Species Status Assessment Report
for
Western Spadefoot
(*Spea hammondii*)
Version 1.1

Photo provided by Chris Brown (U.S. Geological Survey)

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Sacramento Fish and Wildlife Office

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EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service (Service) was petitioned to list the western spadefoot as endangered or threatened under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531–1543) (Act), in April 2012 by the Center for Biological Diversity. In July 2015, the Service published a 90-day finding that the petition presented substantial scientific or commercial information indicating that listing may be warranted for the western spadefoot (80 FR 37568, July 1, 2015). Therefore, a review of the status of the species was initiated to determine if the petitioned action is warranted. Based on the status review, the Service will issue a 12-month finding for the western spadefoot.

This report summarizes the results of the Species Status Assessment (SSA) completed for the western spadefoot. To assess the species' viability, we used the three conservation biology principles of resiliency, redundancy, and representation (together, the 3 Rs). These principles rely on assessing the species at an individual, population, and species level in order to determine whether the species can persist into the future and avoid extinction by having multiple resilient populations distributed widely across its range. The western spadefoot occurs throughout its known historical range associated with vernal pools and upland habitat. There are two genetically distinct, allopatric clades that show no evidence of interbreeding, separated by the Transverse Mountain Range (Transverse Range) in California. In this assessment we refer to them as the northern western spadefoot clade and the southern western spadefoot clade. For this SSA, western spadefoot was separated into 20 unique habitat regions as a surrogate for true populations. Each unique habitat region likely consists of multiple metapopulations of western spadefoot, but each region is unique in its biological communities and the abiotic features, such as soils and geomorphology, that make up the vernal pools or aquatic breeding habitat within the region. For each western spadefoot region, resiliency was measured by assessing the habitat factors of habitat quantity/distribution, habitat quality, and rainfall, and the demographic factor of abundance.

Our analysis of the past, current, and future influences on western spadefoot needs for long term viability revealed that there are several factors that contribute to current condition and pose a risk to future viability of the species. These factors include development, overabundance of vegetation, nonnative predators, drought, noise disturbance, wildfire and effects of climate change.

Under current conditions, we predict the northern western spadefoot clade has four regions with low-moderate resiliency and six regions with low resiliency. The low-moderate or low resiliency is being driven primarily by low quality habitat and a low effective number of breeders estimated for most regions. In addition, recent surveys found western spadefoot present in only 23 percent of pools surveyed throughout the northern clade. The northern western spadefoot clade occurs within 10 regions with 162 known local populations. The broad distribution provides some redundancy against catastrophic events. However, few populations are protected and resiliency is low in most regions so the species may experience some losses from a catastrophic event. Populations exist throughout a range of ecological settings covering

approximately 550 mi (885 km) from north to south, but with limited genetic diversity, currently giving the northern western spadefoot clade some representation.

Under current conditions, we predict the southern western spadefoot clade has seven regions with low-moderate resiliency and one region with low resiliency. Two of the regions in the southern clade, in Mexico, have unknown resiliency. Suitable habitat in the southern regions is generally high quality, so the low-moderate or low resiliency is being driven primarily by a low effective number of breeders estimated for most regions. In addition, recent surveys found western spadefoot present in only 23 percent of pools surveyed throughout the southern clade. The southern western spadefoot clade currently occurs within 10 regions with 322 known local populations. This broad distribution provides redundancy against catastrophic events. Habitat quality is high providing sufficient resiliency to withstand stochastic events and contribute to species redundancy. With a low-moderate population resiliency for more than 300 local populations—of which more than 100 are conserved—the species is likely to be able to withstand a catastrophic event. Populations exist throughout a range of ecological settings covering approximately 350 mi (563 km) from north to south, but with limited genetic diversity, giving the southern clade some representation. With the amount of land that is protected for vernal pool habitat within both the northern and particularly the southern clade, we predict that the species will likely maintain some level of representation and redundancy even if there was a decline in populations in regions with low condition.

The influences on viability described above play a large role in the future resiliency, redundancy, and representation of the western spadefoot. If regions lose resiliency (i.e., the ability to support multiple breeding pools), they are more vulnerable to extirpation, with resulting losses in representation and redundancy. The rates at which future stressors may act on specific regions and the long-term efficacy of current conservation actions (i.e., conservation strategies) are unknown. Therefore, we forecasted how a range of possible future conditions could impact the resiliency, redundancy, representation, and overall condition of the western spadefoot. In order to assess future condition, we developed three plausible future scenarios. The following is a description of the three future scenarios, the status of the western spadefoot when analyzed under each scenario, and a summary of the assumptions we made under each scenario:

Scenario 1: Factors that are currently having an influence on western spadefoot regions increase in severity. Under Scenario 1, we project that all ten regions in the northern western spadefoot clade would have very low resiliency with the potential to be extirpated. We project the southern western spadefoot clade to have five regions with low resiliency, three regions with very low resiliency with the potential to be extirpated, and two regions where the resiliency is unknown. As a result, both the northern and southern western spadefoot clades would likely have reduced redundancy and representation from current condition. In the northern clade populations within all regions have a low probability of persisting in the future. In the southern clade, three populations are at high risk of extirpation. Assumptions made under Future Scenario 1 include:

1. Development would likely increase on the landscape in areas that are not conserved given projected increases in human population, which would decrease habitat quantity/distribution and habitat quality, negatively impacting abundance.

2. Overabundant vegetation and nonnative predators would likely increase from lack of proper management which would decrease the western spadefoot's ability to fully utilize habitat, further decreasing abundance.
3. The effects of climate change would result in a warmer and drier future, with an increase in extended periods of drought decreasing seasonal rains. Warmer and drier climate may also impact overabundance of vegetation, nonnative predators, and the likelihood of wildfire. Habitat quantity/distribution, habitat quality, and rainfall would likely decrease due to the effects of climate change, further decreasing abundance.

Scenario 2: Factors that are currently having an influence on western spadefoot regions continue at the current trend into the future. Future scenario 2 assesses the current conservation efforts continuing into the future. Under Scenario 2, we project the northern western spadefoot would have three regions with low-moderate resiliency and seven regions with low resiliency. We project the southern western spadefoot clade would have seven regions with low-moderate resiliency, one region with low resiliency, and two regions where the resiliency is unknown. The representation and redundancy for both the northern and southern clades would likely be slightly reduced from current condition. However, with the amount of land that is protected for vernal pool habitat within both the northern and southern clade, we predict that the species will likely maintain some level of representation and redundancy even if there was a decline in populations in regions with low condition. Assumptions made under Future Scenario 2 include:

1. Development would likely increase, but would avoid essential habitat due to other listed species that occur within the same habitat, having similar impacts as the current condition on habitat quantity/distribution and habitat quality.
2. The management of overabundant vegetation and nonnative predators would continue at current levels, having similar impacts as current condition to habitat quantity/distribution and habitat quality.
3. The effects of climate change would result in a warmer and drier future. Although droughts are expected to increase into the future under this scenario, the assumption is that they would occur periodically and allow some time in between drought years for average rain years. In this scenario there will likely be impacts to habitat quality and reduced rainfall.

Scenario 3: Similar to the continuation scenario, but with decreased greenhouse gas emissions in comparison to a business as usual future, reducing the effects of climate change. Under Scenario 3, we project the northern western spadefoot clade would have four regions with low-moderate resiliency and six regions with low resiliency. We project the southern western spadefoot clade would have seven regions with low-moderate resiliency, one region with low resiliency, and two regions where the resiliency is unknown. The representation and redundancy for both the northern and southern clades would likely be similar to current condition. Assumptions made under Future Scenario 3 include:

1. Development would likely increase, but would avoid essential vernal pool habitat due to other listed species that occur within the habitat, having similar impacts as the current condition on habitat quantity/distribution and habitat quality

2. The management of overabundant vegetation and nonnative predators would continue at current levels, having similar impacts as current condition to habitat quality and habitat quantity/distribution.
3. The effects of climate change would result in only a slightly warmer and drier future, within the range of adaptability for the western spadefoot having only minor impacts on habitat quality and rainfall.

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1.0 INTRODUCTION

We, the U.S. Fish and Wildlife Service (Service), are reviewing the status of the western spadefoot (western spadefoot; *Spea hammondii*) in response to a petition (CBD 2012, entire) to list the species under the Endangered Species Act of 1973, as amended (Act). As part of this process, we are using an integrated and conservation-focused analytical approach, the Species Status Assessment (SSA), to assess the species' biological status for the purpose of informing our decision under the Act. The initial product of this process is this document, the SSA Report. As envisioned by our guidance document, the Species Status Assessment Framework (Service 2016, entire), an SSA Report begins with a compilation of the best information available on the species (taxonomy, life history, and habitat) and its ecological needs at the individual, population, and/or species levels based on how environmental factors are understood to act on the species and its habitat. Next, an SSA Report describes the current condition of the species' habitat and demographics, and the probable explanations for past and current changes in abundance and distribution within the species' ecological settings (that is, areas representative of geographic, genetic, or life history variation across the range of the species). Lastly, an SSA Report forecasts the species' response to plausible future scenarios of environmental conditions and conservation efforts (Rowland *et al*. 2014, entire). Overall, an SSA Report uses the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3Rs" (Shaffer and Stein 2000, pp. 308–311)) as a lens through which we can evaluate the current and future condition of the species (Smith *et al*. 2018, entire). Ultimately, an SSA Report characterizes a species' ability to sustain populations in the wild over time based on the best scientific understanding of current and future abundance and distribution within the species' ecological settings.

An SSA Report is, in essence, a summary of the information about a species and, simultaneously, a biological risk assessment to aid decision makers who must use the best scientific and commercial information available to make policy-guided decisions. The SSA Report provides decision makers with a scientifically rigorous characterization of the species' biological and conservation status, focusing on the likelihood of whether the species will sustain populations within its ecological settings while also explicitly acknowledging uncertainties in that characterization. The SSA Report does not result in a decision directly, but it provides the best scientific and commercial information available for comparison to policy standards to guide decisions under the Act.

1.1 Previous Federal Actions

On July 11, 2012, we received a petition from the Center for Biological Diversity (CBD; CBD 2012, entire), requesting that 53 species of amphibians and reptiles, including western spadefoot, be listed as endangered species or threatened species and that critical habitat be designated for those species under the Act. On July 1, 2015, we published a 90-day finding in the *Federal Register* affirming that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted for the western spadefoot (80 FR 37568–37579). Our conclusion was based on information in the available literature suggesting that there may be threats to the species from (1) habitat alteration and destruction; (2) disease or predation; (3) inadequacy of existing regulatory mechanisms; and (4) other factors including non-native species predation and competition, and climate change. As part of that finding, we solicited information from governmental agencies, Native American Tribes, the scientific community, industry, and any other interested parties, on various aspects of the species' biology; any potential threats to the species, including possible effects from climate change; any past and ongoing conservation measures; and any information that may help us designate critical habitat for the species, should we determine that listing the species is warranted and that designating critical habitat for the species is prudent and determinable. In addition, although the western spadefoot is not listed as an endangered or threatened species under the Act, we did include the species within our final Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, entire). The recovery plan outlines conservation and management actions to be taken to help conserve the western spadefoot and its habitat. If the Service determines the species is warranted as threatened or endangered under the Act, a proposed rule will be published in the *Federal Register* with appropriate opportunities for public input.

1.2 California State Listing Status

The State of California currently does not include the western spadefoot as a state-listed threatened or endangered species under the California Endangered Species Act (CESA). The California Department of Fish and Wildlife (CDFW), on its Special Animals List, considers the western spadefoot as a "Species of Special Concern" with a global and state ranking as a vulnerable species (G3 and S3—at moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors) (CDFW 2019, entire).

2.0 METHODOLOGY

This document draws scientific information from resources such as primary peer-reviewed literature, reports submitted to the Service and other public agencies, species occurrence information in Geographic Information Systems (GIS) databases, and expert experience and observations. It is preceded by and draws upon analyses presented in other Service documents including the 90-day finding (80 FR 37568 37579) and the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, entire). Finally, we coordinated closely with our partners engaged in ongoing western spadefoot research and conservation efforts including wildlife professionals from Federal and State agencies, universities, and private entities. This assures consideration of the most current scientific and commercial information available regarding the status and conservation of the western spadefoot. Throughout this report, we refer specifically to information on the western spadefoot. When supporting biological information is not specifically available for western spadefoot or is general in nature and applies to one or more of the other spadefoot species outside of range of western spadefoot, we refer to that information as pertaining to "spadefoot(s)" or it is otherwise noted.

2.1 Analytical Framework

The SSA framework (Service 2016, entire) summarizes the information assembled and reviewed by the Service, incorporating the best scientific and commercial data available, to conduct an in-depth review of a species' biology and threats, evaluate its biological status, and assess its resources and conditions needed to maintain long-term viability. For the purpose of the assessment, we define the viability of the western spadefoot as its ability to sustain populations in the wild currently and into the future for approximately 30–40 years. This timeframe represents estimates of mid-century climate projections and human population and development projections for California. Using the SSA framework, we consider what the species needs to maintain viability through an assessment of its resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 308–311; Wolf *et al*. 2015, entire; Smith *et al*. 2018, entire). This SSA Report documents the results of our analysis for the western spadefoot and serves as the biological underpinning of the Service's forthcoming decision on whether the species warrants protection under the Act.

Throughout the assessment, the SSA uses the conservation biology principles of resiliency, redundancy, and representation as a lens to evaluate the current and future condition of the species. The terms resiliency, redundancy, and representation as used throughout this SSA are defined below.

Resiliency is the ability of a species to withstand environmental stochasticity (normal, year-to-year variations in environmental conditions such as temperature, rainfall), periodic disturbances within the normal range of variation (wildfire, floods, storms), and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity) (Redford *et al.* 2011, p. 40). Simply stated, resiliency is the ability to sustain populations through the natural range of favorable and unfavorable conditions. For western spadefoot populations, resiliency was measured by assessing the individual needs of small invertebrate prey, aquatic breeding pools, upland habitat, and seasonal rains, as well as the population needs of reproduction, dispersal, and survival. Resiliency is discussed at the population level.

