



WESTERN SPADEFOOT

Spea hammondi (Baird 1859)

Status Summary

Spea hammondi is a Priority 1 Species of Special Concern, receiving a Total Score/Total Possible of 69% (76/110). During the previous evaluation, it was also considered a Species of Special Concern under the name *Scaphiopus hammondi* (Jennings and Hayes 1994a).

Identification

Spadefoot toads as a group have catlike eyes with vertical pupils, a single black spade on each hind foot, and indistinct paratoid glands (Stebbins 2003). *Spea hammondi* is dusky green or gray dorsally, often with irregular markings (Stebbins 2003). Tubercles on the skin are tipped with orange or red, and the irises are usually pale gold (Jennings and Hayes 1994a, Stebbins 2003). The ventral surface is white to light gray without markings (Stebbins 2003). Adults are 4–6 cm SVL (Stebbins 2003). Larvae can reach approximately 7 cm in TL and their eyes are set close together when viewed from above (Stebbins 2003). This species is unlikely to be confused with other sympatric anurans.

Taxonomic Relationships

North American spadefoots have had a confusing taxonomic history. Studies using allozymes and morphology (Wiens and Titus 1991) and mitochondrial DNA (Garcia-Paris et al. 2003) support the species status of *Spea hammondi*,

Western Spadefoot: Risk Factors

Ranking Criteria (Maximum Score)	Score
i. Range size (10)	5
ii. Distribution trend (25)	20
iii. Population concentration/ migration (10)	10
iv. Endemism (10)	7
v. Ecological tolerance (10)	10
vi. Population trend (25)	10
vii. Vulnerability to climate change (10)	7
viii. Projected impacts (10)	7
Total Score	76
Total Possible	110
Total Score/Total Possible	0.69

