on private land without protection and ownership is unknown for 18 percent (California Natural Diversity Data Base 2003). Of these occurrences, 25 are within existing reserves or mitigation sites: 17 private reserves or mitigation sites, 4 State-owned reserves, and 4 federally-owned reserves (California Natural Diversity Data Base 1997). The California fairy shrimp is protected from direct habitat loss at the Stillwater Plains in Shasta County in the Northwestern Sacramento Valley Vernal Pool Region. In the Northeastern Sacramento Valley Vernal Pool Region the species is protected at the Vina Plains and the Dales Lake Ecological Reserve in Tehama County. In the Southeastern Sacramento Valley Vernal Pool Region the California fairy shrimp is protected from development at Beale Air Force Base in Yuba County, McClellan Air Force Base in Sacramento County, and on a variety of private mitigation areas throughout the region. In the Central Coast Vernal Pool Region the California fairy shrimp is protected from direct habitat loss at Fort Ord and Fort Hunter Liggett in San Benito County. In the San Joaquin Vernal Pool Region the California fairy shrimp is protected from direct habitat loss at the Grasslands Ecological Area in Merced County. In the Southern Sierra Foothill Vernal Pool Region the species is protected from direct habitat loss at the Big Table Mountain Preserve in Fresno County. A cooperative group consisting of the California Department of Fish and Game, California Department of Parks and Recreation, Sierra Foothills Conservancy, Bureau of Land Management, and Bureau of Reclamation has developed a management and monitoring plan for the Big Table Mountain Preserve. Initial efforts focus on grazing as a means to control nonnative grasses while comparing population trends of threatened and endangered species in grazed and ungrazed portions of the tableland (M. Griggs *in litt*. 2000). The California Department of Fish and Game conducted botanical studies on this Preserve in conjunction with a grazing study for the last 5 years and will continue monitoring the Big Table Mountain Preserve in conjunction with the grazing lease (M. McCrary, pers comm). The California fairy shrimp is also protected on the Santa Rosa Plateau in Riverside County in the Western Riverside County Vernal Pool Region.

## 3. WESTERN SPADEFOOT TOAD (*SPEA HAMMONDII*)

### a. Description and Taxonomy

***Taxonomy*.—**Spadefoot toads are members of the family Pelobatidae. Two closely related genera of spadefoot toads have been recognized within this family: *Scaphiopus* and *Spea* (Cannatella 1985, Weins and Titus 1991). We will collectively refer to members of this family in this document as spadefoot toads unless otherwise stated. Western spadefoot toads are officially recognized within the genus *Spea* (Weins and Titus 1991), although many literature sources reference *Scaphiopus* as the genus. Species relationships within *Spea* have been difficult to define due to morphological homogeneity among species. At least four species are currently recognized (Weins and Titus 1991). Named by Baird in 1859, *Spea hammondii* was regarded as having a broad geographic range from California to western Texas and Oklahoma with a distributional gap in the Mojave Desert of California (Storer 1925, Stebbins 1966). However, Brown (1976) identified morphological, vocalization, and reproductive differences between eastern (Arizona eastward) and western (California) populations, justifying species recognition for each. The California populations retained the name *Spea hammondii* (western spadefoot toad) while the eastern populations were designated as *Spea multiplicata* (southern spadefoot toad) This distinction was further supported by electrophoretic analyses conducted by Sattler (1980) and by allozymic and morphological analyses conducted by Weins and Titus (1991). Genetic variation across the range of *Spea hammondii* has not been studied to date.

***Description and Identification***.—Spadefoot toads are distinguished from the true toads (genus *Bufo*) by their cat-like eyes (their pupils are vertically elliptical in bright light but are round at night), the single black sharp-edged "spade" on each hind foot, teeth in the upper jaw, and rather smooth skin (Stebbins 1985) (**Figure II-41**). The parotid glands (large swellings on the side of the head and behind the eye) are absent or indistinct on spadefoot toads. Males may have a dusky throat and dark nuptial pads on the innermost front toes (*i.e.*, thumb).