Redundancy is the ability of a species to withstand catastrophes. Catastrophes are stochastic events that are expected to lead to population collapse regardless of population heath and for which adaptation is unlikely (Mangel and Tier 1993, p. 1083). We can best gauge redundancy by analyzing the number and distribution of populations relative to the scale of anticipated species-relevant catastrophic events. The analysis entails assessing the cumulative risk of catastrophes occurring over time. Redundancy can be analyzed at a population or regional scale, or for narrow-ranged species, at the species level. For western spadefoot, redundancy was measured by assessing the number and location of resilient regions across the species' range. Redundancy was assessed separately for the northern and southern clade of western spadefoot.

Representation is the ability of a species to adapt to both near-term and long-term changes in its physical (climate conditions, habitat conditions, habitat structure, etc.) and biological (pathogens, competitors, predators, etc.) environments. This ability to adapt to new environments—referred to as adaptive capacity—is essential for viability, as species need to continually adapt to their continuously changing environments (Nicotra *et al.* 2015, p. 1269). Species adapt to novel changes in their environment by either [1] moving to new, suitable environments or [2] by altering their physical or behavioral traits (phenotypes) to match the new environmental conditions through either plasticity or genetic change (Beever *et al*. 2016, p. 132; Nicotra *et al*. 2015, p. 1270). The latter (evolution) occurs via the evolutionary processes of natural selection, gene flow, mutations, and genetic drift (Crandall *et al*. 2000, p. 290–291; Sgro *et al*. 2011, p. 327; Zackay 2007, p. 1).

We can best gauge representation by examining the breadth of genetic, phenotypic, and ecological diversity found within a species and its ability to disperse and colonize new areas. In assessing the breadth of variation, it is important to consider both larger-scale variation (such as morphological, behavioral, or life history differences which might exist across the range and environmental or ecological variation across the range), and smaller-scale variation (which might include measures of interpopulation genetic diversity). In assessing dispersal ability, it is important to evaluate the ability and likelihood of the species to track suitable habitat and climate over time. Lastly, to evaluate the evolutionary processes that contribute to and maintain adaptive capacity, it is important to assess [1] natural levels and patterns of gene flow, [2] degree of ecological diversity occupied, and [3] effective population size. In our species status assessments, we assess all three facets to the best of our ability based on available data. For western spadefoot, representation was measured by assessing the genetic diversity and unique ecological settings across the species' range. Representation was assessed separately for the northern and southern clade of western spadefoot.

3.0 SPECIES BACKGROUND

3.1 Taxonomy

Spadefoot toads were historically considered members of the family Pelobatidae (Stebbins and McGinnis 2012, pp. 154–158). However, some sources have recently reclassified spadefoot toads to the family Scaphiopodidae (AmphibiaWeb 2020, unpaginated; Santos-Barrera *et al*. 2018, unpaginated). Two closely related genera of spadefoot toads have been recognized, *Scaphiopus* and *Spea* (Wiens and Titus 1991, p. 21). Western spadefoots are classified within the genus *Spea* (Crother 2017, p. 23), although many older literature sources reference *Scaphiopus* as their genus. Species relationships within *Spea* have been difficult to define due to morphological similarity among species. At least four species in the genus *Spea* are currently recognized; western spadefoot (*Spea hammondii*), plains spadefoot (*Spea bombifrons*), Great Basin spadefoot (*Spea intermontana*), and Mexican spadefoot (*Spea multiplicata*) (Wiens and Titus 1991, p. 21; Neal 2019, pp. 120–121; AmphibiaWeb 2020, unpaginated). The western spadefoot (*Spea hammondii*) was first described and named by Spencer F. Baird in 1859, from a specimen collected by Dr. J.F. Hammond near Redding, California (Baird 1859, p. 12). At that time up into the latter part of the 20th century, the species 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, p. 148). However, Brown (1976, pp. 12–14) identified morphological, vocalization, and reproductive differences between eastern (Arizona eastward) and western (California and Baja California populations) spadefoots, justifying species recognition for each. The California population retained the name *Spea hammondii* (with a common name of western spadefoot) while the remainder of the populations were designated as *Spea multiplicata* (Mexican spadefoot). This distinction was further supported by electrophoretic analysis conducted by Sattler (1980; pp. 605, 608–609), by allozymic and morphological analyses conducted by Wiens and Titus (1991, pp. 21, 25–26), Neal *et al*. (2018, pp. 939–940) using nuclear sequence data, and by Neal (2019, p. 120) using RADseq.

3.2 Genetics

There is substantial genetic evidence that the western spadefoot is biogeographically divided into two clades (a group of organisms having the same ancestral lineage) with no gene flow between the clades. Past genetic work on mitochondrial DNA analysis (Garcia-Paris *et al*. 2003, pp. 16–20) hinted at such separation but the sample size was limited. Recent genetic work has found that the northern and southern distributions of western spadefoot, separated by the Transverse Range in California, are two genetically distinct, allopatric clades that show no evidence of interbreeding, and are likely two separate species (Figure 1; Neal *et al*. 2018, p. 937–943; Neal 2019, p. 114). However, because separation of the species has not been officially proposed to the scientific community, for our purposes in this SSA, we are assessing the two clades (Northern Clade and Southern Clade) as separate entities that are a part of the single species *Spea hammondii*.

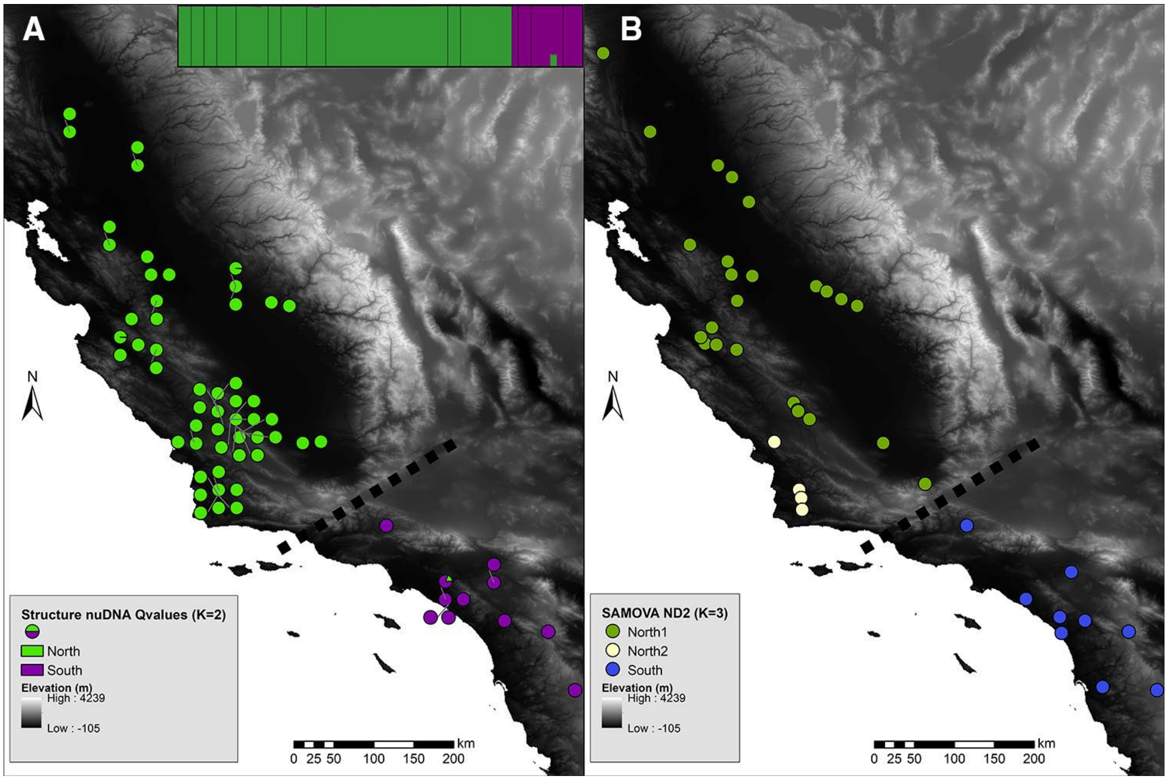

Figure 1: Genetic clustering (A) and Nuclear DNA analysis (B) and Mitochondrial of Spea *hammondii showing separation between Northern and Southern occurrences at the Transverse Range (dotted line) (Adapted from Neal et al. 2018).*

3.3 Species Description

The western spadefoot ranges in size from 3.8 to 6.3 centimeters (cm) (1.5 to 2.5 inches (in.)) snout to vent length (Stebbins and McGinnis 2012, p. 156). They are dusky green or gray on their backs and often have four irregular light-colored stripes, 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, pp. 148–149; Stebbins 1985, p. 57; Stebbins and McGinnis 2012, p. 156). The iris of the eye is usually a pale gold. The abdomen is white in color without any markings. Spadefoots have a wedge-shaped, glossy black "spade" on each hind foot, used for digging. The call of western spadefoot is hoarse and snore-like, and lasts between 0.5 and 1.0 second (Stebbins 1985, p. 57; Stebbins and McGinnis 2012, p. 156). Spadefoots 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, p. 56; Stebbins and McGinnis 2012, p. 154). The parotid glands (large swellings on the side of the head and behind the eye) are absent or indistinct on spadefoots (Stebbins and McGinnis 2012, p. 154). There are currently no known morphological differences described in the literature between the northern and southern western spadefoot clades, although no explicit examination of morphological variation has been conducted to date.

4.0 RANGE AND DISTRIBUTION

The historical range of western spadefoot is from the vicinity of Redding in Shasta County, California, southward to northwestern Baja California, Mexico (Stebbins and McGinnis 2012, p. 157). They have been found at sites from sea level up to 1,385 meters (m) (4,500 feet (ft)) in the Sierra Nevada foothills (Stebbins and McGinnis 2012, p. 157). In California, western spadefoot ranges throughout the Central Valley, and in the Coast Ranges and the coastal lowlands from San Francisco Bay southward to Mexico (Stebbins and McGinnis 2012, p. 157). In Mexico, western spadefoot occurs from the international border to approximately El Rosario near Mesa de San Carlos, but may occur even farther south in some of the larger arroyos (McPeak 2000, p. 15; Grismer 2002, pp. 84–85; iNaturalist 2020, unpaginated). Genetic analysis of nuclear sequence data and RADseq SNPs from the northern and southern populations of western spadefoot, divided by the Transverse Range, indicate two genetically distinct, allopatric clusters that likely make up two species (Neal *et al*. 2018, pp. 937–938; Neal 2019, p. 114). Figure 2 displays the range of the western spadefoot (map projections from CDFW's California Wildlife Habitat Relationships western spadefoot map in California and International Union for Conservation of Nature's projection), divided into the northern and southern western spadefoot clades.

Currently, the species is patchily distributed throughout its historical range. However, the western spadefoot is thought to be extirpated throughout most of the lowlands of southern California and from many historical locations within the Central Valley (Stebbins 1985, p. 67; Jennings and Hayes 1994, p. 96; Thomson *et al*. 2016, p. 133). In the northern western spadefoot range, the largest declines have been observed in the Sacramento Valley and San Joaquin Valley, while declines have been more modest in the Coast Ranges (Fisher and Shaffer 1996, p. 1387). A species distribution model for the northern western spadefoot range (north of Santa Barbara) found the areas predicted to have suitable habitat are patchily distributed along the foothills surrounding the Central Valley and in the southwestern quarter of the northern western spadefoot range including the Salinas Valley (Rose *et al*. 2020, entire).

Figure 2: Range map projections for western spadefoot using the CDFW's California Wildlife Habitat Relationships (CWHR) and International Union for Conservation of Nature (IUCN), with minor adjustments to account for known occurrences. The yellow region represents the portion of the range considered to be the northern western spadefoot clade and the orange region represents the portion of the range considered to be the southern western spadefoot clade.

5.0 LIFE HISTORY

Western spadefoots are primarily terrestrial and inhabit underground burrows. Radio-tagged individuals in southern California were found in underground burrows from 1 cm to 18 cm (0.4–7 in.) depth below the surface during the breeding season (Baumberger *et al*. 2019, p. 3). It is estimated that western spadefoot individuals can burrow approximately 1 m (3 ft) below ground during the dry season to avoid temperature extremes and desiccation (Stebbins and McGinnis 2012, p. 157). During a majority of their life cycle, western spadefoot remains in a torpor state in underground burrows in upland areas surrounding their aquatic (breeding) habitat (Ruibal *et al*. 1969, p. 581). Spadefoots emerge from their burrows to forage and breed in ephemeral pools following seasonal rains in winter and spring (Dimmitt and Ruibal 1980a, p. 21; Jennings and Hayes 1994, p. 94; Thomson *et al.* 2016 pp. 132–133). Emergence is likely related to a sound or vibration cue from the rain (Dimmitt and Ruibal 1980a, p. 26). Most surface activity is nocturnal, presumably to reduce water loss (Morey 2000, p. 1). Depending on temperature and annual rains, western spadefoot breeding and oviposition generally occurs from October to May, most often in temporary pools and non-flowing drainage areas from winter or spring rains (Stebbins 1985, p. 57; Thomson *et al*. 2016, p. 132). Radio tagged individuals, both male and female, have been found at breeding pools in consecutive years, indicating it is likely that individuals can breed consecutive years (Baumberger *et al*. 2020 p. 9). Laboratory experiments have found that water temperatures in pools must be between 9 and 30 degrees Celsius (°C) (48–86 degrees Fahrenheit (°F) for western spadefoot embryos to successfully develop (Brown 1967, p. 746).