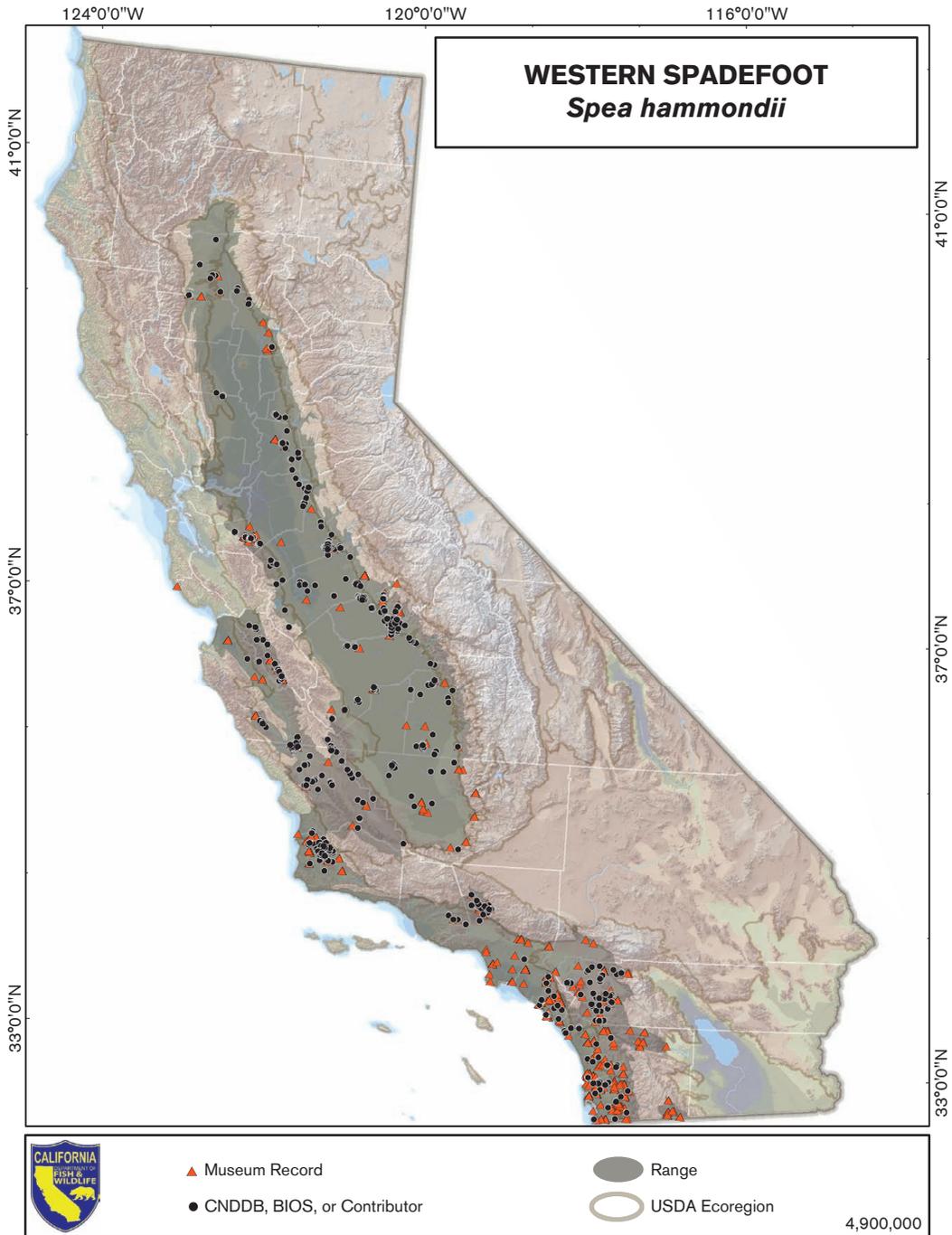


PHOTO ON PREVIOUS PAGE: Western spadefoot, Sacramento County, California. Courtesy of Robert Thomson.

placing it sister to a clade consisting of the Great Basin spadefoot (*S. intermontana*) and the Plains spadefoot (*S. bombifrons*). This arrangement is consistent with Kluge (1966) and Sattler (1980). Relationships within *Spea* are still unresolved however, and cryptic taxa may exist within *S. hammondi* (Garcia-Paris et al. 2003) and *S. intermontana* (Wiens and Titus 1991). Ongoing phylogeographic work should clarify the extent of intraspecific variation in the species. Preliminary data indicate that some mitochondrial introgression has occurred between *S. intermontana* and *S. hammondi* in southern California, but not the Central Valley portions of the species' range (P. Spinks, unpublished data).

Life History

Adult *Spea hammondi* are terrestrial, moving from summer refugia to ephemeral water bodies to breed in the spring following warm late winter or spring rains (Storer 1925, Burgess 1950, Stebbins 1954, Feaver 1971, Brown 1976, Morey 1998). Breeding aggregations can consist of more than 1000 individuals (Jennings and Hayes 1994a). Breeding occurs over a 2–3 week period, during which males can be heard chorusing intermittently (Brown 1976, Morey and Reznick 2004). Additional bouts of breeding can occur, and pools can contain cohorts of different ages (Morey 2005). Onset of breeding activity varies depending on rainfall and region. For example, heavy rains in 1991 resulted in breeding occurring only in March (San Luis Obispo and Riverside Counties; Morey and Reznick 2004). In the two following years, breeding occurred between January and March (Morey and Reznick 2004). Breeding has also been documented in August, and from October to December in San Diego County (Ervin et al. 2005, Ervin and Cass 2007). It is unknown how common early-breeding behavior is, but the October 2004 events may have been in response to very dry conditions, and many of these larvae ultimately succumbed to desiccation. The previous year, 2003, set a record rainless period, and the breeding in 2004 occurred

after the first measurable rain in 181 days (Ervin et al. 2005).

Females lay 300–500 eggs in clusters of 18–25 (Stebbins 1951, Stebbins 1985) that usually hatch in 3–4 days (Morey 2005). Morey and Reznick (2004) surveyed vernal pools in San Luis Obispo and Riverside Counties and found that the larval period lasted an average of 58 days. In the laboratory, the minimum time for larval development was estimated to be 14 days (Morey and Reznick 2004). Males raised experimentally under high food conditions developed secondary sexual characters by the beginning of their first breeding season after metamorphosis, while females of the same age had adult coloration but underdeveloped ovaries (Morey and Reznick 2001). It is unknown how long it takes to reach maturity in the field, but based on this experimental work males probably mature 1–2 years after metamorphosis and females at least 2 years after metamorphosis. Most individuals are mature at 4–4.5 cm SVL (Storer 1925, Morey and Guinn 1992).

Larvae are frequently at risk of desiccation due to pools drying before development is complete. In Fresno County, 17 out of 23 vernal pools dried before larvae metamorphosed (Feaver 1971). Across 20 populations in San Luis Obispo and Riverside Counties, Morey and Reznick (2004) observed that 15% of ponds dried before larvae metamorphosed. As pools dry, larvae experience increased daily variation in temperature, increased ammonia levels, increased water hardness, and decreased depth (Morey and Reznick 2004). These factors lead to crowding and decreased growth rate. While several cues are operating simultaneously, water reduction alone is sufficient to trigger accelerated development within 24 hours (Denver 1997a, Denver 1997b, Denver et al. 1998, Boorse and Denver 2003). In the field, there is a positive correlation between hydroperiod and mass at metamorphosis (Morey and Reznick 2004). In the lab, animals reared at low density were larger (4.96 g) at metamorphosis and metamorphosed sooner (77.8 days) than animals maintained at high density (2.9 g, 87.8 days; Morey and Reznick

2001). Survivorship of metamorphs was also higher for animals that were larger at metamorphosis, regardless of larval density (Morey and Reznick 2001). Effects of the larval rearing environment persisted for several months after metamorphosis, but small metamorphs were able to catch up in growth if terrestrial food availability was high.