The western spadefoot toad ranges in size from 3.7 to 6.2 centimeters (1.5 to 2.5 inches) snout-vent length. They are dusky green or gray above and often have four irregular light-colored stripes on their back, with the central pair of stripes sometimes distinguished by a dark, hourglass-shaped area. The skin tubercles (small, rounded protuberances) are sometimes tipped with orange or are reddish in color, particularly among young individuals (Storer 1925, Stebbins 1985). The iris of the eye is usually a pale gold. The abdomen is whitish without any markings. Spadefoot toads have a wedge-shaped, glossy black "spade" on each hind foot, used for digging. The call of western spadefoot toads is hoarse and snore-like, and lasts between 0.5 and 1.0 second (Stebbins 1985).

The eggs of western spadefoot toads are pigmented and are found in irregular cylindrical clusters of about 10 to 42 eggs attached to plant stems and other submerged objects in temporary pools (Stebbins 1985). Spadefoot toad larvae (tadpoles) can reach 7 centimeters (2.8 inches) in length (Storer 1925). They have an upper mandible that is beaked and a lower mandible that is notched. The larvae have oral papillae (small nipple-like projections that encircle the mouth), and their eyes are set close together and situated well inside the outline of the head as viewed from above. Their body is broadest just behind the eyes (Storer

**Figure II-41.** Photograph of western spadefoot toad *(Spea hammondii).*

1925). Western spadefoot toad larvae resemble those of other *Spea* species in that both cannibal and non-cannibal morphotypes display coloration that is variable relative to their habitat. They also show a uniform iridescence in their pigmentation.

Western spadefoot toads and southern spadefoot toads lack a cranial boss (a ridge between the eyes). This trait distinguishes these species from the plains (*Spea bombifrons)* and the Great Basin (*Spea intermontanus*) spadefoot toads, which each have a cranial boss. Compared to western spadefoot toads, southern spadefoot toads have a more elongate spade, are brownish above, and have a copper-colored iris.

## b. Historical and Current Distribution

***Historical Distribution*.—**The western spadefoot toad is nearly endemic to California, and historically ranged from the vicinity of Redding in Shasta County southward to Mesa de San Carlos in northwestern Baja California, Mexico (Stebbins 1985). In California, western spadefoot toads ranged throughout the Central Valley, and throughout the Coast Ranges and the coastal lowlands from San Francisco Bay southward to Mexico (Jennings and Hayes 1994).

***Current Distribution*.—**The western spadefoot toad has been extirpated throughout most of the lowlands of southern California (Stebbins 1985) and from many historical locations within the Central Valley (Jennings and Hayes 1994, Fisher and Shaffer 1996) (**Figure II-42**). According to Fisher and Shaffer (1996), western spadefoot toads have suffered a severe decline in the Sacramento Valley, and a reduced density of populations in the eastern San Joaquin Valley. Declines in abundance have been more modest in the Coast Ranges. This species occurs mostly below 900 meters (3,000 feet) in elevation (Stebbins 1985), but has been found up to 1,363 meters (4,500 feet) (Morey 1988). The average elevation of sites where the species still occurs is significantly higher than the average elevation for historical sites, suggesting that declines have been more pronounced in lowlands. Since 1996, approximately 146 new occurrences have been reported to the California Natural Diversity Data Base (2005), primarily in Riverside and San Diego Counties. Approximately 44 new occurrences were reported from the San Joaquin Valley and 8 from the Sacramento Valley. Additional sightings of the spadefoot, not reported to the California Natural Diversity Database, were made during 1998-1999 at the Coles Levee Ecosystem Preserve in Kern County (J. Jones pers. comm. 2005).

Three relatively recent sources of data have presented information regarding the current status and distribution of the western spadefoot toad. Jennings and Hayes


Figure II-42. Distribution of western spadefoot toad (*Spea hammondii*).