Field observations suggest breeding calls are audible at great distances and serve to bring individuals together at suitable breeding sites (Stebbins 1985, p. 57). During breeding, highly vocal aggregations of more than 1,000 individuals may have historically formed (Jennings and Hayes 1994, p. 94). Amplexus, the copulatory embrace by males, is pelvic, unlike most other North American anurans (Stebbins 1985, p. 56). Females deposit eggs in numerous, small, and irregular cylindrical clusters of 10 to 42 eggs, with an average of 24 eggs (Storer 1925, p. 157; Stebbins and McGinnis 2012, p. 156). Eggs range in size from 1.0–1.7 millimeter (mm) (0.04 to 0.07 in) and are light olive-green or sooty on their dorsal-facing surface and light colored on the ventral-facing surface (Stebbins and McGinnis 2012, p. 156). The egg clusters are laid in two jelly envelopes with an outer diameter of 3.2 to 5.7 mm (0.1 to 0.2 in) (Stebbins and McGinnis 2012, p.156). Females may lay 300–500 eggs in one season (Morey 2005, p. 515). Eggs are deposited on plant stems or pieces of detritus in temporary rain pools, or sometimes in the pools that form as ephemeral streams dry (Storer 1925, p. 156; Stebbins and McGinnis 2012, p. 156). Eggs hatch in 0.6 to 6 days depending on the temperature (Brown 1967, p. 747). Field observations have found that at relatively high-water temperatures, approximately 21 °C (70 °F), western spadefoot eggs may fail to develop, possibly due to a fungus that thrives in warmer water temperatures and invades western spadefoot eggs (Storer 1925, p. 158; Brown 1967, p. 746). Larval (tadpole) development can be completed in 3 to 11 weeks depending on food resources and temperature, and must be completed before the pools dry (Burgess 1950, p. 49–51; Feaver 1971, p. 53; Morey 1998, p. 86). Larval development occurs more rapidly in warming pools (Feaver 1971, p. 53; Morey 1998, pp. 86–89). The turbid water sometimes found in the aquatic pools provide cover for larvae (Morey 2005, p. 515). Metamorphosing larvae may leave the water while their tails are still relatively long (greater than 1 cm (0.4 in.)), and move toward suitable terrestrial burrowing habitat (Storer 1925, p. 159).

Age of sexual maturity is unknown, but considering the relatively long period of subterranean dormancy (8 to 10 months), individuals may require at least 2 years to mature (Jennings and Hayes 1994, p. 94; Thomson *et al*. 2016, p. 132). Based on laboratory studies, increased food availability may cause males to reach sexual maturity sooner (~one year from metamorphosis) than males that receive lower amounts of food (Morey and Reznik 2001, pp. 510, 513, 515). Regardless of food levels, females have not been found to reach sexual maturity by one year based on the presence/absence of eggs, therefore females likely do not reach sexual maturity until the second breeding season after metamorphosis (Morey and Reznik 2001, pp. 510, 513, 515). Longevity of western spadefoot is unknown, but experts estimate it to be about 5 to 6 years (Shaffer pers. com. 2020). Figure 3 displays the known life history of western spadefoot. There are currently no known life history differences between the northern and southern western spadefoot clades.

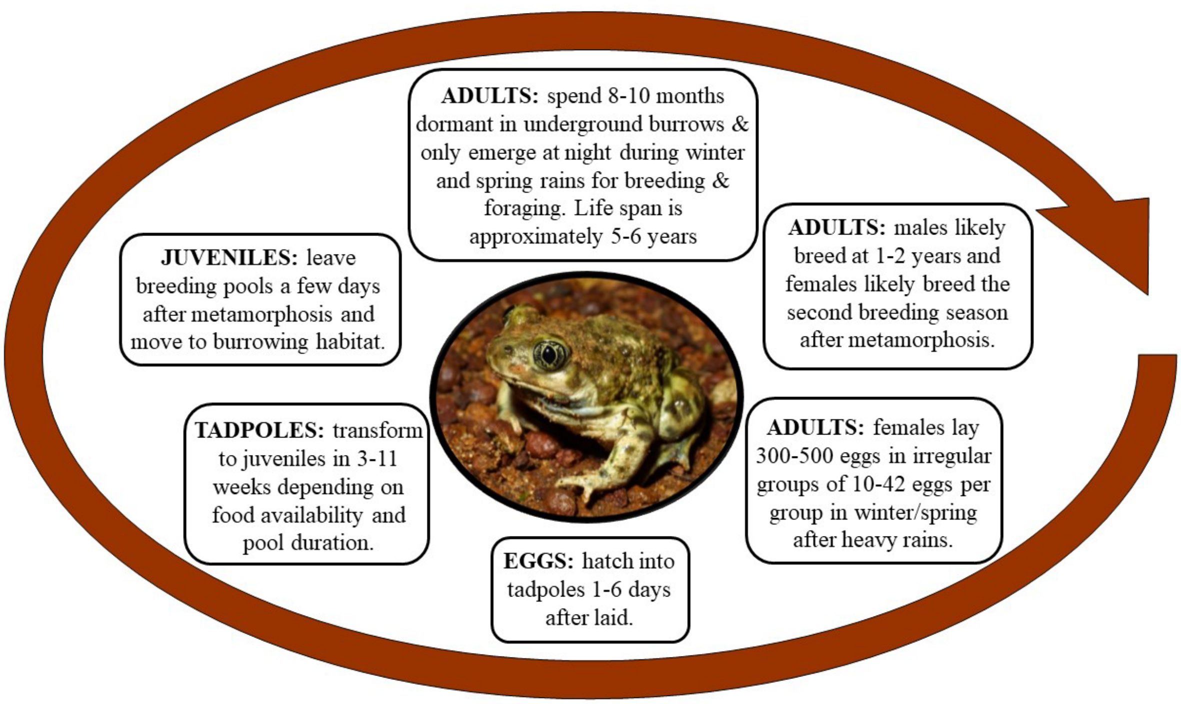

Figure 3: Western spadefoot life history diagram.

6.0 HABITAT

Western spadefoot habitat is primarily open treeless grasslands, scrub, or mixed woodland and grassland where aquatic breeding habitat is available (Stebbins and McGinnis 2012, p. 157). Western spadefoots require both aquatic and terrestrial habitat components in close proximity, within the dispersal distance of the species (See Dispersal Habitat section), to meet all life history requirements. Spadefoots are primarily terrestrial, and require upland habitats for feeding and for constructing burrows for long dry-season dormancy (See Life History section). Western spadefoots have been found to favor areas with grassland cover for burrow sites in both the northern and southern clade, and also shrub/scrub habitat in the southern clade (Baumberger *et al*. 2019, p. 7; Rose *et al*. 2020, p. 6; Rose *et al*. 2022, p. 9). Aquatic habitat is used for breeding and developing larvae and typically includes temporary vernal pools, sand or gravel washes, and small streams that are often seasonal (Stebbins and McGinnis 2012, p. 157). However, eggs and larvae of western spadefoot have been observed in a variety of permanent and temporary wetlands, both natural and altered, including rivers, creeks, artificial ponds, livestock ponds, sedimentation and flood control ponds, irrigation and roadside ditches, roadside puddles, tire ruts, and borrow pits, indicating a degree of ecological plasticity (CNDDB 2019). Although western spadefoot has been observed to inhabit and breed in wetlands altered or created by humans, survival and reproductive success in these pools has not been evaluated relative to that in unaltered natural pools. Temporary wetlands may be optimal aquatic breeding habitat due to reduced abundance of both native and nonnative predators, many of which require more permanent water sources (Jennings and Hayes 1994, p. 96; Stebbins and McGinnis 2012, p. 158; Thomson *et al*. 2016, p. 134). Climate tends to differ throughout the range of western spadefoot which may cause minor differences in habitat between the northern and southern species. Habitat suitability models have shown some differences in predicted habitat between the northern and southern clade (Rose *et al*. 2020, p. 1; Rose *et al*. 2022, p. 9). Western spadefoot occurrences in the northern clade have been found to be associated with grassland habitat, and occurrences in the southern clade have been found to be associated with grassland and shrub/scrub habitat (Rose *et al*. 2020, p. 1; Rose *et al*. 2022, p. 9). See **Individual Needs** section below for more information on aquatic and terrestrial habitat for western spadefoot.

6.1 Dispersal Habitat

Little is known regarding the land surface types western spadefoot are able to move across or distance that western spadefoot may range from aquatic resources for dispersal. A study looking at movement of western spadefoot individuals in an Orange County population found that the mean distance individuals moved away from breeding pools was 40 m (±37) (131 ft), with the longest movement of an individual being 262 m (860 ft), however the study was done during a dry year (Baumberger 2013, p. 14). A study in Orange County on the same population of spadefoot found that the maximum upper 95 percent limit posterior predictive distribution for distance to breeding pool was 460 m (1509 ft), and the maximum distance a spadefoot dispersed was 605 m (1985 ft) (Baumberger 2020, pers. comm.) during a wet year, highlighting the difference that precipitation makes in maximum movement distances recorded (Baumberger *et al*. 2020, p. 7).

7.0 SPECIES NEEDS

In this section we synthesize the information from the preceding sections to highlight the overall needs of the western spadefoot. We start with the individual level needs, then move to the population level, and then finally to the species level. Needs for each level addresses that level; for example, if the needs of the species cannot be met, the species condition will decline and may eventually go extinct. The needs are cumulative across levels. That is, if the needs of an individual cannot be met, then that individual will not survive, and as such, it will not contribute to a population. Therefore, if the needs of individuals in a population are not met over time, the population will not persist. Similarly, if the needs of a population cannot be met, that population will not persist, and in turn, it will not contribute to the species persistence. Thus, failure to meet individual-level or population-level needs (on a large enough scale) can ultimately lead to species extinction as well.

If the needs of individuals in a population are being met, and resources allow for an adequate population size with sufficient rate of growth, then that population is resilient. The number of resilient populations and their distribution (and their level of connectivity) will determine the species' level of redundancy. Similarly, the breadth of genetic or environmental diversity within and among populations will determine the species' level of representation. Thus, for the species to sustain populations in the wild over time, the populations need to be able to withstand stochastic events (to have resiliency), and the species' as a whole needs to be able to withstand catastrophic events (to have redundancy) and to adapt to changing environmental conditions (to have representation). There are currently no known differences in species needs between the northern and southern western spadefoot clades, therefore the species needs identified in this SSA apply to both.

7.1 Individual Needs

We assessed the best available information to identify the resource needs to support individual fitness at all life stages for western spadefoot. For the purpose of this SSA, the needs that were considered most significant include aquatic breeding pools, upland habitat, seasonal rains, and small invertebrate prey. Table 1 summarizes the individual resource needs of western spadefoot by life stage and resource function and Figure 5 illustrates how individual needs affect population resiliency.

Table 1: Individual needs for all life history stages of the western spadefoot.

Individual Need	Life Stage	Resource Function
Aquatic Breeding Pools	Eggs, Tadpoles, Juveniles, Adults	Breeding, Feeding, Sheltering
Upland Habitat	Juveniles, Adults	Sheltering
Seasonal Rains	Adults	Breeding, Feeding
Small Invertebrate and Vertebrate Prey	Tadpoles, Juveniles, Adults	Feeding

7.1.1 Aquatic Breeding Pool

Vernal pools are the primary aquatic breeding environment for western spadefoot (Storer 1925, p. 153). Vernal pools are ephemeral wetland habitat that form in areas where rainwater is restricted from downward percolation due to an impermeable surface or subsurface layer (Keeler-Wolf *et al*. 1998, p. 9). The restrictive layer may be a hardpan, clay pan, or bedrock depending on geographic region and local geology. The pools fill during the rainy season, with inundation varying annually depending on the amount of rainfall. Typical pond depth is 2–48 cm (0.8–19 in) (Barbour *et al*. 2007, p. 23). Most vernal pools are concentrated on the alluvial terraces extending west from the base of the Sierra Nevada foothills, and elevated terraces adjacent to stream and slough channels within the Great Valley basin, basin rim, and margins of the Sacramento-San Joaquin Delta (Holland 1978, pp. 3–5). In the Coast Range vernal pools are known from Los Angeles County north to Contra Costa County (Service 2005, pp. I-9–I-10, I-12). In southern California (Orange, Riverside, and San Diego Counties) and northern Baja California, Mexico, pools occur either on gently sloping mesas standing above the primary drainages or in valleys at the low end of a watershed (Bauder and McMillan 1996, p. 56; Service 1998, pp. 1–20). Although vernal pools are considered the primary aquatic breeding habitat, eggs and larvae of western spadefoot have been observed in a variety of permanent and temporary wetlands, both natural and altered, including non-flowing rivers, creeks, artificial ponds, livestock ponds, sedimentation and flood control ponds, irrigation and roadside ditches, roadside puddles, tire ruts, and borrow pits, indicating a degree of ecological plasticity (CNDDB 2019). Neither rates of survival nor reproductive success have been documented to fully understand the use and relative importance of altered habitats.

In order for western spadefoot to utilize the aquatic breeding pools, water temperatures must be between 9 and 30 °C (48–86 °F) (Brown 1967, p. 746). Eggs are laid in the aquatic breeding pools and larvae are solely aquatic until metamorphosis occurs 3–11 weeks after hatching, depending on food availability and pool duration. Warm water can increase the rate of development to some extent to avoid desiccation from drying pools (Burgess 1950, p. 49–51; Feaver 1971, p. 53; Morey 1998, p. 86). Turbid water sometimes found in vernal pools allows for protection of eggs and larvae from predators (Morey 2005, p. 515). Since vernal pools are ephemeral, they may be optimal aquatic breeding habitat due to reduced abundance of both native and nonnative predators, many of which require more permanent water sources (Jennings and Hayes 1994, p. 96; Stebbins and McGinnis 2012, p. 158; Thomson *et al*. 2016, p. 134). The aquatic breeding pools are necessary for western spadefoot adults to disperse and reproduce, and for eggs and larvae to survive.

