California tiger salamander (*Ambystoma californiense*)
Santa Barbara County Distinct Population Segment

5-Year Review:
Summary and Evaluation

Photo courtesy of Peter Gaede

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

November 2009

5-YEAR REVIEW
California tiger salamander (*Ambystoma californiense*)
Santa Barbara County Distinct Population Segment

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 of 1973, as amended (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: The California tiger salamander is a large, stocky, terrestrial salamander with a broad, rounded snout. The Santa Barbara distinct population segment of California tiger salamander is genetically distinct and geographically isolated from the other listed entities within the range of the species. California tiger salamanders spend the majority of their lives underground in small mammal burrows and migrate to pools and ponds for breeding. There are six recognized metapopulations of California tiger salamanders within the range of the Santa Barbara County Distinct Population Segment (DPS). These metapopulations each utilize an array of vernal pools and swales, created ponds, and uplands, separated from one another by distance, topography, or anthropogenic barriers. The Santa Barbara County DPS of the California tiger salamander is threatened by habitat loss due to agricultural conversion and development and hybridization with non-native tiger salamanders.

Methodology Used to Complete This Review:

This review was prepared by staff of the Ventura Fish and Wildlife Office, U.S. Fish and Wildlife Service. All information pertinent to the status of the California tiger salamander that has become available since its listing in 2000 was reviewed as part of this analysis. Sources of information used for this review included peer-reviewed scientific literature, scientific papers, survey reports, internet sources, and letters to and from the Ventura Fish and Wildlife Office. We incorporated all information from our files into our review, as appropriate.

Contact Information:

Lead Regional Office: Region 8, Pacific Southwest Region: Diane Elam, Deputy Division Chief for Listing, Recovery, and Habitat Conservation Planning, (916) 414-6464; and Jenness McBride, Fish and Wildlife Biologist, (916) 414-6464.

Lead Field Office: Ventura Fish and Wildlife Office: Andrea Adams, Fish and Wildlife Biologist, (805) 644-1766, extension 318; and Michael McCrary, Listing and Recovery Program Coordinator, (805) 644-1766, extension 372. Contributing author: Katie Drexhage, former Fish and Wildlife Biologist.

Federal Register Notice Citation Announcing Initiation of This Review: The Federal Register (FR) notice initiating this review was published on February 14, 2007 (72 FR 7064). This notice opened a 60-day request for information period, which closed on April 16, 2007. We received no information from the public in response to our FR notice initiating this 5-year review.

Listing History:

Original Listing
FR Notice: Emergency Listing, 65 FR 3096
Date of Final Listing Rule: January 19, 2000
Entity Listed: *Ambystoma californiense* (Santa Barbara County DPS)
Classification: Endangered

Revised Listing
FR Notice: Final Rule, 65 FR 57242
Date Listed: September 21, 2000
Entity Listed: *Ambystoma californiense* (Santa Barbara County DPS)
Classification: Endangered

State Listing
As of February 2009, the California tiger salamander is a candidate for listing under the California Endangered Species Act throughout its entire range.

Associated Rulemakings:

May 23, 2003: Proposal to list the Central California DPS of the California tiger salamander (comprised of California tiger salamander populations in the San Francisco Bay Area, Central Valley, southern San Joaquin Valley, and the Central Coast); to reclassify the Santa Barbara County DPS and Sonoma County DPS from endangered to threatened; and establishing a special rule pursuant to section 4(d) of the Endangered Species Act for all three populations. This special rule exempts "routine ranching activities" from the Act's prohibitions against take of California tiger salamanders listed as threatened (68 FR 28648).

January 22, 2004: Proposal to designate critical habitat in Santa Barbara County for the Santa Barbara County DPS of the California tiger salamander (69 FR 3064).

August 4, 2004: Final rule listing 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 tiger salamander population and the former DPSs located in Sonoma and Santa Barbara counties. In this rule we determined that the Santa Barbara and Sonoma populations had the same listing status as the taxon as a whole, and we removed these populations as separately listed DPSs. However, this rule was subsequently vacated by a judicial decision on August 19, 2005, and the Santa Barbara County DPS was reinstated and returned to endangered status. As a result of this judicial decision, the listed entity assessed in this 5-year review is the endangered Santa Barbara County DPS, as determined by the September 21, 2000, final listing rule (65 FR 57242).[1]

November 24, 2004: Final designation of critical habitat for the Santa Barbara County DPS of the California tiger salamander (69 FR 68568).

Review History: No status review, 5-year review, or other relevant reviews/documents have been completed for this species.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for the Santa Barbara County DPS of the California tiger salamander is 5C according to the Service's 2008 Recovery Data Call for the Ventura Fish and Wildlife Office, 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 species that faces a high degree of threats and has a low potential for recovery. A species has a low to moderate recovery potential if the limiting factors or threats to the species are poorly understood or if the needed management actions are not known, are cost-prohibitive, or are experimental with an uncertain probability of success. The "C" indicates conflict with construction or other development projects or other forms of economic activity.

Recovery Plan or Outline: Not applicable. A Recovery Team was appointed in 2001 and began developing a draft recovery plan, but the draft plan has not been completed. The Recovery Team included a science team, whose primary task was to develop scientifically-based recovery criteria for the species, and a stakeholder team whose primary task was to provide input on how recovery criteria can be achieved on the ground. The Recovery Team has not formally met since September 2003, and the process was delayed due to staffing and workload constraints. However, as of August 2009, the Ventura Fish and Wildlife Office is regaining momentum in advancing recovery planning efforts for the Santa Barbara County DPS. Between 2006 and 2008, a regional conservation strategy was being developed by various stakeholders, including the County of Santa Barbara's Planning and Development Department and the Service; however,

[1] Although not a Service-promulgated rulemaking, the downlisting was vacated by the court, thereby invalidating the 4(d) rule with respect to the Santa Barbara DPS.

the County discontinued this effort in March 2008 (Santa Barbara County Planning and Development 2009b).

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 Endangered Species Act (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1996) clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act.

The Santa Barbara County California tiger salamander was listed as a DPS in 2000. 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).

Beginning in 2000, a range-wide survey of genetic variation among occurrences of the California tiger salamander was conducted, the results of which further support the fact that the Santa Barbara County California tiger salamander is discrete (Shaffer et al. 2004). A combination of population genetic and phylogenetic analyses of mitochondrial DNA variation found that the Santa Barbara County population is particularly well differentiated and geographically isolated from the other five genetic units (Sonoma County, Southern San Joaquin Valley, Central Coast Range, Central Valley, and Bay Area). The uplift and formation of the San Luis Range and San Rafael Mountains to the north and Santa Ynez Mountains to the south isolated the Santa Maria Basin, and apparently also isolated the population of California tiger salamanders contained within it, particularly from populations to the north (Ferren and Hecht 2003). California's geologic history is consistent with "molecular clock" evidence from mitochondrial DNA analyses suggesting that the Santa Barbara County population has been isolated from the Sonoma County population for at least 740,000 to 920,000 years, and possibly much longer (Shaffer et al. 2004).

As stated in the September 21, 2000, final listing rule (Service 2000), the Santa Barbara County population constitutes the only population of California tiger salamanders west of the outer Coast Ranges, and it is the southernmost population of the species. The Santa Barbara County DPS of California tiger salamander's survival in this unique landscape provides evidence for this species' ecological adaptive significance, further supporting the fact that the Santa Barbara County California tiger salamander population is biologically and ecologically significant to the species.

Information on the Species and its Status

Species Biology and Life History

California tiger salamanders spend the majority of their lives underground in small mammal burrows. If California tiger salamanders are not able to locate or gain access to underground burrows, they may be prone to predation or desiccation. California ground squirrel (*Spermophilus beecheyi*) and valley pocket gopher (*Thommomys bottae*) burrows are the primary sources of these retreats (Loredo et al. 1996, Trenham 2001). Trenham (2001) found that radio-tracked adults favored grasslands with scattered large oaks over more densely wooded areas.

Little is known about the fossorial (i.e., underground) behavior of California tiger salamanders as they are difficult to observe while underground. Although the upland burrows inhabited by California tiger salamanders have often been referred to as "aestivation" sites, which implies a state of inactivity, most evidence suggests that California tiger salamanders remain active in their underground dwellings. In fact, aestivation has not been observed in California tiger salamanders (Trenham 2009). Trenham (2001) recorded underground movements within burrow systems, and other researchers have used fiber optic or infrared scopes to observe active California tiger salamanders (Semonsen 1998). Because California tiger salamanders arrive at breeding ponds in good condition and are heavier when entering a pond than when leaving, researchers have long inferred that the California tiger salamanders are feeding while underground. Direct observations have confirmed this (Trenham 2001). Thus, "upland" or "nonbreeding" habitat is a more accurate description of the terrestrial areas used by California tiger salamanders.

Among salamanders, California tiger salamanders require a relatively short period to complete development of the aquatic larvae, and may breed successfully in pools or ponds (the terms pool and pond are used interchangeably throughout this review) that last for little more than 2 months. In colder weather the developmental period is prolonged, with periods in excess of 4 months being relatively common. This requirement restricts California tiger salamander breeding to deeper vernal pools, vernal playas, large sag ponds, and artificial ponds that have sufficiently long periods of inundation (AmphibiaWeb 2007). In Monterey County, ponds documented as used for breeding habitat by California tiger salamanders were natural vernal pools and artificial cattle ponds ranging in depth from about 12 inches (in) (30 centimeters (cm)) to less than 7 feet (ft) (2 meters (m)) and ranging in annual hydroperiod (the period of time during which a wetland is covered by water) from 10 weeks to 1 year (Trenham et al. 2001).

Trenham (2001) found that, following breeding, radio-tracked adults migrated away from breeding ponds and initially settled in ground squirrel burrows 10 to 518 ft (3 to 158 m) away. Loredo et al. (1996) observed similar first-night emigration distances. Most of the radio-tracked salamanders moved to another or several different burrow systems farther from the pond during the 1- to 4-month tracking interval. Trenham (2001) found the average final distance traveled from the pond was 374 ± 272 ft (114 ± 83 m). Within individual burrow systems, salamanders frequently made short moves of less than 33 ft (10 m), apparently without surfacing (Trenham 2001).

At Jepson Prairie Preserve in Solano County, California, Trenham and Shaffer (2005) found variation in upland dispersal patterns between adult and subadult California tiger salamanders. Adults were captured at a decreasing rate with distance from the pond as anticipated; conversely, subadult captures increased progressively between distances of 33 ft (10 m) and 1312 ft (400 m) from the breeding site. Models of variation in capture rate suggested that 50 percent, 90 percent, and 95 percent of adults were within 492, 1600, and 2060 ft (150, 490, and 629 m) of the breeding pond, respectively, while 95 percent of subadult captures occurred less than 630 m of the pond. Eighty-five percent of all subadults observed were concentrated in the area between 650 ft (200 m) and 1970 ft (600 m) of the pond.

In a 5-year study, Orloff (2007) found the majority of California tiger salamanders migrated at least 0.5 mile (mi) (0.8 kilometer (km)) from the breeding site. A smaller number of salamanders appeared to migrate even farther, traveling 0.75 mi (1.2 km) to almost 1.3 mi (2.2 km) to and from the breeding ponds and upland habitat on adjacent property. One possible explanation for this long migration distance is that salamanders must travel farther to locate suitable upland habitat when there is a scarcity of ground squirrel burrows and other refugia in proximity to the ponds (Orloff 2007).

Spatial Distribution

The life history and ecology of the California tiger salamander indicate a high likelihood that this population has a metapopulation structure (Hanski and Gilpin 1991). A metapopulation is a set of local populations or breeding sites within an area, where typically migration from one local population or breeding site to other areas containing suitable habitat is possible, but not routine. Because many of the areas of suitable habitat may be small and support small numbers of salamanders, local extinction may commonly occur. A metapopulation's persistence depends on the combined dynamics of these local extinctions and the subsequent colonization or recolonization of these areas through dispersal (Hanski and Gilpin 1991). Since the time of listing, California tiger salamander breeding pools have been discovered in some areas that have the potential to link one metapopulation to another. Because habitat modification and destruction has forced salamanders to seek higher ground (such as cattle ponds further into the uplands) to breed, it is likely that they have dispersed to areas that blur the lines between distinct metapopulations (S. Sweet, U.C. Santa Barbara, pers. comm. 2009). It is unknown at this time whether this has actually occurred, so we refer to the best-available metapopulation structure for the remainder of our analysis in this review.

California tiger salamanders do not reach sexual maturity for a number of years and individuals typically do not survive to breed more than once (Trenham et al. 2000). Thus, isolated metapopulations can decline greatly from unusual, randomly occurring, natural events as well as from human-caused factors that reduce breeding success and individual survival. Factors that repeatedly lower breeding success in isolated ponds that are too far from other ponds for migrating individuals to replenish the population can quickly drive a local population to extinction. Maintaining interpond dispersal (connectivity between ponds) is important for the long-term viability of California tiger salamanders. Large, contiguous areas of scattered vernal pools (vernal pool complexes) containing multiple breeding ponds are ideal to ensure that recolonization occurs at individual pond sites. The California tiger salamander is found in six

metapopulations in Santa Barbara County: West Santa Maria/Orcutt, East Santa Maria, West Los Alamos, East Los Alamos, Purisima Hills, and Santa Rita Valley (See Appendix A, Figure 1) (Service 2009).

Some isolated ponds exist within the range of the Santa Barbara County DPS of the California tiger salamander, some of which were discovered after the DPS' listing. If other ponds are within salamander dispersal distance of these isolated ponds, these isolated ponds could represent new populations of salamanders and connect the existing metapopulations. For example, two isolated ponds were recently discovered between the West Santa Maria metapopulation and the West Los Alamos metapopulation. Because of limited access to the private lands on which they occur, we do not have enough information to determine whether or not these isolated ponds could be part of additional vernal pool complexes.

With the exception of the two isolated ponds that lie between West Santa Maria and West Los Alamos, the metapopulations are separated by over 1.3 mi (2.2 km) (the furthest distance California tiger salamanders have been found from a breeding pond) or by U.S. Highway 101 (See Appendix A, Figure 1). This highway is heavily traveled and creates a barrier to salamander dispersal. A few culverts exist that run under the highway and may allow for some dispersal between the Los Alamos metapopulations.

Known California tiger salamander breeding ponds in Santa Barbara County are found in the six disparate metapopulations of the Santa Barbara County DPS:

1) The West Santa Maria/Orcutt metapopulation contains 15 extant known breeding ponds and is comprised of 2 vernal pool complexes and a few isolated ponds. The designated critical habitat unit (Unit 1, Western Santa Maria/Orcutt) is 4,135 ac (1,673 ha) and contains the two vernal pool complexes and one isolated pond (Service 2004b). (See Appendix A, Figure 2.)

2) The East Santa Maria metapopulation is comprised of six extant known breeding ponds, four of which comprise a vernal pool complex and two are isolated. Critical Habitat Unit 2 (Eastern Santa Maria) consists of 2,909 ac (1,177 ha) (Service 2004b) and contains five of the six known ponds (Service 2009). (See Appendix A, Figure 3.)

3) The West Los Alamos metapopulation contains 11 known breeding ponds spread throughout 3 vernal pool complexes and 2 isolated ponds. The Western Los Alamos/Careaga critical habitat unit (Unit 3) consists of 1,451 ac (587 ha) and includes one of the three vernal pool complexes (Service 2004b). (See Appendix A, Figure 4.)

4) The East Los Alamos metapopulation is comprised of four breeding ponds within one vernal pool complex. The Eastern Los Alamos critical habitat unit (Unit 4) contains 90 ac (36 ha) of upland and dispersal habitat (Service 2004b). (See Appendix A, Figure 5.)

5) The Purisima Hills metapopulation contains 18 breeding ponds within a vernal pool complex and 1 isolated pond. The Purisima Hills critical habitat unit (Unit 5) consists of 1,957 ac (792 ha) and includes 16.33 (the fraction due to land ownership and parcel boundaries) of the 18 ponds within the vernal pool complex (Service 2004b); 1 of the 18 ponds within the complex and

the isolated pond were discovered after critical habitat was designated. The Purisima Hills metapopulation provides a linkage between the Santa Rita Valley metapopulation to the southwest and the Western Los Alamos metapopulation to the north. (See Appendix A, Figure 6.)

6) The Santa Rita Valley metapopulation contains five known breeding ponds, two of which are included in the critical habitat unit for this metapopulation. The Santa Rita Valley critical habitat unit (Unit 6) contains 638 ac (258 ha) of upland and dispersal habitat (Service 2004b). (See Appendix A, Figure 7.)

At the time of the publication of the emergency listing rule in January 2000, the California tiger salamander was known from 14 current and historical ponds in Santa Barbara County. The number of known ponds increased to 27 by the time the final rule was published in September 2000. Currently, there are 60 extant known breeding ponds (Service 2009). The emergency and final listing rules acknowledged that other potential breeding ponds or pond complexes may exist, but could not be surveyed at that time by local biologists due to access restrictions from private landowners. The listing of the Santa Barbara County DPS of California tiger salamander was not premised on the assumption that the population was low; rather, the listing was based on significant threats associated with recent habitat loss and expectations of continued loss and fragmentation of the remaining habitat (Service 2000). Although there has been an increase in the number of known California tiger salamander breeding ponds detected in surveys in Santa Barbara County since listing, they continue to be threatened by urban development and agricultural conversion, resulting in the loss and fragmentation of habitat and the destruction and isolation of ponds (See Appendix A, Figures 2 and 3.)

Since the listing, the Service and the California Department of Fish and Game (CDFG) developed guidance for protocol survey efforts (Service and CDFG 2003) and this guidance likely aided in the discovery of additional breeding ponds found post-listing. Only a portion of localities were surveyed at the time of listing. Several of the additional ponds were discovered as a result of surveys conducted as a part of proposed projects. In most cases, these proposed projects would result in the removal or degradation of these ponds, and the elimination and/or alteration of their surrounding upland habitat. Therefore, the increase in number of breeding ponds does not by itself correlate to an improvement in status or a reduction in threats to the Santa Barbara County DPS of California tiger salamander because these ponds are threatened by development.