**Table II-1.** Western Spadefoot Toad Occurrence Information

| County | Jennings and Hayes (1994) | Fisher and Shaffer (1996) | California Natural Diversity Data Base (2005) |
|---|---|---|---|
| **Alameda** | Extant | Extant | Extant |
| **Amador** | Extant | No Detection | No Data |
| **Butte** | Extant | No Detection | Extant |
| **Calaveras** | Extirpated | Extant | Extant |
| **Colusa** | No Data | No Data | Extant |
| **Fresno** | Extirpated | No Detection | Extant |
| **Glenn** | No Data | Extant | Extant |
| **Kern** | Extant | Extant | Extant |
| **Kings** | No Data | No Data | Extant |
| **Los Angeles** | Extirpated | No Data | Extant |
| **Madera** | Extant | Extant | Extant |
| **Mariposa** | Extant | No Data | No Data |
| **Merced** | No Data | Extant | Extant |
| **Monterey** | Extant | Extant | Extant |
| **Orange** | Extant | No Data | Extant |
| **Placer** | No Data | No Data | Extant |
| **Riverside** | Extant | No Data | Extant |
| **Sacramento** | Extant | Extant | Extant |
| **San Benito** | Extant | Extant | Extant |
| **San Bernardino** | Extirpated | No Data | No Data |
| **San Diego** | Extant | No Data | Extant |
| **San Joaquin** | Extant | No Detection | Extant |
| **San Luis Obispo** | Extant | Extant | Extant |
| **Santa Barbara** | Extant | Extant | Extant |
| **Shasta** | Extirpated | No Detection | No Data |
| **Siskiyou** | No Data | No Data | Extant |
| **Stanislaus** | Extant | Extant | Extant |
| **Tehama** | Extant | No Detection | Extant |
| **Tulare** | Extant | Extant | Extant |
| **Ventura** | No Data | No Data | Extant |
| **Yolo** | Extirpated | No Detection | Extant |

(1994) examined 832 museum and sighting records from 346 locations and concluded that western spadefoot toads were extant in18 California counties and had been extirpated from 6 others. Fisher and Shaffer (1996) conducted field surveys of 315 sites in the Sacramento Valley, San Joaquin Valley, and Coast Ranges from 1990 to 1992. These surveys confirmed the presence of western spadefoot toads in 13 counties and failed to detect the species in an additional 8 counties. The California Natural Diversity Data Base (2005) lists 316 occurrences of western spadefoot toads from 27 counties. These records range from 1978 to 2005 and do not represent a systematic survey. The status of many of the sites recorded prior to 2000 where western spadefoot toads were observed is unknown. Many of these sites have not been revisited since the early 1990s and may no longer exist due to subsequent development. Some records were submitted by biological consultants who were conducting surveys on sites that were about to be developed. **Table II-1** below summarizes the collective findings of these three cited sources.

Western spadefoot toads have been recorded in 11 of the 17 vernal pool regions described by Keeler-Wolf *et al.* (1998). The species has been documented to co-occur with several other rare species, some of which are federally protected. Among the 316 locations for western spadefoot toads in the California Natural Diversity Data Base (2005), the following special status animals have been documented to co-occur: California tiger salamander, California red-legged frog (*Rana aurora draytonii*), vernal pool tadpole shrimp, vernal pool fairy shrimp, and California fairy shrimp. Federally-listed plants covered in this plan that co-occur with the spadefoot toad include *Orcuttia inaequalis*, *Orcuttia pilosa*, *Castilleja campestris* ssp. *succulenta*, *Neostapfia colusana*, and *Chamaesyce hooveri*. Such co-occurrences provide an opportunity to conserve multiple species at one location.

### c. Life History and Habitat

***Food and Foraging*.—**Typical of toads, adult western spadefoot toads will forage on a variety of insects, worms, and other invertebrates. Morey and Guinn (1992) examined the stomach contents of 14 western spadefoot toads and found 11 different food items, including grasshoppers (order Orthoptera, family Gryllacrididae), true bugs (order Hemiptera), moths (order Lepidoptera, family Noctuidae and unidentified moths), ground beetles (order Coleoptera, family Carabidae), predaceous diving beetles (order Coleoptera, family Dytiscidae), ladybird beetles (order Coleoptera, family Coccinellidae), click beetles (order Coleoptera, family Elateridae), flies (order Diptera, family Heleomyzidae), ants (order Hymenoptera, family Formicidae), and earthworms (order Haplotaxida). Adult toads can consume 11 percent of their body mass during a single feeding bout, and Dimmit and Ruibal (1980) speculated that in only a few weeks, adults may be able to acquire sufficient energy for their long dormancy period (8 to 9 months).

The specific food habits of western spadefoot toad larvae are unknown. However, the larvae of southern and plains spadefoot toads consume planktonic organisms and algae, and also will scavenge dead organisms, including other spadefoot toad larvae (Bragg 1964). Larvae of plains spadefoot toads reportedly will prey on fairy shrimp (*e.g.*, *Branchinecta* spp.) (Bragg 1962). Both adult and larval western spadefoot toads consume food items that also are used by other co-occurring amphibians (*e.g.*, Pacific tree frog [*Pseudacris* (*Hyla*) *regilla*], California tiger salamander, and western toad [*Bufo boreas*]) (Morey and Guinn 1992). Thus, some degree of resource competition may occur, depending upon the abundance of food resources.

