not persist long enough for larvae to transform and temperature extremes or fluctuations in water levels during the breeding season may kill large numbers of embryos. Presumably, the longevity of adult California tiger salamanders is sufficient to ensure local population survival through all but the longest droughts (Barry and Shaffer 1994). However, if long term droughts become the norm in the future, this will have significant implications for California tiger salamanders, because the ponds they depend on for breeding may not hold water long enough to support breeding populations. In addition, drought conditions favor non-native hybrid tiger salamanders in areas where hybrids occur (Johnson et al. 2010b; B. Shaffer, pers. comm., 2014).

H. Conservation Efforts

Numerous agencies, non-governmental organizations, and private landowners are engaged in the protection of Central California tiger salamander habitat. Protected habitat within the range of the Central California tiger salamander is depicted in Figure 3 of Appendix A. The Service has determined that over 550,000 acres of suitable Central California tiger salamander habitat is protected by conservation easement or owned in fee title by government agencies or other conservation organizations. Of this total, over 340,000 acres of land have known occurrences of Central California tiger salamander, although this figure includes properties that are only partially occupied. The Service summarizes these properties in the 5-year review for this species (Service 2014). Included within this acreage amount are 12 conservation banks, totaling 7,993 acres in size, that have been established to sell credits for the Central California tiger salamander to offset impacts from projects that result in the loss or degradation of this species' habitat. There are currently four safe harbor agreements that provide a net conservation benefit for Central California tiger (safe harbor agreements are voluntary conservation actions implemented by non-Federal landowners in exchange for incidental take of the covered species). The Service has enrolled over 40,000 acres of habitat under safe harbor agreements for this species. Additional information regarding these agreements is provided in the 5-year review (Service 2014).

II. RECOVERY PROGRAM

This section describes the Central California tiger salamander recovery program by defining the recovery goal and objectives, outlining a strategy, identifying where recovery will occur (recovery units), and delineating criteria to delist the species.

A. Recovery Strategy

The strategy to recover the Central California tiger salamander focuses on alleviating the threat of habitat loss and fragmentation in order to increase population resiliency (ensure each population is sufficiently large to withstand stochastic events), redundancy (ensure a sufficient number of populations to provide a margin of safety for the species to withstand catastrophic events), and representation (conserve the breadth of the genetic makeup of the species to conserve its adaptive capabilities). Recovery of this species can be achieved by addressing the conservation of remaining aquatic and upland habitat that provides essential connectivity, reduces fragmentation, and sufficiently buffers against encroaching development and intensive agricultural land uses. Appropriate management of these areas will also reduce mortality by addressing non-habitat related threats, including those from non-native and hybrid tiger salamanders, other non-native species, contaminants, disease, and road mortality. Research and monitoring should be undertaken to determine the extent of known threats, identify new threats, and reduce threats to the extent possible.

The recovery strategy is intended to establish healthy, self-sustaining populations of Central California tiger salamanders through the protection and management of upland and aquatic breeding habitat, as well as the restoration of aquatic breeding habitat where necessary. It also ensures habitat management and monitoring and the conducting of research. Due to shifting conditions in the ecosystem (*e.g.*, invasive species, unforeseen disease, climate change, and effects from future development and conversion to agriculture), the Service anticipates the need to adapt actions that implement this strategy over time. The recovery strategy ensures that the genetic diversity of the Central California tiger salamander is preserved throughout the DPS to allow adaptation to local environments, maintenance of evolutionary potential for adaptation to future stresses, and reduction in the potential for genetic drift and inbreeding to result in inbreeding depression.

B. Recovery Units

The range of the Central California tiger salamander has been classified into four recovery units. These recovery units are not regulatory in nature; the boundaries of the recovery units do not identify individual properties that require protection, but they are described solely to facilitate recovery and management decisions. The recovery units represent both the potential extent of Central California tiger salamander habitat within the species' range and the biologically (genetically) distinct areas where recovery actions should take place that will eliminate or ameliorate threats. These actions are presented in detail in Section E: Recovery Actions. All recovery units must be recovered to achieve recovery of the DPS.

Definitions

***Recovery Unit*:** A special unit of the listed species range that is geographically or otherwise identifiable and is essential to the recovery of the entire listed DPS. Recovery Units are individually necessary to conserve genetic distinctiveness, demographic robustness, important life history stages, or other features necessary for the long-term sustainability of the entire listed DPS.

***Management Unit*:** These subdivisions of recovery units are areas that might require different management, that might be managed by different entities, or that might encompass different populations. In this recovery plan, the management units are primarily administrative in that they serve to organize the recovery units into separate and approximately equal areas that will assist in managing the implementation of the recovery actions.

***Population*:** A cluster of locality records in a contiguous habitat area. In this recovery plan, a local population can be either one pond or clusters of ponds in close proximity to each other, occupied by one breeding group.

Methodology for Defining Recovery Units

The Central California tiger salamander's historical range encompasses the San Joaquin-Sacramento river valleys, bordering foothills, and coastal valleys of Central California. The habitat characteristics, species status, threats, and needed recovery actions vary across this large geographic area. We have approached recovery planning by dividing the Central California tiger salamander's broad geographic range into four recovery units. These units were created to ensure conservation of the breadth of the Central California tiger salamander's genetic variability (each recovery unit is genetically unique, as described in Section I.B: Species Description and Taxonomy).

Because of the genetic distinctiveness of the recovery units, recovery in each of these units is essential to recovery of the DPS as a whole. Therefore, recovery criteria must be achieved within each designated recovery unit to achieve recovery of the DPS. Recovery units do not represent distinct population segments nor do they reflect designated critical habitat. The recovery units established in this draft recovery plan are based on the unique genetics represented within each area. Maintaining representation throughout the range is necessary for the long-term recovery and conservation of Central California tiger salamander. Specifically, protecting populations distributed throughout the range conserves the natural range of genetic variation of the species, helping ameliorate the vulnerability of a species to environmental fluctuations and catastrophes and protecting evolutionary potential.

The recovery units also contain management units. These management units were created to manage recovery units at a finer scale, as well as to ensure that the full genetic, geographic and ecological range of each distinct recovery unit is represented. The management units face differing levels of threats and may require different management techniques. In this recovery plan, the management units serve to organize the recovery units into separate and approximately equal areas that will assist in managing the implementation of the recovery actions. By ensuring preservation and management actions within each management unit, this recovery plan ensures the conservation of self-sustaining populations of Central California tiger salamanders throughout the full ecological, geographical, and genetic range of the species. The recovery units and management units are illustrated in Figure 5 of Appendix A.

Description of Recovery Units and Management units

The Central Valley Recovery Unit

The Central Valley Recovery Unit occurs in the following Counties: Yolo, Sacramento, Solano, eastern Contra Costa, northeast Alameda, San Joaquin, Stanislaus, Merced, and northwestern Madera. The Central Valley Recovery Unit contains the following 12 management units: (1) Dunnigan Hills; (2) Jepson Prairie; (3) Concord/Livermore; (4) West Side Central Valley; (5) San Luis NWR/Sandy Mush; (6) Rancho Seco; (7) Lockeford; (8) Farmington; (9) Oakdale/Waterford; (10) Hickman/Snelling; (11) Merced; and (12) Le Grand/Raymond. Some management units within this recovery unit, such as Jepson Prairie, have large amounts of habitat protected and have been extensively surveyed and monitored. Other areas, such as Dunnigan Hills, Farmington, Oakdale/Waterford, Hickman/Snelling, and Le Grand/Raymond have very little survey information and very little habitat protected. The management units along the western slope of the Sierra Nevada foothills are also facing a high degree of threat from conversion to agriculture. Conserving rangeland within this area is a high priority. Hybrid tiger salamanders are known to occur in the Le Grand/Raymond and Merced management units in Merced County (Service 2014). Hybrids have also been reported in multiple ponds in the Altamont Pass area (S. Wenner, pers. comm. 2015).

The Southern San Joaquin Valley Recovery Unit

The Southern San Joaquin Valley recovery unit occurs in portions of Madera, central Fresno, and northern Tulare and Kings Counties. The Southern San Joaquin Valley recovery unit contains the following three management units: (1) Little Table Mountain; (2) Fresno; and (3) Orange Cove/Stone Corral. Some habitat protection occurs within this recovery unit, although most populations remain unprotected. Conserving rangeland is a high priority for this recovery unit. The majority of populations within this recovery unit have not been monitored for population status, trends, and threats.