Abundance

We do not have data regarding the absolute number of California tiger salamanders due to the fact that they spend most of their lives underground. Virtually nothing is known concerning the historical abundance of the species. A typical breeding population in a pond can fluctuate due to random, natural processes, declining in some years to fewer than 20 adults plus juveniles (AmphibiaWeb 2007). At one study site in Monterey County, Trenham et al. (2000) found the number of breeding adults visiting a pond varied from 57 to 244 individuals. A Contra Costa County breeding site approximately 124 mi (200 km) north of the Trenham et al. (2000) study site in Monterey County showed a similar pattern of variation, suggesting that such fluctuations

are typical (Loredo and Van Vuren 1996). At the local landscape level, nearby breeding ponds can vary by at least an order of magnitude in the number of individuals visiting a pond, and these differences appear to be stable across years (Trenham et al. 2001).

Lifetime reproductive success for California tiger salamanders is typically low. Less than 50 percent breed more than once (Trenham et al. 2000). In part, this is due to the extended length of time it takes for California tiger salamanders to reach sexual maturity; most do not breed until 4 or 5 years of age. Combined with low survivorship of metamorphs (in some populations, less than 5 percent of marked juveniles survive to become breeding adults (Trenham 1998)), low reproductive success limits California tiger salamander populations. Because of this low recruitment, isolated subpopulations can decline greatly from unusual, randomly occurring natural events as well as from human-caused factors that reduce breeding success and individual survival. Based on metapopulation theory (Hanski and Gilpin 1991), factors that repeatedly lower breeding success in isolated ponds that are too far from other ponds for migrating individuals to replenish the population further threaten the survival of a local population.

Habitat or Ecosystem

The California tiger salamander inhabits low-elevation vernal pools and seasonal ponds and associated grassland, oak savannah, and coastal scrub plant communities of the Santa Maria, Los Alamos, and Santa Rita Valleys in northwestern Santa Barbara County (generally under 1,500 ft (475 m)) (Shaffer et al. 1993, Sweet 1993). Although California tiger salamanders are adapted to natural vernal pools and ponds, they now frequently use manmade or modified ephemeral and permanent ponds. This represents a shift in habitat during historic time, from vernal pools and sag ponds generally located on valley floors to livestock ponds in the foothills. How this affected original patterns of upland habitat use is unknown (Sweet, pers. comm. 2009).

All occurrences of California tiger salamanders in Santa Barbara County are within the Santa Maria Basin Geomorphic Province, which occurs between the interface of the westernmost extent of the east-west trending Transverse Ranges (i.e., the Santa Ynez Mountains) and the southernmost extent of the north-south trending Coast Ranges (i.e., the San Luis Range and San Rafael Mountains). This was termed the Los Osos domain by Lettis et al. (2004). The geomorphology of this area has resulted in the development of several unique soil formations. These include dune fields (e.g., Orcutt Terrace Dune Sheet), folded and faulted ridges (e.g., Casmalia, Purisima, and Santa Rita Hills), and adjacent valleys (e.g., Los Alamos and Santa Rita Valleys) (Hunt 1993, Ferren and Hecht 2003). The complex, geologically active landscape of the area where the Santa Barbara County DPS occurs provides the seasonal depressional wetlands (e.g., pools or ponds) required by California tiger salamanders for breeding.

Natural California tiger salamander breeding sites include: (1) dunal or deflational pools and ponds in once extensive sandy terraces, (2) isolated fold and fault sag ponds within ridges or valleys, and (3) fluvial ponds of varying origins in intermittent drainages within or along the margins of terraces (Ferren and Hecht 2003). California tiger salamander larvae are vulnerable to the predators that commonly occur in permanent waters (Fitzpatrick and Shaffer 2004), and the species is rarely found in permanent ponds, streams, or rivers. Natural breeding sites are covered by shallow water for variable periods from winter to spring, but may be completely dry

for most of the summer and fall. These pools range in size from small puddles to shallow lakes and are typically found in a gently sloping plain of grassland. Although generally isolated, they are sometimes connected to each other by small drainages (e.g., vernal swales). Bedrock or hard clay layers, which help the area retain water, typically lie beneath these wetlands.

Climatic changes associated with each season cause dramatic changes in the appearance of vernal pools or ponds. These wetlands collect water during winter and spring rains, changing in volume in response to varying weather patterns. During a single season, they may fill and dry several times. In years of drought, some pools/ponds may not fill at all. Created ponds or modified natural ponds have resulted in various types of artificial situations in which California tiger salamanders breed, mostly in foothill and upland terrain (Sweet, pers. comm. 2009).

Breeding migrations and breeding events are weather-dependent. California experiences highly variable annual rainfall events and drought conditions that do not consistently provide suitable environmental conditions for breeding or metamorphosis. A lack of rain results in the loss of vernal pools and the degradation of complexes of long-lasting pools that are important breeding habitat.

Genetics

Since the final listing in 2000, a range-wide survey of genetic variation in the California tiger salamander was conducted (Shaffer et al. 2004), the results of which further support the fact that the Santa Barbara County California tiger salamander meets the discreteness criterion of the Service's DPS policy (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1996). Shaffer et al. (2004) noted that the Sonoma and Santa Barbara isolates of California tiger salamanders are the strongest candidates for recognition as separate species because they are demonstrably monophyletic (i.e., each consists of closely related individuals descended from a recent common ancestor) and geographically isolated from the remainder of the species (Shaffer et al. 2004).

Larval and adult tiger salamanders (*Ambystoma mavortium* (*tigrinum*)) were widely sold as fish bait in California during the past century, and a number of populations of the non-native species have become established in the State, some within the range of the California tiger salamander. Riley et al. (2003) studied interbreeding between non-native tiger salamanders and California tiger salamanders, which threatens the genetic purity of the native species. They suggest that the extent of the genetic mixing depends on the breeding habitat. The two vernal pools surveyed held significantly fewer larvae with hybrid genotypes and significantly more with pure parental genotypes. Despite opportunities for hybridization due to the presence of non-native salamanders, they found evidence of some constraints on hybridization in the native breeding habitats. In contrast, there was little evidence of barriers to gene exchange in artificial breeding ponds. Because many available breeding ponds are artificial or highly modified, the authors believe that barriers preventing genetic exchange in natural breeding ponds are unlikely by themselves to prevent merging of the two taxa. This result indicates that concern about contamination, and possibly assimilation, of California tiger salamanders by non-native salamanders is not unfounded because barriers that might prevent genetic exchange do not appear absolute, particularly in artificial or highly modified habitats.

Similarly, Fitzpatrick and Shaffer (2004) further analyzed the frequencies of hybrid genotypes in different breeding habitats, including natural vernal pools, ephemeral cattle ponds, and perennial ponds. They found that there was a predominance of non-native alleles (alternate forms of a gene) in perennial ponds, suggesting that specific life history traits of non-native tiger salamanders give them an advantage to persist in perennial ponds. These characteristics include: (1) a flexible breeding phenology, allowing them to breed earlier in the fall; and (2) facultative paedomorphosis (retention of larval characteristics as an adult). Results from both of these studies suggest that habitat characteristics of native species should be exploited in management strategies to limit hybridization with non-native tiger salamanders. Recent research has shown, however, that once California tiger salamanders and hybrids co-occur in the same environment, time to metamorphosis is delayed in California tiger salamanders, eliminating their natural ability to compete based on early metamorphosis alone (Ryan et al. 2009).

Non-native tiger salamanders are established along the north edge of the Lompoc valley, and recent discoveries have placed the two species in contact at the edge of their respective distributions. A single individual was confirmed as a first-generation hybrid in 2009, and a concerted effort to prevent introgression in the Santa Barbara County DPS is warranted. Refer to the Factor E: Other Natural Or Manmade Factors Affecting its Continued Existence section below for more information about the threat of hybridization to the California tiger salamander.

Species-specific Research and/or Grant-supported Activities

Through cooperative agreements, the Service has allocated grant money for at least two projects that have improved California tiger salamander habitat in Santa Barbara County. One project received $4,000 for berm repair to prevent the sedimentation of a vernal lake which at the time was a potential California tiger salamander pond and has since been discovered as a known breeding pond (Service 2006). Another project was provided $2461.70 for the restoration of an eroding hillside, protecting a known breeding pond from the threat of sedimentation (Service 2001).

Santa Barbara County led an effort to create a regional conservation strategy from March 2006 through March 2008. The Service participated in monthly meetings with a steering committee to develop the plan, and the County committed staff and funding to the effort. The Service allocated approximately $267,000 in habitat conservation planning funds via section 6 of the Act toward the development of this plan. Additionally, the Ventura Fish and Wildlife Office allocated $10,000 for a facilitator to build consensus among the diverse group of stakeholders working on the plan and maintain focus on the project. Santa Barbara County chose to discontinue the regional plan process in March 2008, and funds for both grants were returned to the Service unused.

The Service provided $491,000, funded through section 6 of the Act via the Cooperative Endangered Species Conservation Fund, to purchase conservation easements over California tiger salamander breeding ponds and their uplands in the Purisima Hills metapopulation. Approximately $215,275 of this grant was used to purchase the development rights on 539 ac (218 ha) of potential upland and aquatic California tiger salamander habitat within the Purisima

Hills metapopulation; 60 of these acres (24 ha) fall within the designated critical habitat unit for this metapopulation (Unit 5) (Service 2007b).

A University of California, Santa Barbara student was awarded $18,146 through Ventura Fish and Wildlife Office discretionary recovery implementation funds to study California tiger salamander upland habitat use at the Santa Maria Airport. The reports provided by this study have provided more information about the dispersal habits, abundance, and upland habitat use of California tiger salamanders in this portion of the West Santa Maria designated critical habitat unit (Service 2009).

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

The primary cause of the decline of the Santa Barbara County DPS of California tiger salamanders has been and continues to be the loss, degradation, and fragmentation of habitat as the result of human activities (Service 2000). Most of the known and potential California tiger salamander breeding ponds and surrounding upland habitat in Santa Barbara County occur on private lands. Threats to habitat may have slowed in some areas of the range since the listing of the salamander in 2000 because of the need to obtain an incidental take authorization or exemption from the Act's take prohibitions. Section 3(18) of the Act 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.

The ponds available to California tiger salamanders for breeding have been degraded and reduced in number, and the associated upland habitats inhabited by salamanders for most of their life cycle have been degraded and reduced in area through agricultural conversion, urbanization, and the building of roads and highways (refer to the Factor E: Other Natural Or Manmade Factors Affecting its Continued Existence section below for the latter threat). Aerial photographs from the 1930s through the year 2000 (archived at the Santa Barbara County Planning and Development Department) show that the conversion to intensive agriculture and urban development has resulted in the loss of potential breeding habitat due to the destruction or alteration of natural vernal pools and seasonal ponds, and the loss of upland habitat. We cannot know how many of these ponds supported California tiger salamander breeding; however, many of these vernal features appear large enough to have served this function. At least 500 vernal wetlands were present on the Orcutt Dune Sheet in 1938 aerial photographs, but less than 150 of these were present in 2000. The remaining ponds represent a 75 percent loss of these habitats (L. Hunt, Hunt and Associates, pers. comm. 2003). Amphibian populations naturally undergo large fluctuations in population size as a result of random natural events such as drought and fires. The loss of crucial upland habitats and the loss of individuals through agricultural and development activities can leave small populations that are unable to withstand decreases in size as a result of such events.

Agricultural Conversion

Pools and ponds are destroyed when they are filled during grading and leveling operations or deep-ripping. Deep-ripping or deep slip plowing is a technique that uses a 4- to 7-foot deep plow to break up the hardpan or compacted soil to allow water to drain deeper into the soil and prevent water retention or ponding. In other situations, seasonal ponds have been converted to irrigation ponds, which are often managed in ways that are not conducive to salamander survival (e.g., pumping methods could result in mortality of California tiger salamander larvae; frequent (often daily) changes in water levels could result in desiccation of eggs) (Collins 2000). Ponds and California tiger salamander larvae inhabiting the ponds are also affected by indirect effects of conversion to row crops such as increased siltation, eutrophication (the process of increased nutrient input) from runoff containing fertilizers, and the loss of small burrowing mammal populations in uplands adjacent to ponds. The repeated plowing and discing or deep-ripping of upland habitats can alter the hydrology of the pools, thus destroying them (Coe 1988), and can kill salamanders and destroy the small mammal burrow systems in which they live for the majority of their lifespan.

Agricultural conversion of former grassland and paleodune terrace habitats in northern Santa Barbara County to row crops accelerated in the mid-to-late 1990s, either completely destroying some known and many potential ponds or constricting the upland habitat around these ponds to the point where little California tiger salamander upland habitat remains. Since 2000, more than 8,600 ac (3,480 ha) of land in the Santa Maria, Los Alamos, and Santa Rita Valleys have been converted to intensive agricultural practices. Vineyard acreage has increased from approximately 14,002 ac (5,666 ha) in 2000 to over 21,600 ac (8,741 ha) in 2008 (Santa Barbara County Agricultural Commissioner's Office 2009). Some of the largest agricultural operations of over 1,000 ac (405 ha) are located in the Santa Maria Valley (Santa Barbara County Association of Governments 2007b), where two of the six metapopulations occur. Loss and fragmentation of habitat as a result of agricultural conversion is an on-going, imminent threat to two metapopulations of California tiger salamanders: the East Santa Maria and Santa Rita Valley metapopulations.

Urban Development

In addition to agricultural conversion, urban development also threatens aquatic and upland habitat in the range of the California tiger salamander. Between 1996 and 2006, the human population of the Santa Maria Valley grew 27 percent (Santa Barbara County Planning and Development 2009a). Northern Santa Barbara County is projected to experience a 30 percent increase in population by 2040 (Santa Barbara County Association of Governments 2007a). The city of Santa Maria has the largest human population in Santa Barbara County; the highest proportion of births in Santa Barbara County is occurring in northern Santa Barbara County, specifically in the Santa Maria Valley, and the proportion is increasing (Santa Barbara County Association of Governments 2007a). The population within the city of Santa Maria is forecasted to grow by 35 percent by 2040. It is anticipated that this trend will continue throughout the current decade as Santa Maria continues to be the hub for northern Santa Barbara County, with a projected average 2 percent annual population growth rate (City of Santa Maria 2006). The

Eastern Santa Maria and Western Santa Maria California tiger salamander metapopulations were likely one large metapopulation in pre-settlement times, but have been isolated from one another by the cities of Orcutt and Santa Maria and U.S. Highway 101. Urban development in the Santa Maria and Orcutt areas threatens two of the metapopulations of California tiger salamanders, the West Santa Maria and East Santa Maria metapopulations.

Much of the land zoned for residential development in urban areas of Santa Barbara County has already been developed except in Santa Maria and Orcutt. To meet the needs of the increasing population, the County and cities will need several thousand acres of residentially zoned land on which to build houses. Several thousand more acres of commercial and industrial development (e.g., schools, parks, and other urban infrastructure) will be needed to support the new residents.

Metapopulations at Risk from Agricultural and Urban Development

Threats to each metapopulation resulting from on-going or future agricultural conversion and/or urban development follow. The sources for the following information include Ventura Fish and Wildlife office GIS and other analyses, Ventura Fish and Wildlife Office files for projects evaluated pursuant to sections 7 and 10 of the Act, personal communications, Santa Barbara County documents, and unpublished reports.

West Santa Maria/Orcutt

The West Santa Maria/Orcutt metapopulation is comprised of two vernal pool complexes and a few isolated ponds. The two vernal pool complexes and one isolated pond fall within designated critical habitat for this metapopulation (Western Santa Maria/Orcutt, Unit 1). This metapopulation contains 11 of the 29 natural vernal ponds (approximately 38 percent) that remain in Santa Barbara County. Often, natural ponds do not require as much, if any, maintenance, whereas artificial ponds require continual maintenance (e.g., berm repair, erosion control, sediment removal activities). These natural ponds occur on the Orcutt Dune Sheet, which contains soils that are unique to the Santa Maria Valley. The Orcutt Dune Sheet is an ancient, windblown sand deposit that covers the southern one-half to two-thirds of the Santa Maria Valley (Hunt 1993). All natural California tiger salamander breeding sites occurring on the sheet are classified as dunal or deflation pools and ponds, a type of California tiger salamander breeding pond occurring only within the West Santa Maria and East Santa Maria metapopulations. California tiger salamanders in this location may be adapted to unique conditions not found in the other four metapopulations.

On-going agricultural activities and proposed and approved development projects threaten this metapopulation. Several development projects have been proposed and two projects have received incidental take authorization within the Western Santa Maria/Orcutt critical habitat unit (Unit 1). Approximately 2,457 ac (994 ha) remain undeveloped or unfarmed within critical habitat Unit 1, which contains a total of 4,136 ac (1,674 ha). An additional 354 ac (143 ha) will be developed as a result of an interagency consultation that was completed pursuant to section 7 of the Act for the Federal Aviation Administration's (FAA) release of 926 ac (375 ha) to the Santa Maria Airport District. This land will be developed into a 151-ac (61-ha) research park, 190-ac (77-ha) golf course, a 13-ac (5-ha) storm drain and detention basin for flood control

purposes, and 572 ac (231 ha) will be preserved and/or restored for two listed species, including the California tiger salamander (Service 2007a). Once this development is complete, approximately 51 percent of the land within the Western Santa Maria/Orcutt critical habitat unit will be undeveloped or unfarmed. The preservation and restoration activities associated with the FAA's project will result in the permanent preservation of 572 ac (231 ha) of upland and dispersal habitat, four known breeding ponds, and the creation of up to six suitable breeding ponds west and northwest of the development.

