California Tiger Salamander
Central California Distinct Population Segment
(*Ambystoma californiense*)

5-Year Review:
Summary and Evaluation

Photo of adult California tiger salamander at Jepson Prairie, Solano County.
Photo: John Cleckler, Sacramento Fish and Wildlife Office.

U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Sacramento, California

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5-YEAR REVIEW

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I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview: At the time of listing, the California tiger salamander was divided into three separate Distinct Population Segments (DPSs): the Central California, Sonoma, and Santa Barbara DPSs. While genetically distinct and geographically isolated from each other, these three DPSs have similar biological needs and life histories. The Central California DPS of California tiger salamander (Central California tiger salamander) spends the majority of its life underground in small mammal burrows and migrates to pools and ponds for breeding during rain events. The Central California tiger salamander is restricted to the Central Valley and Inner Coast Range from Tulare and San Luis Obispo Counties in the south, to Sacramento and Yolo Counties in the north. Within this area, 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 (See Figure 1). The Central California tiger salamander is threatened primarily by habitat loss and fragmentation due to agricultural conversion and urban development, competition with and predation from non-native species, and hybridization with non-native tiger salamanders. Other threats include mortality from road crossings, small mammal eradication efforts, mosquito abatement activities, exposure to contaminants, introduction of ranaviruses or other pathogens, and potential effects to habitat from changes in climatic conditions in the future.

Methodology Used to Complete This Review:

This review was prepared by the Sacramento Fish and Wildlife Office (Sacramento FWO), following the Region 8 guidance issued in March 2008. To date, the Service has not published a recovery plan for this species. All information pertinent to the status of the California tiger salamander that has become available since its listing in 2004 was reviewed as part of this analysis. Sources of information used for this review included peer-reviewed scientific literature, scientific papers, survey reports, and letters to and from the Sacramento and Ventura Fish and Wildlife Offices. We incorporated all information from our files into our review, as appropriate.

This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

Contact Information:

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Cooperating Field Office(s): Jacob Martin, Ventura Fish and Wildlife Office, (831)-768-6953.

Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on May 25, 2011 (76 FR 30377). We received two comment letters from the public in response to our Federal Notice initiating this 5-year review. One letter was received from the California Farm Bureau and the second letter was received from Watkins Ag Products and Services, in Linden, California. Both letters emphasized the financial pressures and other pressures placed on agriculture producers as a result of how the Act and other environmental regulations are implemented. Neither letter provided additional information on the biology or threats to the species.

Listing History:

Original Listing
FR Notice: 69 FR 47212
Date of Final Listing Rule: August 8, 2004
Entity Listed: *Ambystoma californiense*, Central California Distinct Population Segment
Classification: Threatened

State Listing
Ambystoma californiense was listed by the State of California as threatened under the California Endangered Species Act in 2010.

Associated Rulemakings:

May 23, 2003: The Service published a proposal to list the Central California tiger salamander as threatened; to reclassify the Santa Barbara County DPS and Sonoma County DPS from endangered to threatened; and establish a special rule pursuant to section 4(d) of the Act to exempt "routine ranching activities" from the Act's prohibitions against take for all three DPSs of California tiger salamanders (68 FR 28648).

August 4, 2004: The Service published a final rule to list the California tiger salamander as a single threatened species range-wide, and special rule exempting existing routine ranching activities (69 FR 47212). This final rule listed the California tiger salamander range-wide as threatened, including the Central California, Santa Barbara, and Sonoma DPSs. In this rule the Service determined that the Santa Barbara and Sonoma populations had the same listing status as the taxon as a whole, and the Service removed these populations as separately listed DPSs. However, this rule was subsequently vacated by a judicial decision on August 18, 2005, and the former DPSs located in Sonoma and Santa Barbara counties were reinstated and returned to endangered status on August 19, 2005. The Central California DPS remained threatened.

August 23, 2005: The Service published a final rule designating critical habitat for the Central California tiger salamander (70 FR 49380).

Review History: Since listing, no status review, 5-year review, or other relevant reviews/documents have been completed by the Service for this species.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for the Central California tiger salamander is 9C according to the Service's 2012 Recovery Data Call for the Sacramento FWO, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). This number indicates that the taxon is a DPS that faces a moderate degree of threat and has a high potential for recovery. The "C" indicates conflict with construction or other development projects or other forms of economic activity.

Recovery Plan or Outline: Not applicable. A recovery plan has not been finalized for this species.

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment Policy

The Endangered Species Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Act (61 FR 4722, February 7, 1996) clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act.

The Central California tiger salamander was listed as threatened in 2004. When listing a population as a DPS under the 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 (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1996).

Shaffer and Trenham (2002) conducted range-wide surveys of genetic variation among occurrences of the California tiger salamander and identified six mitochondrial DNA lineages that correspond to distributional discontinuities or potential barriers to dispersal for the species. Using this information, Shaffer and Trenham (2002) divided the California tiger salamander occurrences into six populations, including: (1) Sonoma County; (2) Santa Barbara County; (3) the Bay Area (central and southern Alameda, Santa Clara, western Stanislaus, western Merced, and the majority of San Benito counties); (4) Central Valley (Yolo, Sacramento, Solano, eastern Contra Costa, northeast Alameda, San Joaquin, Stanislaus, Merced, and northwestern Madera counties); (5) southern San Joaquin Valley (portions of Madera, central Fresno, and northern Tulare and Kings counties); and, (6) the Central Coast Range (southern Santa Cruz, Monterey, northern San Luis Obispo, and portions of western San Benito, Fresno, and Kern counties) (Shaffer and Trenham 2002).

Shaffer and Trenham (2002) found that the Santa Barbara and Sonoma populations were particularly well differentiated and geographically isolated from the other four populations. There has been little, if any, gene flow for a significant period of time between the Sonoma County population, the Santa Barbara County population, and the remaining four populations. The results from Shaffer and Trenham (2002), as well as subsequent research (Shaffer et al. 2004), found that the remaining four DPSs are not as genetically distinct from each other because they abut geographically and some populations show low levels of intermixing, particularly between boundary populations. Because the geographic barriers between these four populations are not entirely clear and low levels of mixing appear to occur, the Service determined that it is not appropriate to treat each of these four populations as four separate DPSs (Service 2003a).

Continued genetic research has further supported the separate DPSs of California tiger salamanders (Shaffer et al. 2013). Shaffer et al. (2013) studied genetic markers for 110 populations and 1,286 individuals throughout the range of the Central California, Santa Barbara, and Sonoma DPSs and found that the most differentiated populations include Sonoma, Santa Barbara, Central Valley, and Coast Range; within the Coast Range, there is evidence for sub-groups in the Peachtree and Bitterwater valleys. Within the Central Valley there is evidence for sub-groups in the Jepson Prairie and Dunnigan Hills areas in the northern Central Valley. Shaffer et al. (2013) found that the split between the Bay Area/Central Coast Range and Central Valley is deeper than previously known, however some mixing still occurs along border populations, particularly in the area around Patterson Pass, near Livermore, in Alameda County.

Therefore, based on the best available genetic data, we treat these four populations (Bay Area, Central Valley, southern San Joaquin Valley, and the Central Coast Range) of California tiger salamander as a single DPS, which is genetically and geographically distinct from the Sonoma County and Santa Barbara County DPSs. A map of the four populations that make up the Central California DPS is provided in Figure 1.

Information on the Species and its Status

Species Biology and Life History

Introduction

California tiger salamanders are endemic to the San Joaquin-Sacramento river valleys, bordering foothills, and coastal valleys of Central California and inhabit primarily annual grasslands and open woodlands of the foothills and valleys (Stebbins 1985; Shaffer et al. 2013). California tiger salamanders spend the majority of their lives underground in small mammal burrows, although ponds play an equally important role as they are required for breeding to occur. Adult California tiger salamanders are rarely seen except during their nocturnal breeding migrations which begin with the first seasonal rains, usually in November or December (Barry and Shaffer 1994). Breeding sites are typically fish-free ephemeral ponds that fill during winter and dry by summer (Petranka 1998). Historically, California tiger salamanders utilized vernal pools as breeding sites, but the species now also commonly breeds in livestock ponds. Vernal pools and ephemeral ponds are better able to support California tiger salamanders than wetlands that hold water year-round because perennial ponds are more likely to support breeding populations of predatory species and typically have higher numbers of hybrid tiger salamanders in areas where hybrids are found (Riley et al. 2003; Wang et al. 2011). Appendix A provides photographs of the various life-stages of the species and typical habitat.

Physical Description

The California tiger salamander is a large, stocky, terrestrial salamander with a broad, rounded snout. In adults total length ranges from approximately 6 to 9.5 inches (16 to 24 centimeters) (C. Searcy, U.C. Davis, personal communication, 2013). The coloration of the adults generally consists of random white or yellowish markings against a black body. These bright and contrasting color patterns may serve as a warning to potential predators. Adults produce noxious skin secretions from the dorsal surface of the tail which may decrease predation (Hansen and Tremper 1993). California tiger salamander larval coloration is variable, with most larvae being pale colored (Hansen and Tremper 1993). Larvae are fully aquatic, with external gills and a fin along the length of their back (CDFG 2010). At metamorphosis, the gills and fin disappear and lungs become fully developed (CDFG 2010).

Changes in CNDDB occurrences from 2004 to 2012

The California Natural Diversity Database (CNDDB) is a program within the California Department of Fish and Wildlife (CDFW) that maintains a computerized inventory of information on the location and condition of California's rare, threatened, endangered, and sensitive plants, animals, and natural communities. Positive sightings of species are voluntarily submitted to the CNDDB as extant occurrences. These occurrences are presumed to be still in existence until evidence to the contrary is received by the CNDDB. At the time of listing in 2004, there were a total of 638 known extant occurrences of Central California tiger salamanders (CNDDB 2012). As of 2012, known extant occurrences increased to 867 (CNDDB 2012). Most of these additional occurrences are within a few miles of previously known occurrences. Although the number of known extant occurrences has increased from 638 to 867, it is important to note that many of these new localities are the result of surveys conducted as part of proposed development projects since the species was listed in 2004. In most cases, development projects are expected to result in the removal or degradation of the breeding ponds, and/or the elimination or alteration of their surrounding upland habitat. Also, some occurrences listed in the CNDDB as "presumed extant" may actually be extirpated as a result of development or other projects because information on the status of these sites have not been provided to CDFW. Therefore, the increase in number of presumed extant breeding ponds does not by itself correlate to an improvement in status or a reduction in threats to the Central California tiger salamander because many of these ponds are likely threatened by development or may have already been destroyed or degraded as a result of development projects. Table 1 below provides a summary of changes in CNDDB occurrences from 2004 to 2012 (CNDDB 2012).

Table 1: Summary of changes in CNDDB occurrences from 2004 to 2012.

Population	*Occurrences 2004*	*Occurrences 2012*
Bay Area	extant: 211 extirpated: 10 possibly extirpated: 0	extant: 257 extirpated: 18 possibly extirpated: 12
Central Valley	extant: 296 extirpated: 14 possibly extirpated: 3	extant: 439 extirpated: 18 possibly extirpated: 17
Southern San Joaquin Valley	extant: 15 extirpated: 10 possibly extirpated: 1	extant: 73 extirpated: 8* possibly extirpated: 7
Central Coast Range	extant: 81 extirpated: 1 possibly extirpated: 1	extant: 98 extirpated: 2 possibly extirpated: 2

*Two occurrences in CNDDB were considered extirpated in 2004 and status in 2012 is considered extant (occurrences 71 and 626, both in Fresno County).

Use of Aquatic Habitat for Breeding and Larvae Development

Adult California tiger salamanders engage in mass migrations during a few rainy nights per year, typically from November through April, although migrating adults can be observed as early as October and as late as May (Hansen and Tremper 1993; Petranka 1998). 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. Results from a 7-year study in Monterey County suggested that males remained in the breeding ponds for an average of 44.7 days while females remained for an average of only 11.8 days (Trenham et al. 2000). Mating typically occurs November through April, although most mating occurs from December through March (Petranka 1998). Courtship consists of the male actively pursuing the female, swimming beneath her and nosing her tail and cloaca. The male eventually deposits a spermatophore on the bottom of the pond. The female picks up the spermatophore and uses it to fertilize her eggs internally (Hansen and Tremper 1993). Females lay their eggs in the water, attaching their eggs to twigs, grass stems, or other vegetation or debris (Storer 1925; Twitty 1941). Adults vacate the ponds shortly after breeding (Petranka 1998; Shaffer et al. 1993). Petranka (1998) reported that California tiger salamander eggs hatch in 10 to 28 days, while Hansen and Tremper (1993) reported 10 to 14 days. The amount of time for hatching is likely related to water temperatures. Searcy (U.C. Davis, personal communication, 2012b) observed

California tiger salamanders hatching from 17 to 28 days at 57.2 degrees Fahrenheit (14 degrees Celsius).

Breeding pools typically have moderate to high levels of turbidity; California tiger salamanders rarely use ponds with clear water (Bobzien and DiDonato 2007). The turbidity may help California tiger salamander larvae and adults avoid predators. California tiger salamander larvae have feathery gills (Petranka 1998) and feed on zooplankton, small crustaceans, and aquatic insects for about six to eight weeks after hatching, after which they switch to larger prey (Anderson 1968, C. Searcy, U.C. Davis, personal communication, 2012a). Larger larvae consume aquatic invertebrates, as well as the tadpoles of other amphibians such as Pacific chorus frogs (*Pseudacris regilla*), western spadefoot toads (*Spea hammondii*), California red-legged frogs (*Rana draytonii*), and bullfrogs (*Rana catesbeiana*) (Anderson 1968; Bobzien and DiDonato 2007). The larval stage of the California tiger salamander usually lasts 3 to 6 months, with metamorphosis beginning in late spring or early summer (Petranka 1998). California tiger salamanders, therefore, breed in deeper vernal pools and wetlands that have sufficiently long periods of inundation. Larvae develop faster in smaller, more rapidly drying pools, and the developmental period is prolonged in colder weather and in larger pools (Feaver 1971). Feaver (1971) reported larvae development (time from eggs laid to larvae leaving the pond) ranging from 74 days to 94 days in Madera County.

Peak periods for metamorphs to leave their natal ponds have been reported from May to July (C. Searcy, U.C. Davis, personal communication, 2012b; Loredo and Van Vuren 1996; Trenham et al. 2000). Peak emergence dates for Jepson Prairie, in Solano County, over the past nine years range from May 16 to June 29 and peak emergence dates from nine years at Hastings Reserve/Oak Ridge Ranch, in Monterey County, ranged from May 27 to July 29 (C. Searcy, U.C. Davis, personal communication, 2012a). Hansen and Tremper (1993) report emergence dates from March to early May in the San Joaquin Valley, and from March to June in the Sacramento Valley. Once metamorphosis occurs, juveniles often depart their natal ponds at night and enter into terrestrial habitat in search of underground burrows (Petranka 1998). Although wet conditions are more favorable for upland travel, metamorphs typically travel during dry weather because summer rain events seldom occur as metamorphosis is completed and ponds begin to dry. However, if a rain event does occur, it is likely that it will trigger a mass emergence from the natal pond. For example, in one instance, an entire cohort of California tiger salamander metamorphs (consisting of approximately 2,300 individuals) was captured in one nighttime rain event at the end of June at Jepson Prairie (C. Searcy, U.C. Davis, personal communication, 2012b). Although California tiger salamanders typically spend one season in breeding ponds, overwintering larvae have been detected in the Los Vaqueros watershed in Contra Costa County (Alvarez 2004; Johnson et al. 2010a). In addition, overwintering larvae have been documented to occur in some permanent ponds at higher elevations in Alameda County (S. Bobzien, in literature, 2003).