***Reproduction and Demography***.—Western spadefoot toads breed from January to May in temporary pools and drainages that form following winter or spring rains. Water temperatures in these pools must be between 9 degrees Celsius (48 degrees Fahrenheit) and 30 degrees Celsius (86 degrees Fahrenheit) for western spadefoot toads to reproduce (Brown 1966, 1967). Oviposition (egg laying) does not occur until water temperatures reach the required minimum of 9 degrees Celsius (48 degrees Fahrenheit) (Jennings and Hayes 1994). Depending on the temperature regime and annual rainfall, oviposition may occur between late February and late May (Storer 1925, Burgess 1950, Feaver 1971, Stebbins 1985). During breeding, highly vocal aggregations of more than 1,000 individuals may form (Jennings and Hayes 1994). Breeding calls are audible at great distances and serve to bring individuals together at suitable breeding sites (Stebbins 1985). Amplexus, the copulatory embrace by males, is pelvic (Stebbins 1985). Females deposit their eggs in numerous small irregularly cylindrical clusters of 10 to 42 eggs (average is 24) (Storer 1925), and may lay more than 500 eggs in one season (Stebbins 1951). Eggs are deposited on plant stems or pieces of detritus in temporary rain pools, or sometimes in pools of ephemeral stream courses (Storer 1925, Stebbins 1985).

Eggs hatch in 0.6 to 6 days depending on temperature (Brown 1967). At relatively high water temperatures (*e.g.*, 21 degrees Celsius [70 degrees Fahrenheit]), Storer (1925) noted that about half of the western spadefoot toad eggs failed to develop, possibly due to a fungus that thrives in warmer water and invades toad eggs. Larval development can be completed in 3 to 11 weeks (Burgess 1950, Feaver 1971) depending on food resources and temperature, but must be completed before pools dry. In eight vernal pools examined by Morey (1998), the average duration to complete larval development (hatching to metamorphosis) was 58 days (range 30 to 79 days). Metamorphosing larvae may leave the water while their tails are still relatively long (greater than 1 centimeter [0.4 inch]) (Storer 1925). Longer periods of larval development were associated with larger size at metamorphosis. Pools that persist for longer periods would permit longer larval development, resulting in larger juveniles with great fat reserves at metamorphosis (Morey 1998). These larger individuals have a higher fitness level and survivorship (Pfennig 1992). Annual reproductive success probably varies with precipitation levels, with success being lower in drier years (Fisher and Shaffer 1996). Recently metamorphosed juveniles emerge from water and seek refuge in the immediate vicinity of natal ponds. They spend several hours to several days near these ponds before dispersing. Weintraub (1979) reported that toadlets of plains spadefoot toads seek refuge in drying mud cracks, under boards, and under other surface objects including decomposing cow manure. Age at sexual maturity is unknown, but considering the relatively long period of subterranean dormancy (8 to 9 months), individuals may require at least 2 years to mature (Jennings and Hayes 1994).

Virtually no data are available on demographic values for western spadefoot toads. Long-term population dynamics, survival rates, reproductive success, and dispersal rates for western spadefoot toads are unknown. It is assumed that connectivity corridors between populations is essential for the conservation of metapopulations. Morey and Guinn (1992) reported that western spadefoot toad abundance appeared to remain stable from 1982 to 1986 at a vernal pool complex in Stanislaus County, California. Based on systematic collections of road-killed western spadefoot toads at this same site, the proportions of adults and juveniles were 70 percent and 30 percent, respectively, and the proportions of adult males and females were about equal.

***Behavior and Species Interactions*.**—Western spadefoot toads are almost completely terrestrial and enter water only to breed (Dimmitt and Ruibal 1980). However, typical of amphibians, western spadefoot toads require a certain level of moisture to avoid desiccation, which can be a challenge in the arid habitats occupied by the species. Spadefoot toads have behavioral and physiological adaptations that facilitate moisture retention.