The Orcutt Community Plan identifies Key Site 22 as suitable for 63 percent buildout (743 of 1,179 acres to be developed) to a maximum of 3,000 dwelling units (Santa Barbara County Planning and Development 2005). This site lies entirely within designated critical habitat and is proposed to include development of Union Valley Parkway between Highway 1 and the eastern site boundary. Additional development projects proposed within Critical Habitat Unit 1 include Union Valley Parkway, for which the Service issued a biological opinion to the California Department of Transportation, and expansion of the Laguna County Sanitation District's wastewater treatment plant (See Appendix A, Figure 2).

Other development proposals outside of Critical Habitat Unit 1 but within the Western Santa Maria metapopulation include: (1) the Mahoney Ranch project, which would convert 216 ac (87 ha) to residential development and would require the widening of Black and Mahoney roads—planning for this project is currently on hold due to financial constraints; however, the potential for the development proposal to resume remains likely; (2) the Area 9 project, an 890-ac (360-ha) industrial and commercial development north of Betteravia Road between Black Road and A Street; (3) a proposal to create a 36-ac (15-ha) County jail facility on Laguna County Sanitation District property; and (4) Rancho Maria, a residential development proposed to surround a golf course that would affect approximately 69 ac (28 ha) of upland habitat and an unknown number of potential breeding ponds—although planning is currently suspended due to financial constraints, this project is also likely to resume in the future. In addition to these development proposals, the County is working with the Service to develop an application package for an incidental take permit pursuant to section 10(a)(1)(B) of the Act for the removal of stockpiled soil that serves as California tiger salamander upland habitat and is adjacent to a known breeding site.

The Area 9 proposed development site once contained a large vernal pool complex that harbored the federally threatened California red-legged frog (*Rana aurora draytonii*) and was a potential yet likely breeding pond for California tiger salamanders. This vernal pool complex, known to support substantial amphibian diversity when inundated, was destroyed by discing and grading for agricultural conversion in 2006 (Service 2009). See the Unauthorized/Illegal Activities section of this review for further discussion of this incident.

East Santa Maria

The East Santa Maria metapopulation consists of two separate, isolated ponds and one vernal pool complex containing four ponds. Designated critical habitat includes five of the six known breeding ponds (Eastern Santa Maria, Unit 2) (see Appendix A, Figure 3). One of the six breeding ponds is separated from the other four breeding ponds in the critical habitat unit by approximately 2 mi (3.2 km) of intensively farmed lands which may preclude California tiger salamanders from moving between the ponds. Because of this large distance, the threat posed by stochastic (unpredictable, random) events that could cause isolated extirpation is increased as the possibility of natural recolonization is unlikely. Prior to the listing of the DPS in 2000, this metapopulation contained several additional potential breeding ponds. Three potential breeding ponds between this pond and the other four ponds in the East Santa Maria critical habitat unit were destroyed as a result of farming activities prior to the listing (Service 2009).

Nearly two-thirds of the available upland habitat surrounding and between known breeding ponds in the East Santa Maria metapopulation has been disced and is currently being transformed to intensive agriculture. The East Santa Maria critical habitat unit (Unit 2) contains 2,909 ac (1,177 ha); approximately 1,015 ac (410 ha) of this remains suitable for salamander upland habitat (i.e., undeveloped or undisturbed) (See Appendix A, Figure 3).

Since the listing in 2000, approximately 800 ac (324 ha) of suitable upland habitat and one potential breeding pond were destroyed as a result of agricultural conversion activities that occurred without incidental take authorization. One of the four breeding ponds in this metapopulation is filling as a result of increased sedimentation from adjacent farming practices; this property was converted into agriculture the night before the listing rule was published (Service 2009). Since the listing, a trench has been created around this pond, which further hinders salamanders from accessing the pond for breeding. Activities such as these that may result in take of California tiger salamanders may be referred to the Service's Division of Law Enforcement for investigation and, where appropriate, prosecution.

The East Santa Maria metapopulation represents one of two metapopulations on the Orcutt Dune Sheet and California tiger salamanders in this metapopulation may be adapted to conditions not found in two-thirds of the DPS' range (Service 2004a). In eastern Santa Maria, both agricultural conversion and urban development threaten known breeding ponds. A proposed 2,000-ac (809-ha) development would result in the loss and fragmentation of suitable upland habitat adjacent to one of the four known breeding ponds in eastern Santa Maria (Service 2009). However, legal development of this habitat would require appropriate mitigation and permits from the Service and potentially CDFG.

West Los Alamos

The West Los Alamos metapopulation consists of two vernal pool complexes and one isolated pond. Designated critical habitat (West Los Alamos/Careaga, Unit 3) includes one of the two vernal pool complexes; the other complex occurs on land that was excluded from the final critical habitat designation because the landowner is implementing conservation activities for the California tiger salamander. These conservation activities consist primarily of best management

practices for cattle grazing. In the vernal pool complex outside of designated critical habitat, one pond is isolated from the other ponds by U.S. Highway 101. The complex within designated critical habitat occurs on property that is owned by multiple landowners. Tentative proposals for vineyards and accessory development would currently avoid the known breeding ponds but could affect some of the adjacent upland habitat. The landowners and the Land Trust for Santa Barbara County are working with the Service develop a conservation strategy for this portion of the West Los Alamos Unit (Service 2009) (See Appendix A, Figure 4).

East Los Alamos

The East Los Alamos metapopulation consists of one vernal pool complex containing four known breeding ponds. Most of this metapopulation occurs on one landowner's property. This property was excluded from final designation of critical habitat because of conservation activities being implemented for the California tiger salamander. Two parcels remain within critical habitat; one contains suitable upland habitat and the other is an existing vineyard. Designated critical habitat for this metapopulation (Eastern Los Alamos, Unit 4) consists of 90 ac (36 ha) of upland and dispersal habitat. The landowner whose property contains the four known breeding ponds has entered into an agreement with the Service to conserve these ponds, create two additional ponds to enhance connectivity, and preserve upland habitat adjacent to the ponds. Any future development activities in this area would likely be limited to areas outside of the suitable upland habitat adjacent to the known breeding ponds (Service 2009) (See Appendix A, Figure 5).

Purisima Hills

The Purisima Hills metapopulation contains 18 ponds within a vernal pool complex and one isolated pond. Critical habitat (Purisima Hills, Unit 5) encompasses 16.33 of the 18 ponds within the vernal pool complex; one pond was designated as critical habitat on one landowner's portion of the pond while the other landowner's portion of the pond was excluded from critical habitat, based largely on conservation activities described in a Memorandum of Understanding with the Service (Service 2009). This known breeding pond is believed to be the largest, and highest elevation, natural vernal pool in the range of the Santa Barbara County DPS. One of the ponds within the complex and the isolated pond were discovered after critical habitat was designated. This metapopulation has been managed for oil extraction and livestock grazing for several decades. However, the parcels in this metapopulation are being sold to different individual landowners. Since the listing, a 4,000-ac (1618-ha) property containing most of the known breeding ponds in this metapopulation has been sold twice to individuals interested in splitting the property into 32 legal parcels for ranchette-style developments with vineyards. At least two of these recently sold parcels contain known breeding ponds (Sweet, pers. comm. 2007). Approximately half of these parcels lie adjacent to known breeding ponds and at least two parcels have been sold (Sweet, pers. comm. 2007). The known breeding ponds in this metapopulation face threats associated with residential development and threats associated with a lack of maintenance (e.g., increased sedimentation, berm or levee failure, etc.) (Sweet 2003) (See Appendix A, Figure 6).

Santa Rita Valley

This metapopulation is bisected by State Highway 246, a heavily traveled thoroughfare between the cities of Buellton and Lompoc. Of the five known breeding ponds in this metapopulation, two are human-made ponds isolated from other metapopulations and/or vernal pool complexes. Another confirmed breeding locality consists of two pools within 50 ft (15 m) of one another, northeast of and adjacent to Highway 246. Adult California tiger salamanders were often found dead on roads after rain events during the 1980s, and are still being documented today (Sweet, pers. comm. 2009). Three ponds on a neighboring property to the east and two ponds on the south side of Highway 246 likely formed a complex with this pond in the past. However, the ponds to the east were degraded by introduced fish and vineyards, while Highway 246 likely forms a substantial dispersal barrier between the northern and southern ponds (See Appendix A, Figure 7).

The habitat supporting the Santa Rita Valley metapopulation is undergoing rapid conversion to agricultural uses. Though vineyards and associated facilities are growing in acreage and in number along State Highway 246, agricultural activities are often not subject to the local permitting requirements applied to development projects. Therefore, it is unknown how much acreage remains suitable habitat for California tiger salamanders in this metapopulation.

Unauthorized/Illegal Activities

According to Service files, incidents that have resulted in the conversion of land without the benefit of incidental take authorization have occurred in northern Santa Barbara County. Nearly two-thirds of the available upland habitat has been disced and is currently being transformed to intensive agriculture in the East Santa Maria metapopulation. One of the four breeding ponds is filling in from farming practices that occurred the night prior to the listing (Service 2009). This is one of the two ponds in this metapopulation that consistently holds water during the breeding season.

Approximately 326 ac (132 ha) of suitable upland habitat and one potential breeding pond were destroyed as a result of agricultural conversion activities that occurred without incidental take authorization in 2001. This property is being split into several lots and sold to individual landowners. Pursuant to a law enforcement action, the Service reached settlement with the landowner in relation to this alleged violation of the Act.

Approximately 500 ac (202 ha) of suitable upland habitat on four separate parcels in eastern Santa Maria were disced and vegetation was cleared and burned in this area without incidental take authorization in 2004. Since that time, a trench was excavated around the known breeding pond on this property, which further hinders salamanders from accessing the pond for breeding.

A dead California tiger salamander was found in 2004 at a Santa Barbara County Public Works administration building construction site on Foster Road in western Santa Maria. This project proceeded without incidental take authorization. The Service is pursuing a law enforcement action in relation to this incident.

In 2006, a large vernal pool complex identified as a potential breeding pond and an unknown amount of upland habitat was graded for agricultural conversion. This pond was known to harbor California red-legged frogs and had never been comprehensively surveyed for California tiger salamanders. The unauthorized destruction of this large vernal pool complex may have constituted a violation of the Act. The Service contacted both the owner of the property and the City of Santa Maria to encourage them to discontinue the ground-disturbing activities and restore the habitat on the property. The Service is currently working to re-engage discussions with the City and the landowner to discuss this incident. In addition, the Service is determining whether the incident should be referred to the Service's Division of Law Enforcement.

Ranching/Grazing

Cattle ranching can be more compatible with California tiger salamander conservation than other land uses, such as vineyards or housing (Service 2003). Like salamanders, cattle need open grasslands and ponds. Partial or complete exclusion of livestock grazing around breeding sites could have the negative effect of allowing vegetation cover to increase. This can alter pool hydrology by reducing the amount of surface runoff into the pool basin as a result of both increased infiltration of water into the soil and increased evapotranspiration (loss of water from the surface of vegetation) (Liacos 1962, Gifford and Hawkins 1978). Exclusion of livestock grazing may also allow the invasion of the aquatic habitat by non-native annual grasses and forbs within and around the bed and shoreline of the pond (Barry 1998). By keeping vegetation cover low, grazing can make areas more suitable for ground squirrels whose burrows are used by California tiger salamanders. Less vegetation may also facilitate the movement of California tiger salamanders from upland areas to breeding ponds (Service 2003). In Santa Barbara County, the remaining vernal pool complexes and isolated ponds with large amounts of suitable salamander habitat are currently being grazed.

While livestock grazing may have beneficial effects on California tiger salamander habitat, grazing species, livestock density, and time of grazing are important considerations for California tiger salamander conservation. Some routine ranching activities, such as creating firebreaks, may result in mortality or injury of California tiger salamanders. Over-grazing can cause erosion and sedimentation of aquatic habitat. Although cattle could have negative impacts on California tiger salamanders, grazing generally is compatible with the continued use of rangelands by the California tiger salamander as long as best management practices are followed, intensive burrowing rodent control programs are not implemented in these areas, and grazing is not excessive (Jones 1993, Shaffer et al. 1993).

Cattle grazing appears to be in decline in Santa Barbara County as shown by the decreasing trend in the annual crop reports for 2001 through 2006 (Santa Barbara County Agricultural Commissioner's Office 2007). There have been fewer head of cattle each year and a decreased total value for the cattle industry despite a generally increasing price per unit.

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

Overutilization for commercial purposes was not known to be a factor at the time of listing and does not appear to be a threat at this time.

FACTOR C: Disease or Predation

Disease

The potential threat posed by disease to the Santa Barbara County DPS of California tiger salamanders is not known, and the risks to the DPS have not been determined. Sam Sweet (pers. comm. 1998) reported that one landowner in the Los Alamos Valley had seen large numbers of dead and dying California tiger salamanders in a pond; however, the cause was not determined. In general, relatively little is known about the diseases of wild amphibians (Alford and Richards 1999). Several pathogenic (disease-causing) agents, including at least one bacterium (Worthylake and Hovingh 1989), a water mold (fungus) (Kiesecker and Blaustein 1997, Lefcort et al. 1997), and a virus (McLean 1998), have been associated with die-offs of closely related tiger salamanders, as well as other amphibian species.

Recently, a chytrid fungus (*Batrachochytrium dedrobatidis*) has been linked to amphibian declines worldwide (Berger et al. 1998, Bosch et al. 2001, Fellers et al. 2001, Young et al. 2001). Chytrid fungus has been found in California tiger salamanders in Santa Clara County, California (Padgett-Flohr 2005). The effect of chytrid fungus on the Santa Clara County California tiger salamander population is currently unknown. Chytrid fungus has also recently been documented in a population of California red-legged frogs in southern Santa Barbara County (AECOM 2009). Translocation of infected amphibians could allow the spread of this pathogen to other populations of amphibians, including California tiger salamanders. A potential threat could result from permit applicants proposing to translocate California tiger salamanders to newly created ponds as a part of mitigation if ponds do not become naturally colonized (Service 2009).

Worthylake and Hovingh (1989) reported repeated tiger salamander (*Ambystoma tigrinum*) die-offs of in Desolation Lake in the Wasatch Mountains of Utah; these salamanders are within the same genus as the California tiger salamander. Affected salamanders had red, swollen hind legs and vents, and widespread hemorrhaging of the skin and internal organs. The researchers determined that the die-offs were due to infection of the bacterium *Acinetobacter*. *Acinetobacter* are common in soil and animal feces. Overstocking of livestock could lead to high levels of nitrogen in ponds in those watersheds and contribute to increased bacterial levels.

In addition to the *Acinetobacter* bacterium discussed above, DNA-containing viruses that occur in insects, fish, and amphibians have been identified by the U.S. Geological Survey National Wildlife Health Center in Madison, Wisconsin, as the cause of death of large numbers of tiger salamanders at Desolation Lake, Utah (Worthylake and Hovingh 1989). Infected salamanders moved slowly in circles and had trouble remaining upright. They also had red spots and swollen areas on the skin. Viruses associated with die-offs of tiger and spotted salamanders in Maine and North Dakota have been isolated (McLean 1998). In 1995, researchers reported similar die-offs

attributed to an iridovirus in southern Arizona and near Regina, Saskatchewan, Canada (McLean 1998). Viruses belonging to the family Iridoviridae have been associated with mass mortality in the common frog (*Rana temporaria*) and the federally listed Sonora tiger salamander (*Ambystoma tigrinum stebbinsi*) (Jancovich et al. 1997, AmphibiaWeb 2007).

Iridoviruses are found in both fish and frogs and may have been introduced to some sites through fish stocking programs (Carey et al. 1999). Little is known about the historical distribution of iridoviruses in salamander populations. Recent research has shown that *Ambystoma tigrinum* virus, an iridovirus that has caused amphibian die-offs, is lethal to California tiger salamanders (Picco et al. 2007). This virus is likely spread through the commercial trade of amphibians, such as for fishing bait, which is illegal in California.

In Georgia, Lefcort et al. (1997) found that tiger salamanders raised in natural and artificial ponds contaminated with silt were susceptible to infection by the water mold *Saprolegnia parasitica*. In this study, the fungus first appeared on the feet and spread to the entire leg, and all infected animals died. Die-offs of western toads (*Bufo boreas*), Cascades frogs (*Rana cascadae*), and Pacific treefrogs (*Hyla regilla*) also have been associated with *Saprolegnia* infections (Kiesecker and Blaustein 1997). *Saprolegnia* species are widespread in natural waters and commonly grow on dead organic material (Wise 1995). High nitrogen and silt levels from overgrazing or other agricultural or urban runoff may increase susceptibility to disease and may interact with other risk factors (e.g., habitat loss, introduced species) to threaten the persistence of a local population.

Predation

Bullfrogs (*Rana catesbeiana*): Bullfrogs are not native to California. Bullfrogs have been found in at least four known California tiger salamander breeding ponds in Santa Barbara County (Service 2009). Bullfrogs prey on California tiger salamander larvae (P.R. Anderson 1968). Shaffer found a newly metamorphosed tiger salamander in the stomach of a bullfrog (H. B. Shaffer unpublished observations *at* AmphibiaWeb 2007). Morey and Guinn (1992) documented a shift in amphibian community composition at a vernal pool complex, with California tiger salamanders becoming proportionally less abundant as bullfrogs increased. Although bullfrogs are unable to establish permanent breeding populations in unaltered vernal pools and seasonal ponds, dispersing immature frogs take up residence in vernal pools during winter and spring (Morey and Guinn 1992) and may prey on native amphibians, including larval California tiger salamanders.

