Western Spadefoot
(Spea [Scaphiopus] hammondii)


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Legal Status
Federal: None.
State: Species of special concern.

Global and State Conservation Status: G3S3: Global Rank, G3 = Vulnerable: At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors; State Rank, Same as global ranks but only for the range of taxa within California.

Recovery Plan: Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (2005).

Species Description and Life History

Western spadefoot (*Spea hammondii*) is an amphibian in the family Pelobatidae. Spadefoot toads are distinguished from true toads (genus *Bufo*) by their cat-like eyes (due to vertically elliptical pupils), black sharp-edged keratinized "spade" on each hind foot, teeth in their upper jaws, the reduction or absence of parotoid glands, and comparatively smooth skin.

Adults range in length from 3.8 to 6.4 cm (1.5 to 2.5 in) (Stebbins 2003). The western spadefoot's coloration ranges from a dusky green to gray, with four irregular light-colored stripes on the back, and a central pair of stripes distinguished by a dark hourglass shape. Skin tubercles (small, rounded protuberances) are sometimes tipped with orange or are reddish in color, particularly among young individuals. The irises of western spadefoots' eyes are pale gold in color, and their abdomens are whitish without markings. Larvae are up to 7 cm (2.8 in) in length (Stebbins 2003), with a rounded body, usually whitish-gray to very light gray-green in color, with eyes on the dorsal (upper) surface of the head (Holland and Goodman 1998). Some populations of spadefoots develop predacious and cannibalistic tadpoles with a beak on the upper jaw, a corresponding notch below, and enlarged jaw musculature (Orton 1954, Bragg 1964, Stebbins 1985).

Typical of toads, adult western spadefoots forage on a variety of insects, worms, and other invertebrates—including crickets, grasshoppers, true bugs, moths, ground beetles, predaceous diving beetles, ladybird beetles, click beetles, flies, ants, and earthworms. Although tadpoles consume planktonic organisms and algae, they are also carnivorous and will feed on dead amphibian larvae as well as their own species. Pfenig and Frankino (1997) found that for tadpoles of *S. multiplicata*, individuals were less likely to express cannibalistic phenotypes in pure sibship groups, but that chemical signals from nonkin were sufficient to trigger the carnivore phenotype. Farrar and Hey (1997) found that carnivorous spadefoots developed more pronounced beaks and jaw musculature and shorter intestines with fewer loops than omnivores. Carnivorous spadefoot tadpoles are also more likely to feed on fairy shrimp (Bragg 1962, Farrar and Hey 1997).

A terrestrial species, western spadefoots enter water only to breed (Dimmit and Ruibal 1980a). The breeding cycle of the western spadefoot is dependent on temperature and rainfall patterns (Jennings and Hayes 1994) but generally occurs between January and May (Stebbins 2003). Western spadefoots utilize vernal pools or other temporary pools for breeding (Jennings and Hayes 1994) but may also breed in slow-moving streams (Stebbins 2003). Western spadefoots require water temperatures between 9° and 30° C (48° and 86° F) for breeding to occur (Brown 1967), and egg deposition does not occur until pools begin warming in late winter (Jennings and Hayes 1994). Western spadefoots are explosive breeders, with the number of individuals in a breeding aggregation potentially exceeding 1,000 (Jennings and Hayes 1994), although they are typically much smaller. Male western spadefoots clasp females during amplexus (breeding position) at the pelvic (hindlimb) region, unlike true toads, which clasp females at the pectoral (forelimb) region (Stebbins 2003). During amplexus the female deposits 10 to 42 eggs in small, irregularly cylindrical clusters, attaching them to plant stems or pieces of detritus (Storer 1925). Larvae hatch from eggs approximately 14.5 hours to 6 days after oviposition (egg-laying) (Brown 1967). Metamorphosis occurs 3 to 11 weeks after hatching, depending on temperature and food availability (Burgess 1950, Feaver 1971). Zeiner *et al.* (1988) reported that while in late metamorphic stages of development, the western spadefoot may spend a few hours to a few days near pond margins prior to dispersing. Holland and Goodman (1998) reported that individuals may remain in the vicinity of natal pools as long as several weeks following metamorphosis, hiding within drying mud cracks or beneath surface objects such as boards or decomposing cow dung (Weintraub 1980).