During dry periods, spadefoot toads construct and occupy burrows that may be up to 0.9 meter (3 feet) in depth (Ruibal *et al.* 1969). Individuals may remain in these burrows for 8 to9 months. While in these burrows, individuals are completely surrounded by soil, and they appear to enter a state of torpor. Like all amphibians, western spadefoot toads have very permeable skin that allows them to absorb moisture from the surrounding soil. Spadefoot toads may retain urea to increase the osmotic pressure within their bodies, which prevents water loss to the surrounding soil and even facilitates water absorption from soils with relatively high moisture tensions (Ruibal *et al.* 1969, Shoemaker *et al.* 1969). Spadefoot toads appear to construct burrows in soils that are relatively sandy and friable as these soil attributes facilitate both digging and water absorption (Ruibal *et al.* 1969).

Spadefoot toads emerge from burrows to forage and breed following rains in the winter and spring. The factors that stimulate emergence are not well understood. In Arizona, spadefoot toads emerged after as little as 0.25 centimeter (0.1 inch) of precipitation, which barely wet the soil surface and obviously did not soak down to burrows (Ruibal *et al.* 1969). Sound or vibration from rain striking the ground appears to be the primary emergence cue used by spadefoot toads, and even the vibrations of a motor can cause toads to emerge (Dimmitt and Ruibal 1980). Spadefoot toads may move closer to the surface prior to precipitation and may even emerge to forage on nights with adequate humidity. Most surface activity is nocturnal. Morey and Guinn (1992) report that surface activity is related to both moisture and cooler temperatures following storms. Surface activity has been observed in all months from October to May (Morey 1988, Morey and Guinn 1992).

Above-ground activity is primarily nocturnal, presumably to reduce water loss. Even when exposed to artificial light, spadefoot toads will immediately move away or begin burrowing underground (Storer 1925, Ruibal *et al.* 1969). During the day, spadefoot toads dig and occupy relatively shallow burrows 2 to 5 centimeters (0.5 to 2 inches) in depth (Ruibal *et al.* 1969), and may even use small mammal burrows. In addition to breeding during periods of above-ground activity, spadefoot toads must acquire sufficient energy resources prior to reentering dormancy (Seymour 1973).

The role of predation on the population dynamics of western spadefoot toads is unclear. The extended dormancy period of adult and juvenile toads reduces their exposure to predators. Also, toxic secretions from dermal glands provide a significant deterrent to predators. Predators pose a much greater threat to larval western spadefoot toads. Larval toads are preyed upon by a variety of native predators, including waterbirds, garter snakes (*Thamnophis* spp.), and raccoons (*Procyon lotor*) (Childs 1953, Feaver 1971). According to Feaver (1971), western spadefoot toad larvae were preyed upon by California tiger salamander larvae whenever the two species co-existed in the same pools and the California tiger salamander larvae matured first. However, if western spadefoot toad and California tiger salamander larvae are the same size, no predation may occur (Anderson 1968).

Nonnative predators introduced within the range of western spadefoot toads include crayfish (order Decapoda), fish, and bullfrogs (*Rana catesbeiana*) (Hayes and Warner 1985, Hayes and Jennings 1986, Morey and Guinn 1992, Jennings and Hayes 1994, Fisher and Shaffer 1996). Nonnative fish, many of which are predatory, have been introduced for sportfishing and other purposes. These fish negatively affect native amphibians by preying upon eggs and larvae (Jennings 1988). In some locations, mosquito fish (*Gambusia affinis*) purposely introduced to control mosquitos also prey on western spadefoot toad eggs and larvae (Grubb 1972, Jennings and Hayes 1994, Fisher and Shaffer 1996). Nonnative species may also compete for resources with western spadefoot toads, thus potentially limiting their foraging success.

Introduced bullfrogs have been implicated in the declines of native amphibians (Moyle 1973, Hayes and Jennings 1986). Bullfrogs may not be significant predators of adult western spadefoot toads, although adults have been found in the stomachs of bullfrogs on at least two occasions (Hayes and Warner 1985, Morey and Guinn 1992). Bullfrogs may present more of a threat to larval western spadefoot toads. During dispersal between permanent water sources, juvenile bullfrogs will use temporary water sources (*e.g.*, vernal pools) as resting and feeding areas, which increases the potential for predation on western spadefoot toad larvae (Morey and Guinn 1992). Thus, bullfrogs are of concern regarding the conservation of western spadefoot toads.