7.1.2 Upland Habitat

Western spadefoots are almost completely terrestrial and enter water only to breed. During a majority of their life cycle, western spadefoots are dormant and estivate (summer dormancy), remaining in a torpor state in underground burrows in upland areas surrounding their aquatic (breeding) habitat (Ruibal *et al.* 1969, p. 581; Morey 2000, entire; Morey 2005, pp. 515–516). This is a behavioral mechanism used by some amphibians to maintain moisture, slow metabolism, and avoid the excessive heat and dry period occurring from late spring through early fall when resources are limiting or environmental conditions are not favorable (Withers and Cooper 2019, p. 952). Research from spadefoots in southeastern Arizona (*Spea multiplicata*) has found that they remain dormant for 8 to 10 months in burrows 20–90 cm deep; during the approximate two-month active season, when spadefoots emerge at night from seasonal rains, they are found in more shallow underground burrows of approximately 2–10 centimeters (Ruibal *et al*. 1969, pp. 571, 575–583). As stated above, western spadefoots typically burrow approximately 1 m (3 ft) below ground during estivation (Stebbins and McGinnis 2012, p. 157). Spadefoots are able to dig their own burrows by digging backwards into soil using their foot spades (Stebbins and McGinnis 2012, p. 154). Burrow sites tend to have a high amount of duff or dead vegetation from previous years (Baumberger 2013, p. 25). Burrows are constructed in soils that are relatively sandy and friable as these soil attributes facilitate both digging and water absorption (Ruibal *et al*. 1969, p. 581; Baumberger 2013, p. 27). A certain level of moisture in the soil is required for burrowing individuals to avoid desiccation, but the required level of moisture is unknown. The permeable skin of the toads allows water absorption from the soil (Ruibal *et al*. 1969, p. 582). Spadefoots 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, p. 582; Shoemaker *et al*. 1969, p. 585). The upland habitat which provides underground burrows are necessary in order for western spadefoot adults to survive. Western spadefoot may also create shallow burrows or use other animal burrows to provide shelter and cover during their above ground active season (Morey 1998, pp. 86–90; Morey and Guinn 1992, pp. 149–156). The availability of and access to suitable upland habitat likely influences the ability of adults to disperse and reproduce. If the upland habitat does not provide the capability to allow for underground burrows, is not accessible, or outside the dispersal capabilities of western spadefoot from aquatic breeding pools, then individual needs are not fulfilled.

7.1.3 Seasonal Rains

Development of aquatic breeding pools is dependent on seasonal rains that occur in the winter and spring. The amount of rain annually can determine the number and depth of pools available (Pyke 2004, p. 123). A majority of pools fill directly from precipitation, but some fill from the surrounding watershed once soils are saturated (Hanes and Stromberg 1998, p. 38). In addition, the vibrations from seasonal rains are likely the environmental cue for spadefoots to emerge from underground burrows (Dimmitt and Ruibal 1980a, p. 26). Precipitation in

California is highly variable from year-to-year (Dettinger *et al*. 2011, p. 445). California has a Mediterranean climate characterized with cool, wet winters (October through April) and warm, dry summers (Dettinger *et al*. 2011, p. 446). The difference between a "wet" year and a "dry" year in California can be accounted for by a few well-timed storms (Dettinger *et al*. 2011, p. 445). Even within the range of western spadefoot, annual average rainfall varies with northern areas typically receiving progressively more rainfall (PRISM 2022). Figure 4 shows average annual precipitation over a 30-year period of 1991–2020 within the range of western spadefoot. Average annual precipitation ranges from as little as approximately 10 centimeters (cm) (4 inches (in)) up to 102 cm (40 in) in higher elevation areas on the peripheral of the projected range (Fig. 4). Northwestern Mexico has high meteorological heterogeneity, as observed in spatial and seasonal variability of precipitation making it difficult to measure the average annual precipitation (Gutierrez *et al.* 2010, p. 133). Historical records from San Pedro Martir in Baja California measured average annual rainfall for the area to be around 18 cm (7 in) (Hastings and Turner 1965, p. 208). Seasonal rains are necessary as a dispersal cue for adult individuals to disperse and reproduce and is necessary to maintain water levels in pools long enough for western spadefoot eggs to hatch and tadpoles to metamorphose to juveniles.

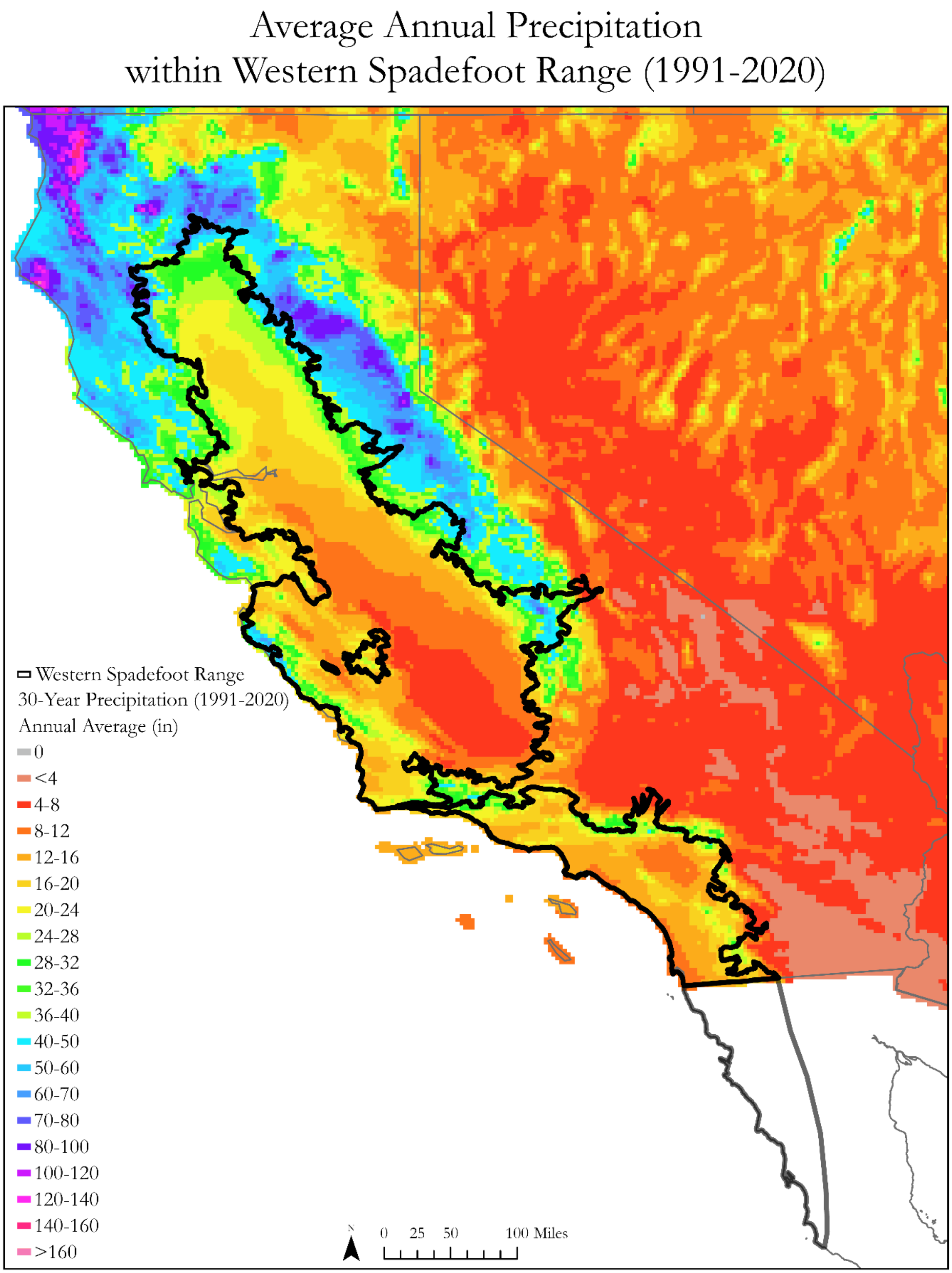

Figure 4: The average annual precipitation over a 30-year period of 1991–2020 within the range of western spadefoot. Precipitation data from PRISM Climate Group at Oregon State University (PRISM 2022).

7.1.4 Small Invertebrate Prey

Adult western spadefoot forage on a variety of small invertebrate prey. Stomach content examinations have found food that includes grasshoppers, true bugs, moths, ground beetles, predaceous diving beetles, ladybird beetles, click beetles, flies, ants, and earthworms (Morey and Guinn 1992, p. 155). Adult western spadefoot can consume 11 percent of their body mass during a single feeding (Dimmitt and Ruibal 1980b, p. 857). Adults must be able to acquire sufficient energy for their long dormancy period of 8 to 10 months in only a few weeks (Seymour 1973, p. 435; Dimmit and Ruibal 1980b, pp. 858–861). The specific food items consumed by western spadefoot larvae are unknown, but they likely need some food to persist. The larvae of plains spadefoots (*Scaphiopus bombifrons*) consume planktonic organisms and algae, fairy shrimp, and will scavenge dead organisms, including other spadefoot larvae (Bragg 1962, p. 144; Bragg 1964, pp. 17–23). Adult, juvenile, and presumably larval western spadefoot consume food items that are also used by other co-occurring amphibians including: pacific tree frog (*Pseudacris regilla*), California tiger salamander (*Ambystoma californiense*), and western toad (*Anaxyrus boreas*) (Morey and Guinn 1992, p. 155). Therefore, resource competition may occur depending on food abundance. Availability of small invertebrate prey is necessary for the survival of western spadefoot adults, juveniles, and larvae. Both aquatic breeding pools and upland habitat contribute to the habitat necessary for western spadefoot foraging.

7.2 Population Needs: Resiliency

At the population level, we used the best information available to assess the resources, circumstances, and demographics that most influence the resiliency of a western spadefoot population. Resiliency describes the ability of a population to withstand stochastic disturbance. Resiliency is often positively related to population size and growth rate and may be influenced by connectivity among populations. If a species is resilient, we assume there exists sufficient suitable habitat in a condition to support large and stable enough populations such that the species can withstand stochastic events. Stochastic events that may impact western spadefoot populations include weather anomalies, such as years of low precipitation. A variety of factors may regulate western spadefoot population levels. These factors may be density-dependent (e.g., habitat quality, habitat abundance) or density-independent (e.g., climate). Figure 5 is a conceptual model that shows how the individual needs discussed in the previous section influence the demographic needs, which ultimately affect population resiliency.

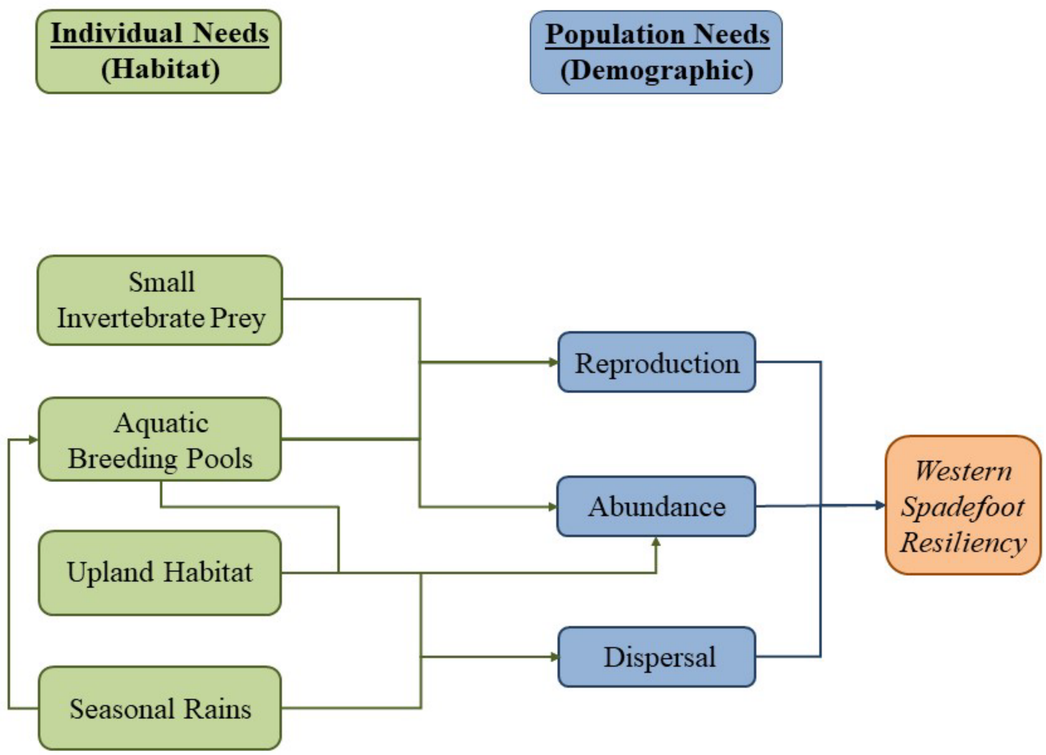

Figure 5: Conceptual model showing the relationship between individual needs and population needs, and how they influence resiliency of western spadefoot populations.