Tiger Salamanders (*Ambystoma mavortium* (*tigrinum*)): Non-native tiger salamanders from the central United States were introduced to California for fishing bait over 60 years ago. Until recently, it was unknown whether *A. tigrinum mavortium* co-occurred with native California tiger salamanders within the range of the Santa Barbara County DPS. Currently, two of these co-occurrence sites have been documented within the Purisima Hills metapopulation. Hybrid salamanders have been documented preying on California tiger salamanders. In one study, all cannibalism observed was unidirectional, with hybrids always predating native California tiger salamanders (Ryan et al. 2009).

Mosquitofish (*Gambusia affinis*): Mosquitofish have been widely introduced in California by vector control agencies to control mosquitoes by preying on their larvae. These fish were first introduced to California in 1922 and are particularly predaceous. The decline of up to 20 aquatic species has been linked to the introduction of the mosquitofish outside of its native range. Recent studies suggest California's declining amphibian populations can be linked to mosquitofish introductions as well (Indiana-Illinois Sea Grant 2007). Mosquitofish are known predators on eggs and larvae of many amphibian species, including the California newt (*Taricha torosa*) (Graf and Allen-Diaz 1993, Gamradt and Kats 1996), California red-legged frog (Schmieder and Nauman 1993), and Pacific treefrog (Goodsell and Kats 1999). Loredo-Prendeville et al. (1994) found no California tiger salamanders in ponds with mosquitofish. Two separate studies that looked at mosquitofish densities and impacts to California tiger salamander larvae revealed different results. Leyse and Lawler (2000) found that adult mosquitofish at high initial densities, as one finds in a permanent pond where the mosquitofish populations can build from year to year, and where the mosquitofish are frequently active during the time when salamander larvae are small, significantly reduced the survival of California tiger salamanders. 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). Smaller size at metamorphosis may reduce survival to breeding age and reproductive potential (Semlitsch et al. 1988, Morey 1998). Salamanders may be especially vulnerable to mosquitofish predation due to their fluttering external gills, which may attract these visual predators (Graf and Allen-Diaz 1993). However, Leyse et al. (in press) found that low densities of adult mosquitofish did not affect California tiger salamander larval survival to metamorphosis. Although we do not have specific presence/absence data, we expect mosquitofish may become a more serious threat to California tiger salamander breeding ponds. As urban areas continue to expand, the introduction of mosquitofish into previously untreated ponds may result in the elimination of California tiger salamanders from additional breeding sites.

Other Introduced Fish: In addition to mosquitofish, other introduced fish, both native and non-native, threaten the California tiger salamander. California tiger salamander eggs, larvae, and adults are prey for a variety of native and introduced arthropods, fish, and other amphibians. Shaffer et al. (1993) considered bullfrogs, mosquitofish, and other introduced fish to be biological indicators of ponds that have been disturbed to a degree that California tiger salamanders are excluded. Non-native or introduced predators of California tiger salamanders include bullfrogs and mosquitofish (discussed above), Louisiana red swamp crayfish (*Procambarus clarkii*), catfish (*Ictalurus* sp.), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), fathead minnow (*Pimephales promelas*), and other introduced fish (P.R. Anderson 1968, Morey and Guinn 1992, Shaffer et al. 1993, Graf and Allen-Diaz 1993, Gamradt and Kats 1996).

Bluegill, largemouth bass, and fathead minnow are some of the fish species that have been found in known California tiger salamander breeding ponds in Santa Barbara County (Collins 2000). A number of ponds in or near occupied California tiger salamander habitat in the west Orcutt area have been home to introduced fish for more than 20 years (B. Daniels, Kiewitt Pacific, pers. comm. 2000), likely eliminating any California tiger salamanders that may have bred there. The introduction of bass and sunfish (*Lepomis cyanellus*) into many ponds that may have been breeding habitat for California tiger salamanders has likely eliminated salamanders from those

sites (Shaffer et al. 1993). The distribution of the California tiger salamander in the west Los Alamos population may be limited by catfish that were introduced several years ago (Sweet 2000). California tiger salamanders are absent from a pond with introduced catfish that appears to have suitable salamander breeding habitat, although a pond less than 250 ft (76 m) away that appears less suitable for breeding is occupied by California tiger salamanders (Sweet 2000).

Louisiana red swamp crayfish also prey on California tiger salamanders (Shaffer et al. 1993) and may have eliminated some populations (Jennings and Hayes 1994). The crayfish prey on California newt eggs and larvae, despite toxins that this species has developed, and may be a significant factor in the loss of newts from several streams in southern California (Gamradt and Kats 1996). Crayfish have been found in salamander ponds in Santa Barbara County; however, their effect on egg and larval survival is unknown (Sweet, pers. comm. 1999).

Native Predators: California tiger salamander larvae, eggs, and adults are also prey for many native species; however, in healthy salamander populations, this is not known to be a substantial threat. 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 snakes (*Thamnophis* spp.), larger California tiger salamander larvae, larger western spadefoot (*Spea hammondii*) larvae, California red-legged frogs, and raccoons (*Procyon lotor*) (Hansen and Tremper 1993). Native predators have been documented at several known breeding ponds in Santa Barbara County (Sweet, pers. comm. 2009).

Adult California red-legged frogs are known predators of California tiger salamander larvae (Baldwin and Stanford 1987, Petranka 1998). California ground squirrels may eat adults, although salamanders do not appear to avoid occupied ground squirrel burrows (Loredo et al. 1996, Petranka 1998). Garter snakes will sometimes prey on larvae, and at least one adult striped skunk (*Mephitis mephitis*) has been observed eating adult California tiger salamanders in pitfall traps (P. C. Trenham, personal observations *at* AmphibiaWeb 2007).

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

The primary cause of the decline of the Santa Barbara County population of California tiger salamanders 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.

Federal Regulations

The National Environmental Policy Act (NEPA) (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, NEPA 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 that could offset those effects (40 C.F.R.

1502.16). Such mitigation is usually developed in coordination with the Service and usually includes some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

Under section 404 of the Clean Water Act, the U.S. Army Corps of Engineers (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. This review requires consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts. If a project falls within Corps jurisdiction and the Corps determines that federally listed species may be affected by project activities, interagency consultation between the Service and the Corps would occur to address the effects.

The Endangered Species Act of 1973, as amended, is the primary Federal law providing protection for this species. Since its 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. 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 C.F.R. § 402.02). For projects without a Federal nexus that may negatively impact listed species, the Service may issue incidental take permits 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 (HCP) that details measures to minimize and mitigate the project's adverse impacts to listed species. The protections afforded by the Act include the review of potential effects of projects on California tiger salamanders and funding for restoration and habitat conservation. The listing of the Santa Barbara County DPS of the California tiger salamander as endangered provided the full protection of the Endangered Species Act and has provided focused protection to this population.

Threats to habitat may have slowed since the listing of the salamander in 2000 because private landowners (without a Federal nexus) must obtain incidental take authorization from the Service before they can undertake actions that would result in take. Though the Ventura Fish and Wildlife Office has worked with several project proponents in developing applications for incidental take permits, to date, none have been completed; thus no incidental take permits for the species have been issued. Additionally, protocol surveys to determine presence or absence of California tiger salamanders can take up to 2 years to complete (to determine absence). For this reason, some applicants, where there exists reason to believe California tiger salamanders occur on the property, assume presence and proceed with their request for incidental take authorization.

Since the listing, eight formal consultations analyzing effects to the Santa Barbara County DPS of the California tiger salamander pursuant to section 7 of the Act have been completed by the Service. These projects include constructing a food bank, realigning a road, and restoring a wetland; installing a 3.4-mi (5.5-km) sewer trunk line; adding treatment processes to an existing

wastewater treatment plant; replacing a bridge; conducting desilting and vegetation removal activities within a creek; developing a research park and golf course on Santa Maria Airport property; and extending Union Valley Parkway between Hummel Drive and Blosser Road in the city of Santa Maria.

In 2007, two Safe Harbor Agreements (permitted under section 10(a)(1)(A) of the Act) that would have resulted in the protection and creation of California tiger salamander habitat were in the early stages of development, one of which would have resulted in the inclusion of over 1,000 ac (405 ha) of upland habitat and four known breeding ponds (Service 2009). Efforts to develop both of these proposed Safe Harbor Agreements have since been discontinued at the landowners' discretion.

Since the listing of the Santa Barbara County DPS of the California tiger salamander in 2000, the Service has issued recovery permits pursuant to section 10(a)(1)(A) of the Act for surveys to obtain better information on the distribution and occurrences of California tiger salamanders in Santa Barbara County. The Service and the CDFG coordinated on the production of protocol survey guidance for California tiger salamander surveys. This guidance addresses both aquatic and upland survey efforts and was made available to the public in October 2003 (Service and CDFG 2003).

California State Regulations

The California Environmental Quality Act (CEQA) 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). In the latter case, projects may be approved that cause significant environmental damage, such as destruction of listed species or their habitat. Protection of listed species and their habitat through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

Since the listing in 2000, the Service has worked with CDFG to prohibit the sale of "waterdogs" (non-native tiger salamanders of the genus *Ambystoma*) as bait and pets. Currently, Title 14 of the California Code of Regulations states in one section (§ 200.31) that bait dealers cannot sell waterdogs less than 3 inches in length, implying that it is legal for bait dealers and their clients to possess them, yet in another section (§671(C)(3)(c)) Title 14 states that that it is illegal to possess salamanders of the genus *Ambystoma* (California Code of Regulations 2009).

The California Fish and Game Commission (Commission) has been petitioned twice to accept the California tiger salamander as a candidate for listing under the California Endangered Species Act (CESA). CESA (California Fish and Game Code, section 2080 *et seq.*) prohibits the unauthorized take of state-listed threatened or endangered species. The CESA requires consultation with the California Department of Fish and Game for those activities that may affect a State-listed species and to mitigate for any adverse impacts to the species or its habitat. Pursuant to CESA, 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. In February 2009, the

Commission was ordered in a California appeals court ruling to accept the California tiger salamander as a candidate for listing under CESA. As a candidate species, the salamander now falls under regulatory authority of the California Department of Fish and Game. As of October 2009, a final listing decision for the California tiger salamander under CESA is expected to be released in February 2010.

Local Regulations

Depending on how parcels are zoned and how much area is affected by an individual action, certain agricultural land conversions do not require discretionary permits from the County of Santa Barbara (B. Gillette, County of Santa Barbara, pers. comm. 2007) and, therefore, may not consider impacts to California tiger salamanders or their habitat. Although the County is required by the Act to consider listed species when permitting development actions, they often defer the responsibility of compliance with the Act to the landowners. This precludes the Service's ability to provide recommendations in the early stages of development planning to meet project objectives as well as the requirements of the Act. However, because landowners do not always contact the Service to ensure compliance with the Act, many such projects are carried out without Service input or awareness.

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

As identified in the listing rule, several other factors, including habitat fragmentation, contaminants, hybridization with and competition from introduced species, and effects from oil production and over-grazing, have negative effects on California tiger salamanders and their aquatic and upland habitats. Drought and roads also have the potential to affect the species' continued existence.

Isolation

Because California tiger salamanders travel such long distances, they are especially vulnerable to the effects of habitat fragmentation and habitat destruction that result in the isolation of ponds. One of the factors that repeatedly lowers breeding success in isolated ponds is that isolated ponds are too far from other ponds for migrating individuals to replenish the population (e.g., in the event of a disease that results in the loss of a breeding population). Because of this, an isolated population can be driven to extinction. California tiger salamanders, like many amphibian populations, exhibit a metapopulation structure where populations exist as an interconnected series of populations within a larger geographic area (Marsh and Trenham 2001, AmphibiaWeb 2007). Metapopulation models predict that isolated populations are more likely to go extinct in the long run than populations that are connected (Hanski 1999, AmphibiaWeb 2007). California tiger salamanders have low reproductive success and recruitment. Because of this, isolated metapopulations can decline greatly from unusual, randomly-occurring natural events as well as from human-caused factors that reduce breeding success and individual survival. The conservation biology literature commonly notes the vulnerability of taxa known from one or very few locations and/or from small and highly variable populations (e.g., Shaffer 1981, 1987, Primack 1998, Groom et al. 2006). Over time, habitat fragmentation and/or isolation of ponds can lead to the loss of genetic diversity, which can affect a population's ability to respond to

environmental changes, compounding the effects of climate change, contaminants, and introduced species (AmphibiaWeb 2007).

Drought and Climate Change

Because California experiences highly variable annual rainfall events and droughts, environmental conditions for California tiger salamander breeding and metamorphosis are not consistent. In years of drought, some pools/ponds may not fill at all. Breeding migrations and breeding events are dependent on weather. A lack of rain results in the temporal loss of vernal pools and can result in the degradation of complexes of long-lasting pools that are important breeding habitat. Droughts may occasionally preclude reproductive success at a given pond; therefore, maintaining connectivity between ponds is important for the long-term viability of California tiger salamanders.

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.

Global amphibian declines have been increasingly attributed to factors resulting from global climate change over the last decade (Corn 2005, Wake 2007, Reaser and Blaustein 2005). Factors such as epidemic disease (Pounds et al. 2006), changes in breeding phenology (Terhivuo 1988; Gibbs and Breisch 2001; Beebee 1995), changes in environmental conditions such as leaf litter (Whitfield et al. 2007), increased evaporation rate (Corn 2005), increased frequency of storm events and drought (Kagarise, Sherman, and Morton 1993) and ultraviolet radiation (Blaustein et al. 1998) have been identified as dynamics that can affect amphibian persistence. Diseases, such as the chytrid fungus *Batrachochytrium dedrobatidis*, may become more virulent in changing climatic conditions (Pounds et al. 2006). Warmer temperatures have been linked to earlier breeding in some amphibians (Blaustein et al. 2001, Beebee 1995). Changes to the hydroperiod of ephemeral ponds due to changing weather patterns has significant implications for the diversity of amphibians that rely on those ponds for breeding (Corn 2005). Ultraviolet radiation has been shown to have negative effects on amphibian eggs and embryos around the world (Blaustein et al. 1998). While it appears reasonable to assume that California tiger salamanders may be affected by factors resulting from climate change, we lack sufficient certainty on knowing how and how soon climate change will affect the species.

Roads

The dispersal and migration distances of California tiger salamanders require a large amount of barrier-free landscape (Shaffer et al. 1993, Loredo et al. 1996). Large roads and highways represent physical obstacles and can block California tiger salamanders from moving to new

breeding habitat or prevent them from returning to their breeding ponds or upland habitat. Roads can accelerate fragmentation by increasing mortality and preventing recolonization of breeding sites (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. Road construction results in the death of slow-moving animals and causes soil compaction underneath and adjacent to the road bed (Trombulak and Frissell 2000). Amphibians are especially vulnerable to being killed on roads due to life histories involving migration between breeding and upland habitats and their slow movements (Trombulak and Frissell 2000). Any California tiger salamanders in underground burrows in the path of the road or in the impact area are likely to be crushed during road construction. Once the road is open to traffic, salamanders are at risk of being run over on their first dispersal migration from the pond, and on future migrations to and from the ponds for breeding.

Roads alter many of the physical characteristics of the environment that may be important to California tiger salamanders, including soil density, soil water content, dust, surface-water flow, patterns of runoff, and sedimentation (Trombulak and Frissell 2000). Sedimentation from road construction, maintenance, and runoff may affect California tiger salamander breeding ponds. Roads alter the hydrology of slopes, in part by diverting water into surface-water systems that can cause erosion, create gullies, and deposit increased loads of sediments into wetland systems (Trombulak and Frissell 2000). Curbs and berms may allow salamanders to climb onto the road but can restrict or prevent their movements off the roads, increasing the potential for salamanders to be killed or injured by traffic (Launer and Fee 1996).

Roads can accelerate metapopulation fragmentation by increasing mortality and preventing recolonization of sites that would otherwise be only temporarily extirpated (Trombulak and Frissell 2000). A majority of known breeding ponds are only 1 mi (1.6 km) from highways or major roads (Service 2009). The East Santa Maria and West Santa Maria metapopulations were likely one large metapopulation in pre-settlement times, but have been isolated from one another by U.S. Highway 101. The California Department of Transportation is in the early stages of consultation with the Service for a proposed widening of Highway 246 between Lompoc and Buellton. The Santa Rita metapopulation is bisected by Highway 246. As a part of the biological evaluation for this project, extensive California tiger salamander surveys have been conducted, which will add to our knowledge of the distribution of the species in this area. In the final listing rule, the Service identified Highway 246 as a significant cause of California tiger salamander habitat fragmentation and mortality from roadkill for the Santa Rita metapopulation (Service 2000). Undercrossing structures are proposed to be installed in some areas as a part of the Highway 246 widening project to lessen the highway's impact to California tiger salamanders (Service 2009).

Two Santa Barbara County California tiger salamander breeding ponds are within 0.2 mi (0.4 km) of a railroad that runs between them, possibly reducing migration and genetic interchange between the ponds. In addition to the barriers created by fill deposited in small canyons and watercourses, the railroad tracks themselves can act as barriers to migrating salamanders (Jones 1993). The animals have difficulty moving under the tracks unless adequate burrows are present.

Contaminants

Like most amphibians, 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 throughout their range. California tiger salamanders are extremely sensitive to these pollutants due to their highly permeable skin which can rapidly absorb pollutant substances (Blaustein and Wake 1990). Toxins at lower than lethal levels may still have adverse effects, such as causing abnormalities in larvae and behavioral anomalies in adults, both of which could eventually lead to lethal effects (Hall and Henry 1992, Blaustein and Johnson 2003). California tiger salamanders also could die from starvation due to the reduction or loss of their prey base from the use of pesticides. Sources of chemical pollution that may adversely affect 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.

Oil Production and Road Runoff

Oil production began within the range of the Santa Barbara County DPS of the California tiger salamander approximately 100 years ago, with the discovery of oil in the Solomon Hills (within the range of the Los Alamos metapopulations). Although oil production is less disruptive to the upland habitats than agriculture, oil sump ponds, particularly those located where natural ponds and pools once existed, may act as toxic sinks. While attracting salamanders seeking breeding sites, these ponds may contain levels of contaminants that kill adults, eggs, and larvae outright, or cause deformities in the developing larvae thus precluding their survival. Oil and other contaminants in runoff from roads have been detected in adjacent ponds and linked to die-offs of and deformities in California tiger salamanders and spadefoot toads, and die-offs of invertebrates that form most of both species' prey base (Sweet 1993).