Little is known about terrestrial activity, although most movement and surface activity is thought to be nocturnal (Morey 2005). Juveniles leave natal pools shortly after metamorphosis in April–June presumably seeking refugia, although their terrestrial habitat is unknown (Morey 2005). Adults and juveniles retreat to burrows by late summer, with juveniles capable of digging burrows 10–20 cm deep even in hard, dry soil (Morey and Reznick 2001). Mammal burrows may also be used (Stebbins 1951).

Larval diet has not been studied, although larvae of other spadefoot species are generalists, consuming animals, plants, and organic detritus (Pomeroy 1981, Pfennig 1990). Cannibal morph larvae with broad heads and enlarged jaw muscles are known from San Luis Obispo and Riverside counties, but it is unknown how common they are throughout the species' range (Morey 2005). Adults are generalized predators on terrestrial arthropods and other prey, including beetles, moths, flies, and earthworms (Morey and Guinn 1992).

Habitat Requirements

Spea hammondi occurs in grasslands, oak woodlands, coastal sage scrub, and chaparral vegetation in washes, floodplains, alluvial fans, playas, and alkali flats (Stebbins 2003, Morey 2005). Temporary pools are used for breeding, but *S. hammondi* will also readily breed in artificial water bodies such as cattle ponds (Morey 2005). Vernal pools used by *S. hammondi* for breeding had an average ponding duration of 81 days (range 36–127, $n = 9$, San Luis Obispo and Riverside Counties) (Morey and Reznick 2004). Pools with at least some successful recruitment lasted on average 3 weeks longer than larval development time (Morey and Reznick 2004).

Pool temperature during larval development ranged from 11°C to 32°C (Morey and Reznick 2004). Brown (1967) found that water temperatures between 9°C and 30°C were necessary for larval development (eggs collected from Riverside County).

Perennial pools containing introduced predators such as crayfish, fish, or bullfrogs are often unsuitable for successful recruitment (Jennings and Hayes 1994a). However, in southern California, ephemeral pools utilized by introduced species with predatory aquatic stages, such as the African clawed frog (*Xenopus laevis*), can still function as breeding habitat for *S. hammondi* (confirmed by the presence of dispersing metamorphs), but the effects these introduced species have on overall recruitment levels are unknown (Ervin and Fisher 2001, Ervin and Burkhardt 2006).

Distribution (Past and Present)

Spea hammondi occurs in the Central Valley and bordering foothills across southern California from Shasta County south into northwestern Baja California, including the Coast Ranges south of Monterey, from sea level to 1365 m (Jennings and Hayes 1994a, Ervin et al. 2001, Stebbins 2003; S. Barry, pers. comm.). Jennings and Hayes (1994a) concluded that as of the 1990s, over 80% of historically occupied habitat in southern California and 30% of habitat in northern California were no longer suitable due to development and habitat conversion. In surveys throughout the Central Valley, Fisher and Shaffer (1996) reported *S. hammondi* as virtually extirpated from the Sacramento Valley and at a reduced density in populations of the eastern San Joaquin Valley.

Trends in Abundance

Current or historical abundance data are largely unavailable or anecdotal, and little recent data is available. Recent surveys of Mather Airport (formerly Mather Air Force Base) in Sacramento County estimated that breeding adults numbered in the few dozens, although this was based on short-duration surveys and limited

data (A. Chang, unpublished data). Morey and Guinn (1992) reported an average of 1.16 individuals/km of roadway during a relatively wet winter (1982–1983) and 0.68 individuals/km during a drier winter (1984–1985) in the San Joaquin Valley.