7.2.1 Reproduction

Spadefoots emerge from burrows to breed following rains in the winter and spring. Adults breed and lay eggs in aquatic pools. Tadpoles rely on aquatic pools and can speed up metamorphosis if necessary when pools begin drying (Feaver 1971, p. 53; Morey 1998, pp. 86–89). Larval development can be completed in 3 to 11 weeks depending on food resources and temperature, but must be completed before the pools dry (Burgess 1950, pp. 49–51; Feaver 1971, p. 53; Morey 1998, p. 86). Annual reproductive success varies with precipitation levels, with success being lower in drier years (Fisher and Shaffer 1996 pp. 1394–1395). Longer periods of larval development have been associated with larger size at metamorphosis and likely increased fitness (Morey 1998, p. 86). Pools that persist for longer periods permit longer larval development, resulting in larger juveniles with greater fat reserves at metamorphosis (Morey 1998, p. 86). Larger individuals of New Mexico spadefoot toads (*Spea multiplicatus*) have been found to have higher fitness level and survivorship (Pfennig 1992, p. 1408). During dry years there may be fewer pools available for breeding and a shorter time period for tadpoles to develop. The rate of reproductive success needed for a population of western spadefoot to persist is unknown. Individuals within a population must have aquatic breeding pools for reproduction to be successful.

7.2.2 Dispersal

Western spadefoots must disperse between aquatic breeding pools and underground burrows during the breeding season. Adults disperse from underground burrows to aquatic breeding pools in order to reproduce. After the breeding season, adults and juveniles must disperse to underground burrows for shelter during the hot, dry summer. Seasonal rains are the environmental cue that initiates the breeding dispersal (Dimmitt and Ruibal 1980a, p. 26). Dispersal distances are heavily dependent on the amount of rain (Baumberger *et al*. 2020, pp. 1, 7–8). The maximum dispersal distance that has been recorded for western spadefoot is 605 m (1985 ft) (Baumberger 2020, pers. comm.). A study looking at movement of western spadefoot individuals in multiple Orange County breeding pools during a dry year found that the mean distance moved away from breeding pools was 69 (±60) meters (m) (75 yards (yd)), with the longest movement of an individual being 262 m (287 yd) (Baumberger 2013, p. 14). A study in Orange County on the same populations of spadefoot during a wet year found that the mean distance moved away from breeding pools was 137 m (±92) (150 yd), highlighting the difference that precipitation makes in maximum movement distances recorded (Baumberger *et al*. 2020, p. 17). The maximum upper 95 percent limit posterior predictive distribution for distance to breeding pool was 460 m (1509 ft) (Baumberger *et al*. 2020, p. 7). The western spadefoot needs opportunities for dispersal and interbreeding among multiple breeding pools. Dispersal between breeding pools creates metapopulations that allow for gene flow, which is vital for preventing inbreeding (Neal *et al*. 2020, pp. 26–28). Habitat corridors between breeding sites are necessary for continued gene flow. In order for dispersal to be successful, individuals in a population must have seasonal rains, aquatic breeding pools, and underground burrows available. The aquatic breeding pools and underground burrows must be within dispersal distance for the population to successfully reproduce.

7.2.3 Abundance

A certain number of individuals is necessary to survive in each generation in order to sustain a viable population, both demographically and genetically, of western spadefoot. However, it is unknown how many western spadefoot individuals are necessary in order to maintain a viable population. Abundance is the census number of individuals in a population, and is the net result of reproduction, dispersal (immigration and emigration), and survivorship. Abundance estimates are not available for this species, but effective number of breeders has been estimated at breeding pools throughout both the northern and southern western spadefoot clades. Although effective number of breeders is not a count of individuals, it is the number of individuals that are contributing to the population size in a single cohort. The average effective number of breeders measured in multiple breeding pools in the northern clade of western spadefoot (north of the Transverse Range) was found to be 5.25 individuals ranging from 2.3 to 18.3, and in the southern clade the average effective number of breeders measured in multiple breeding pools was 4 individuals ranging from 1.4 to 20.7 (Neal 2019, p. 113). Effective population size, which is a generational calculation of individuals contributing to population size, has only been measured in a small portion of the western spadefoot range in Orange County within the southern clade. Measured effective number of breeders in Orange County (a site in the southern DPS's range) was found to vary from 1.4 to 19.8 individuals (Neal *et al*. 2020, p. 620). In comparison to other pond-breeding amphibians the effective number of breeders measured for western spadefoot is very low (Funk *et al*. 1999, pp. 1633, 1637; Rowe and Beebee 2004, pp. 292–298; Wang 2009, p. 3848; Wang *et al*. 2011, p. 914; Wang 2012 pp. 1033–1034; Richmond *et al*. 2013, p. 815). The lowest estimation for another pond breeding amphibian is approximately 7 to 30 individuals in black toad (Wang 2009, p. 3847). It is unknown if the small effective number of breeders that were measured for western spadefoot are due to small populations or inbreeding. It is hypothesized the low number of effective breeders could be due to recent droughts and low rainfall years throughout the western spadefoot range and that the species has likely not always had a low number of effective breeders per population (Neal 2019, p. 32; Neal *et al*. 2020, p. 623). Portions of California within the western spadefoot's range has experienced extreme drought conditions (D3 conditions) in 2007–2009 and again in 2012–2014 and 2020–2021 (Williams *et al*. 2015, pp. 6823–6824; NOAA 2021a, entire), and exceptional drought conditions (D4 conditions) 2014–2016 and 2021 (NOAA 2021a, entire). A drought condition of D3, corresponds to an area where major crop and pasture losses are common, wildfire risk is extreme, and widespread water shortages can be expected requiring restrictions. The D4 condition corresponds to an area experiencing exceptional and widespread crop and pasture losses, wildfire risk, and water shortages that result in water emergencies (NOAA 2021b). With a relatively short life span of 5 to 6 years, extended periods of drought likely have a significant influence on abundance, genetic diversity and the estimated effective number of breeders. Drought is further discussed in section 8.4 (below) of the Species Status Assessment. If the low effective population size is due to inbreeding, then the populations are likely genetically unhealthy which would likely lead to further abundance issues in the future. Occurrence data from Baja California, Mexico, collected as recently as 2019 indicates that western spadefoot is present in Mexico, but abundance information is not available (Peralta and Valdez 2020, pers. comm.).

The minimum number of effective breeders necessary to maintain a stable population is currently unknown for western spadefoot. The 50/500 general rule of thumb in conservation biology is that a minimum effective population size of 50 is necessary to combat inbreeding and a minimum of 500 individuals is needed to reduce genetic drift (Franklin 1980, entire). Without species specific minimum viable population size information available for western spadefoot, the 50/500 general rule of thumb is the best information to estimate the appropriate effective population size for western spadefoot. To maintain sufficient abundance for a viable western spadefoot population, individuals must have all the individual needs as discussed in the previous section including small invertebrate prey, aquatic breeding pools, underground burrows, and seasonal rains.

7.3 Species Needs

At the species level, we assessed the representation and redundancy of the northern western spadefoot clade and the southern western spadefoot clade to ultimately better understand the species' viability. Representation is the ability of a species to adapt to changing environmental conditions and redundancy is the ability of a species to withstand catastrophic events. Viability is defined as the ability of western spadefoot to sustain populations in the wild over time. Using the SSA framework, we describe the species' viability by characterizing the status of the species in terms of its representation and redundancy.

7.3.1 Representation

As discussed above, representation describes the ability of a species to adapt to changing environmental conditions over time. In other words, representation attempts to characterize a species' evolutionary adaptability to its environment. Because this is often difficult to determine, we use the breadth of environmental and genetic diversity within and among populations as a surrogate for evolutionary adaptability. Within the northern western spadefoot clade, three genetic clusters have been identified: populations north of the Sacramento-San Joaquin Delta, populations south of the Sacramento-San Joaquin Delta in the Central Valley, and populations on the central coast (Neal 2019, p. 115). Within the southern western spadefoot clade, two genetic clusters have been identified as optimal: populations in Ventura, Los Angeles, and Orange counties; and populations in San Diego County (Neal 2019, p. 115). Additionally, the geographic range within just the northern western spadefoot clade and within just the southern western spadefoot clade varies in habitat type and climate, indicating some tolerance for adaptation to change. The northern portion of California's Central Valley and the coastal regions within the range of the northern clade receive more rain and have cooler average temperatures than the southern portion of California's Central Valley within the northern western spadefoot clade (PRISM 2022 (Figure 4); WRCC 2020). The southern western spadefoot clade has a range of climatic conditions in the large area between Ventura, California and down throughout the northwestern portion of the Baja Peninsula in Mexico with differences in precipitation and temperature between populations closer to the coast and those that are further inland (Gutierrez *et al.* 2010, p. 133; PRISM 2022 (Figure 4); WRCC 2020). Furthermore, unique vernal pool regions have been identified within the western spadefoot range, ten within the northern western spadefoot clade and three within the southern western spadefoot clade (Keeler-Wolf *et al*. 1998, p. 12). Each identified vernal pool region is unique in the biological communities and the abiotic features, such as soils and geomorphology, that make up the vernal pools within the region (Keeler-Wolf *et al*. 1998, p. 13). Each western spadefoot clade has representation from the variation in climatic conditions and the unique biotic and abiotic features across the range.

7.3.2 Redundancy

Redundancy refers to the ability of species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations). Redundancy is about spreading the risk and can be measured through the duplication and distribution of populations or meta-populations across the range of the species. As a surrogate for population, each western spadefoot clade was separated into 10 habitat regions which have unique biological communities and abiotic features, such as soils and geomorphology, that make up the vernal pools or aquatic breeding habitat within the region. We then used the number of "local populations" within each region to assess redundancy. Local populations were defined using known occurrence data that was buffered from the centroid of the occurrence by 2,000-m in the northern clade and 1,000-m in the southern clade. Occurrences where buffer areas overlapped were considered part of one local population. To determine the appropriate number of local populations for each region, we asked species experts to provide an estimate of the number of local populations they thought were needed for each unique region to be resilient. We then took the median of the numbers we received from experts to determine the appropriate number of local populations for each region to be resilient. Species experts recommended approximately 68 local populations across the northern clade of western spadefoot and 71 local populations across the southern clade of western spadefoot distributed across 10 regions in each clade. A table of the expert feedback that was received for appropriate number of local populations in each region can be found in Appendix B. The greater the number of local populations a species has distributed over a larger landscape, the better it can withstand catastrophic events. Catastrophic events that could impact both northern and southern western spadefoot include extended drought periods or the spread of a deadly disease. Implications of these events are discussed in more detail in the "Influences to Viability" section below. Multiple local populations within the northern western spadefoot clade and the southern western spadefoot clade are distributed throughout the ranges as described above. The wide distribution of both clades provides varying habitat, climatic, and genetic differences which improve the redundancy of both northern western spadefoot and southern western spadefoot in the event of a catastrophic event.

8.0 INFLUENCES TO VIABILITY

We use the term *threat*, in a general sense, to refer to actions or conditions that may be or are reasonably likely to negatively affect individuals of a species. Threats includes actions or conditions that have a direct impact on individuals (direct impacts), as well as those that affect individuals through alteration of their habitat or required resources (stressors). Threats may encompass—together or separately—the source of the action or condition or the action or condition itself. A threat's significance depends upon a population-level assessment of the scope and severity and the related imminence. One or more of the threats identified could be reduced through existing conservation practices or management activities. In our overall analysis of the impacts of threats on western spadefoot, we consider all the threats together cumulatively, regardless of the threat's magnitude or extent.

Below we assess the influence of development, overabundance of vegetation, nonnative predators, drought, chemical contaminants, noise disturbance, disease, and effects of climate change on western spadefoot resiliency, redundancy and representation. We carry forward only the influences that are determined to potentially threaten western spadefoot populations. We address threats that may affect the species in the future separately as part of the scenarios discussed in the Future Condition section, below. In this section, we evaluate the significant past, current, and future influences that are impacting western spadefoot resiliency, redundancy, and representation. These influences impact individual, population, or species needs, ultimately affecting the viability of the species. All influences are known to affect both the northern western spadefoot and the southern western spadefoot, unless otherwise noted. The threats discussed below not only act independently, but also interact with each other. It is important to assess the impacts of combined threats, because there may be new or exacerbated impacts that are not considered when a threat is assessed alone. There are a vast number of ways the combined threats may be interacting with each other, but the SSA will only focus on what is currently most relevant to the viability of the species. Figure 7 shows the relationships between the significant threats, western spadefoot individual needs, western spadefoot population needs, and ultimately western spadefoot viability.

8.1 Development and Land Conversion

Both the northern and the southern western spadefoot clades likely suffered dramatic reductions in the mid to late 1900s when urban development and agricultural conversion were rapidly destroying natural habitats in the Central Valley and southern California (Jennings and Hayes 1994, p. 96; Thomson *et al*. 2016, p. 134). This loss of habitat associated with urban development and agricultural conversion has been attributed as the predominant change to western spadefoot abundance and distribution (Morey 2005, p. 515). Indirect impacts from development and land conversion includes habitat fragmentation, alteration, and degradation. Overtime such fragmentation, degradation, and alteration may cause ponded habitats to be less productive or be lost as breeding habitat for the western spadefoot (Service 2005, pp. I-16–I-28, II-232–II-234). In southern California, within the southern western spadefoot clade, by the early 1990s over 80 percent of the habitat once known to be occupied by western spadefoot had been developed or converted to uses that are incompatible with successful reproduction and recruitment (Jennings and Hayes 1994, p. 96). Soils supporting vernal pools within the southern western spadefoot clade were never extensive in comparison to the Central Valley of California, and large-scale development has significantly reduced vernal pool habitat in the southern western spadefoot clade (Bauder and McMillan 1996, p. 56; Service 2005, p. I-17). In northern and central California, within the northern western spadefoot clade, loss of habitat has been less severe, but estimates suggest that over 30 percent of the habitat once occupied by western spadefoot has been developed or converted to agriculture (Jennings and Hayes 1994, p. 96). Comparing extant vernal pool habitat from 2005 to 2012 within the northern western spadefoot clade, an estimated 6,758 acres (ac) (2,735 hectares (ha)) of vernal pool habitat were lost per year due to agricultural and urban development (Witham *et al*. 2014, pp. 1, 4–5). A total of 764,868 ac (309,532 ha) of vernal pool habitat was found to be extant in 2012, a loss of 42,952 ac (17,382 ha) since 2005 (Witham *et al*. 2014, p. 1). Development can directly destroy aquatic breeding pools and upland habitat, or it can alter the hydrology such that aquatic breeding pools may not form where they once existed. With the loss of aquatic breeding pools and upland habitat, abundance, dispersal, and reproduction within the northern and southern clades have been reduced because individuals no longer have the resources available to survive and disperse in order to reproduce.