The Bay Area Recovery Unit

The Bay Area recovery unit occurs in the following Counties: central and southern Alameda; Santa Clara; western Stanislaus; western Merced; and the majority of San Benito. The Bay Area recovery unit contains the following six management units: (1) North Diablo Range; (2) Northeast Diablo Range; (3) Northwest Diablo Range; (4) East Santa Cruz Mountains; (5) Southwest Diablo Range; and (6) Southeast Diablo Range. This recovery unit has a high degree of habitat protection relative to the other recovery units. However, the majority of populations within this recovery unit have not been monitored for population status, trends, and threats. Hybridization with non-native tiger salamanders is a threat to some populations within this recovery unit (Service 2004).

The Central Coast Range Recovery Unit

The Central Coast Range recovery unit occurs in portions of southern Santa Cruz, Monterey, northern San Luis Obispo, and portions of western San Benito, Fresno, and Kern Counties. The Central Coast range recovery unit contains the following six management units: (1) Fort Ord; (2) Carmel Valley; (3) Salinas Valley; (4) Peachtree Valley; (5) Bitterwater; and (6) Fort Hunter Liggett. Some habitat protection has occurred within this recovery unit; however, most populations are not protected and have not been monitored for population status, trends, and threats. The primary threat to populations within this recovery unit is hybridization with non-native tiger salamanders. Maintaining the genetic integrity of Central California tiger salamanders within this recovery unit is a priority. The origin of hybrid tiger salamanders at Fort Hunter Liggett is unknown at this time, and it is unknown if hybrids were introduced into a native population of Central California tiger salamanders or whether hybrids were introduced to previously unoccupied habitat (DoD 2011).

C. Recovery Goals and Objectives

The ultimate goal of this recovery plan is to outline specific actions that, when implemented, will sufficiently reduce the threats to the Central California tiger salamander, ensure its long-term viability in the wild, and allow for its removal from the list of threatened and endangered species.

To meet the recovery goal, the following objectives have been identified:

1. Permanently protect the habitat of self-sustaining populations of Central California tiger salamander throughout the full range of the DPS, ensuring conservation of genetic variability and diverse habitat types (*e.g.*, high and low elevation sites and areas with higher and lower rainfall).

2. Ameliorate or eliminate the current threats to the species.

3. Restore and conserve a healthy ecosystem supportive of Central California tiger salamander populations.

D. Recovery Criteria

Recovery criteria are conditions that, when met, are likely to indicate that a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. Because the appropriateness of downlisting and delisting is assessed by evaluating the five threat factors identified in the Act, the recovery criteria below pertain to and are organized by these factors. Because the Central California tiger salamander is a threatened species, we have only included delisting recovery criteria below. These recovery criteria are our best assessment at this time of what needs to be completed so that the species may be removed from the list of threatened and endangered species. Because we cannot envision the exact course that recovery may take, and because our understanding of the vulnerability of a species to threats is likely to change as more is learned about the species and its threats, it is possible that a status review may indicate that delisting is warranted although not all recovery criteria are met.

Conversely, it is possible that the recovery criteria could be met and a status review may indicate that delisting is not warranted. For example, a new threat may emerge that is not addressed by the current recovery criteria. Justification for recovery criteria are provided in Appendix B.

In some cases, the target for protected habitat specified in delisting criteria has already been met. For example, multiple management units within the Bay Area recovery unit (*e.g*., North Diablo, Northeast Diablo, and Northwest Diablo management units) and the Central Valley recovery unit (*e.g*., Jepson Prairie, Concord/Livermore, San Luis NWR/Sandy Mush, and Merced management units) have sufficient amounts of habitat protected to satisfy or exceed criteria set forth in this Recovery Plan.

<u>Delisting Criteria</u>

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Recovery criteria A/1 through A/4, below, will ameliorate or eliminate the threat of habitat loss to an extent that it is no longer a threat to Central California tiger salamander populations. This will be accomplished through habitat preservation (in fee title or easement). Requirements for preserves described in criteria A/1through A/4 are described below.

Number of preserves. The number of preserves required within each recovery unit is provided in recovery criteria A/1 through A/4.

Preserve Size. Minimum preserve size is 3,398 acres (1,375.1 hectares) (see Justification for recovery criteria in Appendix B).

Breeding Habitat - Each 3,398-acre area (the minimum preserve size) of protected habitat will have at least four ponds (see Justification for recovery criteria in Appendix B). If more ponds are available, a smaller surface area is required. See Table 3 for a description of pond sizes expected to result in sustainable Central California tiger salamander populations.

Table 3: Required number of ponds and corresponding amount of surface-area.

Number of Ponds	**Minimum Surface Area of Each Pond (Acres)**	**Total Minimum Surface Area of Ponds (Acres)**
4	0.9	3.6
5	0.4	2
6	0.2	1.2
7	0.1	1
8	0.1	0.8
9	0.09	0.8
10	0.07	0.7

Upland Habitat – Upland habitat will contain at least one moderately-sized burrowing mammal colony [as defined by having at least 50 active burrow entrances within a 656-foot (200-meter) radius] that occurs within the average dispersal distance of the salamander

[1,844 feet (562 meters) (Searcy and Shaffer 2011)] of each breeding pond.

A/1 Protection of sufficient high quality habitat within all management units of the Central Valley recovery unit to ensure sustainable Central California tiger salamander populations.

There are 12 management units within the Central Valley recovery unit. Table 4 specifies the target number of preserves for this recovery unit and their distribution by management unit. In addition, each preserve needs to meet the minimum preserve size (3,398 acres), as well as breeding and upland habitat characteristics described in the introduction for Factor A.

Table 4: Target number of preserves and total acreage to be preserved in the Central Valley recovery unit.

Management unit	Size of Management unit (acres)	Number of Preserves	Required Total Area Preserved (acres)
Jepson Prairie	123,286	4	13,592
Dunnigan Hills	193,126	4	13,592
Concord/ Livermore	238,504	5	16,990
Central Valley West Side	151,622	2	6,796
San Luis NWR/ Sandy Mush	152,664	5	16,990
Rancho Seco	207,093	5	16,990
Lockeford	126,142	4	13,592
Farmington	211,291	5	16,990
Oakdale/ Waterford	145,128	5	16,990
Hickman/Snelling	117,884	4	13,592
Merced	189,671	5	16,990
Le Grand/ Raymond	207,012	5	16,990
Total	**2,063,423**	**53**	**180,094**

A/2 Protection of sufficient high quality habitat within all management units of the southern San Joaquin Valley recovery unit to ensure sustainable Central California tiger salamander populations.

There are three management units within the San Joaquin Valley recovery unit. Table 5 specifies the target number of preserves for this recovery unit and their distribution by management unit. In addition, each preserve needs to meet the minimum preserve size (3,398 acres), as well as breeding and upland habitat characteristics described in the introduction for Factor A.

Table 5: Target number of preserves and total acreage to be preserved in the Southern San Joaquin Valley recovery unit.

Management unit	**Size of Management unit (acres)**	**Number of Preserves**	**Required Total Area Preserved (acres)**
Little Table Mountain	188,679	5	16,990
Fresno	260,709	5	16,990
Orange Cove/Stone Corral	236,684	5	16,990
Total	**686,072**	**15**	**50,970**

A/3 Protection of sufficient high quality habitat within all management units of the Bay Area recovery unit to ensure sustainable Central California tiger salamander populations.

There are six management units within the Bay Area recovery unit. Table 6 specifies the target number of preserves for this recovery unit and their distribution by management unit. In addition, each preserve needs to meet the minimum preserve size (3,398 acres), as well as breeding and upland habitat characteristics described in the introduction for Factor A.

Table 6: Target number of preserves and total acreage to be preserved in the Bay Area recovery unit.

Management unit	**Size of Management unit (acres)**	**Number of Preserves**	**Required Total Area Preserved (acres)**
North Diablo Range	178,257	5	16,990
Northeast Diablo Range	258,242	5	16,990
Northwest Diablo Range	406,418	5	16,990
Santa Cruz Mountains	78,774	4	13,592
Southwest Diablo Range	551,730	5	16,990
Southeast Diablo Range	258,990	5	16,990
Total	**1,732,411**	**29**	**98,542**

A/4 Protection of sufficient high quality habitat within all management units of the Central Coast Range recovery unit to ensure sustainable Central California tiger salamander populations.

There are six management units within the Central Coast Range recovery unit. Table 7 specifies the target number of preserves for this recovery unit and their distribution by management unit. In addition, each preserve needs to meet the minimum preserve size (3,398 acres), as well as breeding and upland habitat characteristics described in the introduction for Factor A.

Table 7: Target number of preserves and total acreage to be preserved in the Central Coast Range recovery unit.