Some significant ecological differences exist that may minimize interactions between bullfrogs and western spadefoot toads. Some spatial segregation may exist because bullfrogs may occur less frequently in the temporary wetlands (*e.g.*, vernal pools) used by western spadefoot toads. Also, western spadefoot toads increase activity in response to moisture and low temperatures following storms whereas bullfrogs increase activity in response to warmer temperatures prior to storms (Morey and Guinn 1992). Thus, some temporal segregation may occur as well. Nonetheless, some studies indicate that declining population trends may be associated with introduced predators, including bullfrogs (see general threats discussion in the Introduction section). At a site in Stanislaus County, California, western spadefoot toad abundance remained stable during 1982 to 1986 despite dramatic increases in bullfrog abundance during this same period (Morey and Guinn 1992).

***Habitat and Community Associations*.—**Western spadefoot toads are primarily a species of lowland habitats such as washes, floodplains of rivers, alluvial fans, playas, and alkali flats (Stebbins 1985). However, they also occur in the foothills and mountains. Western spadefoot toads prefer areas of open vegetation and short grasses, where the soil is sandy or gravelly. They are found in the valley and foothill grasslands, open chaparral, and pine-oak woodlands.

Western spadefoot toads require two distinct habitat components in order to meet life history requirements, and these habitats probably need to be in close proximity. Spadefoot toads are primarily terrestrial, and require upland habitats for feeding and for constructing burrows for their long dry-season dormancy. However, little is known regarding the distance that western spadefoot toads may range from aquatic resources for dispersal and estivation. As further discussed in the conservation strategy section, current research on amphibian conservation suggests that average habitat utilization falls within 368 meters (1,207 feet) of aquatic habitats (Semlitsch and Brodie 2003). Typical of amphibians, wetland habitats are required for reproduction. Western spadefoot toad eggs and larvae have been observed in a variety of permanent and temporary wetlands including rivers, creeks, pools in intermittent streams, vernal pools, and temporary rain pools (California Natural Diversity Database 2000), indicating a degree of ecological plasticity. However, it appears that vernal pools and other temporary wetlands may be optimal for breeding due to the absence or reduced abundance of both native and nonnative predators, many of which require more permanent water sources.

Western spadefoot toads have also exhibited a capacity to breed in altered wetlands as well as man-made wetlands. Western spadefoot toads, including eggs and larvae, have been observed in vernal pools that have been disturbed by activities such as earthmoving, discing, intensive livestock use, and off-road vehicle use. Western spadefoot toads, again including eggs and larvae, have also been observed in artificial ponds, livestock ponds, sedimentation and flood control ponds, irrigation and roadside ditches, roadside puddles, tire ruts, and borrow pits (Fisher and Shaffer 1996, California Natural Diversity Database 2000). This behavior again indicates a degree of ecological plasticity and adaptability. However, although western spadefoot toads have been observed to inhabit and breed in wetlands altered or created by humans, survival and reproductive success in these pools have not been evaluated relative to that in unaltered natural pools. In addition, at this time our knowledge of the land surface types that can be successfully traversed by western spadefoot toads is incomplete.

Based on calculations from upland habitat use data analyzed by Semlitsch and Brodie (2003), a minimum conservation area to preserve the ecological processes required for the conservation of amphibians may fall within a distance of approximately 368 meters (1,207 feet) from suitable breeding wetlands. Given a square preserve surrounding a single breeding pond, this estimate would suggest a minimum preserve size of approximately 54.2 hectares (134 acres). In any given western spadefoot toad metapopulation, we expect that some subpopulations will disappear, but the habitat they occupied will eventually be recolonized if it remains acceptable. To enable natural recolonization of unoccupied habitat, and to allow for gene flow that is vital for preventing inbreeding, opportunities for dispersal and interbreeding among subpopulations of the western spadefoot toad must be maintained. Where possible, habitat corridors between breeding sites should be protected and maintained.