Use of Upland Habitat

Upland habitats surrounding known California tiger salamander breeding pools are usually dominated by grassland, oak savanna, or oak woodland (Shaffer et al. 2008). Large tracts of upland habitat are necessary for the California tiger salamander to persist. Based on calculations from studies at Jepson Prairie, in Solano County, it would take approximately 2,706 acres (1,095 hectares) of upland habitat to successfully protect the area occupied by 95 percent of a population utilizing a single breeding pool (based on the findings that 95 percent of the population was found within 1.16

miles (1.86 kilometers) of the breeding pond) (Searcy and Shaffer 2008, 2011; H. Shaffer, in literature, 2009).

California tiger salamander populations are strongly correlated with small burrowing mammal communities, particularly California ground squirrel (*Otospermophilus beecheyi*) and Botta's pocket gopher (*Thommomys bottae*) (Loredo et al. 1996; Pittman 2005; Seymour and Westphal 1994; Shaffer et al. 1993). California tiger salamanders depend on persistent small mammal activity to create, maintain, and sustain sufficient underground refugia. Burrows are short lived without continued small mammal activity and typically collapse within approximately 18 months (Loredo et al. 1996). In addition to small mammal burrows, juvenile and adult salamanders will also sometimes use soil cracks. Loredo et al. (1996) reported that in a study site in Contra Costa County juveniles were roughly as likely to use soil cracks as burrows when first migrating from ponds, and juveniles were much more likely to use soil cracks than adults. A study conducted at the Seal Beach Naval Weapons Station in Contra Costa County found that breeding ponds with documented Central California tiger salamander occurrences tended to also be surrounded with the highest densities of burrows; although the study reported that some documented breeding ponds also had some of the lowest burrow densities (EDAW 2008). Similarly, Pittman (2005) reported that Central California tiger salamanders in Alameda County were more frequently found in areas with high burrow density. In Merced County, Wang et al. (2011) found that the density of rodent burrows, at least in areas where burrows are relatively abundant, is not an important limiting factor for the salamanders. Similar results were seen at Jepson Prairie, Solano County (Searcy et al. 2013). Searcy et al. (2013) reported a negative correlation between high burrow density and Central California tiger salamanders. Searcy et al. (2013) point out that, presumably, adult salamanders are not actually repelled by these burrows, which they rely on as refuge sites. Instead mammal burrows are presumably correlated with other variables (e.g. hydrology, soil type, or prey density) that adult salamanders avoid.

Once a metamorph leaves its natal pond and enters a burrow, it will then spend the vast majority of its life underground. The actual time that adults spend in breeding ponds is short, lasting on average from a few weeks for females to less than two months for males (Trenham et al. 2000). Outside of these breeding activities, occasional switching of burrows during the rainy season (Trenham 2001), and other rare instances (see last paragraph of this section), adult California tiger salamanders spend roughly 90 percent of any given year underground (Van Hattem 2004). Juveniles may spend more time underground than adults, as they have not yet reached sexual maturity and they do not typically leave the burrow systems in the fall and winter and migrate to aquatic habitat (although this has been reported from time to time; for example, Twitty (1941) observed two juveniles travelling with a larger group of adults while they were migrating to breeding habitat).

Little is known about the fossorial (i.e., underground) behavior of California tiger salamanders as they are difficult to observe while underground. California ground squirrel burrows can be quite complex, with multiple tunnels and entrances. Van Vuren and Ordenana (2012) report observations of burrows reaching up to 138 feet (42.1 meters) in aggregate length and reaching depths of 5.5 feet (1.7 meters). Most evidence suggests that California tiger salamanders remain active in their underground dwellings. Trenham (2001) used telemetry to monitor underground movements within burrow systems and found that California tiger salamanders frequently made short moves of less than 33 feet (10 meters) within the burrow systems. Other researchers have used fiber optic or infrared scopes to observe active California tiger salamanders underground and reported that all California tiger salamanders observed were active (Semonsen 1998; Van Hattem 2004).

Although extremely uncommon, there have been observations of juvenile and adults above ground at unusual times of the year. For example, Holland et al. (1990) observed hundreds of dead juvenile salamanders in San Luis Obispo County, all within the same age class, that were apparently attempting to travel from burrows to aquatic habitat in August to October. There were no rain events during these months that would have triggered this mass movement and it is currently unknown why this mass migration of juveniles occurred. Van Hattem (2004) observed seven adult salamanders above ground after a rare summer rain event in June, outside of the breeding season. Observations such as these are extremely rare; however, this type of behavior may be more common and just not observed, since these events occur at night in remote grasslands.

Dispersal

Central California tiger salamanders have the second longest migration distance reported for any salamander and the longest among ambystomatids (Searcy et al. 2013). Searcy and Shaffer (2011) captured 15,212 Central California tiger salamanders at two breeding ponds over a 5-year period at Jepson Prairie, Solano County, and average dispersal distance was estimated to be 1,844 feet (562 meters). Searcy and Shaffer (2011) estimated that 95 percent of the population occurred within 1.16 miles (1.86 kilometers) of the breeding pond. Based on distances travelled per night, Searcy and Shaffer (2011) also estimated that the salamanders were physiologically capable of migrating up to 1.5 miles (2.4 kilometers) each breeding season. In a 5-year study in Contra Costa County, Orloff (2007) found that the majority of California tiger salamanders migrated at least 0.5 mile (0.8 kilometer) from the breeding site. A smaller number of salamanders appeared to migrate even farther, traveling 0.75 miles (1.2 kilometers) to almost 1.3 miles (2.2 kilometers) to and from the breeding ponds and upland habitat.

In Contra Costa County, Loredo et al. (1996) visually tracked the nocturnal movement of adult and newly metamorphosed Central California tiger salamanders from the pond edge until they were no longer visible on the surface. They reported that the mean distance that juveniles travelled before settling in a burrow was 85 feet (26 meters). Adults travelled longer distances, with a reported mean distance of 118 feet (35.9 meters). Although adults may travel longer distances before entering their first burrow, Trenham and Shaffer (2005) reported a decline in adult capture rates at increasing distances from Olcott Lake, and subadult capture rates increased from 33 to 1,312 feet (10 to 400 meters), and then declined to zero at 2,625 feet (800 meters), showing an apparent overall longer dispersal distance for subadults. Searcy et al. (2013) reported a similar pattern, with adults decreasing in density over the first 1,640 feet (500 meters) and juveniles increasing in density over that distance.

It appears that dispersal into the terrestrial habitat occurs randomly with respect to direction. Trenham (2001) studied two ponds that were completely encircled by drift fences and pitfall traps and reported that captures of arriving adults and dispersing new metamorphs were evenly distributed around the two ponds. Orloff (2007) found that most Central California tiger salamanders moved in a relatively straight line to and from the likely breeding ponds, seemingly uninfluenced by topography.

Central California tiger salamanders appear to behave similarly for dispersal distances, regardless of habitat types. Searcy and Shaffer (2011) compared dispersal distances at Jepson Prairie, in Solano County, and Hastings Natural History Reserve, in Monterey County, and found that Central

California tiger salamanders dispersed similar distances, despite the stark differences between these two areas. Jepson Prairie is relatively flat and contains two large aquatic breeding pools, while Hastings Biological Preserve is more rugged, with an elevation difference of 656 feet (200 meters), comprised mostly of oak woodland, and available breeding habitat includes 17 small livestock ponds and other wetland features.

While topography might not be a factor in dispersal routes, land use and vegetation appears to play a role. Trenham and Cook (2008) found that Sonoma DPS California tiger salamanders are more likely to disperse towards grasslands and will actively avoid areas that have urban development. Wang et al. (2009) found that Central California tiger salamander populations in Monterey County were most likely to successfully traverse chaparral, followed by grassland (including grassland with isolated oaks) and then densely wooded areas (areas with continuous wooded oak patches). In addition, Central California tiger salamanders not only tended to favor continuously wooded oak habitat the least, but they appeared to actively avoid it. Trenham (2001) found that radio-tracked adults were more abundant in grasslands with scattered large oaks than in continuously wooded areas.

Central California tiger salamanders appear to actively avoid areas that are likelier to flood. In Jepson Prairie, Searcy et al. (2013) found that juveniles are more common at higher elevation sites. This is even though total elevation range at Jepson Prairie is only 6.5 feet (2 meters). Searcy et al. (2013) conjectured that this may be because the higher elevation sites do not flood in the winter. Searcy et al. (2013) also found that adults were more common in areas with flood-intolerant vegetation, presumably for the same reason (avoiding flooding).

Metapopulation Structure and Site Fidelity

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. California tiger salamander populations are comprised of ponds that support somewhat independent populations linked by dispersal (Trenham et al. 2001). If a population is isolated from other populations and becomes extirpated, it will not be recolonized. Large, contiguous grassland areas containing multiple breeding ponds are ideal to ensure that recolonization occurs at individual pond sites.

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; Trenham et al. 2001). However, some salamanders will disperse to new breeding ponds. Dispersers have been found to be both first time breeders (last captured as newly metamorphosed juveniles) and experienced breeders (last captured as breeding adults) (Trenham et al. 2001). During a mark/recapture study in Contra Costa County, Orloff (2007, 2011) found that after breeding, most California tiger salamanders were captured at a trap point in upland areas near where they were first captured earlier that season. During a three-year mark/recapture study at breeding ponds in Monterey County, Trenham (2001) found that approximately 80 percent of individuals returned to the same breeding ponds in subsequent years, but 20 percent dispersed to different ponds. Similarly, Wang et al. (2009) used microsatellite markers to study gene flow across 16 California tiger salamander breeding sites at Fort Ord, Monterey County. They found that 15 of 16 sites were distinct genetically; with 10.5 to 19.9 percent of individual salamanders moving between breeding sites. Trenham (2001) found that California tiger salamanders travelled as far as 2,200 feet (670 meters) between ponds. Trenham et al. (2001) found that dispersal declined with increasing interpond distance.

Reproductive Success

Central California tiger salamanders are infrequent breeders (H. Shaffer, in literature, 2009) and lifetime reproductive success is low (Trenham et al. 2000, 2001). Trenham et al. (2000) conducted a seven-year study at a breeding pond in Monterey County and found the average female bred 1.4 times and produced 8.5 young that survived to metamorphosis per reproductive effort. This resulted in roughly 12 metamorphic offspring over the lifetime of a female. California tiger salamanders typically require at least 2 years to become sexually mature (Shaffer et al. 1993), although a few sexually mature one-year-old individuals have been reported in Jepson Prairie, Solano County (C. Searcy, U.C. Davis, personal communication, 2013); Trenham et al. (2000) found that most California tiger salamanders during his 7-year study in Monterey County did not reach sexual maturity until reaching 4 to 5 years of age. 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).

Diet

California tiger salamander larvae typically feed on aquatic invertebrates. The larvae feed on zooplankton, small crustaceans, and aquatic insects until they grow large enough to switch to larger prey (Anderson 1968). Anderson (1968) reported that larger larvae consume the tadpoles of Pacific chorus frogs, western spadefoot toads, and California red-legged frogs.

California tiger salamanders also feed in terrestrial habitat. Stomach contents of several sub-adult California tiger salamanders from San Luis Obispo County included spiders, earthworms, and water boatmen (Hansen and Tremper 1993). Van Hattem (2004) anecdotally reported on a California tiger salamander eating a moth while underground. Searcy (U.C. Davis, personal communication, 2012a) examined stomach contents of adult California tiger salamanders at Jepson Prairie, Solano County. Table 2 includes a list of the prey items identified.

Table 2: Terrestrial prey items found in California tiger salamander stomachs (C. Searcy, U.C. Davis, personal communication, 2012b).

Invertebrate Prey	Number of salamanders that were found to contain each prey type
Aphididae	2
Blattellidae	1
Carabidae	6
Collembola	4
Cryptopidae	1
Curculionidae	1
Embioptera	1
Hymenoptera	1

Isopoda	1
Lepismatidae	1
Lithobiidae	2
Lycosidae	3
Noctuidae	5
Opiliones	1
Rhaphidophoridae	3
Scarabaeidae	1
Scolopendra	2
Tipula	9

Spatial Distribution

Historically, California tiger salamanders were endemic to the San Joaquin-Sacramento river valleys, bordering foothills, and coastal valleys of Central California (Storer 1925; Stebbins 1985). Although the historical distribution of 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). The species is known from sites on the Central Valley floor near sea level, up to a maximum elevation of roughly 3,937 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 region. The higher elevation sites in the Coast Range are in the Ohlone Wilderness area.

The Service described the range of the California tiger salamander in the proposed rule to list the Central California DPS as threatened (Service 2003a). The Central California DPS 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, Tuolomne, and Yolo (See Figure 1). The spatial distribution for the California tiger salamander has not changed significantly since the time of listing. One occurrence was detected in a single livestock pond approximately 11 miles southwest from previously known occurrences in the Dunnigan Hills, Yolo County. Tissue samples for this occurrence were analyzed at the University of California, Davis, and determined to be native California tiger salamander (J. Downs, CDFW, personal communication, 2012). In Tulare County, Central California tiger salamanders were detected approximately 8 miles (19.3 kilometers) east of known CNDDB occurrences in Tulare County (Quad Knopf 2011).

The Service (2003a) concluded that, at the time of listing, urbanization and intensive agriculture had eliminated virtually all valley grassland and oak savanna habitat from the Central Valley floor. Shaffer et al. (1993) estimated that at least 75 percent of historical grassland habitat in the Central Valley used by California tiger salamanders has been lost. Grasslands are now distributed primarily in a ring around the Central Valley, and, consequently, the Central California tiger salamander is also primarily distributed within the same ring (Service 2003a) (See Figure 1). Shaffer et al. (1993) compared historical sites to sites that were currently maintaining breeding populations and found that there was a significant increase in elevation of localities, suggesting that low-elevation breeding sites have been eliminated. Because most valley floor habitat has been lost, Central California tiger salamanders are apparently restricted to higher elevation habitat that may be on the margin of their ecological requirements (Shaffer et al. 1993).

Several gaps exist in the distribution of the Central California tiger salamander. In the northeastern Sacramento Valley, the species was reported from only one site, in southern Butte County on the Gray Lodge Waterfowl Management Area, where it has not been located since 1965 despite subsequent surveys (Stebbins 1985; Shaffer et al. 1993). There are no known occurrences of California tiger salamanders along the eastern edge of the Sacramento Valley north of the Cosumnes River, along the southern edge of Sacramento County (CNDDB 2012). Gaps also occur along the western edge of the Sacramento Valley with occurrences in and near the Dunnigan Hills in Yolo County, and no occurrences until Solano County in the Jepson Prairie (CNDDB 2012). It is likely that the species is uncommon or absent in much of the southernmost San Joaquin Valley from approximately Los Banos in Merced County south, and the foothills of the Sierra Nevada south of Visalia in Tulare County because habitat is unsuitable (Shaffer et al. 1993).

<u>Abundance</u>

Virtually nothing is known concerning the historical abundance of the species. We do not have data regarding the total number of Central California tiger salamanders due to the fact that they spend most of their lives underground. The available data suggests 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).

Fluctuation in Population Numbers

There have been multiple studies on breeding populations, some of which have shown large amounts of fluctuation in numbers of breeding adults as well as numbers of larvae produced. It is unknown whether these fluctuations in the number of adults and larvae observed each year necessarily reflect true variation in actual adult population size. California tiger salamanders likely skip breeding in unfavorable years, with females being more likely to skip breeding than males (Trenham et al. 2000). In addition, adults may switch breeding sites based on conditions at the breeding sites; thus, the number of reproductively active adults at a site may vary substantially from one year to the next, while the population itself is less variable (CDFG 2010).