Management unit	Size of Management unit (acres)	Number of Preserves	Required Total Area Preserved (acres)
Fort Ord	79,290	2	6,796
Carmel Valley	120,309	3	10,194
Salinas Valley	333,044	4	13,592
Peachtree	571,440	4	13,592
Bitterwater	387,120	4	13,592
Fort Hunter Liggett	138,816	4	13,592
Total	**1,630,019**	**21**	**71,358**

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for any purpose is not known to be a threat to the Central California tiger salamander at this time. Therefore, no recovery criteria have been developed for this factor.

FACTOR C: Disease or Predation

To delist the Central California tiger salamander, the threat of disease and predation must be controlled or eliminated. This will be accomplished when the following have occurred:

Disease

C/1 Reduce potential that ranaviruses or other pathogens are introduced to Central California tiger salamander populations.

Management plans incorporate measures to ensure that ranaviruses or other pathogens are not introduced to Central California tiger salamander populations within all protected habitat areas counted toward recovery. Measures include ensuring that potential pathogen hosts (*e.g.*, non-native tiger salamanders, other non-native amphibians, and fish species) are not introduced within known or potential Central California tiger salamander habitat, and protocols to ensure sterilization of all field equipment are enforced.

C/2 Ensure early detection of ranaviruses and other pathogens if they are introduced to Central California tiger salamander populations in the future.

Monitoring for ranaviruses and other pathogens are incorporated into management plans (see Criteria E/4). Management plans include contingency plans to quickly isolate infected populations should a ranavirus or other pathogen be detected.

Predation

C/3 Ensure that threats to the Central California tiger salamander from predation are controlled or ameliorated to an extent they are not a threat to Central California tiger salamander populations.

Wherever feasible, hydrology of aquatic breeding habitat will be managed to create optimal breeding habitat conditions for the Central California tiger salamander within all protected areas counted toward recovery. Ideally, all aquatic breeding habitat should be ephemeral to ensure that fish, bullfrogs, and other non-native species cannot establish breeding populations. If the breeding habitat is perennial, then the aquatic habitat will be free from breeding populations of non-native predators, such as bullfrogs and fish.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The inadequacy of existing regulatory mechanisms is not known to be a threat to the Central California tiger salamander at this time. Therefore, no recovery criteria have been developed for this factor.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

Other natural or manmade factors include: mortality from road crossings, hybridization with non-native tiger salamanders, contaminants, mosquito control efforts, livestock grazing, and climate change. To delist the Central California tiger salamander, these threats must be ameliorated or eliminated. This will have been accomplished when the following have occurred:

Hybridization with Non-Native Tiger Salamanders

E/1 All Central California tiger salamander populations on protected lands counted toward recovery are native and show no evidence of hybrid genes for at least 26 years (approximately two Central California tiger salamander lifespans), and no known hybrids are within dispersal distance (1.3 miles) of these protected populations, unless significant barriers to dispersal are present.

At this time, the Service considers genetically pure individuals and those hybrids with only SI markers to count toward recovery. This criterion may be modified in the future as further information is obtained regarding SI markers and the potential for these markers to be a threat to native Central California tiger salamanders.

Exposure to Contaminants

E/2 Ensure that effects to the Central California tiger salamander from contaminants are controlled or ameliorated to an extent they are not a threat to the Central California tiger salamander populations.

All protected areas counted toward recovery are assessed for presence of contaminants. If present, contaminants are assessed for potential adverse effects to Central California tiger salamander populations. If contaminants are determined to have potential adverse effects to the salamander (*i.e.*, result in a non-sustainable Central California tiger salamander population - see E/6 - *Resilience to Stochastic Events*), then a site specific plan will be created to ensure that the effect of the contaminant is resolved, and monitoring will continue until it is determined that the contaminant(s) is no longer a threat.

Mortality from Road Crossings

E/3 Ensure that effects to the Central California tiger salamander from road mortality are controlled or ameliorated to an extent they are not a threat to the Central California tiger salamander populations.

All roads within protected areas counted toward recovery are assessed for road mortality issues. All roads identified as having high levels of road crossing mortality that prevent sustainable salamander populations are identified and measures are implemented to reduce mortality. Measures may include retro-fitting existing roads with wildlife tunnels or constructing elevated roads that allow for salamanders to travel under the road to suitable habitat on the other side of the road. See E/6 - *Resilience to Stochastic Events*.

Management Plans

E/4 Each preserve counted toward recovery has site-specific management plans to maintain habitat suitability in perpetuity and monitor for threats.

Management plans have been developed and implemented that specifically target management of Central California tiger salamander habitat to maintain habitat suitability in perpetuity. Management plans will be updated based on the results of research on life history and behavior of the Central California tiger salamander and information generated from management of existing conservation lands, and they will be adaptive to climate change and other variables.

Management should include, but is not limited to, creation or restoration of breeding habitat, maintenance of wetlands to ensure optimum breeding conditions, livestock grazing management, and monitoring for threats such as hybridization, contaminants, non-native predators, and disease.

Climate Change

E/5 Central California tiger salamander populations occur throughout the current geographic and elevational range of the DPS to maximize their ability to adapt to changing air temperature, ponding duration, and other factors in light of future climate change.

This criterion will be accomplished through criteria A/1 through A/4.

Resilience to Stochastic Events

E/6 Criteria A/1 through A/4 have been met, and monitoring of Central California tiger salamander breeding habitat has resulted in each preserve having at least a minimum effective population size of 132 individuals over a 26 year period.

Each preserve counted toward recovery will have a minimum effective population size of 132 individuals; this number has been determined by the Service to be necessary to achieve a minimum viable population size, based on information provided by the following: Trenham et al. 2001; Traill et al. 2007; Searcy and Shaffer 2008; Wang et al. 2011; and C. Searcy, pers. comm., 2013b and 2015.

III. RECOVERY ACTION NARRATIVE AND IMPLEMENTATION SCHEDULE

The following Implementation Schedule includes a step-down narrative, which is comprised of nine overarching elements that in turn, tier down to individual recovery actions for implementation. The Implementation Schedule outlines actions and estimated costs for this draft recovery plan. It is a guide for meeting the objectives discussed in Chapter II. This schedule also prioritizes actions, provides estimated costs and a timetable for performance of actions, and proposes the responsible parties for actions. For the sake of brevity in the Implementation Schedule, annual costs are shown for the first 5 years, along with an estimated total cost to achieve full recovery. Actions are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions. The most detailed actions are assigned a priority number for implementation. The actions in the Implementation Schedule, when accomplished, should further the recovery and conservation of the species.

Key to Terms and Abbreviations Used in the Implementation Schedule:

Priority numbers are defined per Service policy (Service 1983) as:

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline in the species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Definition of Action Durations:

Continual: An action that is not currently being implemented but will be implemented continuously throughout the recovery period once begun.

Ongoing: An action that is currently being implemented and will continue throughout the recovery period.

TBD: To Be Determined.

Responsible Parties:

BLM Bureau of Land Management
Caltrans California Department of Transportation
CB Conservation Banks
CDFW California Department of Fish and Wildlife

CDPR California Department of Parks and Recreation
CRT California Rangeland Trust
CVP Central Valley Project Conservation Program
FHWA Federal Highway Administration
LA Local Agencies (examples include regional and county park districts, municipal utility districts, HCP/NCCP implementing entities, and county public works agencies)
NGO Non-government organization
NPS National Park Service
NRCS Natural Resources Conservation Service
RCD Resource Conservation District
UC NRS University of California Natural Reserve System
UNIV University
USFWS U.S. Fish and Wildlife Service
WCB Wildlife Conservation Board
ALL All responsible parties

Responsible parties are those agencies who may voluntarily participate in implementation of particular actions listed within this draft recovery plan. Responsible parties may willingly participate in project planning, or may provide funding, technical assistance, staff time, or any other means of implementation; however, responsible parties are not obligated to implement any of these actions. Parties other than those listed as Responsible Parties are also encouraged to participate in recovery actions for the Central California tiger salamander.