### d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to the western spadefoot toad are described below.

Most habitat of the western spadefoot toad is not protected and those areas that are protected are relatively small and therefore still highly subject to external threats. This species likely suffered dramatic reductions in the mid to late 1900s when urban and agricultural development were rapidly destroying natural habitats in the Central Valley and southern California (Jennings and Hayes 1994). According to Jennings and Hayes (1994), over 80 percent of the habitat once known to be occupied by the western spadefoot toad in southern California (from the Santa Clara River Valley in Los Angeles and Ventura Counties southward) has been developed or converted to uses that are incompatible with successful reproduction and recruitment. In northern and central California, loss of habitat has been less severe, but nevertheless significant; it is estimated that over 30 percent of the habitat once occupied by western spadefoot toads has been developed or converted (Jennings and Hayes 1994). Regions that have been severely affected include the lower two-thirds of the Salinas River system, and much of the areas east of Sacramento, Fresno, and Bakersfield. Many of the remaining suitable rainpool or vernal pool habitats, which are concentrated on valley terraces along the edges of the Central Valley floor, have disappeared or been fragmented (Jennings and Hayes 1994).

Changes in vernal pool hydrology may adversely affect spadefoot toad populations. In particular, grazing may play an important role in maintaining vernal pool hydrology by decreasing the abundance of vegetation and therefore reducing evapotranspiration from the pools during the spring. In a study conducted in pools inhabited by spadefoot toads, Marty (2004) found that removal of grazing led to a reduction in the inundation period of the pools below the amount of time required by the toads to successfully metamorphose. Conversely, livestock may crush or even consume egg clusters while utilizing ponds and cause direct mortality to adult and juvenile toads through trampling. Continued use may deplete water levels from ponds, preventing complete metamorphosis of tadpoles or, in some cases, causing accelerated metamorphosis to occur which according to Morey (1998) may result in individuals that are less fit (J. Darren *in litt*., 2005).

Another reason for the population decline of the western spadefoot toad is the introduction of nonnative predators, specifically bullfrogs, crayfishes (*e.g.*, *Procambarus clarkii*), and fishes (*e.g.*, mosquito fish) (Hayes and Warner 1985, Hayes and Jennings 1986, Fisher and Shaffer 1996). All of these were introduced into California in the late 1800s and early 1900s, and through range expansions, additional introductions, and transplants, these exotics have become established throughout most of the state. Fisher and Shaffer (1996) reported an inverse relationship between the presence of western spadefoot toads and that of nonnative predators. Additionally, nonnative predators may have displaced western spadefoot toads at lower elevations, resulting in the toads being found primarily at higher elevation sites where these predators apparently are less abundant (Fisher and Shaffer 1996). Fisher and Shaffer (1996) assessed native amphibian populations in the Coast Ranges, Sierra foothills, and Central Valley. They predicted that widespread declines of western spadefoot toads would occur if nonnative species continued to spread into low-elevation Coast Range habitats. However, in the San Joaquin Valley they found that relatively few nonnative predators were present, but native amphibians still had declined significantly. The San Joaquin Valley was the most intensively farmed and most modified of the three regions examined. It has been subject to extensive habitat loss, degradation, and fragmentation (U.S. Fish and Wildlife Service 1998*a*). Adverse impacts from these activities as well as isolation from other western spadefoot toad populations may have caused the observed declines. Discing the soil as a part of row-cropping and other forms of intensive agriculture are likely to cause mortality of western spadefoot toads in their underground burrows.

Roads represent an additional threat to the western spadefoot toad. Road construction can result in direct mortality of the western spadefoot toad, and can cause direct loss and fragmentation of habitat. Roads cause indirect loss of habitat by facilitating transportation and urban development, a major cause of habitat loss for the western spadefoot toad. Mortality of western spadefoot toads from motor vehicle strikes has been observed by multiple researchers (Morey and Guinn 1992, Jennings 1998, California Natural Diversity Database 2000), and appears to be both widespread and frequent. For instance, Jennings (1998) reported road mortality at all seven sites that he surveyed in Kings and Alameda

Counties. The impact of motor vehicle-caused mortality on populations of western spadefoot toads is unknown. Roads can be a barrier to movements and effectively isolate populations. Roads are significant barriers to gene flow among common frogs (*Rana temporaria*) in Germany, which has resulted in genetic differentiation among populations separated by roads (Reh and Seitz 1990). Similarly, Kuhn (1987, in Reh and Seitz 1990) determined that approximately 24 to 40 cars per hour on a given road resulted in mortality of 50 percent of common toads (*Bufo bufo*) attempting to migrate across the road. In another study, Heine (1987, in Reh and Seitz 1990) identified that 26 cars per hour resulted in 100 percent mortality of common toads attempting to cross a road. Vehicle traffic on dirt roads adjacent to breeding areas can also significantly impact spadefoot toads during certain times of year. Spadefoot toad metamorphs attempting to disperse across dirt roads have been killed, possibly because they often try to bury themselves in the road to avoid an approaching vehicle (J. Vance pers. comm. 2005).