During a seven-year study of a breeding site in Monterey County, Trenham et al. (2000) found that the number of breeding adults visiting a single pond varied from 57 to 244 individuals. Loredo and Van Vuren (1996) conducted a study at a Contra Costa County breeding pool and reported a high amount of variation in numbers of juveniles produced within the pond; ranging from over 1,000 metamorphs in 1992 and only three metamorphs in 1994. At Olcott Lake, in Solano County, metamorph production was 3,115 salamanders in 2005, 3,412 in 2006, zero in 2007 and 2008, and 152 in 2009 (C. Searcy, U.C. Davis, personal communication, 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). Surveys were conducted for California tiger salamanders from 2002 to 2011 in 90 ponds in the Kellogg Creek, Marsh Creek, and Brushy Creek watersheds in the Bay Area region, and only one pond out of the 90 ponds had breeding observed every year (J. Alvarez, The Wildlife Project, personal communication, 2012). The most that breeding was observed in a single year was in 44 ponds. Some of the ponds had gaps in breeding (no breeding observed) for 1 or 2 years, while other ponds had gaps in breeding up to 6 years. On average, the ponds had a gap in observed breeding at an average of every 2.9 years (J. Alvarez, The Wildlife Project, personal communication, 2012).

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 California tiger salamander larvae. For example, Bobzien and DiDonato (2007) reported a significant negative association between the presence of aquatic hexapods and the presence of California tiger salamanders. They also documented nine ponds occupied by California tiger salamanders that were colonized by predacious aquatic hexapods; no larval salamanders were subsequently found in these nine ponds. Three ponds that lost aquatic hexapods were subsequently occupied by Central California tiger salamanders.

Habitat or Ecosystem

The Central California tiger salamander is found in the Central Valley and adjacent foothills and coastal grasslands and primarily inhabits annual grasslands and open woodlands of the foothills and valleys (Shaffer et al. 2013; Stebbins 1985; Storer 1925). Although California tiger salamanders are adapted to natural vernal pools and ponds, they now frequently use livestock ponds and other modified ephemeral and permanent ponds. 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). Central California tiger salamander larvae have been documented in sewage treatment ponds in Calaveras County (EBMUD 2010).

There has been a shift in habitat use from vernal pools located on valley floors to livestock ponds and other artificial wetlands in the foothills (Shaffer et al. 1993). Vernal pool wetlands likely provide higher quality breeding habitat for California tiger salamanders because they are less likely to contain species that predate on salamander larvae. Wang et al. (2011) studied a California tiger salamander population in Merced County that contained both vernal pools and more permanent livestock ponds and found that, for vernal pools, effective population size is positively correlated with vernal pool size (area) but this trend is absent in perennial ponds. This is likely because the permanent water bodies are more likely to contain breeding fish and bullfrog populations (Service 2005) and established populations of predatory aquatic insects (Bobzien and DiDonato 2007). In addition, non-native and hybrid tiger salamanders have higher reproductive success rates in perennial ponds.

Ponding duration is an important factor for breeding success. Wetlands must have a long enough ponding duration for California tiger salamander larvae to mature into juveniles capable of dispersing from the aquatic breeding site to suitable terrestrial habitat. This typically takes three months or more and will vary depending on factors such as water temperature and the depth of the breeding ponds (Feaver 1971). Aquatic habitat that holds water year-round is not optimum for California tiger salamander breeding because these types of habitats are more likely to have breeding populations of bullfrogs and non-native fish species (Service 2005) and established populations of predatory aquatic insects (Bobzien and DiDonato 2007). California tiger salamanders can be found in permanent ponds; however those permanent ponds do not typically have predatory fish or breeding bullfrog populations (Fisher and Shaffer 1996).

The California tiger salamander requires upland habitat that is occupied by small mammals such as California ground squirrel and Botta's pocket gopher that create underground burrow systems that are utilized by the salamanders throughout the year (Loredo et al. 1996; Pittman 2005; Seymour and Westphal 1994; Shaffer et al. 1993). Upland habitats surrounding known California tiger salamander breeding pools are usually dominated by grassland, oak savanna, or oak woodland (Shaffer et al. 2008). Large tracts of upland habitat are necessary for the California tiger salamander to persist. Maintaining inter-pond dispersal (connectivity between ponds) is important for the long-term viability of California tiger salamanders. Large, contiguous areas of scattered breeding pools that also contain the necessary terrestrial habitat components (suitable small mammal burrows) are ideal to ensure that recolonization can occur if a population at an individual pond site is extirpated.

Genetics

Shaffer and Trenham (2002), Shaffer et al. (2004), and Shaffer et al. (2012) conducted a range-wide survey of genetic variation in the California tiger salamander and determined that the Central California, Sonoma, and Santa Barbara DPSs are genetically distinct and geographically isolated. Using this information, the Service determined that the Central California DPS meets the discreteness criterion of the Service's DPS policy (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1996).

The Service (2003a) determined that hybridization between California tiger salamanders and non-native barred tiger salamanders (*Ambystoma mavortium*) (sometimes referred to as *Ambystoma tigrinum mavortium*) poses a significant threat to the California tiger salamander. There was a large-scale introduction of barred tiger salamander approximately 60 years ago, when many tens of thousands of barred tiger salamander were introduced from Arizona, Colorado, Nebraska, New Mexico, and Texas into the Salinas Valley in support of the bass-bait industry (Riley et al. 2003). These introduced barred tiger salamander have been breeding with California tiger salamanders in the Salinas Valley during the past 60 years (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). Hybridization has led to the genetic swamping of several native populations in the Central Coast and Bay Area, and possibly others as well (Service 2003a). Currently, hybrid populations are known to occur in Monterey, San Benito, Santa Clara, and Merced counties (CDFG 2010). Fitzpatrick and Shaffer (2007) determined that the distribution of introduced tiger salamander genes is largely confined to within 7.5 miles (12 kilometers) of introduction sites. Despite this sharp distinction between mostly pure native populations and the admixed populations of the Salinas Valley, Fitzpatrick et al. (2009, 2010) documented invasive genetic markers in populations outside of the Salinas Valley watershed. These invasive markers were labeled as superinvasive (SI) because they move very quickly across the landscape over a relatively short period of time and they sweep to fixation within ponds almost instantaneously. Approximately 5 percent of the invasive genomes sampled (3/68 markers surveyed) were determined to be SI. 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).

Refer to the Factor E: Other Natural or Manmade Factors Affecting its Continued Existence section for more information about the threat of hybridization to the California tiger salamander.

Cooperative Conservation Efforts

In 2003, the Service and CDFW developed the *Interim Guidance on Site Assessment and Field Surveys for Determining Presence or a Negative Finding of the California Tiger Salamander* joint survey protocol to accurately assess the likelihood of California tiger salamander presence in the vicinity of a project site (Service and CDFG 2003). This protocol was developed for the Santa Barbara DPS but has been used to determine presence/absence for the Central California tiger salamander as well. The survey requires aquatic surveys in two consecutive years with a nocturnal drift fence and pitfall trap survey conducted during the second year (Service and CDFG 2003). The aquatic surveys are conducted in the day, typically with a seine net, to detect the presence of larvae, although adults could be captured too. The drift fences in the second year utilize pit fall traps, which are examined after each rain event, to detect adults during breeding migrations.

Academics and agency personnel worked together to complete the *Guidelines for the Relocation of California Tiger Salamanders* (Shaffer et al. 2008). This document discusses in detail the issues that should be considered by land managers and agencies who are considering relocations of California tiger salamanders.

Rangeland experts, Academics, and the Alameda Resource Conservation District worked together to complete the *Managing Rangelands to Benefit the California Red-Legged Frog and California Tiger Salamander* (Ford et al. 2012). These guidelines provide the best available science for managing rangelands that support or have the potential to support California red-legged frogs and California tiger salamanders, and to integrate grazing management to benefit these amphibians with other conservation and production goals.

For a summary of conservation actions that have resulted in the protection of habitat for the Central California DPS of the California tiger salamander, refer to *Habitat Conservation Actions within the Central California DPS*, within Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range.

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

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

Introduction

At the time of listing, the Service determined that the primary cause of the decline of the Central California tiger salamander was the loss, degradation, and fragmentation of habitat as the result of human activities (Service 2004). Urbanization and intensive agriculture have eliminated virtually all valley grassland and oak savanna habitat from the Central Valley floor, leaving most remaining habitat distributed in a ring around the Central Valley (Shaffer et al. 1993). At the time of listing, the correlation between declining California tiger salamander numbers and surrounding urban and agricultural land uses had been well documented (Davidson et al. 2002). The Service (2003b) determined that there was a 20.7 percent loss of known Central California DPS records as of 2002 as a result of this habitat loss and degradation.

Since the time of listing, habitat loss has continued to occur, and the Service still considers habitat conversion and fragmentation to be a primary threat to the Central California tiger salamander. Most of the known and potential Central California tiger salamander breeding ponds and surrounding upland habitat occur on privately-owned grazing lands. Ranches with grazing as their primary land use are declining within the range of the Central California tiger salamander and are being replaced by vineyards, row crops, and urban land uses. California lost 105,000 acres (42,492 hectares) of grazing lands to urbanization between 1990 and 2004 and it could lose 750,000 acres (303,514 hectares) more by 2040 (Kroeger et al. 2009). Habitat loss and fragmentation will continue to occur in the future as California's population continues to increase, resulting in the expansion of urban and agricultural land uses. CDFW (CDFG 2010) conducted a GIS analysis of future California tiger salamander habitat loss (including the Central California, Santa Barbara, and Sonoma DPSs) and estimated that 388,243 acres (157,116 hectares) of existing California tiger salamander habitat will be lost to development and fragmentation by 2020, with a total of 423,789 acres (171,501 hectares) lost by 2030.

Figure 2 provides a map of known Central California tiger salamander occurrences and public and protected lands. Public ownership helps somewhat to blunt the threat from habitat destruction, but many of these lands were not specifically designated for the conservation and management of California tiger salamander. Many California tiger salamander populations outside of these protected lands face threats from habitat loss and fragmentation.

It is difficult to determine the exact number of California tiger salamander populations that have been lost due to habitat conversion. Landowners who have converted grassland to agricultural uses do not always obtain necessary permits and species surveys are not always conducted. Even in situations where a survey is conducted it may miss a population of California tiger salamanders due to the species' fluctuations in population numbers and because they may not breed in an individual pool every year. Surveys conducted in a proposed project area that include multiple potential breeding pools may only detect California tiger salamander larvae in some of the pools, or even in none of the pools (e.g., years with low rainfall and the species does not successfully breed). There is a high likelihood that pools that contained no California tiger salamander larvae at the time of the surveys could provide suitable breeding habitat in future years when conditions are more favorable.

Naturally occurring vernal pools provide long-term breeding habitat for California tiger salamanders (i.e., most remaining vernal pools in the Central Valley have been in existence for thousands of years or longer). While livestock ponds are the only remaining breeding habitat in some areas, a reliance solely on livestock ponds or other artificial wetlands for breeding habitat is problematic because many livestock ponds require periodic repair of eroding dams and spillways and periodic removal of excessive silt and vegetation. Without this periodic maintenance, most livestock ponds will only last 30 to 50 years; and, in most cases, funding for this type of costly maintenance is not assured.

The following discussion under Factor A includes: (1) a discussion of the effects on the California tiger salamander from urbanization and conversion to agriculture; and, (2) a summary of habitat loss that has occurred since the time of listing. To analyze habitat loss that has occurred since the time of listing, the Service: (1) reviewed the amount of take authorized by the Service through sections 7 and 10 of the Act: (2) analyzed extant and extirpated occurrences in the CNDDB (CNDDB 2012);

and, (3) analyzed changes in land use by conducting a GIS analysis of land use cover throughout the range of the Central California tiger salamander. This Factor A discussion concludes with a summary of habitat conservation actions that have occurred within the Central California DPS. Many of these conservation actions have resulted in the protection of habitat for this species, thereby permanently or temporarily reducing the threat of habitat conversion.

Effects from Urbanization

The Service (2004) defined urban impacts to include a variety of non-agricultural development activities, such as building and maintenance of housing, commercial, and industrial developments; construction and widening of roads and highways; golf course construction and maintenance; landfill operation and expansion; operation of gravel mines and quarries; and dam building and inundation of habitat by reservoirs. Urbanization leads to direct and indirect loss of habitat for the California tiger salamander. Direct effects include the loss of suitable aquatic and terrestrial habitat through grading or other habitat modifications such as flooding from reservoir expansion projects or the construction of solar power facilities. Indirect effects can be caused by many actions, including: pond modifications that favor exotic predators; ground squirrel eradication; habitat fragmentation from roads and urban areas; increases in contaminated run-off from urbanized areas; and, increases in native species, such as raccoons (*Procyon lotor*), that may be artificially abundant in association with urban development.

The construction and maintenance of roads and highways results in habitat destruction, and also increases habitat fragmentation because roads create physical obstacles that can prevent the movement of animals as well as increase mortality through vehicle strikes (Trombulak and Frissell 2000). Amphibians are especially vulnerable to being killed on roads due to their slow movements and life histories involving migration between breeding and upland habitats (Trombulak and Frissell 2000). Roads can significantly reduce the breeding population of a pond and, in some cases, cause the loss of a large portion of a metapopulation (Service 2003a). For example, Highway 580 from Pleasanton to Tracy and Highway 680 from Pleasanton to Milpitas have created an impassable 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). See the *Mortality from Road Crossings* section in Factor E .

Effects from Land Conversion to Intensive Agriculture

The Service (2004) defined agricultural impacts to include the conversion of native habitat by discing and deep-ripping; and cultivation, planting, and maintenance of row crops, orchards, and vineyards. Conversion of grasslands to intensive agricultural uses, such as vineyards, orchards, and row crops, has led to the direct loss of Central California tiger salamander populations (Service 2003b). Some less intensive agriculture 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, if vernal pool grasslands are converted to irrigated pasture for cattle grazing, the repetitive flooding of the grasslands throughout the summer months decrease abundance of burrowing mammals such as ground squirrels (Marsh 1994), thereby reducing the number of available burrows for California tiger salamanders. In addition, California tiger salamanders may actively avoid areas prone to flooding, as they have been found to be more common in areas with flood intolerant plants at Jepson Prairie (Searcy et al. 2013).

Suitable habitat adjacent to intensive agricultural uses may also be impacted. Aquatic breeding habitat may be affected by changes to hydrology (e.g. changing seasonal wetlands to perennial wetlands), increases in sediment inputs, increases in harmful contaminants, changes in predator and prey assemblages, and other alterations. Upland habitat may be impacted by the loss of small mammal burrows resulting from ground squirrel or gopher eradication programs, fragmentation from roads, and changes in available forage. All of these factors will result in less favorable conditions for California tiger salamanders and may decrease or eliminate populations. For example, Morey and Guinn (1992) surveyed for amphibians from 1982 to 1986 in Stanislaus County in an area that had experienced recent and large-scale changes in land use, with a shift from grazing to intensive agriculture, particularly orchards and vineyards. Their study documented a significant decline in California tiger salamanders over the four years surveyed. In addition, they also reported a proportional increase in bullfrogs throughout their study area, suggesting that changes in aquatic habitat favored bullfrogs over the salamanders (e.g., vernal pool grasslands converted to irrigated vineyards and orchards that contain permanent and semi-permanent wetlands that favor bullfrog reproduction).

Although conversion of suitable California tiger salamander habitat to intensive agriculture has been one of the primary factors leading to declines in the amount of suitable habitat for the California tiger salamander (Service 2003a, 2004), the Service has received only one request for consultation for the conversion of habitat to intensive agriculture uses since the species was listed in 2004. This consultation request came from the U.S. Army Corps of Engineers (Corps) in 2012 for a project that proposes to install vineyards in Sacramento County and would result in the fill of potential breeding habitat for the salamander.