Movement patterns and colonization abilities of the adult western spadefoots are not fully understood (Jennings and Hayes 1994). Western spadefoots typically emerge at night during periods of warm rainfall to forage (Stebbins 1972). They move toward breeding sites in late winter to spring, in response to favorable temperatures and rainfall. The breeding season is brief (Stebbins 2003), sometimes lasting no more than 1 to 2 weeks. Following breeding, individuals return to upland habitats, where they spend most of the year aestivating (in a dormant state) in burrows. The western spadefoot may breed in the same ponds as California tiger salamanders (*Ambystoma californiense*), in areas where the two species are sympatric (CNDDB 2009).

Habitat Requirements and Ecology

Suitable upland habitat includes washes, floodplains, alluvial fans, and playas (Stebbins 2003), extending into foothills and mountains to an elevation of 1,360 m (4,462 ft) (Jennings and Hayes 1994). The upper elevational limit in the general vicinity of Yolo County appears to be lower. The maximum elevation of records from Alameda County is

229 m (750 feet), and Colusa County at 137 m (450 feet) (CNDDB 2009). Western spadefoot may be active above ground on soil types ranging from loose sand to hardpan clay, although soil characteristics of burrow refugia are not known (Jennings and Hayes 1994). If soil characteristics are similar to those of *S. multiplicatus*, soils may harden significantly during the summer aestivation period (Ruibal *et al.* 1969), suggesting that spadefoots may be capable of utilizing compact soils by burrowing when conditions are moist (Jennings and Hayes 1994).

During dry periods, individuals typically excavate burrows into the ground at depths up to 3 feet, but they may also occupy burrows constructed by small mammals; whether these are used as short-term refugia during periods of surface activity is unknown (Jennings and Hayes 1994). Adult western spadefoots can consume roughly 11% of their body mass at a single feeding (Dimmitt and Ruibal 1980b) and can probably acquire the resources needed for aestivation in just a few weeks (Jennings and Hayes 1994). This aestivation period may continue for 9 months at a time (Jennings and Hayes 1994). The skin of western spadefoots is very permeable, enabling them to absorb moisture from surrounding soil. Spadefoots may also be able to retain urea, increasing their internal osmotic pressure, thereby preventing water loss and facilitating water absorption from soils with relatively high moisture tensions (Ruibal *et al.* 1969, Shoemaker *et al.* 1969).

Species Distribution and Population Trends

Distribution

In North America, the range of the western spadefoot includes portions of California, extending south to Mesa de San Carlos in Baja California Norte, Mexico (Jennings and Hayes 1994, Museum of Vertebrate Zoology and California Academy of Sciences catalogue records). In California, the range of the western spadefoot includes portions of the Central Valley and bordering foothills, and the Coast Ranges south of Monterey Bay (Stebbins 2003). The species has experienced severe declines in the northern California and lower elevation portions of its range (Stebbins 2003).

Jennings and Hayes' (1994) distribution map indicates only one historical occurrence within the Plan Area, which is now considered extirpated, from near the southern border of Yolo County, west of Davis. Queries conducted in January 2008 of the collection databases of the Museum of Vertebrate Zoology at UC Berkeley and the California Academy of Sciences yielded no specimens of western spadefoots from Yolo County. The CNDDB (2009) lists three records of western spadefoots in Yolo County. Those records, from 1990 and 2000, were from Buckeye Creek, 4.8 and 5.6 km (3.0 and 3.5 mi) northwest of Dunnigan. No other extant records are known from Yolo County.

Population Trends

The population status and trends of the western spadefoot outside of California (i.e., Baja California Norte, Mexico) are not well known. In general, populations of the western spadefoot have reportedly declined, and the species is now extirpated from much of lowland California (Stebbins 2003). Extensive losses have occurred in northern California and in southern portions of the state from the Santa Clara River Valley to south of Los Angeles and Ventura Counties (Stebbins 2003).