Amphibians typically have complex life cycles and thus more opportunities for exposure to chemicals and more potential routes of exposure than other vertebrates. The western spadefoot toad is exposed to a variety of toxins throughout its range, but the sensitivity of this species to pesticides, heavy metals, air pollutants, and other contaminants is largely unknown. Each year, millions of kilograms (millions of pounds) of fertilizer, insecticides, herbicides, and fungicides are used on crops, forests, rights of way, and landscape plants in California. Some of these chemicals are extremely toxic to aquatic organisms such as amphibians and their prey. Industrial facilities and motor vehicles also release contaminants that may harm the western spadefoot toad. Contaminants from road materials, leaks, and spills also could adversely affect western spadefoot toads by contaminating the water in wetlands. Refer to Appendix E for a list of chemicals most likely to be harmful to the western spadefoot toad.

Activities that produce low frequency noise and vibration, such as grading for development and seismic exploration for natural gas, in or near habitat for western spadefoot toads, may be detrimental to the species. Dimmitt and Ruibal (1980) determined that spadefoot toads were extremely sensitive to such stimuli and would break dormancy and emerge from their burrows in response to these disturbances. Disturbances that cause spadefoot toads to emerge at inappropriate times could result in detrimental effects such as mortality or reduced fitness.

### e. Conservation Efforts

The western spadefoot toad was a Category 2 candidate for listing in 1994 (U. S. Fish and Wildlife Service 1994*b*). Due to a change in policy regarding candidate species (U.S. Fish and Wildlife Service 1996*c*), western spadefoot toads are now considered a *species of concern*. Species of Concern are sensitive species that have not been listed, proposed for listing or placed in candidate status. "Species of concern" is an informal term used by some but not all U.S. Fish and Wildlife Service offices. Species of concern receive no legal protection and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species. The western spadefoot toad was designated a species of special concern by the State of California in 1994 (Jennings and Hayes 1994, California Department of Fish and Game 1998).

A number of sites with suitable habitat for western spadefoot toads are already being protected through National Wildlife Refuges, National Monuments, State Parks, State Ecological Reserves, private preserves, mitigation banks, and conservation easements. Specific protected sites where the presence of western spadefoot toads has been confirmed include the Kesterson Unit of the San Luis National Wildlife Refuge (Merced County), the Arena Plains Unit of the Merced National Wildlife Refuge (Merced County), the Carrizo Plain National Monument (San Luis Obispo County), a reserve for the endangered Stephens' kangaroo rats (*Dipodomys stephensi*) at March Air Force Base (Riverside County), Corral Hollow State Ecological Reserve (San Joaquin County), Allensworth State Ecological Reserve (Tulare County), Stone Corral State Ecological Reserve (Tulare County), the Center for Natural Land Management's Pixley Vernal Pool Preserve (Tulare County), The Nature Conservancy's Simon-Newman Ranch (Stanislaus County), Mather Regional Park (Sacramento County), the Howard Ranch protected with a conservation easement (Sacramento County), Casper Regional Park (Orange County), two Caltrans mitigation sites (Madera County), and private habitat mitigation sites in Sacramento, Placer, and Merced Counties. Western spadefoot toad observations have also been reported from Camp Roberts and Fort Hunter Liggett Military Reservations (San Luis Obispo and Monterey Counties), Naval Air Station Lemoore (Kings County), and a site owned by the California State University - Fresno (California Natural Diversity Database 2000), and at Coles Levee Ecosystem Preserve (Kern County) (J. Jones pers. comm. 2005). These locations on public lands present conservation opportunities for the species. Some conservation measures have already been implemented at Camp Roberts and Fort Hunter Liggett. The western spadefoot toad is also included for conservation under several habitat conservation plans currently in existence or under development. Additionally, 23 vernal pool species are now federally protected including 18 plants and 5 animals. This protection will result in habitat conservation and management efforts that will contribute to the conservation of western spadefoot toads.