Habitat Loss within the Central California Tiger Salamander's Range

In this section of the 5-year status review, we summarize temporary and permanent loss of California tiger salamander habitat that has been authorized by the Sacramento Fish and Wildlife Office and the Ventura Fish and Wildlife Office through sections 7 and 10 of the Act. The Service also reviewed extant and extirpated CNDDB occurrences within the range of the Central California tiger salamander (CNDDB 2012). In addition, we provide a comparison of land use changes from 2001 to 2006 within the four regions of the Central California tiger salamander (Bay Area, Central Valley, southern San Joaquin Valley, and the Central Coast Range). A summary of these analyses follows.

Habitat Loss Authorized under Section 7 of the Act

The Service reviewed all Incidental Take Statements for the Central California tiger salamander rendered through section 7 of the Act from the time of listing to present as part of this 5-year status review. The Service also reviewed all conference opinions rendered prior to the listing of the species. Projects that resulted in permanent habitat loss included: road construction and maintenance; water conveyance, including reservoir maintenance and expansion, and construction and maintenance of pipelines and canals; energy projects such as construction and maintenance of substations and energy plants, including wind and solar facilities, and construction and maintenance of transmission lines and gas pipelines; and, urbanization, including construction of residential, industrial, and government facilities. Table 3 provides a summary of the project types that resulted in permanent and temporary habitat loss authorized by the Service through section 7 of the Act from 2004 to 2012. Table 4 provides a summary of the amount of take authorized within each region (Bay Area, Central Valley, Southern San Joaquin Valley, and Central Coast Range), broken down by county. It is important to note that these amounts do not reflect the actual amounts of permanent and temporary habitat loss that have occurred from 2004 to 2012. Rather, these amounts only reflect the acreage amounts of projects where federal agencies have consulted with the Service and take was authorized by the Service. In addition, while some of these projects have been authorized by the Service, some projects have yet to break ground. However, these acreage amounts provide an indication of the habitat loss that has occurred or is expected to occur in the future.

Table 3: Project types and Central California tiger salamander habitat loss authorized through section 7 of the Act from 2004 to 2012.

Project Type	*Authorized Permanent Habitat Loss (acres)**	*Authorized Temporary Habitat Loss (acres)**
Water conveyance/reservoirs	3,033	1,075
Urbanization	3,988	1,047
Road maintenance and construction	850	191
Energy facilities and infrastructure	184	793
Restoration/wetland creation**	242	311
Military training exercises	158.5	3,901
Mining	135	0
Communication towers	1	52
Site clean-up/abatement	3	11,950
Prescribed burning	0	4,965
Fuel break	0	440
Recreation (trail)	62	0
Total	**8,657**	**24,725**

*Acreage amounts in tables 3 and 4 differ slightly due to rounding errors.
** These projects authorized take for the permanent loss of upland habitat that was converted to suitable aquatic breeding habitat, or projects that restored wetland features to improve/sustain habitat for the salamander.

Table 4: Permanent and temporary Central California tiger salamander habitat loss authorized through section 7 of the Act by region and county from 2004 to 2012.

Region/Counties	*Authorized Permanent Habitat Loss (acres)*	*Authorized Temporary Habitat Loss (acres)*
Bay Area		
Alameda*	361	1,242
San Benito	432	2
Santa Clara	104.5	4,812
Bay Area total	**897.5**	**6,056**
Central Valley		

Alameda*	1,080	3,721
Calaveras	205	0
Contra Costa	2,088	4,671.5
Multiple**	500	0
Merced	2.5	1
Sacramento	143.5	513
San Joaquin	52	0
Solano	385	180
Stanislaus	47.5	105.5
Tuolumne	1	106.5
Yolo	1	1
Central Valley total	**4,506.5**	**9,300**
Southern San Joaquin Valley		
Fresno	756	1
Kings	0	0
Madera	1,595	150.5
Tulare	3	0
Southern San Joaquin Valley total	**2,354**	**151.5**
Central Coast Range		
Monterey	881	8,834
San Luis Obispo	16	5
Santa Cruz	1	378
Central Coast Range total	**898**	**9,217**
Totals for all regions	**8,656**	**24,724.5**

Note: Acreage amounts in tables 3 and 4 differ slightly due to rounding errors.
* Alameda County occurs within both the Bay Area and Central Valley regions. The total habitat loss for Alameda County (total for Bay Area and Central Valley combined) are correct; however, the total habitat loss authorized for Alameda County within each of these two regions are estimates.
** Biological opinions rendered for Bureau of Reclamation actions that spanned large portions of the Central Valley.

The East Alameda Conservation Strategy (Conservation Strategy) was finalized in 2012 and addresses effects to Central California tiger salamander within the 271,485-acre (109,866-hectare) area. The Conservation Strategy establishes a baseline condition for acres of protected land in the study area and establishes which land cover types and focal species should be the focus of project planning and conservation efforts. In addition, the Conservation Strategy standardizes avoidance, minimization, mitigation, and compensation requirements to comply with federal, state, and local laws and regulations. As part of this effort, the Service finalized the Programmatic Biological Opinion for the East Alameda Conservation Strategy in 2012. As of 2012, no projects were appended to the programmatic biological opinion. This programmatic biological opinion requires ratios to be utilized by local jurisdictions and the Service to determine the level of mitigation necessary to offset project impacts. Ratios are determined by the number of covered species present within a proposed project area, where the project is located (i.e., within a priority conservation area or not), and the quality of the proposed mitigation sites. At this time the Service is unable to determine exactly how much grassland habitat will be converted to urban or other uses or how much habitat will be preserved for the Central California tiger salamander as a result of the Conservation Strategy. The biological opinion states that an Implementation Committee will be formed in order to track how the strategy is working and update the Conservation Strategy over time.

Habitat Loss Authorized under Section 10 of the Act from 2004 to 2012

Regional Habitat Conservation Plans (HCPs) have been finalized that provide incidental take coverage for the loss of Central California tiger salamander habitat. These HCPs also result in lands protected to conserve the species. HCPs that cover the Central California tiger salamander include the East Contra Costa County HCP, the San Joaquin Multi-Species Plan, the Santa Clara Valley HCP, and the Pacific Gas and Electric Company's HCP for Operation and Maintenance in the San Joaquin Valley. Two other HCPs include the Central California tiger salamander as a covered species because it was not clear at the time these HCPs were developed whether the species occurred within the covered area or not; however, the salamander was not detected after significant survey efforts that occurred after the HCP permits were issued (Natomas HCP and Kern Water Bank HCP). The Service has permitted three low-effect HCPs that cover the Central California tiger salamander as well. As of 2012, two additional HCPs that cover the Central California tiger salamander are near in completion but not yet finalized: The Stanford University HCP and the Southern California Edison's San Joaquin Valley Cross Valley Loop Transmission Project.

While thousands of acres of permanent and temporary take have been authorized through these HCPs, the actual amount of habitat lost at this time has not approached these take limits. Table 5 provides a summary of take amounts authorized under HCPs and also summarizes the acreage amount of actual projects permitted through these HCPs since 2012. It is important to note that while the regional HCPs provide authorized take for covered species, the authorized take is measured in terms of habitat types (such as grassland, chaparral, vernal pool wetland, etc.). The take amounts listed in Table 5 reflect the amount of habitat that could potentially support Central California tiger salamanders that has/may be lost, but do not necessarily reflect loss of occupied habitat. For example, the San Joaquin County Multi-Species Plan (SJCMSP) may authorize a project that will result in the permanent loss of valley grassland habitat, but presence/absence surveys for Central California tiger salamanders are not required. Consultants only determine if the habitat could serve as potential habitat, and it will not be known whether the species occurred at the site or not. Therefore, while the SJCMSP provides authorized take for 4,499 acres (1,820.7 hectares) of potential habitat for the species, it is unknown how many acres of Central California tiger salamander habitat actually occurs within this acreage amount.

Table 5: Amount of habitat loss authorized through HCPs (section 10 of the Act).

Habitat Conservation Plan	*Authorized Habitat Loss (acres)*	*Take that has occurred up to 2012 (acres)*
East Contra Costa County HCP	5,639	60 permanent/ 129 temporary *
Pacific Gas and Electric Company HCP for the San Joaquin Valley (Kern, Kings, Tulare, Fresno, Madera, Merced, Mariposa, Stanislaus, and San Joaquin counties)	11 permanent/ 990 temporary	0.55 permanent/ 0 temporary
San Joaquin County Multi-Species Plan	4,499	19.19 permanent **

Santa Clara Valley HCP	12,932 permanent/ 1,543 temporary	0
Three low-effect HCPs (2 in Solano County, 1 in Yolo County)	300.14 permanent	300.14 permanent

Note: Acres are rounded to nearest whole numbers; amounts authorized may differ.
*Take amounts from ECCCHB 2012, table 4.
**Take amounts from SJCG 2011, table 4.

Habitat Conservation Actions within the Central California DPS

Although the trend of habitat loss has continued since the time of listing, permanent and temporary protection of land through conservation easements and other conservation tools has resulted in the preservation of breeding and upland habitat for the Central California tiger salamander. A summary of some of these protected areas follows.

Conservation Banks

There are 12 conservation banks that have been established to sell credits for the California tiger salamander to offset impacts from projects that result in the loss or degradation of this species' habitat. These conservation banks are protected by perpetual conservation easements and have funding mechanisms such as endowment funds for the perpetual management of the habitat to ensure the survival of California tiger salamanders present within the conservation banks. Ten of these conservation banks are in the Central Valley population, one conservation bank is located within the San Joaquin population, and one bank is located in the Bay Area population. Table 8 summarizes these conservation banks, and the conservation bank locations are shown in Figure 2.

Table 8: Summary of conservation banks established for the Central California tiger salamander.

Bank Name	***County***	***Size (acres)***
Central Valley Population		
Burke Ranch	Solano	964
Deadman Creek	Merced	684
Drayer Ranch	Merced	254
Elsie Gridley	Solano	1,837
Fitzgerald Ranch	San Joaquin	808
Flynn Ranch	Merced	1,067
Mountain House	Alameda	147
Noonan Ranch	Solano	152
North Suisun	Solano	609
Viera-Sandy Mush	Merced	333
Southern San Joaquin Valley Population		
Sand Creek	Tulare	498
Bay Area Population		
Ohlone Preserve	Alameda	640
		Total (acres) = 7,993

Other permanently protected lands

This section provides information on other protected lands that have known extant occurrences of Central California tiger salamander. Some of these properties are managed specifically for Central California tiger salamanders, while other properties are managed for other land uses that are compatible with Central California tiger salamander conservation. Populations within these properties vary greatly, with some properties having large populations occurring throughout the property, while other properties may have only one or two small populations. Table 9 describes lands protected as public lands, with conservation easements, or privately owned by a conservation partner. Table 10 provides a summary of safe harbor agreements that provide a net conservation benefit for the Central California tiger salamander.

Table 9: Summary of protected lands that have known occurrences of Central California tiger salamander.

Property Name	*Manager*	*Size (ac.)*	*Protection*
Central Valley Population			
Jepson Prairie/Wilcox Ranch, Solano County	Solano Land Trust	3,626	Easement
SMUD Nature Preserve, Sacramento County	Sacramento Municipal Utility District	1,132	Easement
Howard Ranch, Sacramento County	The Nature Conservancy (TNC) and U.S. Bureau of Land Management (BLM)	12,362	Easement
Forster Ranch, Sacramento County	TNC and BLM	3,185	Easement
Great Valley Grasslands State Park, Merced and Stanislaus Counties	California Department of Parks and Recreation (CDPR)	2,826	Public lands
Flying M Ranch, Merced County	TNC	5,000	Easement
San Luis National Wildlife Refuge, Merced County	Service	26,600*	Public lands
Ichord Ranch, Merced County	Private	2,918	Easement
Lazy K Ranch, Merced and Madera Counties	Private	93	Easement
Black Diamond Mines Regional Preserve, Contra Costa County	East Bay Regional Parks District (EBRPD)	5,375	Public lands
Brushy Peak Regional Preserve, Contra Costa County	EBRPD	1,833	Public lands
Clayton Ranch Regional Preserve, Contra Costa County	EBRPD	4,195	Public lands
Contra Loma Regional Preserve, Contra Costa County	EBRPD	780	Public lands
Vasco Caves Regional Preserve, Contra Costa County	EBRPD	1,644	Public lands
Round Valley Regional Park,	EBRPD	1,911	Public

Contra Costa County			lands
Southern San Joaquin Valley Population			
McKenzie Table Mountain Preserve, Fresno County	Sierra Foothill Conservancy (SFC)	2,960	Privately owned by SFC
Stone Corral Ecological Reserve, Tulare County	California Department of Fish and Wildlife	968	Owned by CDFW
Bay Area Population			
Del Valle Regional Park, Alameda County	EBRPD	4,316	Public lands
Garin Regional Park, Alameda County	EBRPD	4,794	Public lands
Ohlone Regional Wilderness, Alameda County	EBRPD	9,737	Public lands
Mission Peak Regional Preserve, Alameda County	EBRPD	3,000	Public lands
Sunol Regional Wilderness, Alameda County	EBRPD	6,859	Public lands
Los Vaqueros Reservoir, Contra Costa County	Contra Costa Water District	5,079	Easement[+]
Don Edwards San Francisco Bay NWR (Warm Springs Unit)	Service	700	Public lands
Joseph D. Grant County Park, Santa Clara County	Santa Clara County Department of Parks and Recreation	9,560	Public lands
Almaden Silver County Park, Santa Clara County	Santa Clara County Department of Parks and Recreation	4,152	Public lands
Anderson Lake County Park, Santa Clara County	Santa Clara County Department of Parks and Recreation	3,144	Public lands
Calero County Park, Santa Clara County	Santa Clara County Department of Parks and Recreation	4,455	Public lands
Kammerer Ranch, Santa Clara County	The Nature Conservancy	1,400	Owned by TNC
Palassou Ridge Open Space Preserve, Santa Clara County	Santa Clara Valley Open Space Authority	3,523	Public lands
Sierra Vista Open Space Preserve, Santa Clara County	Santa Clara Valley Open Space Authority	1,795	Public lands
Blue Oak Ranch, Santa Clara County	University of California Preserve System	3,240	Public lands
Henry W. Coe State Park, Santa Clara and Stanislaus Counties	CDPR	89,000*	Public lands
Cañada de los Osos Ecological Reserve, Santa Clara County	CDFW	4,400	Public lands
Pinnacles National Monument, San Benito County	U.S. National Park Service	26,000*	Public lands
Central Coast Range			
Ellicot Slough NWR, Santa Cruz	Service and CDFW	298	Public

County			lands
Buena Vista Preserve, Santa Cruz County	CDFW	289	Public lands
Fort Ord National Monument, Monterey County	BLM	7,200	Public lands
Hastings Natural History Reservation, Monterey County	University of California Preserve System	2,373	Public lands

+Easement not recorded as of 2012
*Central California tiger salamanders occur in only a small portion of this area.

Table 10: Summary of safe harbor agreements completed that benefit the Central California tiger salamander.

Safe Harbor Agreement	*Notes*	*Size (acres)*
Alameda County Resource Conservation District Programmatic, Alameda County	10 properties, 20 livestock ponds restored.	16,000
East Bay Municipal Utility District, Amador, Calaveras, and San Joaquin Counties	Creation of breeding ponds, removal of fish and bullfrogs from existing ponds.	28,000
Palo Corona Regional Park, Monterey County	Habitat management	4,300
Agriculture and Land Based Training Association, Monterey County	Creation of breeding ponds. State SHA through CDFW only	130

Summary

The historic and continuing loss and modification of breeding pool habitat and associated uplands continues to be a primary threat to the Central California tiger salamander, especially in areas where urbanization and agriculture conversion is expected to expand further. Even in areas where habitat is protected, the urbanization and conversion to agriculture of surrounding lands results in the fragmentation and degradation of protected habitats, likely causing increased edge effects to protected habitat as well as preventing dispersal of the Central California tiger salamander within and between populations. Many of the protected areas that have populations of Central California tiger salamander are not monitored for threats to this species.