Distribution and Population Trends in the Plan Area

While western spadefoot toads once ranged throughout the Central Valley (Jennings and Hayes 1994), the paucity of current or historic recorded occurrences in Yolo suggests that the western spadefoot may never have been a common species in Yolo County. It is likely that the current land use patterns in the Central Valley portion of Yolo County (actively cultivated agriculture and increased road density) have significantly decreased any habitat suitability that may have been there. Populations in northern California have generally experienced severe declines (Stebbins 2003), and Yolo County populations may have experienced similar declines (USFWS 2005). The principal factors contributing to the decline of the western spadefoot are loss of habitat due to urban development, conversion of native habitats to agricultural lands, introduction of non-native predators, and pesticide use (Fisher and Shaffer 1996, Hobbs and Mooney 1998, Davidson *et al.* 2002). Habitat loss and fragmentation result in small, isolated populations, which reduce individual movements and genetic exchange between populations. Reduction in gene flow may result in inbreeding depression and a subsequent reduction in population fitness. Furthermore, many remaining vernal pools and wetlands are suffering from habitat degradation by disking, intensive livestock grazing, off-road vehicle use, and contaminant run-off (Fisher and Shaffer 1996, Hobbs and Mooney 1998, Davidson *et al.* 2002).

Threats to the Species and Other Conservation Issues

The loss of vernal pool or other seasonal pool habitats due to land conversion is likely the greatest threat to the western spadefoot. More than 80 percent of occupied habitat in southern California and more than 30 percent in northern California have been lost to development or other land uses (Jennings and Hayes 1994). Habitat fragmentation and loss due to urban development, conversion of native habitats to agricultural lands, introduction of non-native predators, and pesticide use are among the causes (Fisher and Shaffer 1996, Hobbs and Mooney 1998, Davidson *et al.* 2002). The relationship between habitat fragmentation and the metapopulation structure of the western spadefoot is not entirely understood (Jennings and Hayes 1994); however, ongoing land conversion is undoubtedly resulting in smaller, isolated populations.

Western spadefoots are suffering from habitat degradation by disking, intensive livestock grazing, off-road vehicle use, and contaminant run-off (Fisher and Shaffer 1996, Hobbs and Mooney 1998, Davidson *et al.* 2002). Direct mortality of toads may occur when toads burrow in actively tilled fields, or are hit by vehicles when dispersing across roads. Where agricultural activities must coincide with the conservation of western spadefoot toad, appropriately grazed pastures will provide better habitat than intensively farmed lands subject to discing, planting, harvesting and other activities that could kill aestivating western spadefoot toad (USFWS 2005)

Natural predators of larval and post-metamorphic western spadefoots include raccoons (*Procyon lotor*), garter snakes (*Thamnophis* spp.), great blue herons (*Ardea alba*), and California tiger salamanders (Childs 1953). There are indications that the presence of introduced predators in breeding pools, such as mosquitofish (*Gambusia affinis*), crayfish (order Decapoda), and bullfrogs (*Rana catesbeiana*) may prevent recruitment (Jennings and Hayes 1994).

Although the degree to which predation affects the population dynamics of western spadefoots is poorly understood, their extended period of aestivation reduces exposure to predators. Spadefoots also produce toxic dermal secretions that deter predation (Duellman and Trueb 1986). Feaver (1971) noted that California tiger salamander larvae preyed on western spadefoot larvae whenever the two species co-occurred and California tiger salamander larvae metamorphosed first. However, Anderson (1968) found that if larvae of the two species are the same size, predation may not occur.

Non-native invasive species are also a threat to the western spadefoot. The predation of spadefoot eggs and larvae by mosquitofish introduced into vernal pools through mosquito abatement programs may threaten some populations (Jennings and Hayes 1994, Stebbins 2003). Bullfrogs, which have been reported to emigrate to some western spadefoot breeding pools, may threaten those populations through predation of spadefoot eggs and larvae. Exotic predators such as mosquitofish may also compete with western spadefoot larvae for limited food resources.