Implementation Schedule for the Central California Tiger Salamander											
Recovery Action Information					**Cost estimate in $1,000 units**						
Number	**Priority**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2017**	**2018**	**2019**	**2020**	**2021**	**Comments/Notes**
1.0	**Maintain current distribution of species.** Maintaining the current distribution of the species will increase the resiliency of the Central California tiger salamander to withstand stochastic events and ensure that the genetic diversity of the species is maintained.										
1.1		Protect Central California tiger salamander habitat as described in recovery criteria A/1 to A/4.									
1.1.1	1	Protect Central California tiger salamander habitat by: (1) purchasing of land by a government agency or conservation organization in fee title; or, (2) purchasing a conservation easement for privately-owned lands. Whenever possible, prioritize preservation of land that includes natural vernal pool breeding habitat, then land that includes ephemeral pond breeding habitat that remains dry for at least 30 days prior to fall rains.	50 years	BLM, CB, CDFW, CDPR, CRT, CVP, LA, NGO, NPS, NRCS, UC NRS, USFWS, WCB	$69,200	1,384	1,384	1,384	1,384	1,384	Assumes properties are protected through conservation easements. Estimated cost will be approximately 40% higher if through fee title.
1.1.2	1	Prioritize protection of habitat that will create corridors between metapopulations. Sufficient connectivity between breeding locations allows for genetic exchange and recolonization.	O	BLM, CB, CDFW, CDPR, CRT, CVP, LA, NGO, NPS, NRCS, UC NRS, USFWS, WCB							Included in 1.1.1 cost estimate.
1.2		Ensure that high-quality breeding habitat is available within protected habitat.									
1.2.1	2	Perennial ponds should be drained annually to replicate the conditions described above in action 1.2.2. If not feasible to drain a pond annually, even a one-time draining event will benefit Central California tiger salamanders by removing fish species and removing paedomorphs in areas where hybrids occur.	C	BLM, CDFW, CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS	TBD						The cost of this action is unknown at this time. The number of ponds that will require draining is unknown, and methods for draining ponds will vary (*e.g.*, installation of drains, use of pumps, or other techniques).
1.2.2	1	Ensure that funding is secured for maintenance of livestock ponds on protected habitat in perpetuity. Many livestock ponds have a lifespan of 30-50 years and will require spillway/berm repair and sediment or vegetation removal during this time span.	C	BLM, CB, CDFW, CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS	TBD						Cost of maintenance will vary depending on repair/maintenance needs, permit requirements, location, etc.
1.2.3	2	Create breeding habitat in areas where breeding habitat is limited. Created breeding habitat should	C	BLM, CB, CDFW,	TBD						Cost will vary depending on how many properties will require creation of additional

Implementation Schedule for the Central California Tiger Salamander											
Recovery Action Information					**Cost estimate in $1,000 units**						
Number	**Priority**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2017**	**2018**	**2019**	**2020**	**2021**	**Comments/Notes**
		hold water long enough for Central California tiger salamanders to successfully metamorphose (typically 3 months is desirable) and be dry for at least 30 days before the rains begin in the fall, to limit breeding populations of bullfrogs, fish, crayfish, and non-native tiger salamanders.		CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS							breeding sites. In addition, the cost of each instance of habitat creation can range from a few thousand dollars to tens of thousands of dollars, depending on size, surrounding habitat, and other factors.
1.3		Ensure that high-quality upland habitat is available within protected habitat.									
1.3.1	1	Implement measures to increase ground squirrel, pocket gopher, or other small mammal burrowing populations. This may be accomplished through livestock management, modification or discontinuation of small burrowing mammal eradication efforts, or enhancing habitat for small burrowing mammals.	O	BLM, CB, CDFW, CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
1.3.2	3	Remove exotic or invasive vegetation to ensure sufficient upland grassland habitat is available for burrowing mammal populations that support the Central California tiger salamander's habitat.	O	BLM, CB, CDFW, CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation. Priority is "1" in areas where upland habitat is extremely limited, such as Ellicot Slough NWR.
1.4		Work with partnership and funding programs to protect and manage habitat for the Central California tiger salamander.									
1.4.1	3	Work with private landowners to provide funding, technical assistance, and other resources to benefit the Central California tiger salamander.	O	CDFW, NRCS, RCD, USFWS,							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
1.4.2	2	Coordinate with partners to ensure that mitigation required in HCPs and NCCPs is coordinated and aids in the recovery of the Central California tiger salamander.	O	CDFW, USFWS, LA							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
1.4.3	2	Coordinate with partners to prioritize the conservation of rangeland within the range of the Central California tiger salamander.	C	CDFW, CRT, CVP, NGO, NRCS, RCD, USFWS, WCB							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
2.0	**Maintain genetic structure across the species range.** The preservation of genetic diversity is necessary to preserve genes adapted to local environments, maintain evolutionary potential for adaptation to future stresses, and reduce the potential for inbreeding depression. Recovery actions described in 1.1 will assist in this recovery action as well.										

Implementation Schedule for the Central California Tiger Salamander											
Recovery Action Information					**Cost estimate in $1,000 units**						
Number	**Priority**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2017**	**2018**	**2019**	**2020**	**2021**	**Comments/Notes**
2.1		Decrease threat of hybrid tiger salamanders.									
2.1.1	1	Conduct targeted eradication of hybrid tiger salamander populations when determined to be beneficial to the DPS as a whole.	C	BLM, CB, CDFW, CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS	TBD						Costs are unknown at this time, because the extent of this action still needs to be determined. Prior to conducting these actions, the Service and CDFW should be consulted.
2.1.2	1	Reintroduce native Central California tiger salamanders once hybrids are eradicated from an area.	C	BLM, CB, CDFW, CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS	TBD						Costs are unknown at this time, because the extent of this action still needs to be determined. Prior to conducting these actions, the Service and CDFW should be consulted.
2.1.3	1	Ensure that created breeding habitat in areas where hybrids occur is ephemeral and hydrology favors native California tiger salamander genotypes.	C	BLM, CB, CDFW, CDPR, NGO, NRCS, NPS, RCD, LA, UC NRS, USFWS	TBD						Cost will vary depending on how many breeding ponds will be created within areas where hybrids occur.
2.2	1	Translocate Central California tiger salamanders within the same recovery unit. If it is determined that individual Central California tiger salamanders need to be translocated to another area, it should be as close to the original location as possible, and absolutely within the same recovery unit.	O	CDFW, USFWS							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation. Prior to translocation, the Service and CDFW should be consulted. Translocation activities should follow recommendations in Shaffer et al. (2008).
2.3	3	Conduct education to inform the public that it is illegal to use *Ambystoma* sp. as bait in California.	C	CDFW, CDPR, NGO, LA, USFWS							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
2.4	3	Develop a genetic monitoring plan for each recovery unit. Knowledge about genetics of local populations will inform decisions regarding relocations, hybrid tiger salamander eradication efforts, and identification of high priority areas for breeding habitat modification to favor native genotypes.	C	BLM, CDFW, CDPR, LA, NGO, NPS, UNIV, USFWS							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
3.0	**Reduce road mortality.**										
3.1	3	Coordinate with transportation agencies to incorporate wildlife tunnels in design plans for new	C	Caltrans, CDFW,							Costs are incidental to normal operating budget for ongoing coordination and

Implementation Schedule for the Central California Tiger Salamander											
Recovery Action Information					**Cost estimate in $1,000 units**						
Number	**Priority**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2017**	**2018**	**2019**	**2020**	**2021**	**Comments/Notes**
		roads and road improvement projects to decrease Central California tiger salamander road mortality.		FHWA, LA, USFWS							conservation implementation.
3.2	3	Upgrade existing roads to include wildlife tunnels to decrease Central California tiger salamander road mortality.	C	All	TBD						
4.0	**Reduce the risk of introduction of diseases (*e.g.*, ranaviruses or other pathogens) within preserves.**										
4.1.1	3	Monitor breeding sites to detect disease outbreaks. Monitoring should be conducted during the breeding season to detect rapid die-offs of larvae, which may be the result of ranavirus or other pathogens.	C	USFWS, CDFW, NGO, LA							Included in 6.1 cost estimate.
4.1.2	3	Determine the cause of die-offs. If a rapid die-off is detected, tests for ranaviruses or other pathogens should be conducted immediately. Land managers should coordinate with the Service and CDFW to determine the appropriate next steps.	C	USFWS, CDFW, NGO, LA	TBD						It is unknown at this time how often this recovery action (if ever) will be required. To date, there have been no known die-offs of California tiger salamander.
4.1.3	3	Develop contingency plans. Contingency plans should be incorporated into all management plans to ensure that a population infected with a ranavirus or other pathogen is quickly isolated and the disease does not spread to uncontaminated populations.	C	USFWS, CDFW, NGO, LA							Included in 6.1 cost estimate.
4.1.4	1	Develop measures to sterilize field equipment to minimize disease transmission.	C	USFWS, CDFW, NGO, LA							Included in 6.0 cost estimate.
5.0	**Reduce levels of non-native predator species within preserves.**										
5.1		Reduce populations of non-native predators to a level where they are determined to not decrease Central California tiger salamander populations.									
5.1.1	1	Identify sites within each preserve that require non-native predator eradication or control. As a short-term method, physical removal of these non-native species may be most beneficial. However, proactive means of reducing the conditions in which these non-native species thrive is a long-term priority (see action 1.2.2 for a description of optimal breeding habitat to reduce non-native predators).	C	USFWS, CDFW, NGO, LA	TBD						Some planning for this action may be included in 6.2 cost estimate. Unable to determine at this time because we don't know how many ponds will require non-native predator removal, techniques utilized will vary in cost, cost will vary due to non-native species present; and strategies will differ to remove different non-native species.
5.1.2	1	Prohibit introduction of fish species to breeding habitat or within any aquatic system that has the potential to convey non-native fish to breeding habitat.	C	CB, CDFW, CDPR, NGO, LA, USFWS							Included in 6.2 cost estimate.