The Service, as well as numerous other agencies, non-governmental organizations, and private landowners are engaged in the protection of Central California tiger salamander habitat. Since the species was listed in 2004, multiple conservation banks have been established and large, contiguous tracts of vernal pool and grassland habitat have been protected with conservation easements. Other conservation tools such as safe harbor agreements have resulted in the temporary protection of habitat as well. However, despite these proactive efforts to conserve habitat, pressures from urbanization and conversion to agriculture continue to threaten this species.

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

Overutilization for commercial purposes was not known to be a factor in the 2004 final listing rule. Overutilization for any purpose does not appear to be a threat at this time.

FACTOR C: Disease or Predation

Disease

At the time of listing, the specific effects of disease on the Central California tiger salamander were not known and disease was not considered an imminent threat at the time (Service 2004). However, it was assumed that Central California tiger salamanders could be infected by a ranavirus since other closely related sub-species of tiger salamander were susceptible to ranaviruses (Service 2004). Ranaviruses are emerging pathogens in a group of viruses in the family Iridoviridae, which are known to infect amphibians, reptiles, and fishes. Ranaviruses have caused tiger salamander die-offs throughout western North America (Jancovich et al. 2001, 2003, 2005). For example, ranaviruses such as *Ambystoma tigrinum* Virus (ATV) and regina ranavirus (RRV) were known at the time of listing to cause die-offs of other *Ambystoma* species (Jancovich et al. 2001, 2003, 2005). ATV, in particular, has been known to cause frequent and recurring die-offs of populations of multiple tiger salamander subspecies, including the Arizona tiger salamander (*A. t. nebulosum*) (Brunner et al. 2004) and the federally-listed Sonoran tiger salamander (*A. t. stebbinsi*) (Service 2002, 2007). 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 California tiger salamanders in experimental conditions (Picco et al. 2007). Picco et al. (2007) infected six California tiger salamanders with ATV and 5 of the 6 salamanders died from the virus. Death of the five individuals occurred within 14 to 18 days.

The history of ATV in Arizona and how this virus affects Ambystoma salamander populations in Arizona is worthy of discussion because it is likely that the virus would affect California tiger salamanders in a similar manner if the virus was introduced in California. ATV is believed to have been introduced to Ambystoma salamanders in Arizona through the introduction of non-native tiger salamander species used as fishing bait (Jancovich et al. 2005; Service 2007). ATV is transmitted via direct contact among salamanders, feeding on infected tissues, and in water with high viral titers (Service 2007). Fish and frogs are not susceptible to ATV, and only salamanders and newts appear susceptible to ATV, as no other hosts of the disease are known (Jancovich et al. 2001). ATV quickly degrades in pond water and mud in the absence of salamander hosts (Brunner et al. 2004; Service 2007). Infection with ATV will kill almost all larval and adult salamanders in the pond at the time, usually within 2 to 3 weeks (Service 2002, 2007). However, a small number of larval and adult salamanders will typically recover from ATV and carry sublethal infections for more than five months, and these recovered individuals become carriers that can then re-infect other individuals (Brunner et al. 2004; Service 2007). For example, Brunner et al. (2004) reported that toward the end of one epidemic on the Kaibab Plateau in Arizona, 78 percent of the young-of-the-year Arizona tiger salamanders were found to be infected as they left the pond for burrows, many without visible signs of infection. The researchers later found two sublethally infected Arizona tiger salamander adults returning to breed at this same pond, providing indirect evidence that these individuals can return the next season to re-infect the breeding population.

Diseases, such as ATV and other ranaviruses, are considered a threat because if a Central California tiger salamander population at a single breeding pond 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 disperse to other ponds where they will infect other individuals. The fact that many of the remaining Central California tiger salamander breeding sites are increasingly fragmented may be a benefit to the species in this particular case because it will limit the number of populations that are infected by ATV to the isolated ponds; although this fragmentation is also considered to increase the significance of the threat of disease because if an isolated population is extirpated by ATV or other ranavirus, it will be impossible for that site to be naturally recolonized.

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 in the laboratory, California tiger salamanders were susceptible to infection by chytrid fungus, but infection did not result in mortality or clinical signs of disease during the 18-month study. Padgett-Flohr (2008) observed that infected salamanders continued to eat well, swim in their ponds, and move about their tanks in a consistent manner. However, none of the infected California tiger salamanders were able to rid themselves of the fungus during the 18-month study. Infected California tiger salamanders sloughed (i.e., molted) whole skins approximately every two to three days; whereas, uninfected individuals sloughed whole skins approximately once every one to two weeks. It is possible that this rapid sloughing of the skin helps prevent mortality from the fungus; however, this increased sloughing will also require more energy and reduce the fitness of the infected salamander. Chytrid fungus has been found in Central California tiger salamanders in Santa Clara County (Padgett-Flohr and Longcore 2005). Because chytrid fungus is widespread throughout the Central California tiger salamander's range, it is likely that California tiger salamanders in other areas also carry chytrid fungus. The Service is not aware of any information on the effects of Chytrid fungus on salamander larvae, which may be more susceptible to the fungus since they remain in an aquatic environment. To date, chytrid fungus has not been found to be responsible for California tiger salamander mortality in the laboratory or the field, but its potential to cause mortality cannot be ruled out (CDFG 2010).

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 eliminated some California tiger salamander populations (Shaffer et al. 1993). Bullfrogs and California tiger salamander tend to not co-occur in the same wetlands (Fisher and Shaffer 1996; 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 California tiger salamander larvae and migrating adults.

At the time of listing, non-native tiger salamanders and hybrids were considered a threat for a variety of reasons, including the potential for the larger non-native and hybrid salamanders to predate on the smaller Central California tiger salamanders. At a population in the Santa Barbara DPS, 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 (Ryan et al. 2009). 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 the time of listing, western mosquitofish (*Gambusia affinis*) were determined to be a threat to California tiger salamander. The introduction of western mosquitofish to a breeding pond can eliminate an entire population of California tiger salamander (Jennings and Hayes 1994). Leyse and Lawler (2000) observed that mosquitofish did not have detectable effects on California tiger salamander larvae in experimental ponds that simulated vernal pool hydrology. However, mosquitofish did reduce the survival of salamander larvae in simulated perennial ponds, likely because permanent ponds allow mosquitofish populations to build from one season to the next, which increases predation on salamander larvae and also results in less prey species available to salamander larvae. 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 to mosquitofish, other introduced fish threaten the California tiger salamander (Shaffer and Stanley 1991; Shaffer et al. 1993). The Service determined that introductions of non-native fish species into Central California tiger salamander breeding habitat was a potential threat to the persistence of the species (Service 2003a, 2004). 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*) into many ponds that may have been breeding habitat for California tiger salamanders has likely eliminated salamanders from those sites (Shaffer et al. 1993). Other non-native predators cited by the Service (2004) as a threat to Central California tiger salamander include non-native crayfish species (*Pacifastacus*, *Orconectes*, and *Procambarus* spp.). Crayfish prey on California tiger salamanders (Shaffer et al. 1993) and are thought to have eliminated some populations (Jennings and Hayes 1994).

California tiger salamander eggs, larvae, and adults are also prey for many native species; however, in healthy salamander populations, this is not known to be a substantial threat (Service 2003a, 2004). When combined with other impacts, such as predation by non-native species, contaminants, or habitat alteration, the collective result may be a substantial decrease in population abundance and viability. Native predators include great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), western pond turtle (*Clemmys marmorata*), various garter snake species (*Thamnophis* spp.), larger California tiger salamanders, western spadefoot toads, California red-legged frogs, raccoons, striped skunks (*Mephitis mephitis*) and ravens (*Corvus Corax*) (C. Searcy, U.C. Davis, personal communication, 2012b; Hansen and Tremper 1993). Birds such as American avocet (*Recurvirostra Americana*) and Forster's tern (*Sterna forsteri*) have also been observed predating on Central California tiger salamander larvae (Allaback et al. 2005). Various gull species (*Larus* spp.) have been observed predating on Central California tiger salamander larvae at Frick Lake and Brushy Peak Regional Preserve in Alameda County (S. Bobzien, in literature, 2003). Raccoons are highly effective predators on California tiger salamanders both during migration and when in the breeding ponds (S. Sweet pers. comm., as cited in CDFG 2010).

Predacious hexapods, including giant water bugs (*Belostomatidae*), predacious diving beetles (*Dytiscidae*), waterscorpions (*Nepidae*), and dragonfly nymphs (*Anisoptera*) are known to predate on Central California tiger salamander larvae and the presence of predacious hexapods within a wetland may actually prevent California tiger salamanders from successfully breeding in the wetland (Bobzien and DiDonato 2007). California tiger salamander larvae and predatory aquatic insects will each prey on the other, and high densities of one can suppress the other. Ponding duration plays a role in determining which species will be more successful in a particular wetland. Newly-hatched California tiger salamander larvae in permanent ponds will face a higher density of mature predatory insects that will predate on the salamander larvae. Seasonal ponds, on the other hand, are more likely to be initially free of these insects. Immigrating insects would enter seasonal ponds at low densities, and newly hatched insects are generally smaller than, and vulnerable to predation from, the California tiger salamander larvae present (Bobzien and DiDonato 2007).

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The primary cause of the decline of the Central California tiger salamander is the loss, degradation, and fragmentation of habitat that results from human activities. Federal, State, and local laws have not been sufficient to prevent past and ongoing losses of the California tiger salamander and its habitat. There are several State and Federal laws and regulations that are pertinent to the protection of Central California tiger salamanders. A summary of these laws follows.

State Protections in California

The State's authority to conserve rare wildlife is comprised of three major pieces of legislation: the California Endangered Species Act, the California Environmental Quality Act, and the Natural Community Conservation Planning Act.

California Endangered Species Act: The California tiger salamander was listed by the State of California as threatened under the California Endangered Species Act in 2010. The California Endangered Species Act (California Fish and Wildlife Code, section 2080 et seq.) prohibits the unauthorized take of State-listed threatened or endangered species. This law requires State agencies to consult with CDFW on activities that may affect a State-listed species and mitigate for any adverse impacts to the species or its habitat. Pursuant to the California Endangered Species Act, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The State may authorize permits for scientific, educational, or management purposes, and to allow take that is incidental to otherwise lawful activities.

California Environmental Quality Act: This law requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 21002). Protection of listed species through this law is, therefore, dependent upon the discretion of the lead agency involved.

Natural Community Conservation Planning Act: The Natural Community Conservation Program is a cooperative effort to protect regional habitats and species. The program helps identify and provide for area wide protection of plants, animals, and their habitats while allowing compatible and appropriate economic activity. Many Natural Community Conservation Plans are developed in conjunction with Habitat Conservation Plans prepared pursuant to the Federal Endangered Species Act.

California Lake and Streambed Alteration Program: The Lake and Streambed Alteration Program (California Fish and Game Code sections 1600-1616) may promote the recovery of listed species in some cases. This program provides a permitting process to reduce impacts to fish and wildlife from projects affecting important water resources of the State, including lakes, streams, and rivers. This program also recognizes the importance of riparian habitats to sustaining California's fish and wildlife resources, including listed species, and helps prevent the loss and degradation of riparian habitats.

Other California Regulations: As of December, 2000, it is illegal to use *A. tigrinum* as bait (commonly referred to as "waterdogs") or possess any member of the genus *Ambystoma* in California without a special permit from the CDFW (CCR, Title 14, §4.00 and §671). This regulation change was made to protect California tiger salamanders from hybridization with non-native tiger salamanders by further spread of the non-native species via deliberate or accidental release into state waters (CDFG 2010). Although possession and use for bait are now prohibited, a relict regulation still allows sale of non-native tiger salamanders as bait (Title 14 §200.31(c). This oversight will be eliminated in the next appropriate Department regulation change cycle (D. Steele, CDFW, personal communication, 2012).

Federal Protections

National Environmental Policy Act: This law (42 U.S.C. 4371 et seq.) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, the National Environmental Policy Act requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species. However, this law does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

Clean Water Act: Under section 404, the Corps regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term "wetland" refers to areas meeting the Corps' criteria of hydric soils, hydrology (either sufficient annual flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any action with the potential to impact waters of the United States must be reviewed under the Clean Water Act, National Environmental Policy Act, and Endangered Species Act. These reviews require consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts.

The Corps interprets "the waters of the United States" expansively to include not only traditional navigable waters and wetlands, but also other defined waters that are adjacent or hydrologically connected to traditional navigable waters. However, recent Supreme Court rulings have called this definition into question. On June 19, 2006, the U.S. Supreme Court vacated two district court judgments that upheld this interpretation as it applied to two cases involving "isolated" wetlands. Currently, Corps regulatory oversight of such wetlands (e.g., vernal pools) is in doubt because of their "isolated" nature. In response to the Supreme Court decision, the Corps and the U.S. Environmental Protection Agency have released a memorandum providing guidelines for determining jurisdiction under the Clean Water Act. The guidelines provide for a case-by-case determination of a "significant nexus" standard that may protect some, but not all, isolated wetland habitat (USEPA and USACE 2007). The overall effect of the new permit guidelines on loss of isolated wetlands, such as vernal pool habitat, is not known at this time.

Endangered Species Act: The Act is the primary Federal law providing protection for the Central California tiger salamander. The Service's responsibilities include administering the Act, including sections 7, 9, and 10 that address take. Since listing, the Service has analyzed the potential effects of Federal projects under section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project. The adverse modification standard ensures that federal actions do not appreciably diminish the value of critical habitat to satisfy the survival or recovery needs of a listed species. 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 located within 19 California counties (Service 2005) (Figure 3). 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).

Section 9 prohibits the taking of any federally listed endangered or threatened species. Section 3(18) defines "take" to mean "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Service regulations (50 CFR 17.3) define "harm" to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that results from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to section 10(a)(1)(B). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved Habitat Conservation Plan that details measures to minimize and mitigate the project's adverse impacts to listed species. Regional Habitat Conservation Plans in some areas now provide an additional layer of regulatory protection for covered species, and many of these Habitat Conservation Plans are coordinated with California's related Natural Community Conservation Planning program.

Sikes Act: The Sikes Act (16 U.S.C. 670) authorizes the Secretary of Defense to develop cooperative plans with the Secretaries of Agriculture and the Interior for natural resources on public lands. The Sikes Act Improvement Act of 1997 requires Department of Defense installations to prepare Integrated Natural Resource Management Plans (INRMPs) that provide for the conservation and rehabilitation of natural resources on military lands consistent with the use of military installations to ensure the readiness of the Armed Forces. INRMPs incorporate, to the maximum extent practicable, ecosystem management principles and provide the landscape necessary to sustain military land uses. While INRMPs are not technically regulatory mechanisms because their implementation is subject to funding availability, they can be an added conservation tool in promoting the recovery of endangered and threatened species on military lands. Approximately 6 percent of known California tiger salamander occurrences (including Santa Barbara and Sonoma DPSs) are found on military lands (CDFG 2010).

The Lacey Act: The Lacey Act (P.L. 97-79), as amended in 16 U.S.C. 3371, makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any United States or Indian tribal law, treaty, or regulation, as well as the trade of any of these items acquired through violations of foreign law. The Lacey Act further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of "wild animal" includes parts, products, eggs, or offspring.