Habitat degradation can also occur in areas fragmented by or adjacent to developed areas due to management constraints such as limiting grazing or prescribed fire causing a build-up of vegetation. Nonnative vegetation or overabundance of vegetation can degrade vernal pool habitat by intrusion into the ponded areas or cause shortening to the hydroperiod of the pools (Clark *et* *al*. 1998, pp. 251–252). Vernal pools are a major component of northern western spadefoot and southern western spadefoot habitat. The fragmentation and encroachment into vernal pool habitats due to urbanization and agricultural conversion has resulted in smaller areas of unmanaged vernal pool habitat, further degrading and altering habitat used by the western spadefoot(Shedd 2016, pp. 20–23).

Roads represent an additional threat associated with development to the western spadefoot. Road construction can result in the direct mortality of spadefoots and can cause loss and fragmentation of habitat that could limit dispersal necessary for reproduction. Mortality of western spadefoot from motor vehicle strikes has been observed by multiple researchers throughout the range of both the northern and southern clade (Morey and Guinn 1992, p. 150; CNDDB 2019). Roads can also be a barrier to movement and effectively isolate populations. A recent compilation (Brehme *et al*. 2018, p. 922) found that western spadefoot road risk level was "high" (the second most impactful of five possible levels). Development will likely continue to impact both western spadefoot clades as California's human population continues to grow (California Department of Finance 2017, entire). The range of predicted human population growth into the future, which will likely lead to increased development, varies across the range of western spadefoot. Amador County in California is predicted to have a human population decrease by about 20 percent by 2050, whereas Kings County is predicted to have a human population increase by about 49 percent by 2050 (CalTrans 2016, pp. 10, 62). Of the 37 counties within the western spadefoot range, only four are projected to have a decrease in human population size and 33 are expected to increase (CalTrans 2016, entire). Within just the southern western spadefoot clade, all five counties are expected to increase by 14–42 percent (Caltrans 2016, pp. 74, 118, 130, 146, 222). From a genetic perspective, current urbanization increased genetic landscape resistance (how the surrounding landscape and environment facilitates or hinders gene flow) by 3100 percent in southern western spadefoots (Neal 2019, p. 114), and additional development will only further exacerbate this problem. Overall, development reduces the availability and quality of the individual needs of aquatic breeding pools and upland habitat, which impacts the western spadefoot population needs of abundance, dispersal, and reproduction.

Some conservation efforts reduce the impact and extent of development and land conversion on the western spadefoot. Land preservation and habitat restoration, some of which has been accomplished through the implementation of Habitat Conservation Plans (HCPs) and State Natural Community Conservation Plans (NCCPs), has been implemented throughout the species range, but particularly in the southern clade. For more information on measures that address the threat of development and land conversion, see 8.11 Conservation.

8.2 Overabundance of Vegetation

The plant community within the grassland landscapes in California has dramatically changed since European settlement of the area (Burcham 1956, pp. 81–85). These changes resulted from numerous factors including the reduction of wetlands, changes to native herbivore abundance and distribution, reduction of wildfire, and changes in vegetation from mostly perennial grasslands to annual nonnative species (Barry et al. 2006, pp. 7–9). Nonnative annual vegetation or overabundance of vegetation can degrade vernal pool habitat by intrusion into the ponded areas, increasing vegetative matter, or causing shortening of the hydroperiod of the pools (Clark et al. 1998, pp. 251–252; Marty 2005, pp. 1626–1632). As stated above, vernal pools make up the majority of aquatic habitat for the western spadefoot. Changes in vernal pool hydrology caused by overabundant vegetation may adversely affect western spadefoot populations. Overabundant vegetation is caused by both nonnative plant invasion as well as the lack of wild grazers on native vegetation. When there is too much vegetation around aquatic breeding pools, the vegetation absorbs the water and the pools dry more quickly. Grazing by both wild grazers and livestock grazers plays an important role in maintaining a balance of vegetation in areas with aquatic breeding pools. Removal of grazing has been found to reduce the inundation period of pools below the amount of time required for western spadefoot to successfully metamorphose (Marty 2005, p. 1626). An assessment of vernal pool habitats in the northern clade found that regions with no grazing had more invasive weeds that cause pools to dry more quickly (Vollmar *et al*. 2017, pp. 2–13). However, livestock may crush or even consume egg clusters while utilizing ponds and cause a minor amount of direct mortality to adult and juvenile toads through trampling. Additionally, in some soil types, particularly in southern California, grazing can impact the crust and cause an invasion of weeds rather than enhance vernal pools. Breeding habitat in the various regions experience unique threats and may need to be managed differently. Overabundant vegetation reduces the quality of aquatic breeding pools by causing them to dry more quickly, which then has impacts on reproduction and abundance.

8.3 Nonnative Predators

Western spadefoots have many natural predators including, but not limited to, water birds, raptors, garter snakes, rattlesnakes, California tiger salamanders, and raccoons (Childs 1953, p. 228; Feaver 1971, pp. 44–45; Baumberger *et al*. 2020, p. 6). Natural predation is not known to be occurring at a higher than normal frequency on western spadefoot populations. However, there have been nonnative crayfish (*Procambarus clarkia*), mosquitofish (*Gambusia affinis*), African clawed frogs (*Xenopus laevis*), and bullfrogs (*Lithobates catesbeianus*) introduced within the range of both western spadefoot clades that have been found to be predators to western spadefoots (Hayes and Warner 1985, p. 109; Hayes and Jennings 1986, p. 490; McCoid et al. 1993, pp. 29–30; Jennings and Hayes 1994, p. 96; Fisher and Shaffer 1996, pp. 1389, 1392; Kuperman *et al*. 2004, p. 229; Touré et al. 2004, p. 2; Balfour and Ranlet 2006, p. 212; Peralta-Garcia et al. 2014, pp. 431–434; Thomson *et al*. 2016, p. 134; CaliforniaHerps 2023, entire). However, researchers looking at the diet of African clawed frogs at a site in Riverside, California, found the species' diet was mostly slow-moving invertebrates (McCoid and Fritts 1980, pp. 273–274). In an ephemeral aquatic habitat in southern California occupied by both the African clawed frog and western spadefoot, western spadefoots were still able to reproduce as confirmed by the presence of dispersing metamorphs (Ervin and Fisher 2001, pp. 265–266). All of the nonnative predators 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, pp.

1392–1393). An inverse relationship has been observed between the presence of nonnative predators and western spadefoots (Fisher and Shaffer 1996, p. 1393). Nonnative predators may have displaced western spadefoots at lower elevations, resulting in western spadefoots being found primarily at higher elevation sites where predators are less abundant (Fisher and Shaffer 1996, pp. 1392–1394). Nonnative predators likely pose a greater threat to western spadefoot eggs and larvae given both life history needs and morphological and physiological differences between life stages. Adults and juveniles have an extended dormancy period which reduces interaction time with nonnative predators. Western spadefoot adults 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, p. 156). This may reduce the amount of contact and predation adult western spadefoots have with nonnative bullfrogs. In addition, toxic secretions from dermal glands of adult and juvenile spadefoots provide a significant deterrent to predators. However, nonnative species may also compete for resources with western spadefoots, thus potentially limiting adult and juvenile foraging success (Morey and Guinn 1992, p. 153). The extent to which nonnative predators are impacting western spadefoot populations is unknown. Nonnative predators can negatively impact the individual needs of small invertebrate prey, which can impact the abundance of western spadefoot populations because the number of individuals that can be supported by the food source would be compromised. Additionally, western spadefoots are prey for nonnative predators further reducing the abundance of populations. Figure 6 displays the known locations of nonnative species that may be impacting both clades of western spadefoot populations.

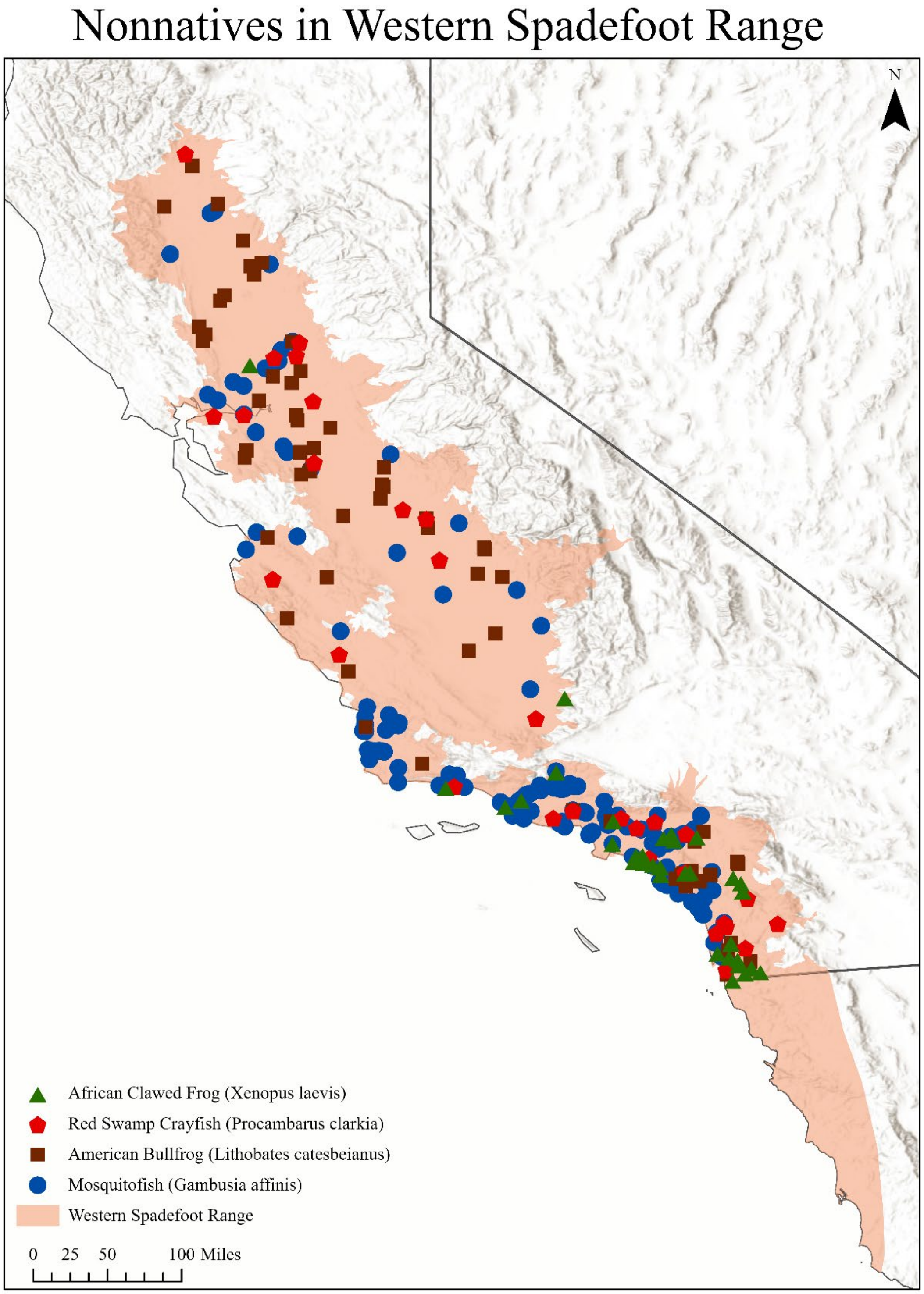

Figure 6: Figure displaying common nonnative species within the projected range of western spadefoot. Nonnative species locations are from U.S. Geologic Survey Nonindigenous Aquatic Species Database. Range projections for western spadefoot are from IUCN and CWHR.

8.4 Drought

California's annual and seasonal precipitation patterns are extremely variable and dry conditions are common (California Department of Water Resources 2021, entire). Western spadefoots are adapted to dry conditions by both behavioral and physiological characteristics (see *Species' Life History and Habitat*, above; Service 2023, pp. 9–10). The U.S. Drought Monitor (a partnership of several Federal agencies and programs) gathers national precipitation information and categorizes normal and dry (drought conditions) into six categories of increasing dryness and severity from normal or wet conditions (None), abnormally dry (level D0), moderate drought (level D1), severe drought (level D2), extreme drought (level D3), and exceptional drought (level D4) (U.S. Drought Monitor 2023, entire). Portions of California within the western spadefoot's range has experienced extreme drought conditions (D3 conditions) in 2007–2009, 2012–2014, and again in 2020–2021 (Williams *et al*. 2015, pp. 6823–6824; NOAA 2021a, entire) and exceptional drought conditions (D4 conditions) in 2014–2016 and 2021 (NOAA 2021a, entire). A drought condition of D3, corresponds to an area where major crop and pasture losses are common, wildfire risk is extreme, and widespread water shortages can be expected requiring restrictions. The D4 condition is more severe than D3 and corresponds to an area experiencing exceptional and widespread crop and pasture losses, wildfire risk, and water shortages that result in water emergencies (NOAA 2021b). Within the last 15 years portions of California within the western spadefoot's range have experienced extreme drought conditions (D3 conditions) in 2007–2009, 2012–2014, and again in 2020–2022 (Williams et al. 2015, pp. 6823–6824; NOAA 2021a and 2021b, entire; California Department of Water Resources 2022, pp. 2–4) and exceptional drought conditions (D4 conditions) in 2014–2016 and 2021 (NOAA 2021a and 2021b, entire). Anthropogenic warming likely contributed to the 2012–2014 drought anomaly (Williams *et al*. 2015, pp. 6819, 6826). It is hypothesized that the recent extended drought periods have led to low effective population size in western spadefoot populations (Neal 2019, p. 32). Drought decreases the quality and quantity of aquatic breeding pools available for western spadefoots. Without aquatic breeding pools available, dispersal and reproductive opportunities are limited, ultimately reducing the abundance of the population. Small invertebrate prey that also depend on vernal pool ecosystems and the seasonal rains that create them are likely also negatively impacted by drought conditions (Colburn *et al.* 2008, pp. 120–122). With a lifespan of only 5–6 years, individuals that experienced the 2007–2009 or the 2012–2016 droughts likely had limited opportunities for breeding and feeding, likely contributing to the low effective population sizes that have been observed (Neal 2019, p. 32). Anthropogenic warming increases the overall likelihood of extreme droughts in California into the future (Williams *et al*. 2015, pp. 6819, 6826). Projected climate change conditions indicate an increased likelihood of more frequent, longer, and intense droughts in the future (Bedsworth *et al*. 2018, p. 57; Swain *et al*. 2018, p. 427).