Implementation Schedule for the Central California Tiger Salamander											
Recovery Action Information					**Cost estimate in $1,000 units**						
Number	**Priority**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2017**	**2018**	**2019**	**2020**	**2021**	**Comments/Notes**
6.0	**Develop and implement management and monitoring plans for protected habitat counted toward recovery.** All preserves (as described in recovery criteria A/1 through A/4) should have management and monitoring plans. These plans should specifically target management and monitoring of Central California tiger salamander breeding and upland habitat to maintain habitat suitability in perpetuity. The plans may include, but are not limited to, actions to identify and reduce: harmful contaminants, non-native predator species, road mortality, and non-native tiger salamanders and hybrids. Management plans should describe grazing management and disease prevention strategies. Plans should be updated based on feedback from land managers and adaptive to climate change and other variables.										
6.1	1	Secure funding in perpetuity for habitat management and monitoring either through an endowment or other funding mechanism.	C	CB, CDFW, CDPR, NGO, LA, USFWS	$11,500	230	230	230	230		This estimate is for monitoring of habitat and qualitative site evaluation. Other costs cannot be determined at this time, because we are unable to determine how often certain actions will be required and what actual costs will be.
6.2	1	Management plans should be developed to ensure high quality upland and breeding habitat is available for the Central California tiger salamander in perpetuity.	O	CB, CDFW, CDPR, NGO, LA, USFWS	$2,225	44.5	44.5	44.5	44.5		Assumes $20,000 per management plan per preserve.
7.0	**Monitor trends to gain a better understanding of population health, trends in habitat loss, and other information that will help to guide conservation planning for the Central California tiger salamander.**										
7.1	3	Establish and maintain a database that tracks the amount of incidental take authorized through section 7 and 10 of the Act.	O	USFWS							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
7.2	3	Monitor habitat land use change. Utilize GIS land use cover data to determine amount of suitable habitat that has been lost.	O	USFWS							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
7.3	2	Survey lands for Central California tiger salamander in areas that have not been well surveyed. The following management units have not been well surveyed: Dunnigan Hills, Central Valley West Side, Northeast Diablo Range, Southeast Diablo Range, Farmington, and Oakdale/Waterford. Other areas will likely require surveys as well.	C	NGO, LA, UNIV	500	10	10	10	10	10	
7.4	2	Conduct population viability analyses for Central California tiger salamander metapopulations throughout the range of the DPS. Population viability analyses are tools that can identify populations in need of recovery actions, as opposed to those that may be viable over the long-term without intervention.	C	CDFW, UNIV, USFWS	400	8	8	8	8	8	Cost will vary depending on how many populations of CTS will be examined to determine PVAs for each recovery unit. Total cost is a rough estimate, assuming $100,000 would be needed for each recovery unit.
7.5	3	Research should be conducted to determine the effectiveness of standard avoidance and minimization measures (*e.g.*, exclusion fencing, burrow excavation, and seasonal work windows) to	C	UNIV	50	1	1	1	1	1	

Implementation Schedule for the Central California Tiger Salamander											
Recovery Action Information					**Cost estimate in $1,000 units**						
Number	**Priority**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2017**	**2018**	**2019**	**2020**	**2021**	**Comments/Notes**
		ensure the most successful measures are being used during implementation of projects that may impact Central California tiger salamanders and their habitat.									
7.6		Conduct research on the effects of contaminants.									
7.6.1	3	Conduct investigations on effects of contaminants on Central California tiger salamander (or a surrogate salamander species if determined appropriate).	C	UNIV	100	2	2	2	2	2	
7.6.2	3	Conduct research that determines which pesticides and other contaminants are commonly used on agriculture lands within the range of the Central California tiger salamander.	C	UNIV	100	2	2	2	2	2	The research should distinguish the type of crop that the chemicals are used on, what time of year the chemicals are applied, how these chemicals behave in aquatic vs. terrestrial habitat, and other important factors that may affect the salamander.
7.6.3	3	Conduct research on the effects of mosquito abatement chemicals on Central California tiger salamander populations.	C	UNIV	100	2	2	2	2	2	
7.7		Conduct genetic research.									
7.7.1	2	Monitor projects designed to increase native species genomes and limit hybridization. These studies should occur within a variety of geographic areas (*e.g.*, Salinas Valley floor, foothill areas to the north and east of Salinas Valley, and Bay Area) to determine the most effective strategies in various geographic areas.	C	BLM, UC NRS, LA, UNIV, USFWS	500	10	10	10	10	10	This could include research on direct removal of hybrids (paedomorph removal, collecting adults with drift fence and pitfall traps, etc.), breeding habitat modification (*e.g.*, perennial to ephemeral), or other strategies designed to increase native genomes and limit hybridization.
7.7.2	2	Conduct focused research on SI markers to determine how each non-native gene is physically expressed and the subsequent ecological impact of these genes.	C	UNIV	500	10	10	10	10	10	
7.8		Conduct research on small burrowing mammal communities.									
7.8.1	3	Conduct research to determine burrow requirements for Central California tiger salamander populations (*i.e.*, what burrow densities are optimal for Central California tiger salamanders, and how many small burrowing mammals are required to maintain these densities?).	O	UNIV	100	2	2	2	2	2	

Implementation Schedule for the Central California Tiger Salamander											
Recovery Action Information					**Cost estimate in $1,000 units**						
Number	**Priority**	**Description**	**Duration**	**Responsible Parties**	**Total Costs**	**2017**	**2018**	**2019**	**2020**	**2021**	**Comments/Notes**
7.8.2	3	Conduct research to determine optimum grazing regimes to increase small mammal burrowing communities.	O	UNIV	100	2	2	2	2	2	
8.0	**Develop and implement participation plans for each Recovery Unit.**										
8.1	3	Participation plans will assist in the realization of recovery goals by facilitating commitments from participating agencies and stakeholders to implement recovery actions, where feasible.	C	ALL							Costs are incidental to normal operating budget for ongoing coordination and conservation implementation.
Total Cost : $85,375,000											