National Wildlife Refuge System Improvement Act of 1997: This act establishes the protection of biodiversity as the primary purpose of the National Wildlife Refuge system. This has led to various management actions to benefit federally-listed species on refuge lands. Central California tiger salamanders occur on a number of National Wildlife Refuge (NWR) lands, including San Luis NWR, Merced County, Ellicot Slough NWR, Santa Cruz County, and Don Edwards San Francisco Bay NWR, Alameda County.

In summary, the Act is the primary Federal law that provides protection for the Central California tiger salamander since its listing as threatened in 2004. This species was listed by the State of California as threatened under the California Endangered Species Act in 2010, which provides a similar level of protection for this species. Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Federal Act and California Endangered Species Act.

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

The listing rule (Service 2004) identified several other factors that may also be causing direct or indirect adverse effects to Central California tiger salamanders or their habitat, including direct mortality while they are crossing roads, the species' hybridization with non-native salamanders, their exposure to various contaminants, the effects from rodent population control efforts, mosquito abatement efforts, and livestock grazing. The Service now 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. This threat has been more extensively studied within the Sonoma DPS. For example, mortality on Stony Point Road within the Sonoma DPS has been well studied. From 2000-2007 at total of 125 dead California tiger salamanders have been found on Stony Point Road out of 197 observations (D. Cook, in literature, 2009). Approximately 5 to 20 percent of the breeding adults are killed at this site annually (D. Cook in literature, 2009). Although not as extensively studied, the Service is aware of Central California tiger salamanders that have been killed by vehicular traffic while crossing roads (Launer and Fee l996; Twitty 1941). Launer and Fee (1996) recorded over 100 California tiger salamander deaths due to vehicle strikes in a study from 1995 to 1996 at the Lagunita Reservoir in Contra Costa County. This population has a long history of vehicle mortality (Barry and Shaffer 1994; Twitty1941). A road mortality study was conducted from November 2007 to February 2009 along a 2.5-mile (4.02-kilometer) portion of Vasco Road in Contra Costa County (CCCPWD 2009).

The study reports 50 dead California tiger salamanders detected during this period. Statistical analysis found the distribution of mortality to be distributed in a random pattern along the study area. The CNDDB (2012) reports 22 occurrences of Central California tiger salamanders that are threatened by vehicular traffic and road mortality. Of these 22 occurrences, 17 have reported observations of Central California tiger salamanders that were struck by vehicles. The majority of these occurrences are reported in Alameda County (eight), and other occurrences are reported in Contra Costa, Mariposa, Merced, Santa Cruz, San Benito, and Stanislaus counties.

Mortality may be increased by constructed barriers along roadways, such as roadway curbs and berms (D. Cook, in literature, 2009). For example, California tiger salamanders may be able to drop from the top of a curb to the road, but are then prevented from exiting from the road. In addition, while dispersing to or from breeding habitats, California tiger salamanders may also be directed into storm drains along curbed roads, which can also lead to mortality (D. Cook, in literature, 2009). In a 19-month study along Vasco Road (CCCPWD 2009) found that, although not statistically significant, two clusters of mortalities were identified, with both locations associated with constructed barriers along the road. In both locations, California tiger salamanders appeared to travel along the barrier and then enter the road once the barrier ended, where they were struck by vehicles (CCCPWD 2009).

Hybridization with Non-native Tiger Salamanders

Exotic species threaten native biodiversity through predation, competition, and habitat alteration, but also by hybridizing with native species. Hybridization between species can lead to genetic swamping, loss of native genetic diversity, and, in rare or endangered species, extirpation or extinction (Collins et al. 1988; Fitzpatrick and Shaffer 2007; Riley et al. 2003; Shaffer et al. 1993). At the time of listing in 2004 the Service considered hybridization between non-native and native tiger salamanders a threat to the species. Hybridization with non-native tiger salamanders continues to threaten this species. Figure 4 shows the location of known hybrid and non-native populations.

There was a large-scale introduction of barred tiger salamander into the Salinas Valley about 60 years ago, when many tens of thousands of barred tiger salamander were introduced in support of the bass-bait industry (Riley et al. 2003). These introduced barred tiger salamander have been breeding with Central California tiger salamanders in the Salinas Valley for at least 60 years (Ryan et al. 2009). 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 addition to the Salinas Valley release site, barred tiger salamander 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). Three additional hybrid populations are also known in Merced County (CDFG 2010). The Merced County hybrid populations are likely due to introduction sites as well (Fitzpatrick and Shaffer 2007). The hybrids are able to produce viable and fertile offspring (Riley et al. 2003). The hybrid offspring have higher survival rates than either pure California tiger salamanders or pure barred tiger salamander, which ultimately results in higher fitness, but reduced genetic purity (Fitzpatrick and Shaffer 2007).

Just prior to listing, the Service (2003a, b) concluded that the Central California tiger salamanders within the Bay Area and the Central Coast regions were heavily affected by hybridization. Sixteen populations of hybrids and the non-native barred tiger salamander were known to occur in southern Santa Clara, eastern Merced, San Benito, and northern Monterey counties, with hybrids dominating most of Monterey County, San Benito County, and the southern half of Santa Clara County (Shaffer and Trenham 2002). Four populations consisting of pure *A. tigrinum mavortium* were located in Monterey County (Shaffer and Trenham 2002). The Service (2004) determined that 48 records (22 percent) in the Bay Area region, 56 records (78 percent) in the Central Coast region, and 27 records (8 percent) in the Central Valley region were threatened by hybridization because of their close proximity (within 1.3 miles) to non-native and hybridized tiger salamanders.

At this time, Central California tiger salamanders in the Salinas Valley, in particular, are threatened by hybridization with non-native tiger salamanders. Breeding populations in Monterey and San Benito counties often have hybrid index scores (that is, the fraction of the genome that is non-native barred tiger salamander based on a set of molecular markers) that are in the 50 to 75 percent range (Fitzpatrick and Shaffer 2007; Fitzpatrick et al. 2010). Hybrid index scores decrease in populations the further they are from the suspected release sites in the Salinas Valley. In the San Francisco Bay area, low frequencies (i.e., 1.25 percent) of introduced alleles may be found as far away as 22 to 29 miles (35 to 47 kilometers) from the nearest suspected release site (Fitzpatrick and Shaffer 2007; Shaffer et al. 2013).

Fitzpatrick and Shaffer (2007) reported that the distribution of introduced tiger salamander genes is largely confined to within 7.5 miles (12 kilometers) of introduction sites. Fitzpatrick and Shaffer (2007) conjecture that the hybrid swarm may have remained contained within the Salinas Valley during this time because of Salinas Valley's relative high amount of perennial breeding ponds compared to other areas to the north that have more natural seasonal pools. 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.

Despite this sharp distinction between mostly pure native populations and the admixed populations of the Salinas Valley, approximately 5 percent of the invasive genomes sampled (3/68 markers surveyed) were found to sweep to fixation within ponds almost instantaneously and to spread much farther across the landscape (Fitzpatrick et al. 2009, 2010). It appears that natural selection has favored both the movement and fixation of these exceptional invasive alleles. These genetic markers were determined to be superinvasive (SI), because they tend to move very quickly across the landscape and over a relatively short period of time (Fitzpatrick et al. 2009, 2010). These SI markers extend through Alameda County, with only the very northern-most populations in Alameda County appearing to be free, or nearly free, of these SI markers. Frick Lake, in Alameda County, is at the transition point with a frequency of SI alleles of about 50 percent (Shaffer et al. 2013). During genetic surveys in the Los Vaqueros watershed, in Alameda County, one individual California tiger salamander was found to contain a single non-native SI marker out of 90 markers sampled (J. Alvarez, The Wildlife Project, personal communication, 2012).

Once the northern extent of the SI markers was detected, additional sampling sites were added in locations further to the north, including Olcott Lake in Solano County. Although the study did not have continuous sampling for these additional northern sites, data indicates that non-native SI markers are present as far north as Olcott Lake (Shaffer et al. 2013). Because the Solano County populations are completely isolated from the rest of the range, it is unknown where these genes originated, although they likely originated from human transport of non-native tiger salamanders in the area.

Effects of Ponding Duration on Native California Salamander vs. Hybrids

Natural vernal pools and wetland features that mimic vernal pool hydrology appear to favor reproductive success for native California tiger salamanders. Therefore, habitat management strategies should focus on preserving natural vernal pools and ensuring that livestock ponds and other constructed wetlands resemble the hydrology of natural vernal pools as much as possible. This should help to limit hybridization, and possibly assimilation, with non-native tiger salamanders.

In Monterey County, Riley et al. (2003) examined both vernal pools and artificial livestock ponds and found that the natural vernal pools surveyed had significantly fewer hybrid larvae and significantly more larvae with pure parental genotypes. Riley et al. (2003) found little evidence of barriers to gene exchange in the four artificial breeding ponds. Similarly, Fitzpatrick and Shaffer (2004) analyzed the frequencies of hybrid genotypes in different breeding habitats within Salinas Valley, including natural vernal pools, ephemeral livestock ponds, and perennial ponds. They found that there was a predominance of non-native alleles in perennial ponds.

Because non-native tiger salamander alleles dominate in perennial ponds, this suggests that specific life history traits of non-native tiger salamanders give them an advantage to persist in perennial ponds (Fitzpatrick and Shaffer 2004). Ryan et al. (2009) found that once California tiger salamanders and hybrids co-occur in the same environment, time to metamorphosis is delayed in California tiger salamanders, lowering their natural ability to compete with the hybrids. Fitzpatrick and Shaffer (2004) conjectured that the non-native salamanders may be able to breed earlier which would give them an advantage over the native California tiger salamanders. Fitzpatrick and Shaffer (2004) point out that the non-native salamanders are more flexible in the timing of their breeding migrations. This is based on the fact that they managed to shift from breeding in the summer in their native range to breeding in the winter in California. Based on this flexibility, they surmised that non-native tiger salamanders might breed even earlier than the native California tiger salamanders and thus have a head start.

In addition, non-native tiger salamanders and their hybrids can opportunistically forgo metamorphosis in perennial ponds and reproduce as sexually mature paedomorphs (CDFG 2010), which are a larval-like adult form that is capable of breeding (Collins et al. 1998). California tiger salamanders are the only species of tiger salamander that are not known to become paedomorphs (Collins et al. 1988). Perennial ponds in areas where California tiger salamanders and non-native tiger salamanders 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, and paedomorphs will cannibalize on other tiger salamanders (Collins et al. 1988; Fizpatrick and Shaffer 2004).

Most breeding ponds that are currently available are artificial or highly modified and do not match historic ponding regimes, which likely further increases opportunities for contamination of California tiger salamander populations by non-native salamanders (Riley et al. 2003). In addition, 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).

At this time, it is unknown how successful habitat modification alone would be as a strategy to prevent the hybrid swarm from advancing further from the original barred tiger salamander introduction sites. It appears that individuals that are mostly non-native (i.e., individuals with high non-native hybrid index scores) can successfully reproduce in both ephemeral and perennial ponds. An ephemeral pond, for example, may have tiger salamanders that have the appearance of native Central California tiger salamanders, but can still have high non-native hybrid index scores. This is especially likely for areas that have large populations of non-native barred tiger salamanders (J. Johnson, Western Kentucky University, personal communication, 2013; M. Ryan, University of Washington, personal communication, 2013). Therefore, it appears that in areas with high levels of non-native hybrids, habitat conversion from perennial to ephemeral will not be a successful management approach, and other actions, such as eradication, would likely be necessary to prevent the spread of hybrid alleles.

Contaminants

Contaminants were considered a threat to Central California tiger salamanders at the time of listing 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; Corn 1994). Like most amphibians, Central California tiger salamanders inhabit both aquatic and terrestrial habitats at different stages in their life cycle, and are likely exposed to a variety of pesticides and other chemicals (Service 2003b). 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 2003b).

Although the effects of contaminants on amphibians have been studied worldwide, there has been no research on the effects of contaminants on California tiger salamanders. However, research on contaminants has been conducted on several other *Ambystoma* salamander species. There have been a number of studies that have documented how exposure to pesticides increases the susceptibility of *Ambystoma* salamanders to parasitic or bacterial infections. Forson and Storfer (2006a) found that when tiger salamanders (*Ambystoma tigrinum*) in Arizona were exposed to low levels of atrazine and sodium nitrates (both are common chemicals found in herbicides) the salamanders were more susceptible to viral infections and had increases in larval mortality. Similar results were found with the effects of chlorpyrifos (an organophosphate insecticide) on tiger salamander's ability to survive viral infections (Kerby and Storfer 2009).

Contaminants have also been shown to alter rates of metamorphosis for *Ambystoma* salamander species, which may reduce their chances for survival (Larson et al. 1998). A study on long-toed salamanders (*A. macrodactylum*) indicated that high doses of atrazine resulted in the salamanders undergoing metamorphosis earlier and at a smaller size (Forson and Storfer 2006b). Insecticides, such as methoxychlor (which is widely used as a replacement for DDT) has been shown to negatively impact the survival of long-toed salamanders. Exposure to non-lethal and ecologically realistic concentrations of methoxychlor resulted in premature egg hatching; and, once hatched, larvae moved very little, had lower response rates to stimuli, and were therefore more susceptible to predation (Ingermann et al. 1999; Verrell 2000).

Other substances, such as petroleum byproducts also negatively affect salamanders. Hatch and Burton (1998) found that ecologically realistic levels of fluoranthene (a component of petroleum products typically found as run-off from roads) reduced survival and resulted in growth abnormalities in spotted salamanders (*A. maculatum*). These substances can also have indirect effects. For example, Lefcort et al. (1997) found that motor oil at concentrations equivalent to service station runoff did not appear to directly affect marbled salamanders (*A. opacum*) and *A. tigrinum*; however, the presence of oil did negatively affect the food chain, with effects to algae growth and less prey species available, resulting in smaller salamander larvae.

Although little research is available on the effects of contaminants on California tiger salamanders, we believe that there is sufficient information available on the effects of contaminants on other *Ambystoma* salamander species to conclude that contaminants likely adversely affect California tiger salamanders. Exposure to contaminants may not always result in direct mortality; however, based on studies on other *Ambystoma* salamanders (Forson and Storfer 2006a,b), we believe that contaminants play a direct role in reducing the fitness of California tiger salamanders, therefore making them more susceptible to predation and viruses, less capable of competing with other species for limited resources, and less able to reproduce successfully.

Rodent Population Control Efforts

California tiger salamanders are strongly correlated with California ground squirrel and pocket gopher populations as the burrows created by these mammals are necessary for the salamanders to survive (Loredo et al. 1996; Shaffer et al. 1993; Van Hattem 2004). Because ground squirrels and pocket gophers are critical for burrow construction and maintenance, and therefore critical to the California tiger salamander, rodent population control efforts are a potential threat to California tiger salamanders. The extent to which small mammal eradication efforts are conducted within the range of the Central California tiger salamander is unknown at this time. The effects of these control efforts are often short-lived because recovery of ground squirrel populations can be very rapid through immigration from nearby populations and high levels of reproductive success (Gilson and Salmon 1990).

Most Central California tiger salamander populations are found on grazing lands. Livestock owners' concern over livestock injuring their legs in rodent burrows is a reason for many California ground squirrel control efforts, especially around livestock watering tanks and ponds. Also, numerous agencies, particularly flood control agencies and levee districts, conduct extensive California ground squirrel control programs around levees, canals and other facilities they manage (Service 2003a). These and other California ground squirrel and pocket gopher control efforts have potential to adversely affect Central California tiger salamanders if they are implemented without knowledge of, and concern for, California tiger salamanders present within the area (Service 2003a).

The Service is not aware of how much land within the range of the Central California tiger salamander undergoes active ground squirrel control management. Clark (1978) estimated that, from 1968 to 1978, an average of 1,747,828 acres (707,320.89 hectares) per year were treated for ground squirrel control in California. The use of ground squirrel eradication programs may have decreased over the past two decades, as the California Department of Food and Agriculture reported that California ground squirrels are controlled on approximately 300,000 acres (121,405.69 hectares) total in California (CDFA 2003, as cited in CDFG 2010).