Nature and Degree of Threat

The major threat to *Spea hammondi* is habitat loss and fragmentation due to agriculture and urban development. Other threats include invasive species and climate change. Davidson et al. (2002) found that currently occupied sites had less surrounding urban development than extirpated sites. Extant populations also occur at higher elevations than extirpated sites on average, possibly due to invasive species being more common at lower elevation (Fisher and Shaffer 1996, Davidson et al. 2002). *Spea hammondi* is sensitive to invasive species such as crayfish, bullfrogs, and mosquitofish; however, many of these species cannot persist in the highly ephemeral breeding habitats *S. hammondi* uses (Jennings and Hayes 1994a, Morey 2005). Bullfrogs have been documented to prey on *S. hammondi* (Morey and Guinn 1992, Balfour and Ranlet 2006), although the impact of this predation on overall abundance is unknown.

Spea hammondi may be at risk from climate change because breeding is dependent upon temperature and rainfall cues, and larval development requires ephemeral pools to persist long enough to complete development (Morey and Guinn 1992, Jennings and Hayes 1994a). Mean annual temperatures are projected to increase throughout the range of *S. hammondi*, with warmer winters and summers and earlier spring warming expected (reviewed in PRBO 2011). The frequency of extremely hot days is predicted to increase by up to 25 days per year in some parts of the range (Bell et al. 2004). There is less certainty about future precipitation patterns, with estimates ranging from little change to roughly 30% decreases in rainfall (Snyder and Sloan 2005, PRBO 2011). Changes in temperature and precipitation will likely affect vernal pool hydrology (e.g., Pyke 2005) and may

also affect the timing of breeding, though how *S. hammondi* will respond to these changes needs further study. The largely unsuccessful early breeding observed by Ervin et al. (2005) may be indicative of the kinds of mismatches in environmental cues and breeding behavior that this species may suffer under climate change. The probability of large (>200 ha) wildfires is expected to change very little in the Central Valley (Westerling and Bryant 2008). In the more northern coastal part of the range, the probability of large fires is expected to increase (Westerling and Bryant 2008), and the area burned is expected to increase by up to 50% (Lenihan et al. 2008). In the southern part of the range where wildfire is common, there is little consensus on future fire dynamics because of the difficulty in modeling Santa Ana weather events (Westerling et al. 2004, Westerling and Bryant 2008). The largely subterranean lifestyle of *S. hammondi* may make it relatively resistant to the effects of fire. However, wildfires occurring during dispersal may be particularly detrimental due to direct mortality and habitat degradation and this issue requires more study. Vegetation shifts due to climate change are expected to be modest in the Central Valley, where land use is a more important determinant of habitat type (PRBO 2011). Elsewhere in the range, chaparral and shrublands are expected to decrease in area, while grassland is expected to increase (Lenihan et al. 2008, PRBO 2011). The impact of these shifts may be modest as *S. hammondi* uses all of these habitat types.

Status Determination

Ongoing habitat loss and extirpations throughout the range of *Spea hammondi* warrant Priority 1 Species of Special Concern status.

Management Recommendations

Remaining sites should be protected from urban and agricultural development, with emphasis on larger habitat blocks that allow for more natural metapopulation dynamics to persist. The fact that *Spea hammondi* readily breeds in anthropogenic structures can be exploited to

create breeding habitat in response to habitat loss and potentially also to climate changes that affect natural vernal pool phenology. Terrestrial habitat is likely not so easily restored, and minimizing or eliminating disturbance around breeding habitat would help protect adults (see the “Monitoring, Research, and Survey Needs” section). Efforts to remove introduced predators from breeding habitat should be considered. In some cases, cattle grazing operations may be beneficial to *S. hammondi*. Over 3 years in Sacramento County, Marty (2005) found that experimentally grazed vernal pools experienced fewer drying and refilling cycles within a season, and had a longer maximum inundation period (115 days) than ungrazed treatments (65 days) or treatments where grazing occurred seasonally (65–78 days).

Monitoring, Research, and Survey Needs

Research is needed into terrestrial habitat use (Jennings and Hayes 1994a, Morey 2005), including juvenile dispersal, adult migration patterns and distances, and the importance (if any) of rodent burrows for all age classes. This

information is important for determining how much and what kinds of terrestrial habitat to protect around breeding sites. For example, Morey and Reznick (2001) found that the quality of juvenile terrestrial habitat in terms of food availability compensated for stressful larval conditions. Additional study on which environmental conditions promote post-metamorphic survival will aid in management planning. It is also unknown what proportion of adults breed each year and how long individual adults spend at breeding sites (Morey 2005). Underground habitat use is poorly known, including feeding and dormancy patterns. Remaining populations are likely highly fragmented, and research is needed into connectivity among populations at both the local and the regional levels; additional landscape ecology and genetic studies would help determine patterns of differentiation (Jennings and Hayes 1994a). Finally, comparative studies of this species in the Central Valley and southern California would help determine the extent of biological variation in life history patterns across this ecological gradient.