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V. APPENDICES

Appendix A – Figures

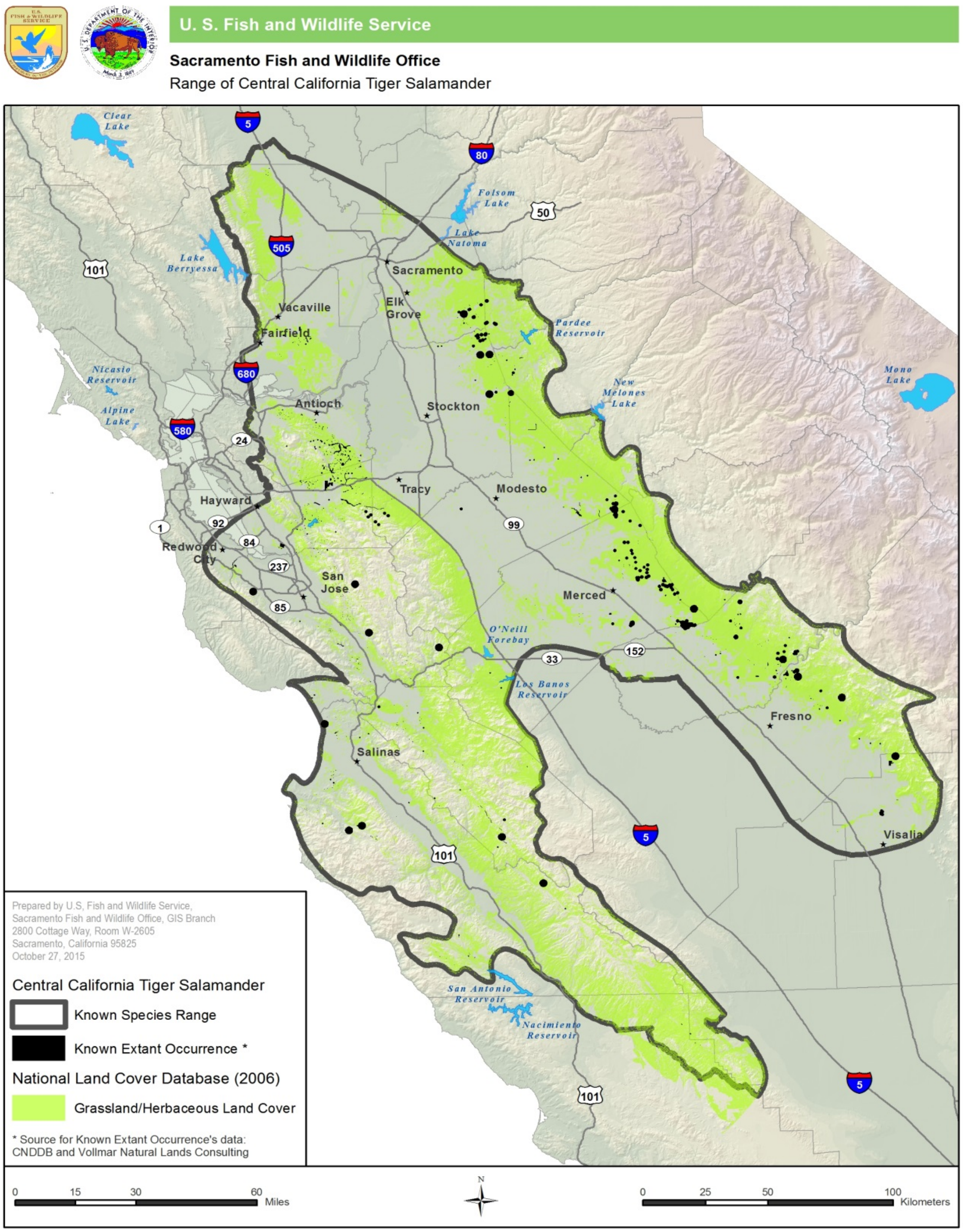

Figure 1: Range of Central California tiger salamander

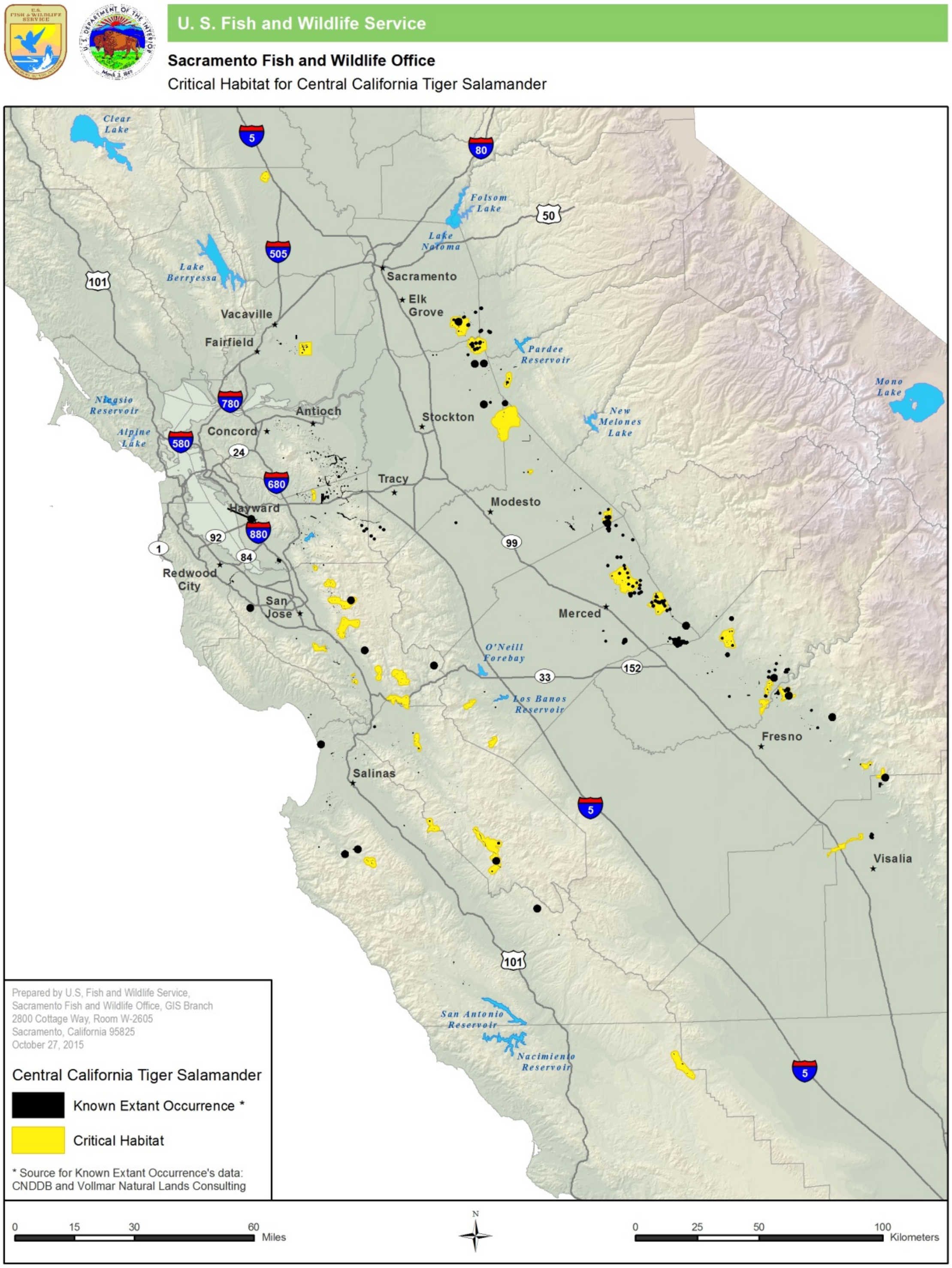

Figure 2: Critical Habitat for Central California tiger salamander

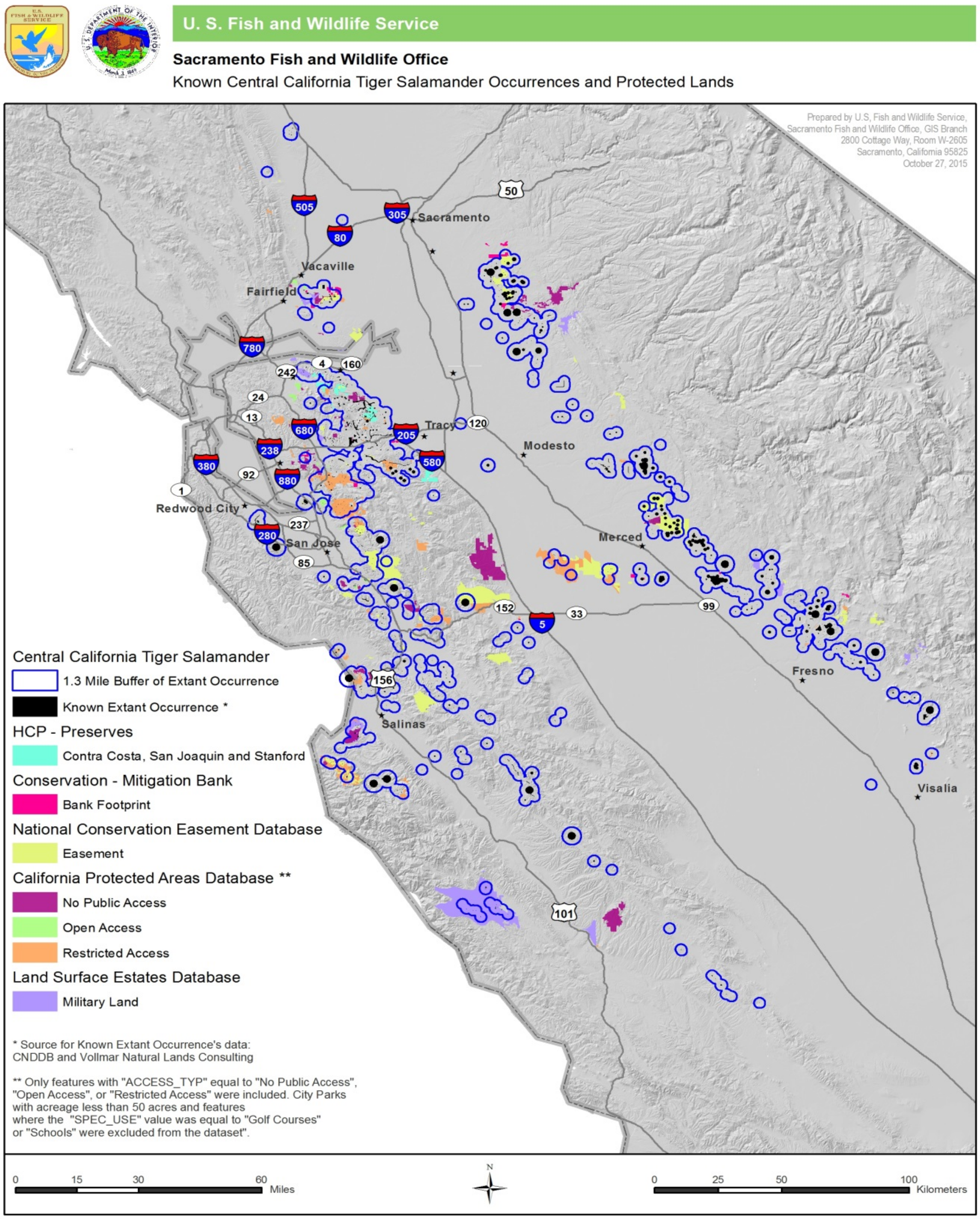

Figure 3: Known Central California tiger salamander occurrences and protected lands