Poisoned grains are the most common method used to control ground squirrels on rangelands (Marsh 1994). Other eradication techniques include the application of fumigant rodenticide to burrows. Gases, including aluminum phosphide, carbon monoxide, and methyl bromide, can be introduced into burrows through cartridges, pellets, and other methods (Salmon and Schmidt 1984). Another control method, with rising popularity, is to inject combustible gas into burrow complexes and then ignite the gas (Ford et al. 2012). Other rodent control measures include habitat modifications such as deep ripping of rodent burrow areas or using flood irrigation (Gilson and Salmon 1990). All of these techniques can both directly and indirectly result in mortality of California tiger salamanders. Fumigants applied to burrows could result in direct mortality of California tiger salamanders. Discing and deep ripping may crush salamanders and could also entomb salamanders because it is unlikely that they will be able to dig themselves out of the burrows if the burrow openings are collapsed. Other methods may avoid direct mortality of salamanders, but will decrease ground squirrel and pocket gopher populations, which will in turn decrease the amount of available burrow habitat.

Mosquito Control

Mosquito control was considered a threat to Central California tiger salamanders at the time of listing and it is still considered a threat at this time. Mosquito abatement agencies typically introduce mosquitofish to wetlands, including potential breeding habitat for Central California tiger salamanders. Mosquito fish 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 (Jennings and Hayes 1994). In addition, both California tiger salamanders and mosquitofish feed on invertebrates and it is possible that large numbers of mosquitofish may out-compete the salamander larvae for food (Graf and Allen-Diaz 1993).

Other methods of mosquito control include the application of methoprene, which disrupts the molting process in insect larvae. The use of methoprene and other insecticides will likely have an indirect adverse effect on Central 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; however, research has shown that methoprene appears to have both direct and indirect effects on growth and survival of larval amphibians. Ankley et al. (1998) reported that low concentrations of methoprene had no effect on exposed northern leopard frogs (*Rana pipiens*); however, high concentrations of methoprene led to fatal deformities in northern leopard frog larvae. Sparling (1998) studied southern leopard frogs (*Rana utricularia*) in wetlands treated with methoprene and reported that 15 percent of southern leopard frogs collected had limb deformities, as compared to 4 percent of southern leopard frogs in control wetlands that were not treated with methoprene. Blumberg et al. (1998) also correlated exposure to methoprene with delayed metamorphosis and high mortality rates in northern leopard frogs and mink frogs (*R. septentrionalis*).

A bacterium, *Bacillus thuringiensis israeli* (Bti), is also used for mosquito control throughout the California tiger salamander Central California DPS. Bti reportedly does not affect insects other than larvae of mosquitoes and blackflies. The effects of Bti on the salamander prey base have not been quantified. However, the success of many aquatic vertebrates relies on an abundance of invertebrates in wetlands; therefore, the reduction in density of available prey will likely affect the California tiger salamander (Lawrenz 1984/1985).

Because of a lack of information regarding which mosquito control chemicals are used and where, and about the chemicals' effects on salamanders, the degree to which the practices directly affect the California tiger salamanders within the Central California DPS cannot be determined at this time. We believe the use of these chemicals is a potentially serious 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) expressed concerns regarding cattle use within livestock ponds, which may result in lower water quality via increased siltation levels related to excessive trampling as well as increased nitrogen levels from cattle excrement. Despite these concerns, the Service (2004) stated that livestock grazing is for the most part compatible with California tiger salamanders and that light to moderate livestock grazing is generally thought to be compatible with the continued successful use of rangelands by the Central California tiger salamander, provided the grazed areas do not also have intensive burrowing rodent control efforts. Grazing management plays an important role in vernal pool habitat management, as grazed vernal pools have longer ponding durations (Marty 2005). Taller grass, or grass with significant thatch build-up, may make dispersal more difficult for migrating California tiger salamanders. In addition, taller grass heights have been associated with declines in ground squirrel populations (Ford et al. 2012).

Climate Change

Climate change was not considered a threat to Central California tiger salamanders at the time of listing. However, climate change is considered a potential threat at this time. Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field et al. 1999, Cayan et al. 2005, Intergovernmental Panel on Climate Change 2007). Climate simulations have shown that California temperatures are likely to increase by 2.7 degrees Fahrenheit (1.5 degrees Celsius) under a lower emissions scenario, and by up to 8.1 degrees Fahrenheit (4.5 degrees Celsius) under a higher emissions scenario (Cayan et al. 2008).

Because of the diversity of California's landscape, it is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects. While it appears reasonable to assume that California tiger salamanders may be affected by factors resulting from climate change, we lack sufficient certainty of how and how soon climate change will affect the species. For example, the distribution of the Central California tiger salamander spans a considerable range in climatic conditions (including annual variation) 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 an adapted 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 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. During drought, 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 Central California tiger salamanders because they depend on these ponds for breeding.

Changes in climatic conditions could have other significant implications for Central California tiger salamanders, including; altered prey/predator relationships; increased effects from ultraviolet radiation; and increased effects from diseases such as chytrid fungus and ATV. All of these changes in environmental conditions could have significant impacts on local populations of Central California tiger salamander. Because of the isolated and fragmented distribution of this species, this may lead to further population extirpations. In addition, climate change will likely result in warmer air temperatures in California, and this may serve as an advantage for hybrid tiger salamanders, which are able to disperse longer distances and have better endurance than native California tiger salamanders at higher air temperatures (Johnson et al. 2010b).

III. RECOVERY CRITERIA

There is no final Recovery Plan for the Central California tiger salamander and recovery criteria have not yet been established.

IV. SYNTHESIS

The Central California tiger salamander is a genetically and geographically distinct DPS, which has been further substantiated since its listing in 2004 through a range-wide survey of genetic variation in the California tiger salamander (Shaffer et al. 2013). The number of known Central California tiger salamander occurrences has increased since the time of listing, probably owing to increased and focused survey efforts related to proposed development projects, and does not necessarily indicate that the species is recovering or expanding its range. All of the populations of Central California tiger salamander face the same threats known at the time of listing.

California tiger salamanders do not reach sexual maturity for a number of years and reproductive success for this species is low. Factors that repeatedly lower breeding success in isolated ponds (ponds that are too far from other ponds for migrating individuals to recolonize) can quickly drive a local population to extinction. Large, contiguous areas of vernal pools (i.e., vernal pool complexes) containing multiple breeding ponds are ideal to ensure that recolonization occurs at individual pond sites. Habitat loss and fragmentation of such pond complexes prevent the natural exchange of individuals and their genetic information that promote the survival of California tiger salamander metapopulations.

One of the primary threats to the continued survival of the Central California tiger salamander is the loss and fragmentation of habitat. Urban development and agricultural conversion continue to threaten the species. Grazing is a compatible land use with Central California tiger salamander survival; however, ranches with grazing as their primary land use are declining within the range of the Central California tiger salamander and are being replaced by vineyards, orchards, row crops, and development, which are not compatible with California tiger salamander conservation. The Service utilized GIS to analyze the amount of habitat lost from 2001 to 2006 and found that habitat loss has occurred within each of the four regions of the Central California tiger salamander, with the Central Coast Range and the Central Valley undergoing the largest amounts of habitat loss. From 2001 to 2006, the Central California tiger salamander lost approximately 8,000 acres (3,237 hectares) of potential habitat that was converted to urban and agricultural uses. Since the time of listing, approximately 8,656 acres (3,503 hectares) of permanent habitat loss has been exempted through section 7 of the Act. Incidental take permits associated with HCPs have permitted the loss of over 25,000 acres (10,117 hectares) of potential habitat.

Since the time of listing in 2004, 7,993 acres (3,234.6 hectares) of habitat have been permanently protected as conservation banks. In addition, there are multiple public and private lands that protect known occurrences of California tiger salamander. These properties protect large, intact, areas of suitable habitat for the species; although it is unknown at this time how much occupied habitat occurs on many of these properties as thorough surveys have not been conducted on many of these lands. In addition, many of these lands are not managed solely for California tiger salamanders and have other priority land uses.

Hybridization with non-native tiger salamanders continues to be a primary threat to the Central California tiger salamander. Many populations, particularly in the Bay Area and Central Coast Range regions, are threatened by genetic swamping, predation, and competition from non-native tiger salamanders. Fitzpatrick and Shaffer (2007) determined that the distribution of introduced tiger salamander genes was largely confined to the Salinas Valley watershed. Fitzpatrick et al. (2010) reported that the majority of non-native genetic markers sampled (65 of 68) showed little evidence of spread beyond the Salinas Valley. Despite this sharp distinction between mostly pure native populations and the admixed populations of the Salinas Valley, Fitzpatrick et al. (2009, 2010) determined that approximately 5 percent of the invasive markers sampled (3 of 68) were found to sweep to fixation within ponds almost instantaneously and move quickly across the landscape. These SI markers extend through Alameda County, with only the very northern-most populations in Alameda County appearing to be free, or nearly free, of these SI markers. The SI markers have also been detected as far north as Olcott Lake, in Solano County (Shaffer et al. 2013). Because non-native tiger salamander alleles dominate in perennial ponds, this suggests that specific life history traits of non-native tiger salamanders give them an advantage to persist in perennial ponds (Fitzpatrick and Shaffer 2004). Most breeding ponds that are currently available are artificial or highly modified and do not match historic ponding regimes, which likely further increases opportunities for genetic contamination of California tiger salamanders by non-native salamanders (Riley et al. 2003).

The Service has determined that the Central California tiger salamander does not warrant a change in listing status at this time and the listing status for the species should remain threatened. Central California tiger salamander habitat loss continues to occur. The level of threats to the species from hybridization with non-native tiger salamanders appears to be similar to what was known at the time of listing. Other threats, such as predation from non-native species, exposure to contaminants, and mortality from road crossings appear to be at similar levels to what was known at the time of listing. It is difficult to determine the extent to which small mammal eradication programs and mosquito abatement programs are reducing Central California tiger salamander populations and, therefore, it is difficult to determine whether these threats have changed since the time of listing.

V. RESULTS

Recommended Listing Action:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (indicate reason for delisting according to 50 CFR 424.11):
    ____ *Extinction*
    ____ *Recovery*
    ____ *Original data for classification in error*
_X_ No Change

New Recovery Priority Number and Brief Rationale: No change to Recovery Priority Number is needed.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

Recovery Plan

Complete a recovery plan for the Central California tiger salamander. The plan would establish a framework for agencies to coordinate conservation efforts. The plan would set recovery priorities and estimate costs of various tasks necessary to accomplish them. It also would describe site-specific management actions necessary to achieve conservation and survival of the Central California tiger salamander. A primary recovery objective should be the establishment of preserve areas with sufficient breeding and upland habitat for long-term persistence (Searcy and Shaffer 2008, 2011). Strategies worth considering may include protecting corridors of upland habitat between breeding sites, pond creation to enhance connectivity among distant sites, and even translocation of individuals to currently isolated unoccupied sites, if appropriate (see Shaffer et al. 2008). Monitoring for threats should also occur within these protected areas.

Conservation of Habitat

Actively manage Central California tiger salamander habitats, including maintenance of appropriate vegetation conditions and ponding duration as appropriate, and removal and/or control of non-native predators (See Ford et al. 2012 for considerations when managing rangelands to benefit California tiger salamanders).

Restore or create ephemeral ponds to enhance existing Central California tiger salamander populations and restore degraded upland habitats adjacent to known breeding sites. Maintaining, restoring or creating a breeding pond will have the most benefit to the local population if the pond is already occupied or is near an existing population for colonization, and as far as possible from predator and hybrid tiger salamander source-areas. California's variable weather can make a given pond vary in habitat quality from year to year, so having ponds with different characteristics (size, depth, vegetation, etc.) increases the odds that at least one pond will be suitable in a given year and have good reproductive output.

Work with conservation partners to increase awareness of the potential incidental adverse impacts to Central California tiger salamanders and other native species associated with ground squirrel eradication efforts. Encourage public and private livestock pond management practices consistent with California tiger salamander conservation as described in the Special Rule Exempting Routine Ranching Activities (Service 2004).

Outlying populations in the northern and southern areas of the Central California tiger salamander's range, as well as populations at elevation extremes, may provide potentially significant genetic diversity in terms of the species' ability to adapt to different climate change scenarios. These outlying populations should be a focus of study and conservation efforts.

California tiger salamanders can exhibit high fluctuation in population numbers and may not breed in an individual pool every year. Surveys conducted in a proposed project area that include multiple potential breeding pools may only detect California tiger salamander larvae in some of the pools, or even in none of the pools (e.g., in years with low rainfall when the species does not successfully breed). There is a high likelihood that pools that contained no California tiger salamander larvae at the time of the surveys could provide suitable breeding habitat in future years when conditions are more favorable. This should be taken into consideration when analyzing the potential effects of a proposed project on the species.

Strategy to address non-native tiger salamanders

A strategy should be developed in cooperation with CDFW and other agencies, academics, and other involved stakeholders to address the issue of hybridization with non-native tiger salamanders. Strategies to be discussed include the potential elimination of confirmed hybridized tiger salamander populations. Other strategies include habitat management and manipulation that would favor native Central California tiger salamanders. Initial restoration actions should target sites where paedamorphs have been observed because presence of paedamorphs would indicate presence of non-native alleles in the tiger salamander population. Identification and protection of non-hybridized populations should be a high priority.

Decrease mortality from road crossings

Investigate use and effectiveness of wildlife crossing structures and/or tunnels designed for California tiger salamanders in circumstances where road-kill mortality due to migration to/from breeding ponds is significant.

Ranaviruses and other diseases

Monitor for ranaviruses and other diseases in as many California tiger salamander populations as feasible to ensure early detection and implementation of management practices to reduce threats of widespread disease transmission.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW

California tiger salamander, Central California Distinct Population Segment
(*Ambystoma californiense*)

Current Classification: Threatened

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Review Conducted By: Rick Kuyper

Date Submitted to Region 8: ____________________

FIELD OFFICE APPROVAL:

Field Supervisor, Sacramento Fish and Wildlife Office

Approve [signature] Date October 21, 2014

Figures 1 to 4.