8.5 Chemical Contaminants

Western spadefoots are exposed to a variety of toxins throughout their range, but the sensitivity and overall population impacts of the western spadefoot 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, including areas within the western spadefoot range (DPR 2017, p. 5). Some of these chemicals can be toxic to aquatic organisms including amphibians and their small invertebrate prey (Davidson 2004, p. 1892; Relyea 2005, p. 1118; Bruhl *et al*. 2013, p. 1). Industrial facilities and motor vehicles also release contaminants. Contaminants from road materials, leaks, and spills could contaminate the water in vernal pools. There is currently no evidence that chemical contaminants are impacting western spadefoots. Research looking into proximity of vernal pool habitat that may be impacted by pesticide drift and the presence of western spadefoot found no significant correlation between presence or absence of western spadefoot and the use of pesticides (Davidson *et al.* 2002, entire). Other than pesticide drift, there has been no research looking into other potential chemical contaminants that could be impacting vernal pool habitat. There is currently no other literature indicating impacts of chemical contamination and in the absence of evidence to the contrary, we do not consider chemical contamination a threat driving individual, population, or species level concerns.

8.6 Noise Disturbance

Western spadefoots are sensitive to noise stimuli and break dormancy and emerge from their burrows in response to noise disturbance (Dimmitt and Ruibal 1980a, p. 26). Activities that produce low frequency noise and vibration, such as grading from construction and development activities, recreational off-road vehicle use, and seismic exploration for natural gas, in or near habitat for western spadefoot, may be detrimental to the species (Ouren *et al*. 2007, p. 20; Service 2005, p. II-234). Disturbances that cause western spadefoot to emerge at inappropriate times could result in mortality or reduced fitness (Dimmitt and Ruibal 1980a, pp. 27–28). Since western spadefoot are dependent on moisture from underground burrows to survive the hot and dry summers (Ruibal *et al.* 1969, p. 571), emerging when rains are not present may cause desiccation of individuals. Once western spadefoot break dormancy and emerge, individuals seek out small invertebrate prey to replenish energy stores. If western spadefoot individuals use the energy to emerge at inappropriate times, and prey species are not present, they may not have the energy available to return into underground burrows and resurface when conditions are appropriate (Dimmitt and Ruibal 1980a, pp. 27–28; Service 2005, p. II–234).

8.7 Disease

Western spadefoots are currently not known to be significantly impacted by any identified diseases, but there are known fungal and parasitic species that infect individuals in both DPSs. Chytridiomycosis (chytrid), a fungal skin disease caused by the pathogen Bd (*Batrachochytrium dendrobatidis*), impacts the young and juveniles of some species of frogs and other amphibians and eventually causes death. Chytrid has caused large-scale extirpation in susceptible amphibian species and occurs in the range of the western spadefoot (Weldon *et al*. 2004, pp. 2100–2104; Padgett-Flohr and Hopkins 2009, pp. 2–8). Bullfrogs, African clawed frogs, and native Pacific chorus frogs (*Pseudacris regilla*), known hosts of Bd, occur in the range of the western spadefoot. They are at least partially resistant to Bd and may act as a reservoir and vector for the disease (Reeder et al. 2012, pp. 1, 4–5; Eskew et al. 2015, pp. 515–516; Tinsley et al. 2015, pp. 380–381). Individual western spadefoots have tested positive for chytrid fungus (*Batrachochytrium dendrobatidis*), but widespread mortality from this disease has not been recorded (Fisher pers. comm. 2020). Out of 139 individuals that were tested for chytrid fungus, 116 tested positive (Fisher pers. comm. 2020). It has also been hypothesized that western spadefoot eggs may fail to develop potentially due to a fungus that thrives in warmer water temperatures and invades spadefoot eggs, and there have been documented cases of western spadefoot infected with nematodes (Storer 1925, p. 158; Brown 1967, p. 746; Goldberg and Bursey 2002, pp. 491–492). Other amphibians have experienced recent significant declines due to disease including chytrid fungus, white fungus (*Saprolegnia ferax*), ranavirus (Family *Iridoviridae*, Genus *Ranavirus*), bacterial infections, and trematodes (Daszack *et al*. 1999, entire; Densmore and Green 2007, entire; Wake and Vredenburg 2008, entire; Duffus *et al*. 2015, pp. 10–14). There is no evidence that indicates western spadefoot is significantly impacted by disease, but there are very few relevant studies and diseases such as chytrid can mutate and potentially create more virulent strains in the future (Adams 2022, entire).

8.8 Wildfire

Wildland fires are a natural part of the environment within the range of the western spadefoot, however due to years of wildfire suppression, increased ignition sources, and climate change causing warmer and dryer conditions, more intense wildfires are occurring more frequently on the landscape (Keeley *et al*. 1999, entire). Within the range of the northern and southern DPSs of the western spadefoot, the areas most susceptible to wildfire are the foothill regions of the Sierra Nevada Mountains and Coast Ranges as well as chaparral and coastal sage scrub habitats in southern California (Rochester et al. 2010, p. 342; Williams et al. 2019, pp. 896–906) that are outside the agricultural areas of the Central Valley (Sacramento Valley and San Joaquin Valley) and low-elevation urbanized areas of southern California (Thomson et al. 2016, p. 134). It is more likely for wildfires to impact populations in the coastal portions of the range and in southern California, and less likely for large wildfires to impact the portions of the range in the Central Valley of California (Thomson *et al*. 2016, p. 134). In a study examining pre- and post-fire amphibian capture rates, western spadefoots were found to have reduced capture rates post-fire in chaparral and coastal sage scrub habitats, indicating that wildfire may be impacting western spadefoot populations (Rochester *et al*. 2010, p. 342). Although wildland fire season typically coincides with the time of year western spadefoot individuals are dormant in underground burrows, high intensity wildfire may reduce the survival of individuals. If a wildfire was to occur during the dispersal period for western spadefoot, it may be particularly devastating for a population (Thomson *et al*. 2016, p. 134). In addition, wildfires may alter the hydrology of an area making it more or less suitable for aquatic breeding habitat during the wet season. Specifically, in the southern clade, vegetation changes that reduce habitat suitability are often the result of increased wildfire frequencies leading to type conversions of habitats overtime (e.g. native grassland or shrub/scrub to non-native grassland). Depending on the characteristics of the fire and time of year, the individual needs of aquatic breeding pools, upland habitat, and small invertebrate prey may or may not be reduced by wildfire. Wildfire likely reduces the abundance of a population.

8.9 Effects of Climate Change

Western spadefoots are dependent on environmental conditions and seasonal weather patterns for supplying both feeding and breeding resources. The transition from estivation to emergence from underground burrows is linked to the vibrations from seasonal precipitation felt by western spadefoot in the fall and winter (Dimmitt and Ruibal 1980a, p. 26). Both foraging on small invertebrate prey and breeding in aquatic breeding pools occurs after western spadefoots emerge from burrows. As stated above, the aquatic pools must be a particular temperature for western spadefoot reproduction to be successful (e.g., 48 to 86 °F (9–30 °C)) (Storer 1925, p. 158; Brown 1967, p. 746); higher ambient temperatures can influence water temperatures. In addition, larval development and metamorphosis must be completed before pools dry (Burgess 1950, p. 49–51; Feaver 1971, p. 53; Morey 1998, p. 86). In California, annual average temperatures have increased by about 0.8 °C (1.5 °F) since 1895 (Kadir *et al.* 2013, p. 38). Additionally, extreme heating events have increased throughout the state (Kadir *et al.* 2013, p. 48). Furthermore, climate change likely contributed to the 2012–2014 drought anomaly discussed above which may be a contributing factor to low effective population size of western spadefoot populations (Williams *et al.* 2015, pp. 6819, 6826; Neal 2019, p. 32).

Climate change will likely increase temperatures throughout the range of both western spadefoot clades into the future (Bedsworth *et al*. 2018, p. 22). In California, statewide models project warming of 2–4 °C (3.6–7.2 °F) (RCP 4.5, medium emissions scenario) to 4–7 °C (7.2–12.6 °F) (RCP 8.5, business as usual scenario) by the end of the century depending on future greenhouse gas emissions (Pierce *et al*. 2018, pp. iv, 17–18). Although the mean annual changes in temperature will likely have impacts, in many ways the effects of climate change will be felt most strongly as extreme temperature events are predicted to increase (Pierce *et al*. 2018, pp. 18–19). Modeled changes in precipitation are more complex and projections are less clear than for temperature. The effects of climate change have significantly increased drought risk in the state (Diffenbaugh *et al*. 2015, p. 3931), leading to increased concern over the reliability of ephemeral vernal pool breeding habitat. Seasonal shifts to precipitation may also occur in California, with less precipitation in the early- to mid-fall (September/November) and more in early winter (December/January) (Pierce *et al*. 2018, pp. iv, 26, Figure 16). These shifts in precipitation may disrupt the timing of emergence and breeding for western spadefoot. Even if average precipitation were to occur within a year, it must occur over a period of time such that the aquatic breeding pools retain water for the eggs to hatch and larvae to become juveniles. In the Baja Peninsula of Mexico, a significant reduction of precipitation is expected as well as temperature changes larger than 2 °C (3.6 °F) warming by 2050 using downscaled regional climate modeling (Cavazos and Arriaga-Ramirez 2012, p. 5904). Climate change has and will likely continue to alter the temperature and precipitation regimes, generally making the environment warmer and dryer, having impacts on the individual needs of seasonal rains, aquatic breeding pools, and small invertebrate prey that will likely cause population impacts to reproduction, dispersal, and abundance. Effects of climate change in the future will be further discussed in chapter 10.0, Future Conditions.

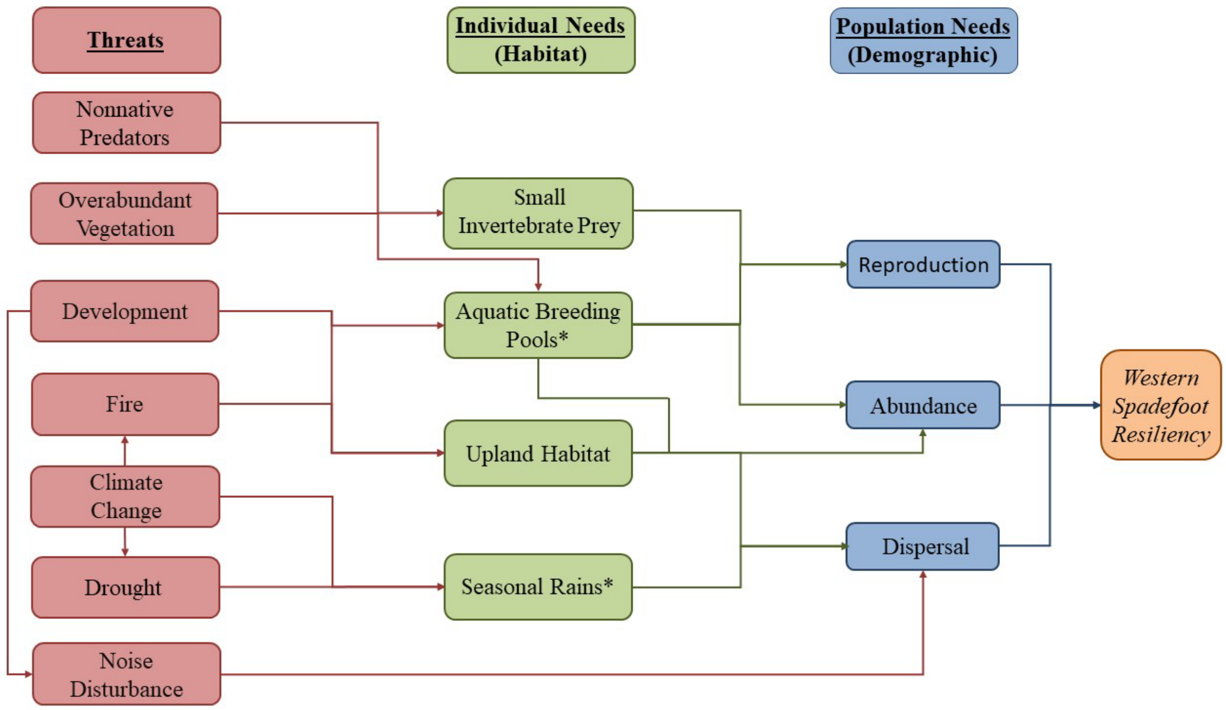

Figure 7: Conceptual model showing the interactions among threats, individual needs, and population needs, and how they interact to impact resiliency of western spadefoot. The green asterisk in the aquatic breeding pools and seasonal rains boxes indicate that these individual needs are connected to each other.