Lefcort et al. (1997) found that oil had limited direct effects on 5-week-old marbled salamanders (*Ambystoma opacum*) and eastern tiger salamanders (*Ambystoma mavortium* (*tigrinum*)). However, salamanders from oil-contaminated natural ponds metamorphosed earlier at smaller sizes, and those from oil-contaminated artificial ponds had slower growth rates than larvae raised in non-contaminated ponds. Their studies did not address effects on eggs and early larval stages, where the effects may be more pronounced. Oil production in Santa Barbara County, including offshore production based in the County, reached an all-time high in 1995 (Santa Barbara County Energy Division 2007). Although oil production has since slowed in Santa Barbara County, at least one proposal to expand an existing drilling operation and one proposal to drill for oil in an area currently used for cattle grazing would affect California tiger salamander habitat (Service 2009).

Hatch and Burton (1998) and Monson et al. (1999) investigated the effects of one component of petroleum products and urban runoff (fluoranthene, a polycyclic aromatic hydrocarbon) on spotted salamanders (*Ambystoma maculatum*), northern leopard frogs (*Rana pipiens*), and African clawed frogs (*Xenopus laevis*). In laboratory and outdoor experiments, using levels of the contaminant comparable to those found in service station and other urban runoff, the

researchers found reduced survival and growth abnormalities in all species and that the effects were worse when the larvae were exposed to the contaminant under natural levels of sunlight, rather than in the laboratory under artificial light. There are a number of known breeding ponds along secondary roads and highways in Santa Barbara County. In light of increased urbanization and concurrent increases in traffic, the risk factor associated with contaminants in runoff likely will increase in both roadside ditches and across the general landscape.

Agricultural/Urban Chemicals

During 2007, Santa Barbara County used over 4,482,140 pounds (2,033,065 kilograms) of pesticide active ingredients (California Department of Pesticide Regulation 2007). These chemicals included methyl bromide, mancozeb, petroleum oil, phosmet, chlorpyrifos, pendimethalin, parathion, paraquat dichloride, fosetyl-aluminum, acephate, cryolite, malathion, and other chemicals, some of which are extremely toxic to aquatic organisms, including amphibians and the organisms on which they prey. Some of these pesticides, such as chlorpyrifos and malathion, are cholinesterase inhibitors. Reduced cholinesterase activity has been linked to uncoordinated swimming, increased vulnerability to predation, depressed growth rates, and increased mortality in tadpoles (de Llamas et al. 1985, Rosenbaum et al.1988, Berrill et al. 1998, Sparling et al. 2001). In laboratory studies, environmentally relevant concentrations of atrazine, an herbicide, and chlorpyrifos increased susceptibility of ranavirus infection in *Ambystoma* salamanders (Forson and Storfer 2006, Kerby and Storfer 2009). Although there is some evidence that some amphibians may be affected by chemicals applied during the migration and dispersal seasons (Sparling et al. 2001), Davidson et al. (2001, 2002) were unable to find a significant overall relationship between upwind agriculture and the California tiger salamander's decline.

Although occurrence of pesticides in breeding ponds in Santa Barbara County has not been determined, approximately 19,000 to 20,000 pesticides, which include insecticides, herbicides, and fungicides, are currently approved for use by the U.S. Environmental Protection Agency (Boone and Bridges 2003). The most common study performed for licensing a pesticide is an acute toxicity test. The standard test animals used for aquatic environments are usually bluegill, sunfish, fathead minnows, and rainbow trout (*Oncorhynchus mykiss*) (AmphibiaWeb 2007). Initially, researchers thought amphibians would be more sensitive to contaminants than the standard vertebrates used in the acute toxicity tests due to their permeable eggs, skin, and gills, but research by Bridges et al. (2002) suggests that, for some amphibian species, pesticide concentrations necessary to induce mortality may, in fact, be comparable to and in some cases higher than concentrations that induced mortality in some fish species. Researchers are finding that there is a wide variation in tolerance levels among amphibians, even between closely related species (Bridges et al. 2002). Therefore, conclusions drawn from studies on only a few species cannot reveal the full effects of potentially harmful chemicals to amphibians in general (McDiarmid and Mitchell 2000, AmphibiaWeb 2007).

Rodent Control

Rodent control programs can both directly and indirectly affect the California tiger salamander. Poisoned grains are the most common method used to control ground squirrels on rangelands.

While there is little risk of ingestion by California tiger salamanders, the use of poisoned grains may impact the California tiger salamander indirectly if washed into burrows or ponds used by the species. Two of the most commonly used rodenticides – chlorophacinone and diphacinone – are anticoagulants that cause animals to bleed to death internally. They can be absorbed through the skin and are considered toxic to fish, birds, and other wildlife (Tasheva 1995). Both, along with strychnine, are used in Santa Barbara County to control rodents (PAN Pesticides Database – California Pesticide Use 2005). Zinc phosphide, an acute rodenticide and a restricted material, turns into a toxic gas once ingested. Although the effects of these poisons on California tiger salamanders have not been assessed, use along roadways or railways may result in contamination of salamander breeding ponds, with undetermined effects. Gases, including aluminum phosphide, carbon monoxide, and methyl bromide, can be introduced into burrows either by using cartridges or by pumping. When such fumigants are used, all animals inhabiting the burrow are killed (Salmon and Schmidt 1984).

In addition to possible direct effects of rodent control chemicals, control programs likely have an adverse indirect effect on California tiger salamander populations. Maintaining adequate rodent populations to supply refugia (i.e., upland habitat) is crucial for California tiger salamander survival. Control of ground squirrels could significantly reduce the number of burrows available for use by salamanders (Loredo-Prendeville et al. 1994). Because the burrow density required to support California tiger salamanders in an area is not known, the loss of burrows as a result of control programs and its effect on salamanders cannot be quantified at this time. However, Shaffer et al. (1993) believe that rodent control programs may be responsible for the lack of California tiger salamanders in some areas. Active ground squirrel colonies are needed to sustain tiger salamanders because inactive burrow systems become progressively unsuitable over time. Loredo et al. (1996) found that burrow systems collapsed within 18 months following abandonment by or loss of the ground squirrels. Although the researchers found that California tiger salamanders used both occupied and unoccupied burrows, they did not indicate that the salamanders used collapsed burrows. Also, deep ripping of rodent burrow areas as a rodent control measure would be likely to completely destroy burrows and harm or kill any California tiger salamanders using them.

Many California tiger salamander sites in Santa Barbara County are currently occupied by livestock. 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. These and other California ground squirrel and pocket gopher control efforts have potential to adversely affect California tiger salamanders. Current risks to the California tiger salamander in Santa Barbara County from rodent control programs are unknown.

Mosquito Control

A commonly used method to control mosquitoes, including in Santa Barbara County (California Department of Pesticide Regulation 2007), is the application of methoprene, which increases the level of juvenile hormone in insect larvae and disrupts the molting process. Lawrenz (1984–85) found that methoprene (Altosid® SR–10) retarded the development of selected crustacea that had the same molting hormones (i.e., juvenile hormone) as insects, and anticipated that the same hormone may control metamorphosis in other arthropods. Because the success of many aquatic

vertebrates relies on an abundance of invertebrates in temporary wetlands, any delay in insect growth could reduce the numbers and density of prey available (Lawrenz 1984–85). The use of methoprene would likely have an indirect adverse effect on California tiger salamanders by reducing the availability of prey. In more recent studies, methoprene did not cause increased mortality of gray treefrog (*Hyla versicolor*) tadpoles (Sparling and Lowe 1998), but it did cause reduced survival rates and increased malformations in northern leopard frogs (*Rana pipiens*) (Ankley et al. 1998) and increased malformations in southern leopard frogs (*R. utricularia*) (Sparling 1998). 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*). Methoprene appears to have both direct and indirect effects on the growth and survival of larval amphibians. A bacterium, *Bacillus thuringiensis israeli* (Bti), is also used in Santa Barbara County for mosquito control (City of Santa Barbara 2007). Bti reportedly does not affect insects other than larvae of mosquitoes and blackflies, but research does not indicate which insects have been tested (Federation of BC Naturalists 2003). Its effects on the salamander prey base have not been quantified. 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 salamander in Santa Barbara County 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.

Hybridization

Introduced species can have negative effects on California tiger salamander populations through hybridization (Shaffer et al. 1993), and introduced salamanders may interbreed with the natives to create hybrids. Riley et al. (2003) have shown that the hybrids are able to breed with California tiger salamanders, resulting in the loss of pure native salamanders (i.e., genetic loss). In addition, non-native tiger salamanders and hybrids pose a direct predation threat to California tiger salamanders and other native species in pond ecosystems (Ryan et al. 2009). Non-native tiger salamanders are present at the Lompoc Federal Penitentiary grounds in Santa Barbara County and a hybrid was recently discovered at a site in the Purisima Hills metapopulation (Service 2009). The loss of any metapopulations to hybridization with introduced species is of serious concern. Because the interaction was detected at a much earlier stage in the Santa Barbara County DPS of the California tiger salamander than in the Salinas Valley of central California, there is a high likelihood of containment if action is taken soon. The Service is currently coordinating with local biologists to eradicate non-native tiger salamanders at Lompoc Federal Penitentiary and is providing $39,000 for a project that will evaluate the extent of the problem in Santa Barbara County and begin to implement eradication measures.

Competition

Introduced species also can have negative effects on California tiger salamander populations through competition (Shaffer et al. 1993). Competition from fish that prey on mosquito larvae and other invertebrates can reduce the survival of salamanders. Both California tiger salamanders (Stebbins 1962, J. D. Anderson 1968, Holomuzki 1986) and mosquitofish feed on microinvertebrates and macroinvertebrates; large numbers of mosquitofish may out-compete the salamander larvae for food (Graf and Allen-Diaz 1993). The introduction of other fish either

inadvertently (e.g., fathead minnow) (P. Collins, Santa Barbara Museum of Natural History, pers. comm. 1999) or for recreational fishing (e.g., largemouth bass, green sunfish) (Sweet, pers. comm. 1999) or other purposes may also affect the prey base, reducing growth and survival rates of salamanders. Fish, such as bass, green sunfish, carp (*Cyprinus carpio*), and catfish, may also prey on tiger salamander larvae and adults, reducing or eliminating salamander populations (Shaffer et al. 1993).

III. RECOVERY CRITERIA

There is no approved final or draft recovery plan for the species. Please refer to Section I above for more information.

IV. SYNTHESIS

The Santa Barbara County population of the California tiger salamander is a genetically and geographically distinct DPS, which has been further substantiated since its listing in 2000 through a range-wide survey of genetic variation in the California tiger salamander (Shaffer et al. 2004). The number of known California tiger salamander breeding ponds has doubled since the time of listing, probably owing to increased and focused survey efforts, and does not necessarily indicate that the species is recovering or expanding its range. All of the ponds now known to support breeding of the California tiger salamander face the same threats as the ponds known at the time of listing. Since the listing, guidance for survey protocols has aided in the discovery of additional breeding ponds. Only a portion of localities had been surveyed at the time of listing. Many of the additional ponds were discovered as a result of surveys conducted as a part of proposed projects.

The habitat quality of isolated ponds can decline greatly from unusual, randomly occurring, natural events as well as from human-caused factors that reduce breeding success and individual survival. California tiger salamanders do not reach sexual maturity for a number of years and individuals typically do not breed more than once. Factors that repeatedly lower breeding success in isolated ponds that are too far from other ponds for migrating individuals to replenish the population (i.e., recolonize the pond) 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.

The most important threat to the continued survival of the Santa Barbara County DPS of the California tiger salamander is the loss and fragmentation of habitat. Federal, State, and local laws have not been sufficient to prevent past and ongoing losses of California tiger salamander habitat during a formal permitting process. Urban development and agricultural conversion continue to threaten the species. All but one metapopulation is under the threat of development or agricultural conversion. Three of the six metapopulations of California tiger salamanders in Santa Barbara County face on-going and future threats from agricultural conversion and/or urban development (West Santa Maria/Orcutt, East Santa Maria, and Santa Rita Valley). Future threats

are those that are reasonably certain to occur as indicated by incidental take authorization requests or draft CEQA documents. Depending on how land is zoned and how much land is affected by an individual action, some of these conversions do not require County permits and, therefore, may not consider impacts to California tiger salamanders or their habitat. Since the listing in 2000, approximately 800 ac (324 ha) of suitable upland habitat and one potential breeding pond in the East Santa Maria metapopulation were destroyed as a result of agricultural conversion activities that occurred without incidental take authorization. As a result of these and similar activities, only approximately one-third of the upland habitat in this metapopulation remains suitable for California tiger salamanders. Approximately 51 percent of the land within the Western Santa Maria/Orcutt critical habitat unit remains suitable (i.e., is undeveloped or unfarmed) for California tiger salamanders; this critical habitat unit encompasses the only vernal pool complex for this metapopulation. The amount of remaining suitable habitat in the Santa Rita Valley metapopulation is unknown. Development proposals and approved developments in the West Santa Maria/Orcutt metapopulation surround and threaten to further fragment the vernal pool complex that comprises most of this metapopulation; one of the breeding ponds within this complex will be fragmented from the rest of the vernal pool complex as a result of a project that has received incidental take exemption. Although this pond will be isolated from the rest of the vernal pool complex, approximately 572 ac (231 ha) of upland habitat will be protected in perpetuity and up to six ponds will be created within dispersal distance of this vernal pool complex. Only one of the six metapopulations is proposed to be protected in its entirety (East Los Alamos).

Grazing is a compatible land use with California tiger salamander survival; however, ranches with grazing as their primary land use are declining in Santa Barbara County and are being replaced by vineyards, row crops, and development, which are not generally compatible with California tiger salamander conservation. In addition to loss and fragmentation of habitat and direct loss of individuals, urban development and agricultural conversion result in changes in the moisture regimes, microtopography, and ground cover that: (1) require migrating salamanders to cross areas of rapid runoff that may not have existed previously; (2) expose animals to potentially toxic levels of fertilizers, pesticides, fungicides, and herbicides; (3) interfere with the ability of salamanders to travel the distances necessary to reach a breeding pond or upland habitat while rain or moisture conditions are suitable; and (4) increase California tiger salamanders' susceptibility to predators. The Santa Barbara County DPS of California tiger salamanders is particularly vulnerable because it is comprised of small, separate metapopulations (with two of these metapopulations containing as few as 4 known breeding ponds) that face intense development pressure.

Amphibian populations, such as the Santa Barbara County DPS of the California tiger salamander, naturally undergo large fluctuations in population size as a result of random natural events such as drought. Their ability to recover from these events is dependent upon year-to-year survival of larvae and adults, the presence of refugia to endure natural events and escape predators, and successful reproduction during years of adequate rainfall. The loss of upland habitats and the loss of individuals through agricultural and development activities can leave small populations that are unable to withstand decreases in size as a result of such events.

Other factors affecting the salamander include the effects of isolated breeding ponds on individual populations, drought, roads, contaminants, hybridization with non-native tiger salamanders, and competition from fish. As urban areas continue to expand, roads continue to fragment remaining habitat in Santa Barbara County and increase the threat of pollution from runoff into known or potential breeding sites.

Disease and predators continue to threaten the California tiger salamander in Santa Barbara County. Although the direct effect of disease on the Santa Barbara County DPS of California tiger salamanders is unknown, several pathogenic agents, including at least one bacterium, a fungus, and viruses have been associated with die-offs of closely related tiger salamander species. Native and non-native predators are present at several of the known breeding ponds in Santa Barbara County. In healthy salamander populations, predation by native species is not known to be a significant threat; however, when combined with other impacts, such as predation by non-native species, contaminants, or habitat alteration, the cumulative result may be a significant decrease in population abundance and viability.

Based on our analysis of the status and threats to the Santa Barbara County DPS of the California tiger salamander, we are recommending that it remain listed as endangered for the following reasons: (1) threats to the species identified at the time of listing, particularly loss and fragmentation of habitat, remain; (2) the species faces natural and human-related threats (e.g., drought, isolation of breeding habitat as a result of fragmentation, predators, hybridization with non-native salamanders, low breeding success and recruitment) that repeatedly lower breeding success; (3) existing regulations have not been sufficient to prevent loss of California tiger salamander habitat; and (4) few conservation measures are in place to work toward the survival or recovery of the California tiger salamander in Santa Barbara County.

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:

The Santa Barbara County DPS of California tiger salamander is a species that has a high potential for recovery, and threats to this species are high in magnitude and imminent. There is a potential for conflict with economic activities. Thus, we are changing this species' recovery priority number to 3C.

VI. RECOMMENDATIONS FOR FUTURE ACTIONS

Recommendations for actions over the next 5 years

Research

- Research the distribution of non-native tiger salamanders in northern Santa Barbara County, within 10 miles of the native species' range.

- Research methods for effective eradication of non-native tiger salamanders.

Non-native Species Eradication

- Continue efforts to eradicate the non-native salamander population at the Lompoc Federal Penitentiary property.

- Begin efforts to eradicate non-native tiger salamanders from other known localities within the range of the Santa Barbara County DPS.

- Remove non-native predators from known and potential breeding ponds.

Mosquito Control

- Work with mosquito and vector control districts to minimize conflicts between public health and the California tiger salamander, and look for sources of funding for necessary research. Alternatives to the use of mosquitofish as a means of mosquito abatement should be investigated to decrease this practice. Additionally, research should be

conducted on the impacts on California tiger salamander of other methods used to control mosquitoes.