Dimmitt and Ruibal (1980a) reported that low-frequency noises and vibrations can cause aestivating western spadefoots to become active and emerge from their burrows. Potential anthropogenic sources of such low-frequency noises and vibrations include seismic exploration for natural gas, land grading, or other motorized vehicles or machinery. Artificial irrigation can induce spadefoots to emerge and begin vocalizing in any month (Zeiner *et al*. 1988). Such artificially induced, aseasonal emergence could result in adverse effects such as mortality or decreased productivity.

The construction of roadways near conservation lands or other occupied habitat should be avoided, to the extent possible. Breeding habitats located near roads are especially vulnerable to mortality caused by automobile strikes, which results in the loss of individuals and impedes access to potential movement corridors. Moreover, the low-frequency noises and vibrations that would occur during road construction, and the normal automobile and truck usage that would follow, could result in aseasonal emergences of aestivating spadefoots, generating additional adverse effects.

The western spadefoot was included for coverage in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (USFWS 2005). The USFWS's stated goals for the western spadefoot and 12 other species of special concern covered under the Recovery Plan are to achieve and protect in perpetuity self-sustaining populations of each species and ensure the species' long-term conservation. The primary focus of the Recovery Plan is protection of vernal pool habitat—in the largest blocks possible—from loss, fragmentation, degradation, and incompatible uses (USFWS 2005). For the western spadefoot, the Recovery Plan calls for:

- Conducting research on juvenile and adult dispersal to and from breeding locations,
- Conducting research on the effects of habitat management practices on the western spadefoot and their habitat in order to determine the limiting factors with respect to determining minimum reserve sizes,
- Studying the impacts of low-frequency noises and vibrations, and
- Determining the influence of non-native aquatic vertebrate predators (e.g., bullfrogs and mosquitofish) on population dynamics.

Jennings and Hayes (1994) state that the most significant data gap related to understanding western spadefoot populations is the relationship between habitat fragmentation and metapopulation structure. Movement patterns and colonization abilities of adult western spadefoots are also not fully understood. Comprehension of the life history and important habitat requirements of the western spadefoot is essential for conservation of the species (Jennings and Hayes 1994). Within Yolo County, there are few records for the species that could be used to focus conservation or recovery efforts toward specific locations. Generally, however, habitat protection remains the primary strategy for conserving the western spadefoot.

Land acquisition is also an important conservation strategy. Land acquisition is a process in which a public agency or nonprofit land conservation organization purchases all the ownership rights to the land from a willing seller. The property that is to be acquired should contain all the parameters mentioned above. An important quality of the acquired property should be the allowance of genetic flow between populations via wildlife corridors. However, since movement patterns and colonization abilities of adult spadefoots are not fully understood, it is unknown how effective movement corridors between populations will affect the species.

The species has been documented to cooccur with several other rare species, some of which are federally protected (USFWS 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 (USFWS 2005). Federally-listed plants that cooccur with the spadefoot toad include *Orcuttia inaequalis*, *Orcuttia pilosa*, *Castilleja campestris* ssp. *succulenta*, *Neostapfia colusana*, and *Chamaesyce hooveri* (USFWS 2005). Such co-occurrences provide an opportunity to conserve multiple species at one location.

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References

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Anderson, P.R. 1968. The reproductive and developmental history of the California tiger salamander. Master of Science Thesis. Fresno State College, Fresno, CA.

Bragg, A.N. 1962. Predation on arthropods by spadefoot tadpoles. Herpetologica 18(2):144.

Bragg, A.N. 1964. Further study of predation and cannibalism in spadefoot tadpoles. Herpetologica 20(1): 17-24.

Brown, H.A. 1967. Embryonic temperature adaptations and genetic compatibility of two allopatric populations of the spadefoot toad, *Scaphiopus hammondii*. Evolution 21:742-761.

Burgess, R.C., Jr. 1950. Development of spade-foot toad larvae under laboratory conditions. Copeia 1950:49-51.

California Academy of Sciences Herpetology Department. 2008. Web site. http://www.research.calacademy.org/research/herpetology/catalog/.