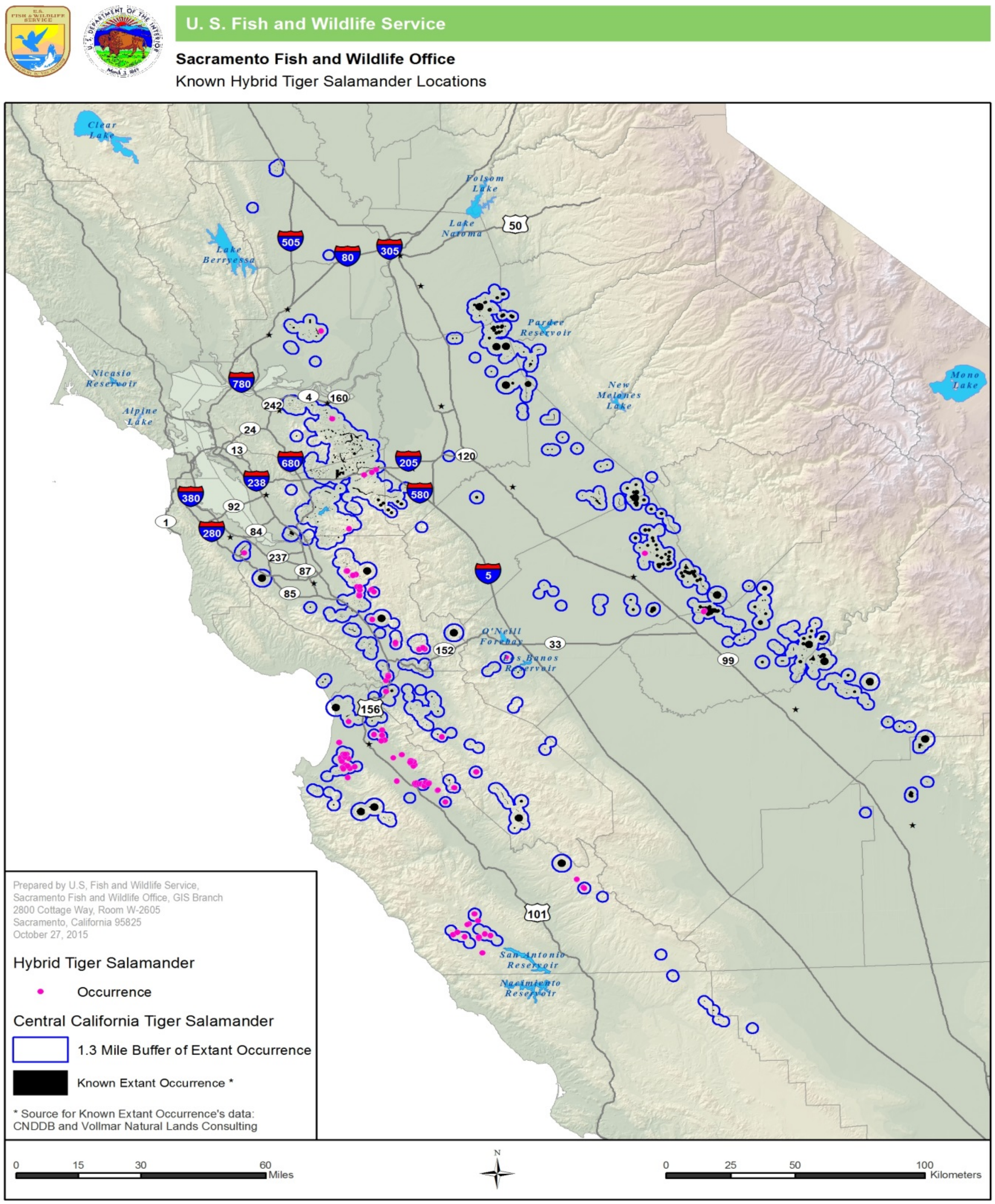

Figure 4: Known hybrid tiger salamander locations

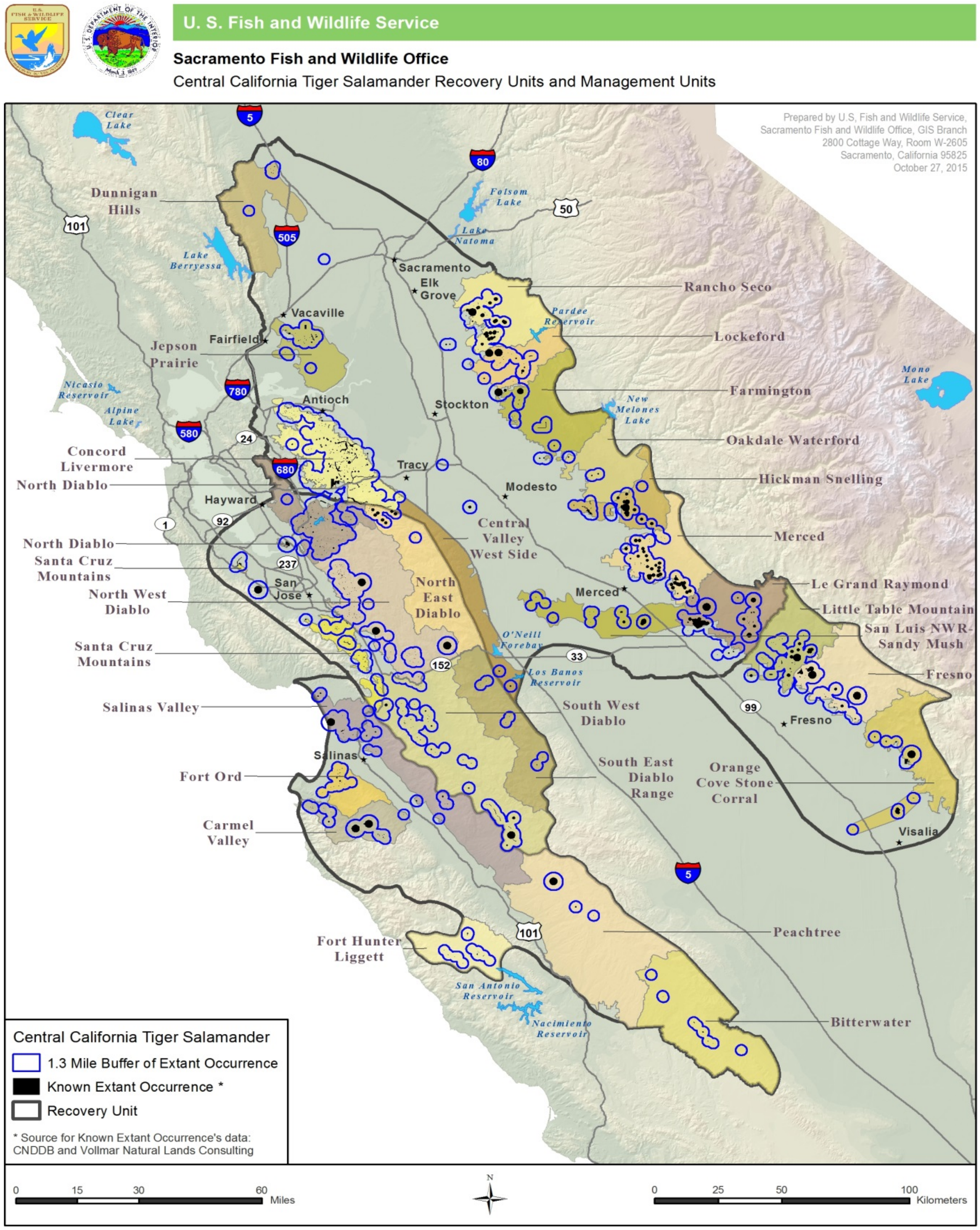

Figure 5: Recovery units and management units

Appendix B - Justification for recovery criteria

A/1 through A/4

Number of preserves. The Service determined that the number of preserves proposed within each recovery unit is sufficient to ensure increased resiliency, representation, and redundancy to prevent endangerment in the foreseeable future. The number of required preserves within each management unit was determined in consultation with numerous species experts by considering multiple factors, including the acreage size of management units, the number of known Central California tiger salamander populations within the management unit, proximity to other management units, and amount of remaining suitable habitat within the management unit. The Service determined that multiple preserves will better ensure the long-term sustainability of the species (*e.g*., if a population at one preserve is extirpated due to the introduction of ATV, populations from other nearby preserves can be re-introduced to the unoccupied preserve in the future). Because the genetic, geographic, and ecological range within each distinct recovery unit is distributed across the management units of a given recovery unit, multiple preserves within each management unit will better ensure conservation of the genetic and geographic range of the species.

Preserve Size. Minimum preserve size is 3,398 acres (1,375.1 hectares). The acreage for the minimum preserve size was determined based on the 1.3 mile (2.09 kilometer) maximum known dispersal distance (Orloff 2011) (a preserve with a radius of 1.3 miles is 3,398 acres). The Service has determined that this amount of habitat is necessary to ensure that Central California tiger salamander populations have adequate space for sufficient upland and breeding habitat and enough populations to ensure metapopulation dynamics (*i.e.*, if a population at one pond is extirpated, it can be quickly recolonized in the future).

Breeding Habitat - Each 3,398-acre area (the minimum preserve size) of protected habitat will have at least four ponds. The Service believes that a minimum of four ponds provides the necessary amount of redundancy to ensure availability of breeding habitat within each preserve in the long-term. If more ponds are available, a smaller surface area is required. There is flexibility in application of pool numbers and sizes, and final requirements should be resolved through the adaptive management process with site-specific data and using effective population size (or appropriate abundance metrics) as the guiding principle and metric (See also criteria E/6 – *Resilience to Stochastic Events* for a discussion of effective population size). These breeding pond surface acreage amounts are expected to result in viable populations of Central California tiger salamander.

The following paragraph is from Chris Searcy, pers. comm., 2013b and 2015 – Pond buffer area and minimum viable population size estimates:

"According to Traill et al. (2007), the average minimum viable population size for a population of herptiles is 5,409 individuals. Since our equation relating pond area to population size is in terms of effective population size, we needed a conversion factor between effective and census population size. I calculated the census number of metamorphs for Blomquist Pond, taking the average of the six years covered in Trenham et al. (2000). I chose to base the census population size on metamorphs, because all metamorphs should be captured each year, while a large fraction of the juveniles and adults remain underground each year. Using the census number of metamorphs, I then calculated the census number of juveniles and adults based on the growth, survivorship, and maturity functions in the integral projection model developed from the Jepson Prairie recapture data. My final calculations for the census population size at Blomquist Pond were: 190 adults, 362 juveniles, and 397 metamorphs. Wang and Shaffer (unpublished data) give two estimates for the effective population size of Blomquist Pond: 11 and 16. I averaged these two values (13.5) and then divided the census population size of Blomquist Pond by this value to get the conversion factors: adults (14.074x), juveniles (26.815x), and metamorphs (29.407x). When calculating the minimum viable population size, I only considered adults and juveniles, since metamorphs are not present for the majority of the year. Getting a census population size of 5,409 individuals thus requires an effective population size of 5,409/(14.074+26.815) = 132. The equation relating effective population size to pond area [measured in m^2] from Wang et al. (2011) is Ne = 7.721*ln(area) – 30.999. So, in order to get the sufficient pond area with a single pond, that pond would need to be 364,189 acres. In order to get it with two ponds, each would need to be 71 acres (slightly smaller than Olcott Lake). In order to get it with three ponds, each would need to be 4.1 acres, which is a typical size for the playa pools at Jepson Prairie. So, in almost any landscape, getting the sufficient pond area would require at least three ponds, which will provide at least some redundancy in breeding sites. The average pond size in Santa Barbara County is 1.47 acres, so it would require four ponds with this size in order to get a stable metapopulation there. In order to get it with eight ponds, each would need to be 470 m^2 [0.17 acre], and in order to get it with nine ponds, each would need to be 370 m^2 [0.09 acre]."