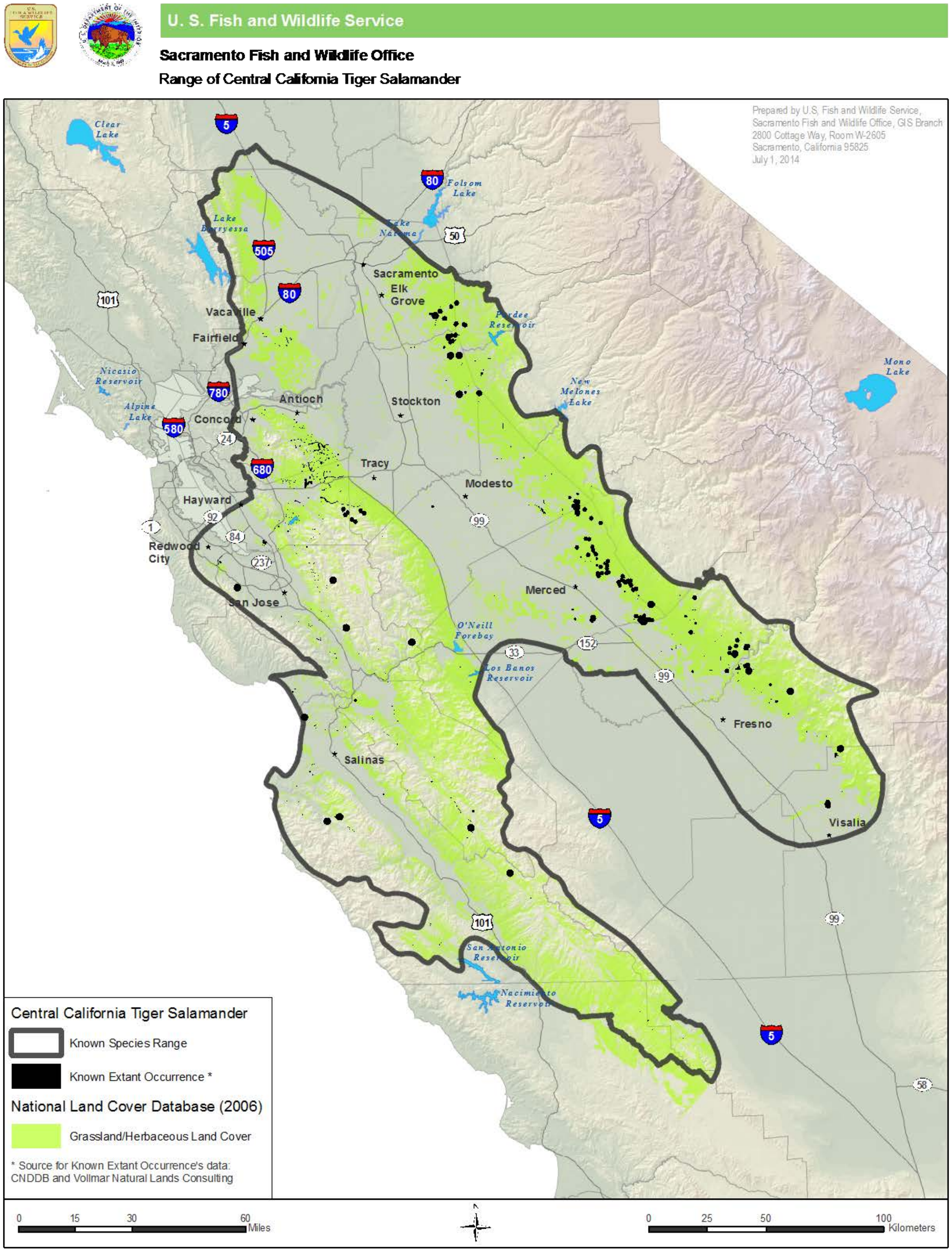

Figure 1: Extant California tiger salamanders and populations within the Central California DPS.

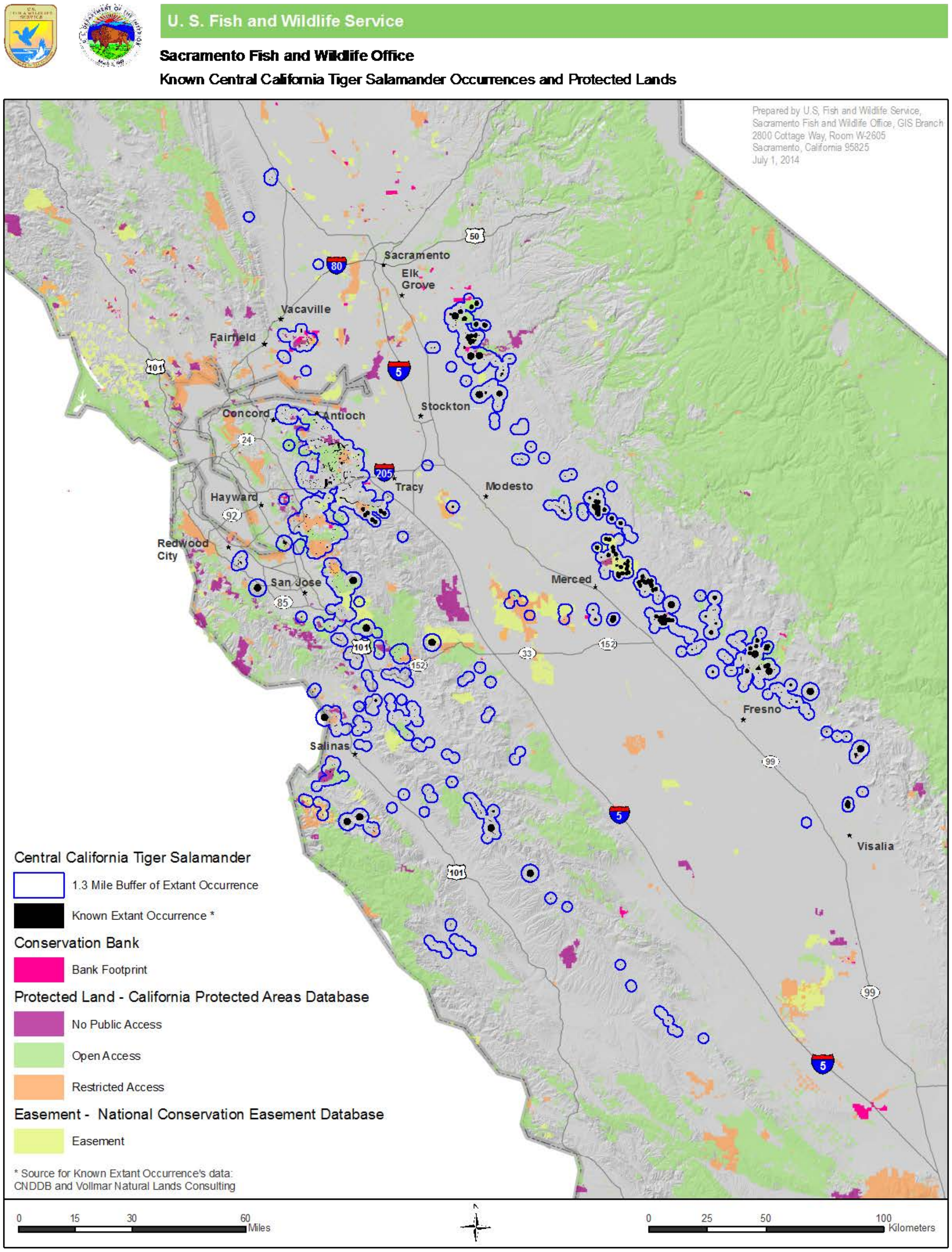

Figure 2: Extant California tiger salamander occurrences and public and protected lands.

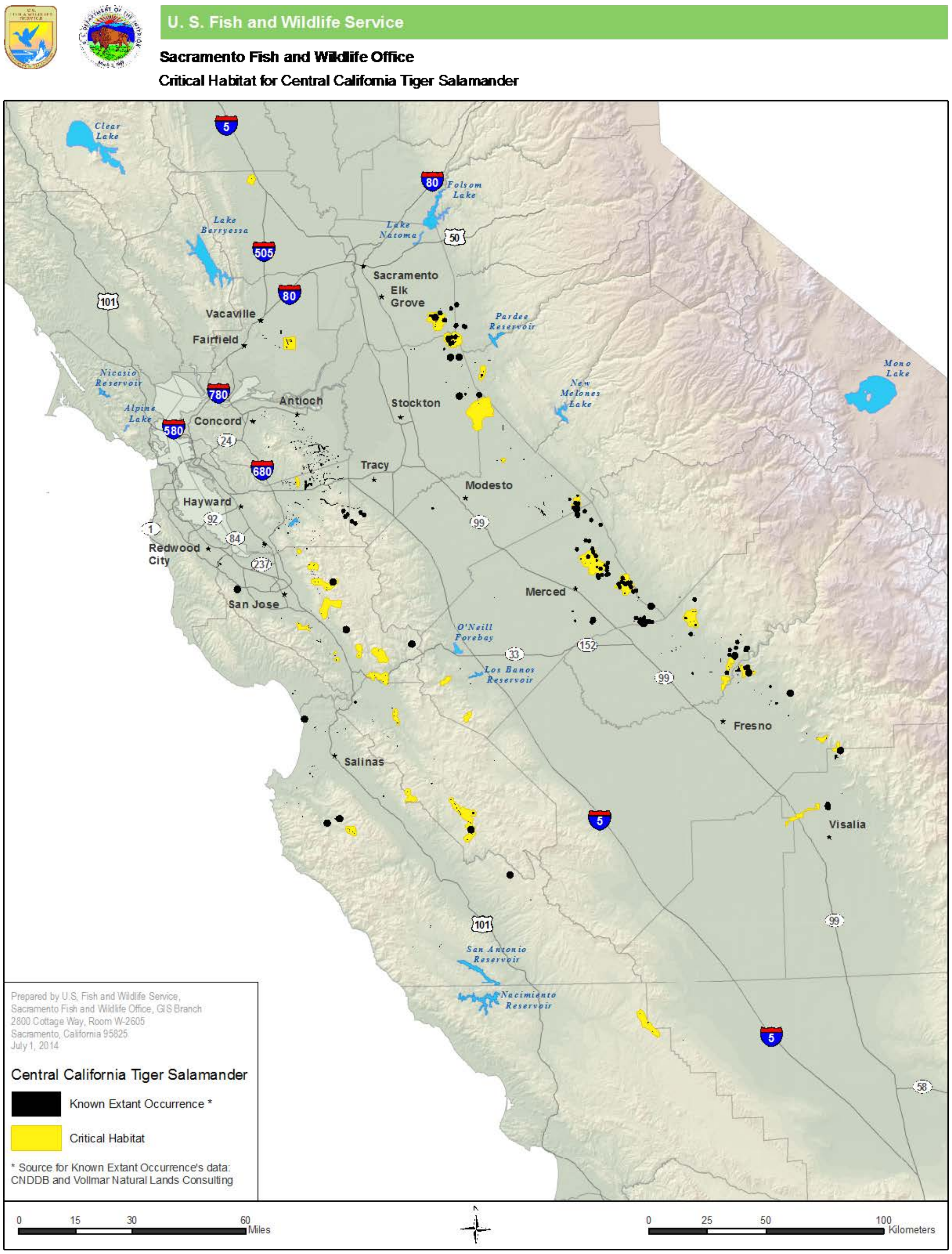

Figure 3: Critical habitat units within the Central California tiger salamander DPS.

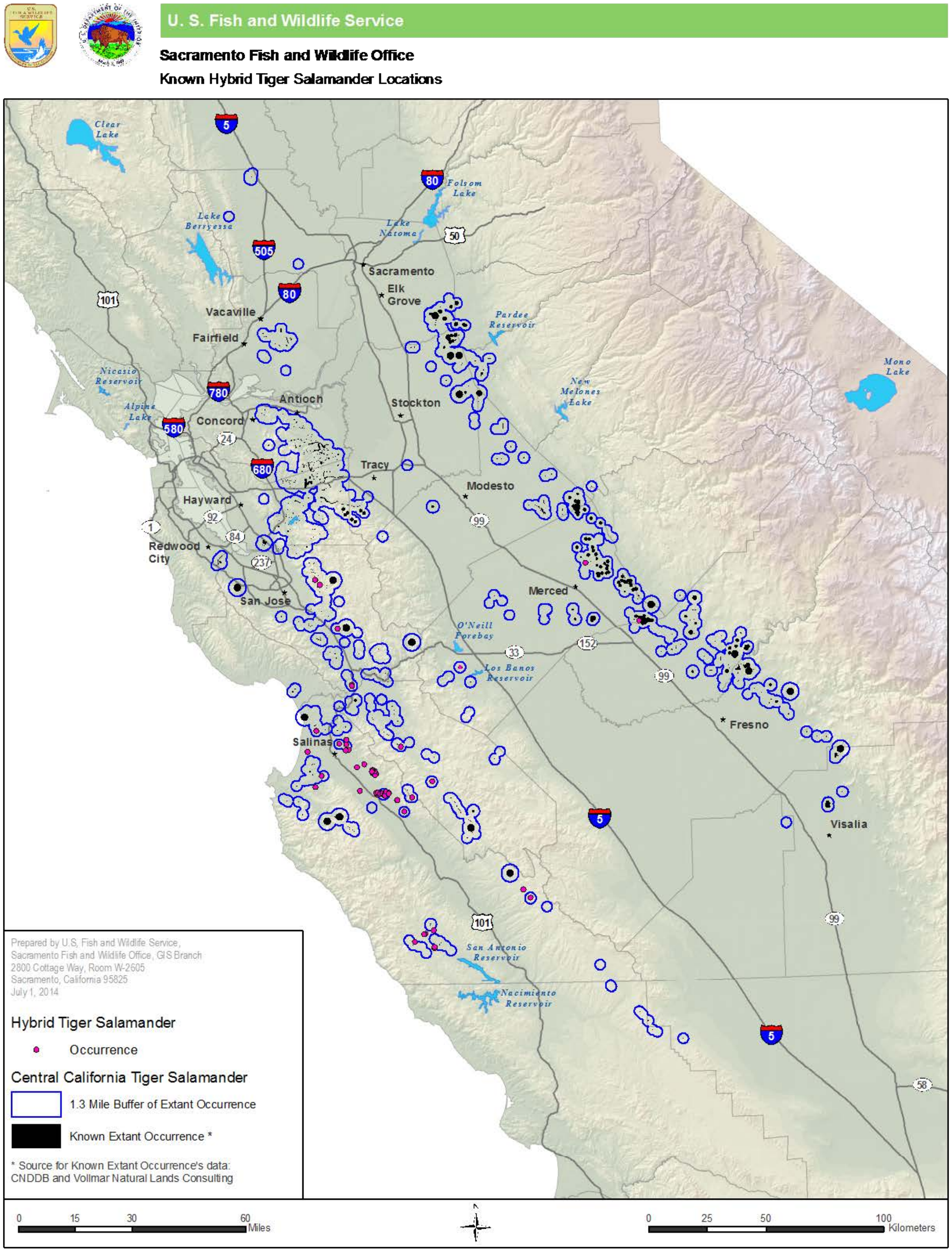

Figure 4: Known locations of non-native and hybrid tiger salamanders.

Appendix A: Photos of California tiger salamanders and habitat.

Egg mass in Contra Costa County.
Photo: Michael Van Hattem, CDFW.

California tiger salamander egg, Sonoma County.
Photo: Carlos Alvarado, Cardno-Entrix.

Larvae in Monterey County.
Photo: Dwight Harvey, Service.

Metamorph in Yolo County.
Photo: Rick Kuyper, Service.

Transforming adult in Solano County.
Photo: Adam Clause, UC Davis.

Transforming adult in Alameda County.
Photo: Rick Kuyper, Service.

Adult in Solano County.
Photo: Sacramento Fish and Wildlife Office.

California tiger salamander larva and California red-legged frog tadpole in Alameda County.
Photo: Rick Kuyper, Service

California tiger salamander larva and vernal pool tadpole shrimp (*Lepidurus packardi*) in Solano County.
Photo: Sacramento Fish and Wildlife Office.

Surveying for larvae in a livestock pond in Alameda County.
Photo: Rick Kuyper, Service.

Surveying for larvae in Monterey County.
Photo: Dwight Harvey, Service.

East Bay Regional Park District staff conducting surveys for larvae in Alameda County.
Photo: Rick Kuyper, Service.

Surveying for larvae in Olcott Lake, Solano County.
Photo: Sacramento Fish and Wildlife Office.

Aquatic habitat in San Joaquin County.
Photo: Sacramento Fish and Wildlife Office.

Typical livestock pond utilized by California tiger salamanders for breeding in Alameda County.
Photo: Rick Kuyper, Service.

Typical livestock pond utilized by California tiger salamanders for breeding in Alameda County.
Photo: Rick Kuyper, Service.

Constructed California tiger salamander breeding habitat on EBMUD property in Calaveras County.
Photo: Rick Kuyper, Service.

Ground squirrel burrow opening in Monterey County.
Photo: Dwight Harvey, Service.