California Natural Diversity Data Base (CNDDB). December 1, 2009. California Department of Fish and Game, Biogeographic Data Branch. Sacramento, CA.

Childs, H.E. 1953. Selection by predation on albino and normal spadefoot toads. Evolution 7:228–233.

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.

Dimmitt, M.A. and R. Ruibal. 1980a. Environmental correlates of emergence in spadefoot toads (*Scaphiopus*). Journal of Herpetology 14(1):21-29.

Dimmitt, M. A., and R. Ruibal. 1980b. Exploitation of food resources by spadefoot toads (*Scaphiopus*). Copeia 1980(4):854-862.

Duellman, W.E. and L. Trueb. 1986. Biology of Amphibians. John Hopkins University Press, Baltimore, MD. xxi + 670 pp.

Feaver, P.E. 1971. Breeding pool selection and larval mortality of three California amphibians: *Ambystoma tigrinum californiense* Gray, *Hyla regilla* Baird and Girard, and *Scaphiopus hammondii* Girard. M.A. thesis, Fresno State College, Fresno, CA.

Ferrar, E.S. and J.D. Hey. 1997. Carniverous spadefoot (*Spea bombifrons*) tadpoles and fairy shrimp in western Iowa. Journal of the Iowa Academt of Science 104:4-7.

Fisher, R.N. and H.B. Shaffer. 1996. The decline of amphibians in California's Great Central Valley. Conservation Biology 10:1387-1397.

Hobbs, R.J. and H.A. Mooney. 1998. Broadening the Extinction Debate: Population Deletions and Additions in California and Western Australia. Conservation Biology 12:271-283.

Holland, D.C. and R.H. Goodman. 1998. A guide to the amphibians and reptiles of MCB Camp Pendleton, San Diego County, California. Report to AC/S Environmental Security, Resource Management Division. Contract M00681-94-C-0039.

Jennings, M.R. and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA. iii+255 pp.

Museum of Vertebrate Zoology Data Access. 2008. Web site: http://mvz.berkeley.edu/Herp_Collection.html.

Orton, G.L. 1954. Dimorphism in larval mouthparts in spadefoot toads of the *Scaphiopus hammindii* group. Copeia1954(2): 97-100.

Pfennig, D.W. and W.A. Frankino. 1997. Kin-mediated morphogenesis in facultatively cannibalistic tadpoles. Evolution 51(6):1993-1999.

Ruibal, R., L. Tevis, Jr., and V. Roig. 1969. The terrestrial ecology of the spadefoot toad *Scaphiopus hammondii*. Copeia 1969:571-584.

Semlitsch, R.D., and J.R. Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17:1219-1228.

Shoemaker, V.H., L. McClanahan, Jr., and R. Ruibal. 1969. Seasonal changes in body fluids in a field population of spadefoot toads. Copeia 1969:585-591.

Stebbins, R. C. 1951. Amphibians of western North America. University of California Press, Berkeley, California.

Stebbins, R.C. 1972. Amphibians and Reptiles of California. University of California Press, Berkeley, Los Angeles, and London.

Stebbins, R. C. 1985. A field guide to western reptiles and amphibians. Second edition, revised. Houghton Mifflin Company, Boston, Massachusetts.

Stebbins, R.C. 2003. A Field Guide to Western Reptiles and Amphibians. Third edition Houghton Mifflin Company, Boston, MA. 533 pp.

Storer, T.L. 1925. A synopsis of the amphibia of California. University of California Publications in Zoology 27:1-342.

U.S. Fish and Wildlife Service (USFWS). 2005. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Portland, OR. xxii + 574 pp.

Weintraub, J.D. 1980. Selection of daytime retreats by recently metamorphosed *Scaphiopus multiplicatus*. Journal of Herpetology 14(1):83-84.

Zeiner, D.C., W.F. Laudenslayer, Jr., and K.E. Mayer (compiling editors). 1988. California's wildlife. Volume I. Amphibians and reptiles. California Statewide Wildlife Habitat Relationships System, California Department of Fish and Game, Sacramento, CA.