Upland Habitat – Each of the preserves maintains robust and self-sustaining small burrowing mammal populations (*i.e.*, ground squirrels and/or pocket gophers) capable of creating and maintaining the necessary amount of burrow habitat for the Central California tiger salamander to persist. The number of active burrow entrances can be used to predict ground squirrel population densities (Fehmi et al. 2005; Loredo-Prendeville et al. 1994). At this time, we do not have sufficient data to determine how many small burrowing mammal colonies are necessary, or what size a colony needs to be in order to sustain a Central California tiger salamander population. The number of necessary small burrowing mammals also likely varies greatly from one geographic area to another, or even within the same geographic area. In a study in Contra Costa County, Loredo-Prendeville et al. (1994) considered a moderate ground squirrel colony as having 50 to 100 burrow entrances within a 656-foot (200-meter) radius. Fehmi et al. (2005) defined active California ground squirrel colonies as those having evidence of recent use in terms of soil disturbance, no spider webs or other debris in the openings, and active use of paths to other entrances. Therefore, upland habitat will contain at least one moderately-sized burrowing mammal colony [as defined by having at least 50 active burrow entrances within a 656-foot (200-meter) radius] that occurs within the average dispersal distance of the salamander [1,844 feet (562 meters) (Searcy and Shaffer 2011)] of each breeding pond.

E/1

Hybridization with Non-Native Tiger Salamanders

The issue of hybridization between native Central California tiger salamanders and non-native barred tiger salamanders is extremely complex. With our current knowledge, we are unable to say exactly when a hybridized tiger salamander population is a threat to an adjacent native tiger salamander population. It is problematic to set an arbitrary limit of hybridization for which a population will be considered "pure" (Allendorf et al. 2001). For example, if hybrid index scores for a population are 90 percent non-native, it seems reasonably safe to assume that this is a threat to native salamander populations within dispersal distances; however, if the hybrid index score is 10 percent non-native, it is less clear whether this should be considered a threat to nearby native populations. At this time, with the current information that we have, the Service believes that the only way to be truly confident that hybridization with non-native barred tiger salamanders is not a threat to the species is to have all hybrid tiger salamanders removed from areas within the range of the Central California tiger salamander. In addition to removing non-native tiger salamander populations, it is important to also ensure that habitat in areas formerly occupied by hybrid tiger salamanders is protected in amounts sufficient to meet recovery criteria.

Another confounding issue is that the SI markers are likely to remain within the genotype of all exposed native Central California tiger salamanders, because these genes are always selected for and move through populations very quickly (Fitzpatrick et al. 2007). The Service at this time has no information regarding whether SI markers are a threat to native Central California tiger salamanders. The SI markers replace native markers, but at this time it is unknown what trait(s) is reflected through these SI markers (*i.e.*, what effects do these SI markers have on Central California tiger salamander appearances or behaviors?), and whether this is a threat to the persistence of the Central California tiger salamander. It appears that pure Central California tiger salamanders and salamanders with only SI markers behave similarly ecologically (Searcy et al. 2014). Since we do not yet know the morphological and ecological consequences of the fixation of introduced alleles, Fitzpatrick et al. (2009) recommend treating individuals with SI markers as the listed entity. Additional research must be conducted to determine whether SI markers are a threat, and this recovery plan should be updated once this information is obtained. Due to this lack of information, the Service at this time recommends that populations be counted toward recovery even if they have SI non-native markers, as long as they are otherwise considered genetically pure Central California tiger salamanders.

E/6

Effective population size of 132

See information provided by Chris Searcy, pers. comm., 2013b and 2015 - Pond buffer area and minimum viable population size estimates (above, under justification for criteria A/1 through A/4, breeding habitat).