Conservation Planning

- Reconvene the recovery team for the California tiger salamander and update and complete the recovery plan. This would bring together Federal, State, local, and private efforts for the conservation of the species. The plan would establish a framework for agencies to coordinate activities and cooperate with each other in 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 Santa Barbara County DPS of California tiger salamanders.

- Re-engage local jurisdictions and stakeholders, including the County of Santa Barbara, City of Santa Maria, and local landowners, in the advancement of proactive, regional conservation planning efforts.

Recommendations for actions beyond the next 5 years

Research

- Research salamander underground activities including preferred depth at which they remain and whether this depth varies seasonally.

- Research salamander ability to disperse through vineyards.

- Research metapopulation structure to determine ecological relevance.

- Study the aquatic ecology of larvae to understand physical and biological determinants of recruitment; research water quality parameters to determine acceptable California tiger salamander breeding conditions.

- Research the effects of agrochemicals on California tiger salamanders from nearby vineyards or row crops (e.g., drift, runoff).

- Research the effects of small mammal control methods on the California tiger salamander.

Education/Outreach

- Work with teachers in Santa Barbara County to develop an education program on California tiger salamanders to use in schools.

- Develop an interactive web site to be used for education concerning the California tiger salamander.

VII. REFERENCES CITED

AECOM. 2009. Results of chytrid testing for the Tajiguas Landfill reconfiguration and Baron Ranch restoration project. Report addressed to Santa Barbara County Department of Public Works. AECOM, Santa Barbara, California.

Alford, R.A., and S.J. Richards. 1999. Global amphibian declines: a problem in applied ecology. Annual Review of Ecology and Systematics 30:133-165.

AmphibiaWeb: Information on amphibian biology and conservation [internet application]. 2007. Berkeley, California: AmphibiaWeb. Available at: http://amphibiaweb.org/. (Accessed: July 6, 2007).

Anderson, J.D. 1968. Comparison of the food habits of *Ambystoma macrodactylum sigillatum, Ambystoma macrodactylum croceum,* and *Ambystoma tigrinum californiense.* Herpetologica 24(4):273-284.

Anderson, P.R. 1968. The reproductive and developmental history of the California tiger salamander. Master's thesis, Department of Biology, Fresno State College, Fresno, California. 82pp.

Ankley, G.T., J.E. Tietge, D.L. DeFoe, K.M. Jensen, G.W. Holcombe, E.J. Durhan, and S.A. Diamond. 1998. Effects of ultraviolet light and methoprene on survival and development of *Rana pipiens*. Environmental Toxicology and Chemistry 17:2530-2542.

Baldwin, K.S. and R.A. Stanford. 1987. Life history notes: *Ambystoma tigrinum californiense* (California tiger salamander): predation. Herpetological Review 18(2):33.

Barry, S.F. 1998. Managing the Sacramento vernal pool landscape to sustain native flora. Pp. 236-240 in: C. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Eds.). Ecology, conservation, and management of vernal pool ecosystems. Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, California.

Beebee, T.J.C. 1995. Amphibian breeding and climate. Nature 374:219-220.

Berger, L., R. Speare, P. Daszak, D.E. Green, A.A. Cunningham, C.L. Goggin, R. Slocombe, M.A. Ragan, A.D. Hyatt, K.R. McDonald, H.B. Hines, K.R. Lips, G. Marantelli, and H. Parkes. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. Proceedings of the National Academy of Sciences of the United States of America 95:9031-9036.

Berrill, M.,D. Coulson, L. McGillivray, and B. Pauli. 1998. Toxicity of endosulfan to aquatic stages of anuran amphibians. Environmental Toxicology and Chemistry 17:1738-1744.

Blaustein, A.R., Kiesecker, J.M., Chivers, D.P., D.G. Hokit, A. Marco, L.K. Belden, and A. Hatch. 1998. Effects of ultraviolet radiation on amphibians: field experiments. American Zoologist 38:799-812.

Blaustein, A.R., and D.B. Wake. 1990. Declining amphibian populations: a global phenomenon. Trends in Ecology and Evolution 5:203-204.

Blaustein, A.R., L.K. Belden, D.H. Olson, D.M. Green, T.L. Root, and J.M. Kiesecker. 2001. Amphibian breeding and climate change. Conservation Biology 15:1804-1809.

Blaustein, A.R., and P.T. Johnson. 2003. The complexity of deformed amphibians. Frontiers in Ecology and the Environment 1(2):87-94.

Blumberg, B., D.M. Gardiner, D. Hoppe, and R.M. Evans. 1998. Field and laboratory evidence for the role of retinoids in producing frog malformities. P. 6 in G.S. Casper, editor. Midwest Declining Amphibians Conference. Milwaukee, Wisconsin. 21 pp.

Boone, M.D., and C.M. Bridges. 2003. Effects of pesticides on amphibian populations. Pages 152-167 in R.D. Semlitsch, editor. Amphibian Conservation. Smithsonian Institution, Washington.

Bosch, J., I. Martinez-Solano, and M. Garcia-Paris. 2001. Evidence of a chytrid fungus infection involved in the decline of the common midwife toad (*Alytes obstetricans*) in protected areas of central Spain. Biological Conservation 97:331-337.

Bridges, C.M., F.J. Dwyer, D.K. Hardesty, and D.W. Whites. 2002. Comparative contaminant toxicity: are amphibian larvae more sensitive than fish? Bulletin of Environmental Contamination and Toxicology 69:562-569.

California Code of Regulations. 2009. Title 14: Natural Resources, Division 1. Fish and Game Commission—Department of Fish and Game. Available at: http://government.westlaw.com/linkedslice/search/default.asp?RS=GVT1.0&VR=2.0&SP=CCR-1000. (Accessed: August 18, 2009).

California Department of Pesticide Regulation. 2007. 2007 Annual Pesticide Use Report Indexed by Commodity, Santa Barbara County. Available at: http://www.cdpr.ca.gov/docs/pur/pur07rep/comcnty/sanbar07_site.pdf. (Accessed: March 30, 2009).

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent changes towards earlier springs: early signs of climate warming in western North America? U.S. Geological Survey, Scripps Institution of Oceanography, La Jolla, California.

Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate change scenarios for the California region. Climatic Change 87 (Supplement 1):S21-S42.

City of Santa Barbara. 2007. Integrated pest management strategy: 2006 annual report. Available at: http://www.santabarbaraca.gov/NR/rdonlyres/8F9F1663-400D-4C20-AE06-364BBFB028A3/0/2006IPMAnnualReportFinalNR.pdf. (Accessed: July 20, 2009).

City of Santa Maria. 2006. Housing Element Update of the General Plan. Available at: http://www.ci.santa-maria.ca.us/housing/Part1.pdf. (Accessed: March 31, 2009).

Coe, T. 1988. The application of section 404 of the Clean Water Act to vernal pools. Pp. 356-358 in: J. A. Kuslen, S. Daly, and G. Brooks, editors. Urban wetlands. Proceedings of the National Wetlands Symposium, June 26-29, 1988.

Collins, P. 2000. Report addressed to the Ventura Fish and Wildlife Service. Santa Barbara Museum of Natural History, Santa Barbara, California.

Corn, P.S. 2005. Climate change and amphibians. Animal Biodiversity and Conservation 28.1:59-67.

Davidson C., H.B. Shaffer, and M.R. Jennings. 2001. Declines of the California red-legged frog: climate, UV-B, habitat, and pesticides hypotheses. Ecological Applications 11:464-479.

Davidson, C., H.B. Shaffer, and M.R. Jennings. 2002. Spatial tests of the pesticide drift, habitat destruction, UV-B, and climate-change hypotheses for California amphibian declines. Conservation Biology 16:1588-1601.

de Llamas, M.C., A.C. De Castro, and A. M. Pechen de d'Angelo. 1985. Cholinesterase activities in developing amphibian embryos following exposure to the insecticides dieldrin and malathion. Archives of Environmental Contamination and Toxicology 14: 161–166.

Fellers, G.M., D.E. Green, and J.E. Longcore. 2001. Oral chytridiomycosis in the mountain yellow-legged frog (*Rana muscosa*). Copeia 2001: 945-953.

Federation of BC Naturalists. 2003. West Nile Virus, healthy wetlands, and natural predators. Available at: http://www.burnsbog.com/pdf/westnile.pdf. (Accessed: July 15, 2009).

Ferren, W. and B. Hecht. 2003. Hydrology and physiography of California tiger salamander habitats in Santa Barbara County, California. Submitted to the Ventura Fish and Wildlife Office, Ventura, California.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting climate change in California. Ecological impacts on the Golden State. A report of the Union of Concerned Scientists, Cambridge, Massachusetts, and the Ecological Society of America, Washington, DC.

Fitzpatrick, B.M. and H.B. Shaffer. 2004. Environment-dependent admixture dynamics in a tiger salamander hybrid zone. Evolution 58:200-211.

Forson, D. and A. Storfer. 2006. Effects of atrazine and iridovirus infection on survival and life history traits of the long-toed salamander (*Ambystoma macrodactylum*). Environmental Toxicology and Chemistry 25:168-173.

Gamradt, S.C. and L.B. Kats. 1996. Effect of introduced crayfish and mosquitofish on California newts. Conservation Biology 10:1155-1162.

Gibbs, J.P., and A. R. Breisch. 2001. Climate warming and calling phenology of frogs near Ithaca, New York, 1900-1999. Conservation Biology 15:1175-1178.

Gifford GF, R.H. Hawkins. 1978. Hydrologic impact of grazing on infiltration: a critical review. Water Resources Research 14:305-13.

Goodsell, J.A. and L.B. Kats. 1999. Effect of introduced mosquitofish on Pacific treefrogs and the role of alternative prey. Conservation Biology 14:921-924.

Graf, M. and B. Allen-Diaz. 1993. Evaluation of mosquito abatement district's use of mosquitofish as biological mosquito control: case study - Sindicich Lagoon in Briones Regional Park. Unpublished manuscript. 22 pp.

Groom, M.J., G.K. Meffe, and C.R. Carroll. 2006. Principles of conservation biology, third edition. Sinauer Associates, Inc., Sunderland, Massachusetts.

Hall, R.J. and P.F. Henry. 1992. Assessing effects of pesticides on amphibians and reptiles: status and needs. Herpetological Journal 2:65-71.

Hansen, R.W. and R.L. Tremper. 1993. Amphibians and reptiles of central California. California Natural History Guides. University of California Press, Berkeley. 11 pp.

Hanski, I. and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society 42:3-16.

Hanski, I. 1999. Metapopulation ecology. Oxford University Press, Oxford.

Hatch, A.C. and G.A. Burton, Jr. 1998. Effects of photoinduced toxicity of fluoranthene on amphibian embryos and larvae. Environmental Toxicology and Chemistry 17:1777-1785.

Holomuzki, J.R. 1986. Intraspecific predation and habitat use by tiger salamanders (*Ambystoma tigrinum nebulosum*). Journal of Herpetology 20:439-441.

Hunt, L.E. 1993. Origin, maintenance, and land use of aeolian sand dunes in the Santa Maria Basin. Prepared for The Nature Conservancy, San Luis Obispo, Califorina. 72 pp.

Indiana-Illinois Sea Grant. 2007. Mosquito fish (*Gambusia affinis* and *G. holbrooki*). Available at: http://www.iisgcp.org/exoticsp/mosquitofish.htm. (Accessed: October 3, 2007).

Intergovernmental Panel on Climate Change. 2007. Climate change 2007: the physical science basis. Summary for policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC Secretariat, World Meteorological Organization and United Nations Environment Programme, Geneva, Switzerland.

Jancovich, J.K., E.W. Davidson, F. Morado, B.L. Jacobs and J.P. Collins. 1997. Isolation of a lethal virus from the endangered tiger salamander *Ambystoma tigrinum stebbinsi*. Diseases of Aquatic Organisms 31:161-167.

Jennings, M.R., and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. Final report to California Department of Fish and Game. Pp. 12-16.

Jones, T.R. 1993. Intraspecific genetic variation and cladogenesis in California tiger salamanders *Ambystoma tigrinum californiense* Gray. Unpublished manuscript. 49 pp.

Kagarise Sherman, C. and M. L. Morton. 1993. Population declines of Yosemite Toads in the Eastern Sierra Nevada of California. Journal of Herpetology 27(2):186-198.

Kerby, J.L. and A. Storfer. 2009. Combined effects of atrazine and chlorpyrifos on susceptibility of the tiger salamander to Ambystoma tigrinum virus. EcoHealth. Published online May 5, 2009.

Kiesecker, J.M. and A.R. Blaustein. 1997. Influences of egg laying behavior on pathogenic infection of amphibian eggs. Conservation Biology 11:214-220.

Launer, A. and C. Fee. 1996. Biological research on California tiger salamanders at Stanford University. 25 pp. plus figures, tables, and appendix.

Lawrenz, R.W. 1984-85. The response of invertebrates in temporary vernal wetlands toAltosid® SR-10 as used in mosquito abatement programs. Journal of the Minnesota Academy of Science 50:31-34.

Lefcort, H., K.A. Hancock, K.M. Maur, D.C. Rostal. 1997. The effects of used motor oil, silt, and the water mold *Saprolegnia parasitica* on the growth and survival of mole salamanders (Genus *Ambystoma*). Archives of Environmental Contamination and Toxicology 32:383–388.

Lettis, W.R., K.L. Hanson, J.R. Unruh, M. McLaren, and W.U. Savage. 2004. Quaternary tectonic setting of south-central coastal California. Bulletin 1995—AA. U.S. Department of the Interior, U.S. Geological Survey. Available at: http://pubs.usgs.gov/bul/1995/aa/. (Accessed: July 27, 2009).

Leyse, K. and Lawler, S.P. 2000. Effect of mosquitofish (*Gambusia affinis*) on California tiger salamander (*Ambystoma californiense*) larvae in permanent ponds. Mosquito Control Research, annual report 2000.

Leyse, K.E., S.P. Lawler, H.B. Shaffer, and T. Strange. In Press. *Gambusia* effects in different habitats: Introduced mosquitofish have different effects on an endangered salamander in temporary versus perennial pond conditions. Department of Entomology, University of California, Davis, California.

Liacos, L.G. 1962. Water yield as influenced by degree of grazing in the California winter grasslands. Journal of Range Management 15:67-72.

Loredo, I. and D. VanVuren. 1996. Reproductive ecology of a population of the California tiger salamander. Copeia 1996:895-901.

Loredo, I., D. Van Vuren, and M.L. Morrison. 1996. Habitat use and migration behavior of the California tiger salamander. Journal of Herpetology 30:282-285.

Loredo-Prendeville, I., D. Van Vuren, A.J. Kuenzi, and M.L. Morrison. 1994. California ground squirrels at Concord Naval Weapons Station: alternatives for control and the ecological consequences. Pp. 72-77 in: W. S. Halverson and A. C. Crabb (editors). Proceedings of the 16th Vertebrate Pest Conference. University of California Publications.

Marsh, D.M., and P.C. Trenham. 2001. Metapopulation dynamics and amphibian conservation. Conservation Biology 15:40–49.

McDiarmid, R.W., and J.C. Mitchell. 2000. Diversity and distribution of amphibians and reptiles. Pp.15-69 in: D. W. Sparling, G. Linder, and C. A. Bishop, editors. Ecotoxicology of amphibians and reptiles. Society of Environmental Toxicology (SETAC), Pensacola, Florida. 904 pp.

McLean, B. 1998. Wildlife health alert no. 98-02. Virus associated with tiger salamander mortality on Utah Lake. National Wildlife Health Center, Madison, Wisconsin. 1 p.

Monson, P.D., D.J. Call, D.A. Cox, K. Liber, and G.T. Ankley. 1999. Photoinduced toxicity of fluoranthene to northern leopard frogs (*Rana pipiens*). Environmental Toxicology and Chemistry 18:308-312.

Morey, S.R. 1998. Pool duration influences age and body mass at metamorphosis in the western spadefoot toad: implications for vernal pool conservation. Pp. 86-91 In: C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (editors). Ecology, conservation, and management of vernal pool ecosystems - proceedings from a 1996 conference. California Native Plant Society, Sacramento, California. 1998.

Morey, S.R. and D.A. Guinn. 1992. Activity patterns, food habits, and changing abundance in a community of vernal pool amphibians. Pp. 149-157 In: D.F. Williams, S. Byrne, and T.A. Rado (editors). Endangered and sensitive species of the San Joaquin Valley, California. California Energy Commission, Sacramento, California.

Orloff, S. 2007. Migratory movements of California tiger salamander in upland habitat – a five-year study, Pittsburg, California. Prepared for Bailey Estates LLC. 47 + pp.

Padgett-Flohr, G.E. 2005. Natural history notes: *Ambystoma californiense* (California tiger salamander); fungal infection. Herpetological Review 36:50-51.

PAN Pesticides Database – California Pesticide Use. 2005. Pesticide use in Santa Barbara County in 2005, South Coast Region. Available at: http://www.pesticideinfo.org/DCo.jsp?cok=42. (Accessed: October 3, 2007).

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C.

Pounds, J.A., M.R. Bustamante, L.A. Coloma, J.A. Consuegra, M.P.L. Fogden, P.N. Foster, E. La Marca, K.L. Masters, A. Merino-Viteri, R.Puschendorf, S.R. Ron, G.A. Sanchez-Azofeifa, C.J. Still and B.E. Young. 2006. Widespread amphibian extinctions from epidemic disease driven by global warming. Nature 439:161-167.

Primack, R.B. 1998. Essentials of conservation biology. Sinauer Associates, Sunderland, Massachusetts.

Reaser, J.K. and A. Blaustein. 2005. Repercussions of global change. Pp. 60-63. In: M. Lannoo, editor. Amphibian declines: The conservation status of United States species. University of California Press, Berkley, California, USA.

Riley, S.P.D., H.B. Shaffer, S.R. Voss, and B.M. Fitzpatrick. 2003. Hybridization between a rare, native tiger salamander (*Ambystoma californiense*) and its introduced congener. Ecological Applications 13:1263-1275.

Rosenbaum, E.A., A. Caballero de Castro, L. Gauna, and A.M. Pechen de d'Angelo. 1988. Early biochemical changes produced by malathion on toad embryos. Archives of Environmental Contamination and Toxicology 17:831– 835.

Ryan, M.E., J.R. Johnson, and B.M. Fitzpatrick. 2009. Invasive hybrid tiger salamander genotypes impact native amphibians. Proceedings of the National Academy of Sciences 106:11166-11171.

Salmon, T.P., and R.H. Schmidt. 1984. An introductory overview to California ground squirrel control. Proceedings of the Vertebrate Pest Conference. 11:32-37.

Santa Barbara County Agricultural Commissioner's Office. 2007. 2006 agricultural production report, Santa Barbara County. Available at: http://www.countyofsb.org/agcomm/cropRpt/2008.pdf. (Accessed: July 17, 2009.)

Santa Barbara County Agricultural Commissioner's Office. 2009. 2008 agricultural production report, Santa Barbara County. Available at: http://www.countyofsb.org/agcomm/cropRpt/2008.pdf. (Accessed: July 7, 2009.)

Santa Barbara County Association of Governments. 2007a. Regional growth forecast 2007 summary. Available at: http://www.sbcag.org/PDFs/draft/ForecastSummary.pdf. (Accessed: October 3, 2007).

Santa Barbara County Association of Governments. 2007b. Regional growth forecast 2007. Available at: http://www.sbcag.org/default.htm. (Accessed: October 3, 2007).

Santa Barbara County Energy Division. 2007. Oil and gas production. Available at: http://www.countyofsb.org/energy/information/oil&GasProduction.asp. (Accessed: October 3, 2007).

Santa Barbara County Planning and Development. 2005. Orcutt community plan. Available at: http://longrange.sbcountyplanning.org/planareas/orcutt/documents/Orcutt%20Community%20Plan%20Final%20web%20version.pdf. (Accessed: July 9, 2009).

Santa Barbara County Planning and Development. 2009a. County statistical profile. Available at: http://www.countyofsb.org/ceo/pdf/budget/0708/Sectionb.pdf. (Accessed: July 17, 2009).

Santa Barbara County Planning and Development. 2009b. Regional conservation strategy. Available at: http://longrange.sbcountyplanning.org/programs/regionalconservationstrategy/reg_cons_strategy.php. (Accessed: July 14, 2009).

Schmieder, R.R. and R.S. Nauman. 1993. Effects of non-native aquatic predators on premetamorphic California red-legged frogs (*Rana aurora draytonii*). Unpublished manuscript. 12 pp.

Semlitsch, R.D., D.E. Scott, and J.H.K. Pechmann. 1988. Time and size at metamorphosis related to adult fitness in *Ambystoma talpoideum*. Ecology 69:184-192.

Semonsen, V. 1998. California tiger salamander; survey technique. Natural history notes. Herpetological Review 29.

Shaffer, H.B., R.N. Fisher, and S.E. Stanley. 1993. Status report: the California tiger salamander (*Ambystoma californiense*). Final report for the California Department of Fish and Game. 36 pp. plus figures and tables.

Shaffer, H.B., G.B. Pauly, J.C. Oliver, and P.C. Trenham. 2004. The molecular phylogenetics of endangerment: cryptic variation and historical phylogeography of the California tiger salamander, *Ambystoma californiense*. Molecular Ecology 13:3003-3049.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. Bioscience 31:31-134.

Shaffer, M.L. 1987. Minimum viable populations: coping with uncertainty. Pp. 69-86. In: M.E. Soulé, editor. Viable populations for conservation. Cambridge University Press, New York, New York.

Sparling, D.W. 1998. Field evidence for linking Altosid® applications with increased amphibian deformities in southern leopard frogs. Abstract, Midwest Declining Amphibians Conference, March 20-21. Joint meeting of Great Lakes and Central Division working groups of the Declining Amphibian Populations Task Force. http://www.mpm.edu/collect/vertzo/herp/daptf/ mwabst.html. Accessed: October 3, 2007).

Sparling, D.W. and P.T. Lowe. 1998. Chemicals used to control mosquitoes on refuges differ in toxicity to tadpoles. Patuxent Wildlife Research Center, U.S. Geological Survey, Biological Resources. Available at: http://www.pwrc.usgs.gov/tadnew.htm. (Accessed: July 27, 2009.)

Sparling, D.W., G.M. Fellers, and L.L. McConnell. 2001. Pesticides and amphibian population declines in California, USA. Environmental Toxicology and Chemistry 20(7):1591-1595.

Stebbins, R.C. 1962. Amphibians of the western United States. Ambystomids. Pp. 29-49 and plates.

Sweet, S. 1993. Report addressed to Ventura Fish and Wildlife Office. University of California, Santa Barbara, California.

Sweet, S. 2003. Section 1 D Purisima Metapopulation. Dated June 16. University of California, Santa Barbara, California.

Sweet, S. 2000. Report addressed to Ventura Fish and Wildlife Office regarding new localities of California tiger salamanders as a result of studies conducted under permit [PRT-702631]. Received on May 4, 2000. University of California, Santa Barbara, California.

Tasheva, M. 1995. International programme on chemical safety. Published under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation, and the World Health Organization. Available at: http://www.inchem.org/documents/ehc/ehc/ehc175.htm#SectionNumber:2.2. (Accessed: July 27, 2009.)

Terhivuo, J. 1988. Phenology of spawning for the common frog (*Rana temporaria* L.) in Finland from 1846 to 1986. *Annales Zoologici Fennici* 25: 165-175.

Trenham, P.C. 1998. Demography, migration, and metapopulation structure of pond breeding salamanders. Ph.D. dissertation. University of California, Davis, California.

Trenham, P.C. 2001. Terrestrial habitat use by adult California tiger salamanders. Journal of Herpetology 35:343-346.

Trenham, P.C. 2009. California tiger salamander biology and conservation. California tiger salamander 2009 workshop presentation. Elkhorn Slough Coastal Training Program, Watsonville, California.

Trenham, P.C. and H.B. Shaffer. 2005. Amphibian upland habitat use and its consequences for population viability. Ecological Applications 15:1158-1168.

Trenham P.C., H.B. Shaffer, W.D. Koenig and M.R. Stromberg. 2000. Life history and demographic variation in the California tiger salamander. Copeia 2000(2):365-377.

Trenham, P.C., W.D. Koenig, and H.B. Shaffer. 2001. Spatially autocorrelated demography and interpond dispersal in the California tiger salamander, *Ambystoma californiense*. Ecology 82:3519-3530.

Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14(1):18-30.

[Service] U.S. Fish and Wildlife Service. 2000. Endangered and threatened wildlife and plants; Final rule to list the Santa Barbara County distinct population of the California tiger salamander as endangered. Federal Register 65:57242.

[Service] U.S. Fish and Wildlife Service. 2001. Ventura Fish and Wildlife Office project files, cooperative agreement number 11440-1-J005. Ventura Fish and Wildlife Office, Ventura, California.

[Service] U.S. Fish and Wildlife Service. 2003. Endangered and threatened wildlife and plants; Listing of the central California distinct population segment of the California tiger salamander; proposed rule. Federal Register 68:28648.

[Service] U.S. Fish and Wildlife Service. 2004a. Endangered and threatened wildlife and plants; Proposed designation of critical habitat for the Santa Barbara County distinct population segment of the California tiger salamander. Federal Register 69:3064.

[Service] U.S. Fish and Wildlife Service. 2004b. Endangered and threatened wildlife and plants; Designation of critical habitat for the California tiger salamander (*Ambystoma californiense*) in Santa Barbara County. Federal Register 69:68568.

[Service] U.S. Fish and Wildlife Service. 2006. Ventura Fish and Wildlife Office project files, Wildlife extension agreement number 81440-5-J002. Ventura Fish and Wildlife Office, Ventura, California.

[Service] U.S. Fish and Wildlife Service. 2007a. Biological Opinion for the Santa Maria Public Airport District Research Park and Golf Course Project West of the City of Santa Maria, Santa Barbara County, California (1-8-06-F-6). Ventura Fish and Wildlife Office, Ventura, California.

[Service] U.S. Fish and Wildlife Service. 2007b. Purisima Hills California tiger salamander metapopulation conservation easement project (grant number E-6-RL-3). Ventura Fish and Wildlife Office, Ventura, California.

[Service] U.S. Fish and Wildlife Service. 2009. California tiger salamander species files. Ventura Fish and Wildlife Office, Ventura, California.

[Service and CDFG] U.S. Fish and Wildlife Service and California Department of Fish and Game. 2003. Interim guidance on site assessment and field surveys for determining presence or a negative finding of the California tiger salamander. Available at: http://www.fws.gov/pacific/ecoservices/endangered/recovery/documents/CalTigerSalamander.2003.protocol.pdf. (Accessed: July 19, 2009).

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1996. Policy regarding the recognition of distinct vertebrate population segments under the Endangered Species Act. Federal Register 61:4722.

Wake, D.B. 2007. Climate change implicated in amphibian and lizard declines. Proceedings of the National Academy of Sciences 104 (20):8201-8202.

Whitfield, S.M., K.E. Bell, T. Phillippi, M. Sasa, F. Bolaños, G. Chaves, J.M. Savage, and M.A. Donnelly. 2007. Amphibian and reptile declines over 35 years at La Selva, Costa Rica. Proceedings of the National Academy of Sciences 104 (20):8352-8356.

Wise, D. 1995. Winter kill in channel catfish. Mississippi State University Extension Service newsletter for fish farmers. Available at: http://ext.msstate.edu/newsletters/forfishfarmers/fff95d2.html. (Accessed: October 3, 2007)

Worthylake, K.M., and P. Hovingh. 1989. Mass mortality of salamanders (*Ambystoma tigrinum*) by bacteria (Acinetobacter) in an oligotrophic seepage mountain lake. Great Basin Naturalist 49(3):364-372.

Young, B.E., K.R. Lips, J.K. Reaser, R. Ibanez, A.W. Salas, J.R. Cedeno, L.A. Coloma, S. Ron, E. La Marca, J.R. Meyer, A. Munoz, F. Bolanos, G. Chaves, and D. Romo. 2001. Population declines and priorities for amphibian conservation in Latin America. Conservation Biology 15:1213-1223.

Personal Communications Cited

Collins, Paul. 1999. Santa Barbara Museum of Natural History, Santa Barbara, California. Personal communication with Bridget Fahey, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California.

Daniels, Brady. 2000. Kiewitt Pacific, Santa Maria, California. Personal communication with Bridget Fahey, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California.

Gillette, Bill. 2007. Santa Barbara County Agricultural Commissioner, Santa Barbara, California. Personal communication with Katie Drexhage, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California.

Hunt, Larry. 2003. SM Valley Wetlands. Electronic mail message to Katie Drexhage, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California. Electronic mail accessed January 2, 2004. Hunt and Associates, Santa Barbara, California.

Sweet, Sam. 1998. University of California, Santa Barbara, California. Personal communication with Bridget Fahey, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California.

Sweet, Sam. 1999. University of California, Santa Barbara, California. Personal communication with Bridget Fahey, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California.

Sweet, Sam. 2007. Re: Fw: 5 year review comments. Electronic mail message to Katie Drexhage, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California. Dated October 3, 2007. University of California, Santa Barbara, California.

Sweet, Sam. 2009. University of California, Santa Barbara, California. Personal communication with Andrea Adams, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office, Ventura, California.

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

Santa Barbara County DPS of the
California tiger salamander (*Ambystoma californiense*)

Current Classification: Endangered

Recommendation Resulting from the 5-Year Review:

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

Review Conducted By: Andrea Adams and Katie Drexhage

FIELD OFFICE APPROVAL:

Field Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date 11/13/09

Appendix A. Status of metapopulations, California tiger salamander, Santa Barbara County DPS. Prepared for Five-year review, November 2009.

Figure 1. Distribution of California Tiger Salamander in Northern Santa Barbara County, California

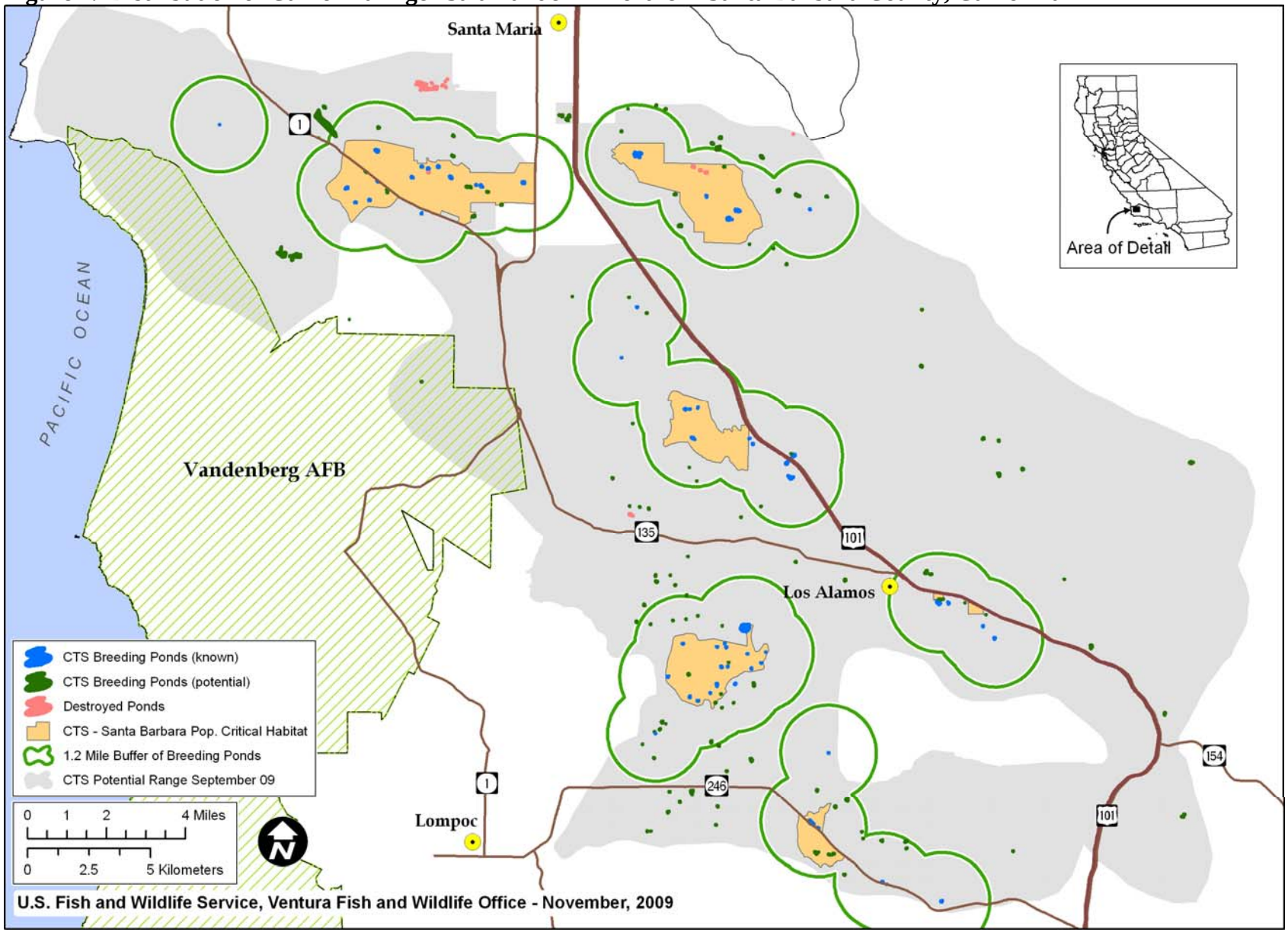

Figure 2. Current Land Use In and Adjacent to California Tiger Salamander Critical Habitat: West Santa Maria Unit

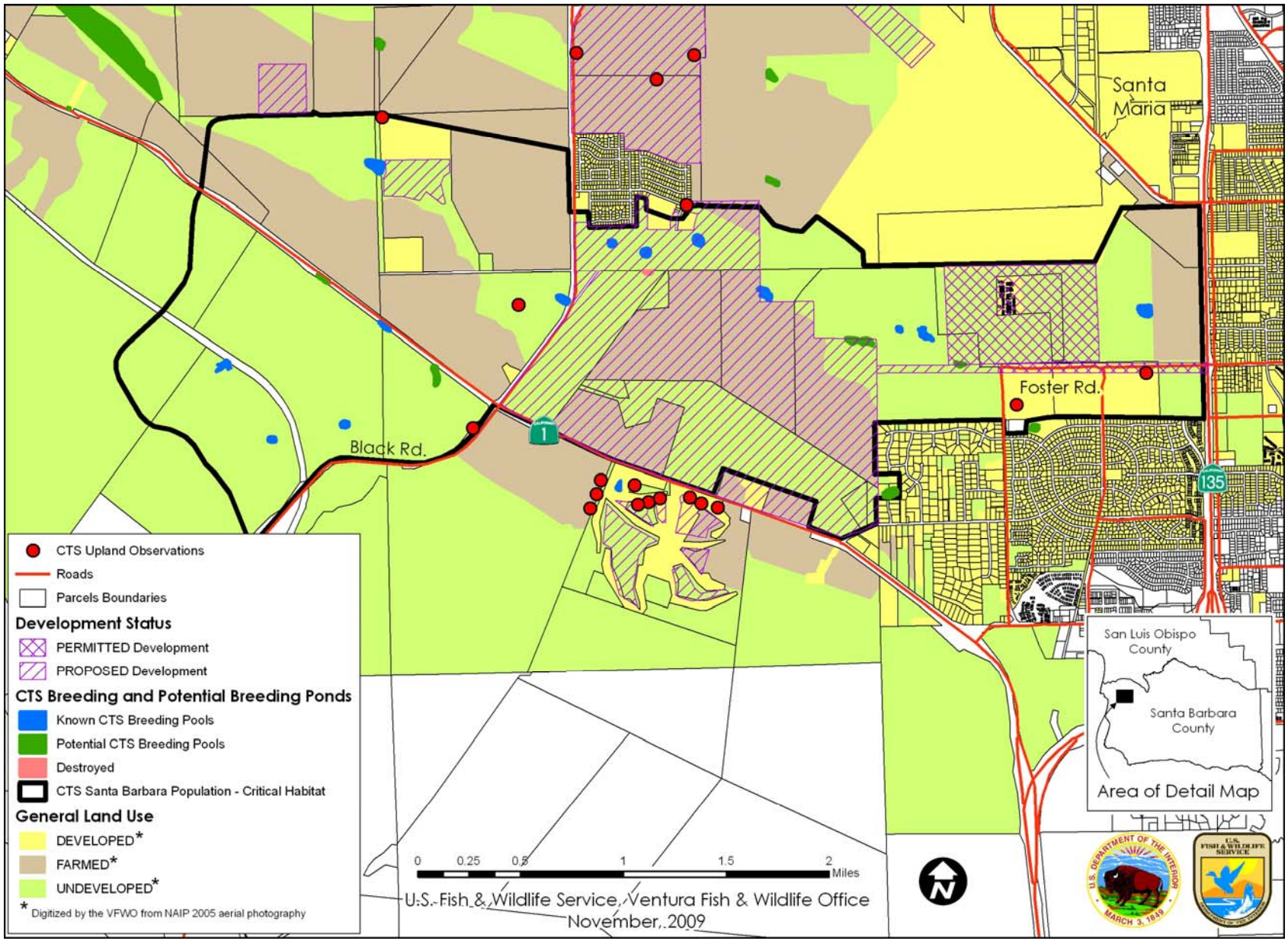

Figure 3. Current Land Use In and Adjacent to California Tiger Salamander Critical Habitat: East Santa Maria Unit

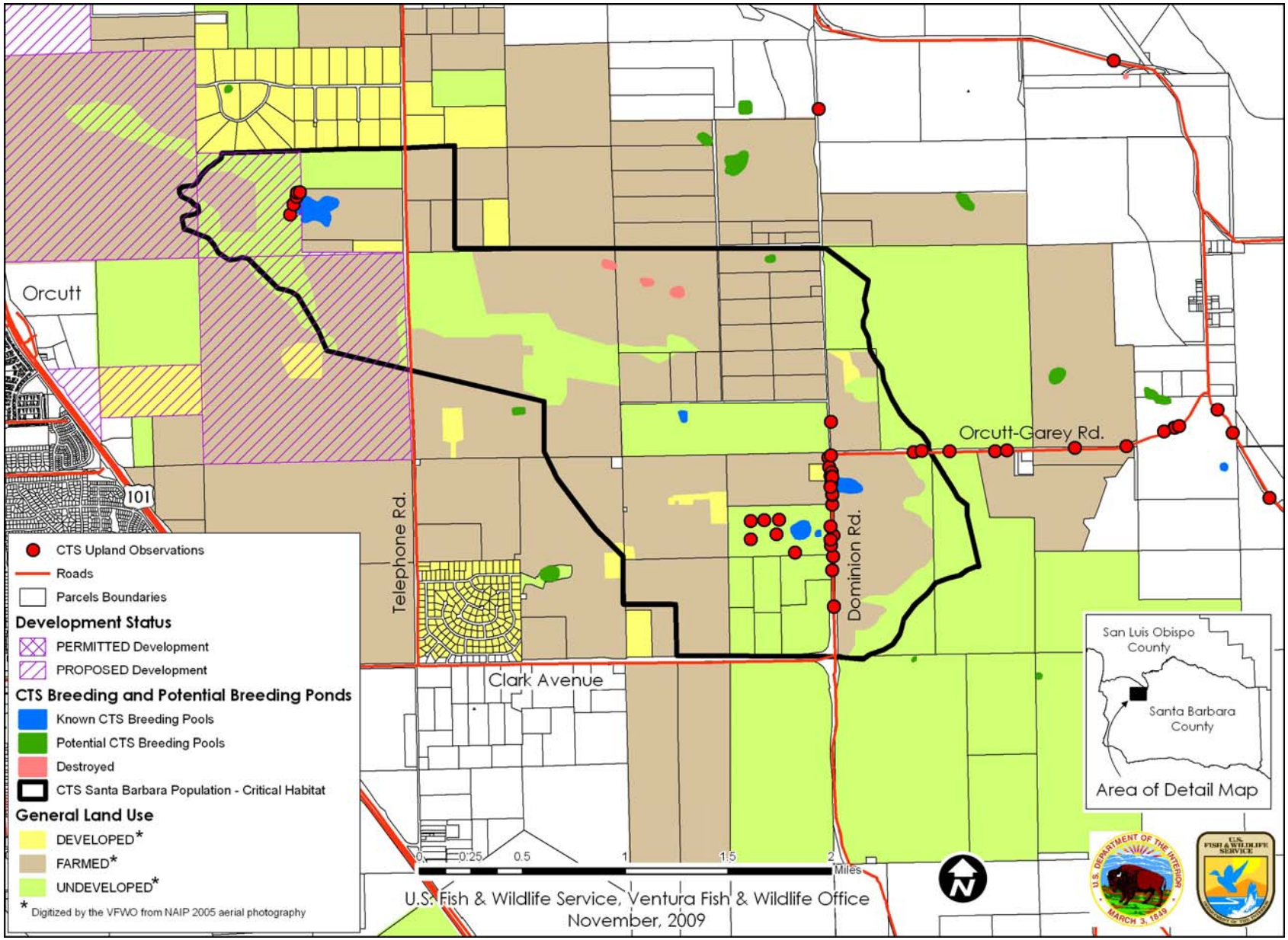

Figure 4: Current Land Use In and Adjacent to California Tiger Salamander Critical Habitat: West Los Alamos Unit

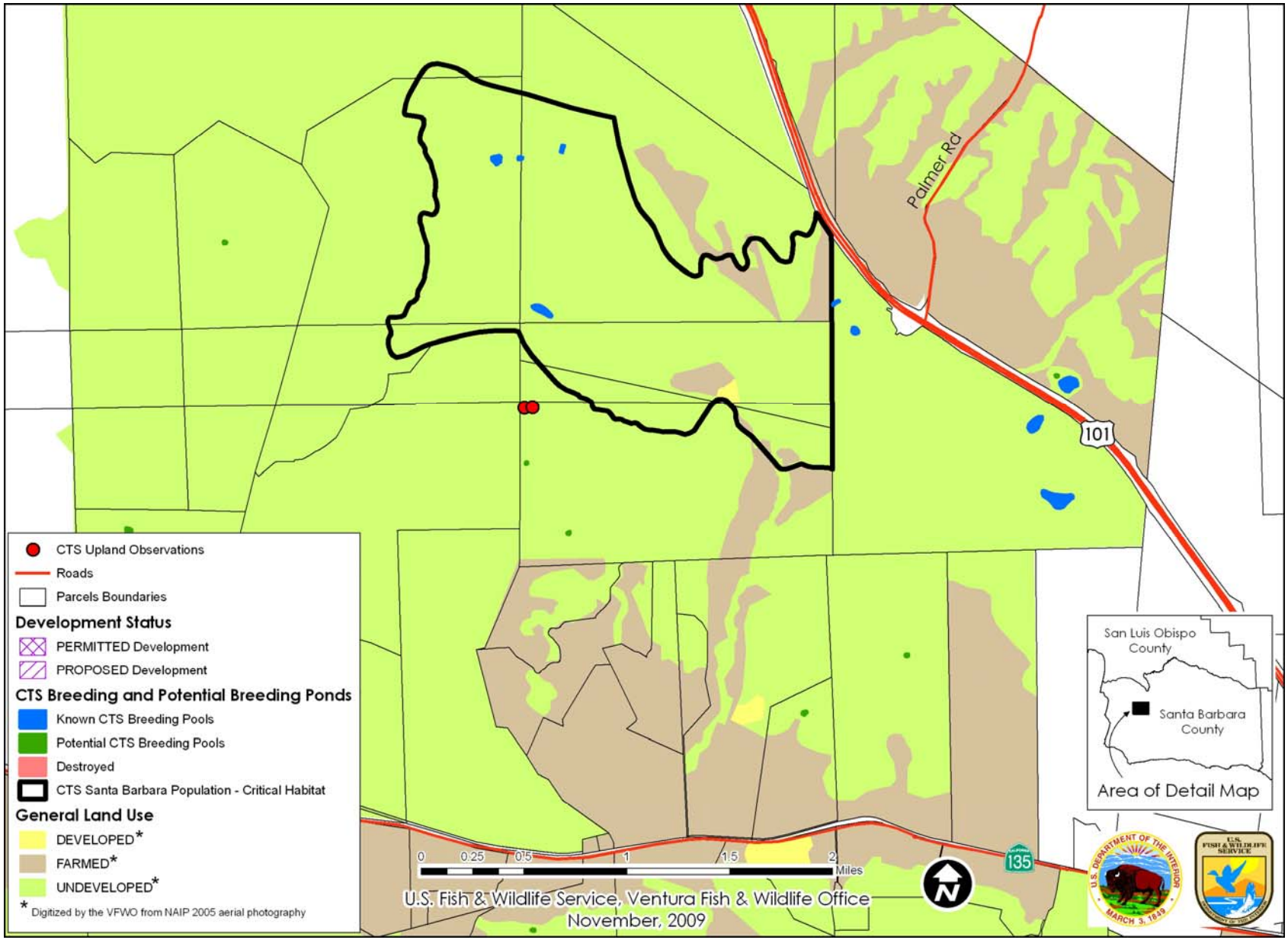

Figure 5: Current Land Use In and Adjacent to California Tiger Salamander Critical Habitat: East Los Alamos Unit

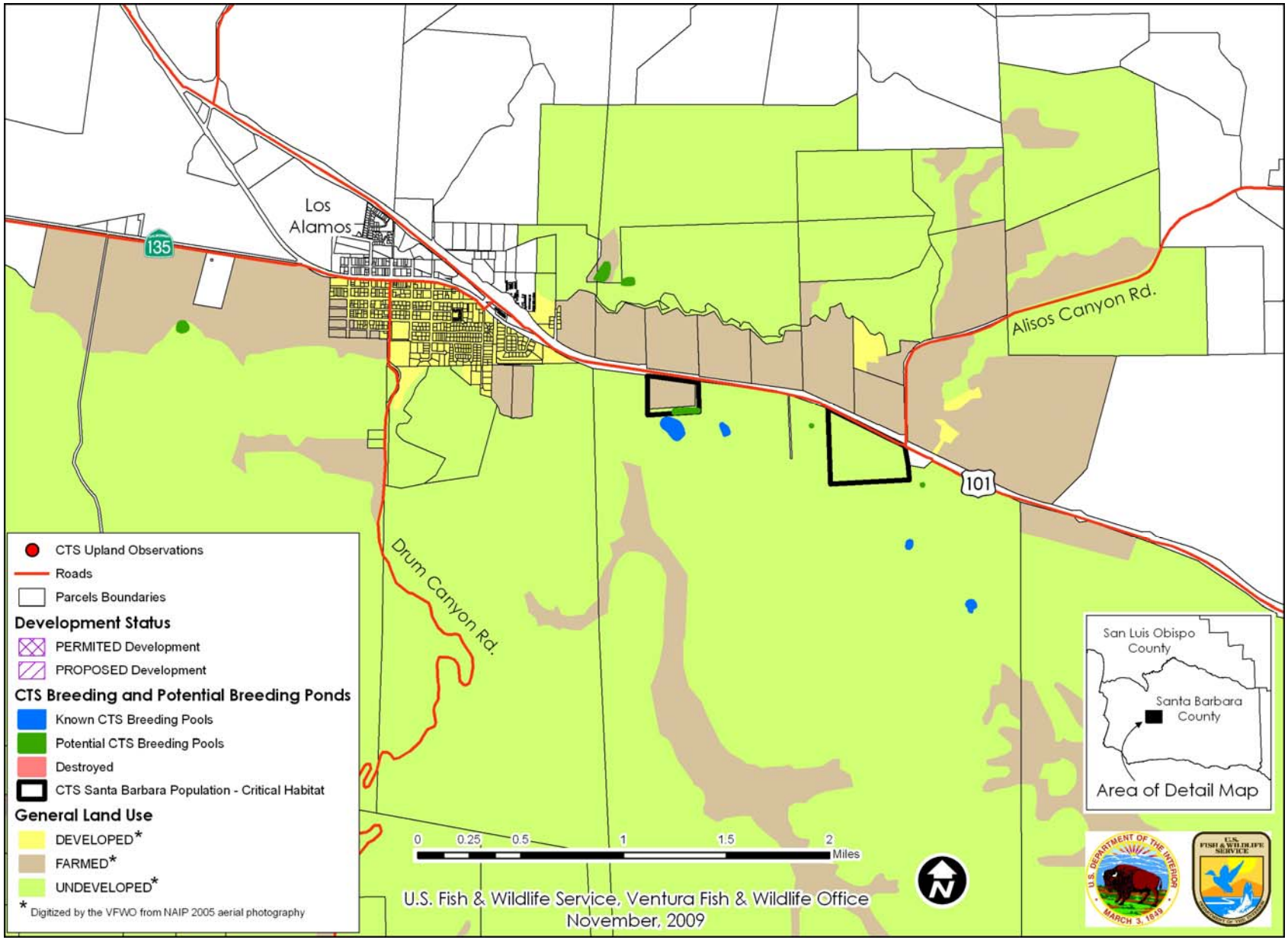

Figure 6. Current Land Use In and Adjacent to California Tiger Salamander Critical Habitat: Purisima Unit

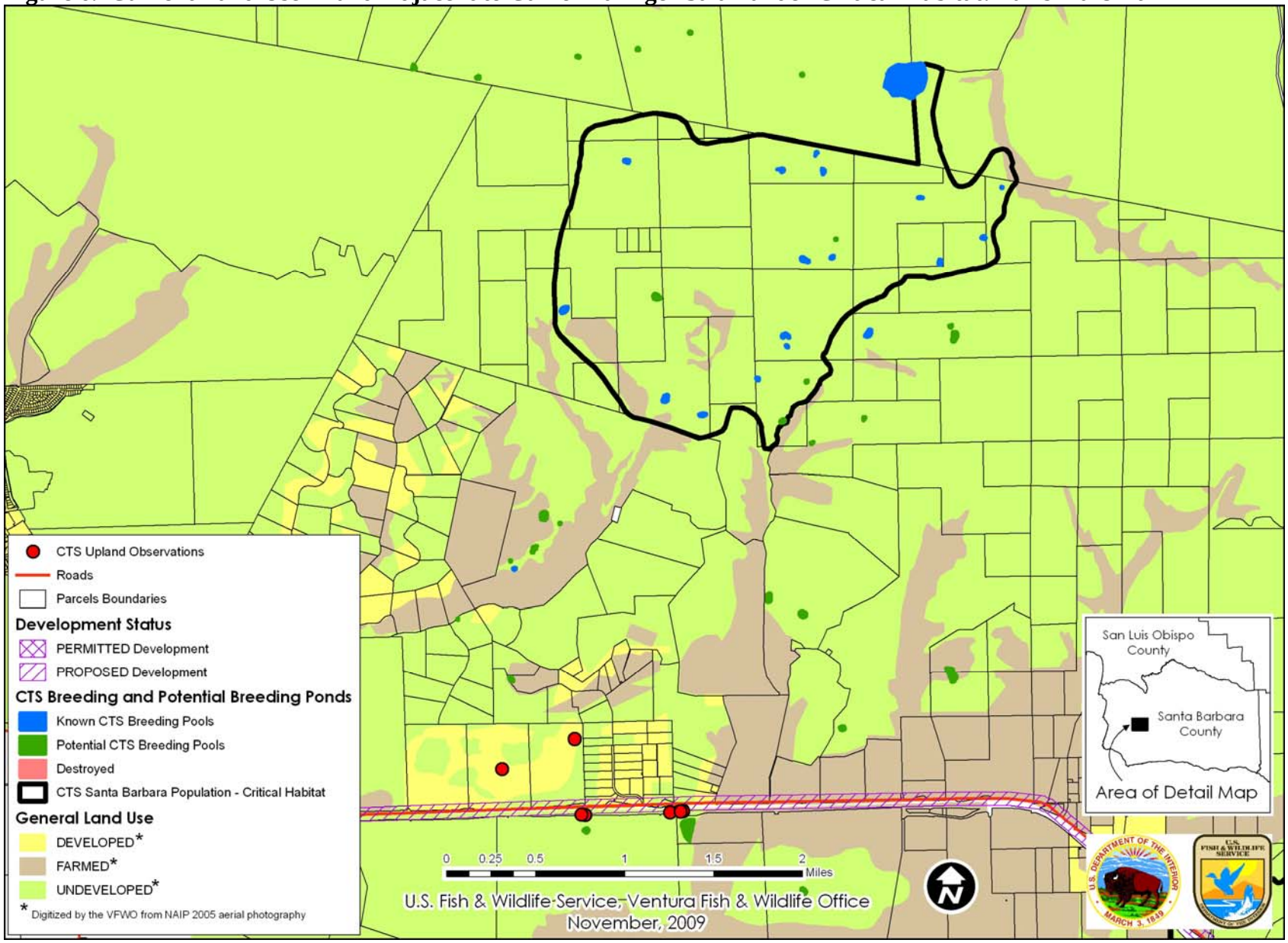

Figure 7: Current Land Use In and Adjacent to California Tiger Salamander Critical Habitat: Santa Rita Unit