8.11 Conservation

There are several vernal pool species (vernal pool crustaceans and plants) within the range of both the northern western spadefoot clade and the southern western spadefoot clade that are listed as threatened or endangered under the Act (Service 1998, p. 3; Service 2005, pp. I-4–I-7). In the northern clade the Santa Barbara DPS (Service 2000, entire) and Central California DPS (Service 2004, entire) of the California tiger salamander (*Ambystoma californiense*) and the California red-legged frog (*Rana draytonii*) (Service 1996, entire) are found with the western spadefoot range. The western spadefoot is included as a covered species in the 2005 Recovery Plan for Vernal Pool Species (Service 2005, pp. II-220–II-235). As a result of these regulatory and nonregulatory actions a number of conservation efforts have been carried out directly and indirectly for the purpose of conserving and recovering listed vernal pool species and the western spadefoot. Some of those conservation actions have included land acquisition and restoration for the purpose of protecting vernal pool habitat, which is also beneficial for the western spadefoot.

A study of extant vernal pool habitat preserved within regions of the northern western spadefoot clade has found 270,329 ac (109,398 ha) of habitat has been preserved out of 764,862 ac (309,529 ha) of extant vernal pool habitat, meaning approximately 35 percent of extant vernal pool habitat has been conserved in the northern clade (Vollmar *et al*. 2017, pp. 1–14). In southern California, approximately 157,554 ac (63,760 ha) of known western spadefoot habitat has been conserved out of approximately 306,782 ac (124,151 ha) of known extant habitat, approximately 51 percent of known western spadefoot habitat in the southern clade (Table 6). Some land acquisition and restoration activities have been completed as a result of HCPs and NCCPs(Appendix A)(CDFW 2015, entire). HCPs and NCCPs provide paths forward to balance wildlife conservation with development or other activities that may negatively impact species. The primary objective of the HCP program is to conserve species and the ecosystems they depend on while streamlining permitting for economic development. Being included as a covered species under an HCP can result in an applicant setting aside habitat and managing for the species while also receiving an incidental take permit for covered activities, reducing the risk of unpermitted take for planned urban development or business operation activities, within the area the HCP covers. In addition, within the permitted area, avoidance, minimization, and other conservation measures (e.g., monitoring, seasonal work windows, habitat management, etc.) are put into place. There are currently 15 HCPs and 15 NCCPs (some are combined HCP/NCCPs) that include western spadefoot as a covered species, five HCPs are within the range of the northern western spadefoot clades and ten HCPs are within the range of the southern western spadefoot clade. Conservation activities that have been included in HCP's for western spadefoot include habitat protection, light pollution minimization, erosion control of vernal pool habitat, work windows that avoid the reproductive season when western spadefoot are dispersing, exclusion fencing, entrapment avoidance, and monitoring. The full list of HCP's that include western spadefoot or conservation measures that would benefit western spadefoot can be found in Appendix A. In addition to HCP's, there are also several military bases within the range of both the northern and southern western spadefoot clades. These installations have developed Integrated Natural Resources Management Plans (INRMP) that help guide management of natural resources in a manner that is consistent with sustainability of natural resources. Conservation measures are included specifically for the western spadefoot or the vernal pool habitat that western spadefoots utilize.

9.0 CURRENT CONDITION

Current condition may be described in terms of past and ongoing changes in a species' habitat, demographics, and distribution (Smith et al. 2018, p. 306). To assess the current condition of both the northern and southern clades of western spadefoot, we used the best scientific and commercial data available to analyze and describe, both quantitatively and qualitatively, past and ongoing changes in the species' habitat, demographic parameters, and distribution across the two clades and 20 regions described in Chapters 4 through 7. The methods and results of our assessment of current condition are described in this chapter.

9.1 Current Condition Summary of Methods

For our current condition analysis, we consider two clades of western spadefoot, the northern and southern clades. To analyze both clades in more detail, the species' range was divided into multiple regions within both northern and southern western spadefoot clades shown in Figure 8. The regions are not true populations, and are likely made up of multiple metapopulations, but they provide a geographic unit of analysis to assess the current and future conditions of western spadefoot populations across the range of the two clades. The regions in the northern western spadefoot clade were chosen to align with the recovery units in the Service's Recovery Plan for Vernal Pool Ecosystems of California and Oregon (Service 2005, entire). The recovery units were based on the CDFW California Vernal Pool Assessment Preliminary Report defining the vernal pool regions as discrete geographic regions identified largely on the basis of endemic species, with soils and geomorphology as secondary elements, but with some overlap of these features among vernal pool regions (Keeler-Wolf *et al*. 1998, entire). Overall, the vernal pool recovery units are representative of the range of biotic and abiotic features of the vernal pool ecosystem. The regions in the southern western spadefoot clade were estimates provided by species experts to best capture the different habitat types the western spadefoot is found in across southern California and Mexico (Fisher 2020, pers. comm.). Although these regions do not encompass all western spadefoot occurrences, they capture a majority of the vernal pool habitat that is considered ideal for western spadefoot and are representative of the range of both the northern and southern clade. In total, 20 western spadefoot regions were identified, 10 northern western spadefoot regions and 10 southern western spadefoot regions.

A Conditions Category Table (Table 2) was created to assess the individual and population needs outlined earlier in the SSA. Categories were chosen in collaboration with species experts to best address the needs of the species. Table 3 represents the current conditions assigned to the northern western spadefoot regions and Table 4 represents the current conditions assigned to the southern western spadefoot regions. An overall low current condition means that the region has low resiliency and therefore a low probability of persistence under current conditions. A moderate overall condition score means that the region has moderate resiliency and a moderate probability of persistence under current conditions. A high overall condition score means that the region has high resiliency and therefore a high probability of persistence under current conditions.

In order to compile condition category definitions for the Conditions Category Table (Table 2), the best available scientific information was used, including peer-reviewed studies, surveys, feedback from species experts, and reports from U.S. Fish and Wildlife Service and California Department of Fish and Wildlife. Using best available information, we developed condition categories for habitat metrics that include Habitat Quantity/Distribution, Habitat Quality, and Rainfall. We also developed condition categories for the demographic metric of Abundance. Table 2 below, identifies the definitions of high, medium, and low conditions and was used to define the condition categories for both clades.

To assess the current condition of habitat quantity and distribution, we looked at the number of local populations in each region to determine if western spadefoot habitat is on the landscape and if it is geographically spread out to support multiple populations in each region. To determine the appropriate number of local populations for each region, we asked species experts to provide an estimate of the number of local populations they thought were needed for a region to be resilient (see Appendix B). We then took the median of the numbers we received from experts to determine the appropriate number of local populations for each region to be in high condition. To estimate the number of local populations that currently exist in each region, we used positive occurrence data we received from the California Natural Diversity Database (CNDDB), USGS, East Bay Municipal Utility District, military bases, and species experts in Mexico to determine where western spadefoots have been found on the landscape (CNDDB 2020; Black 2020, pers. comm.; Evans 2020, pers. comm.; Fisher 2020, pers. comm.; Jones 2020, pers. comm.; Peralta and Valdez 2020, pers. comm.). A unique occurrence was considered anything greater than 0.25 miles apart from another occurrence, similar to the methods to determine unique occurrence points in CNDDB. We only used occurrence data that was recorded from 1980 to present to try to eliminate occurrence points that have not been seen in 40+ years. All occurrence data used in the analysis is considered to be opportunistically collected, and not a part of a controlled survey, but represents the best available data for this species. Recent research has determined that habitat within a 2,000-meter (6,562-ft) buffer of a spadefoot occurrence in the northern clade, and 1,000-m (3,281-ft) buffer in the southern clade, is the best predictor of occurrence, indicating that is likely the scale at which local populations are utilizing habitat. For all occurrence records, buffers were drawn from the centroid of the occurrence for 2,000-m in the northern clade and 1,000-m in the southern clade to determine how many local populations exist on the landscape (See Appendix C for maps of buffered areas). Occurrences where buffer areas overlapped were considered part of one local population. A high condition was given to regions that had the average number of local populations needed to be resilient as determined by experts. A moderate condition was given to regions that had at least 65 percent of the local populations needed for the region to be resilient, and a low condition was given to any region that had less than 65 percent of the local populations needed for a region to be resilient.

To assess the current condition of habitat quality, we looked at the amount of grasslands in the northern clade and amount of grasslands and shrub/scrub in the southern clade within each local population; the local populations were created as described in the paragraph above. Recent research has found that when western spadefoots are selecting burrow locations, they select for grasslands (Baumberger *et al*. 2019, p. 1). Habitat modeling in both the northern and southern clades has found that western spadefoot occurrence is positively associated with the proportion of grassland habitat in the 2,000-m buffer in the northern clade and grasslands and shrub/scrub habitat in the 1,000-m buffer in the southern clade (Rose *et al*. 2020, p. 1; Rose *et al*. 2022, p. 9). Habitat suitability dramatically increased with grassland in the northern clade and grassland and shrub/scrub in the southern clade with >60 percent in the 2,000-m or 1,000-m buffer. In the northern clade, habitat suitability seemed to plateau around 80 percent grassland cover within the 2,000-m buffer. To determine the amount of grassland percentage in the local populations in the northern clade or grassland and shrub/scrub percentage in each local population in the southern clade, the National Landcover Dataset from 2016 was used and a zonal histogram analysis was performed to determine the percentage of raster pixels with grassland habitat for each local population in the northern clade or the percentage of raster pixels with grassland and shrub/scrub habitat for each local population in the southern clade within the United States (Yang *et al*. 2018, entire). The National Landcover Dataset is only available within the United States, so for local populations in Mexico, we utilized Mexico's National Institute of Statistics and Geography data layer on "use of soil and vegetation" for grasslands and shrub/scrub habitat (INEGI). A high condition was given to any region that had 80 percent or higher grassland or grassland and shrub/scrub habitat in the number of local populations the experts determined to be necessary for a region to be resilient. A moderate condition was given to regions that had 60 percent to 80 percent grassland or grassland and shrub/scrub habitat in the number of local populations that experts determined to be necessary for a region to be resilient. A low condition was given to regions that did not have the number of local populations determined for each region to be resilient with 60 percent or greater grassland or grassland and shrub/scrub cover.

As discussed above in individual needs, seasonal rains are an important habitat factor for spadefoots. Breeding can only occur if there is enough rainfall to fill and hold water in the aquatic breeding habitat. To determine the condition of rainfall for each region, we looked at the number of average rainfall years that have occurred within the regions in the last six years. Six years is approximately the generation time for an individual. Precipitation data was collected from weather stations available within each region (usclimatedata.com). For a region to be in high condition, three of the past six years have had at least average rainfall. For a region to be in moderate condition, at least one of the past six years has had at least average rainfall. A low condition is any region that has not had a year of at least average rainfall in the past six years.

Finally, to examine abundance, the effective number of breeders was used to determine high, moderate, and low conditions for abundance. Measured effective number of breeders in western spadefoot breeding pools varied from 1.4 to 20.7 individuals (Neal 2019, p. 113). The minimum number of effective breeders necessary to maintain a stable population is currently unknown for western spadefoot. Without species specific minimum viable population numbers available, we used the 50/500 general rule of thumb in conservation biology that a minimum effective population size of 50 is necessary to combat inbreeding and a minimum effective population size of 500 individuals is needed to effectively reduce the threat from genetic drift (Franklin 1980, entire). There has been some debate in the scientific community over whether the 50/500 rule is sufficient, or whether it should be increased to 100/1,000 (Frankham *et al*. 2014, p. 56). There is no empirical data to support a 100/1,000 rule over a 50/500 rule, and the 50/500 rule remains a commonly used metric to apply genetics to conservation (Franklin *et al*. 2014, 284). To determine the estimated number of individuals in each local population, we counted the number of occurrence points that made up each local population. Each occurrence point within a local population is similar in scale and likely an observation from a breeding pond due to the fact that spadefoot toads are most opportunistically observed in breeding ponds, therefore each occurrence point likely is a similar scale as the effective number of breeders measured for breeding ponds in Neal 2019 (Neal 2019, p. 113). Neal 2019 measured effective number of breeders at multiple locations within most of the northern and southern clade regions, but not all local populations were measured. Since not all local populations were measured in each region, we used the average of the effective number of breeder calculations available for each region. The averaged values are discussed for each individual region below. The average number of breeders in each region was multiplied by the number of occurrence points, our proxy for breeding ponds, within a local population to get an estimated number of breeders for each local population. For example, if the average effective population size for a region was 10, and one local population was made up of 5 occurrence points, then our estimate for the local population would be 50 effective breeders. For a region to have a high condition for abundance, a region must have 500 effective breeders in the number of local populations determined for each region to be resilient. For a region to have a moderate condition for abundance, a region must have 500 effective breeders in 65 percent of the local populations experts determined are necessary for a region to be resilient. A region is in low condition for abundance if it has less than 500 effective breeders in 65 percent or more of the local populations. Abundance was weighted three times higher than the other habitat categories (habitat quantity/distribution, habitat quality, and rainfall), because it is the only demographic factor considered. Appendix C is a summary of all the metrics described above for each region in a table.

Surveys were conducted by experts at the U.S. Geological Survey from 2016-2020 throughout both the western spadefoot northern and southern clades (USGS 2021, entire). A total of 428 pools were evaluated for western spadefoot presence, and western spadefoots were found at 100 pools. These surveys provide one year of presence/absence information for each pool evaluated, and there may be temporal variability in whether spadefoots return to pools every year. This recent presence/absence survey information is included in this SSA for each region regarding how many pools were surveyed and the number of pools where western spadefoot were found. However, we did not include it in the results of our resiliency scoring. Because this recent presence/absence survey information suggests that all occurrence records may not be currently occupied, our calculation of the number of local populations and abundance in the SSA, and thus our overall resiliency scores, may be overestimates. However, we acknowledge the species is cryptic and a negative finding from only one year of surveys does not mean the location is unoccupied.

To determine the overall current condition of a region, we assessed habitat quality, habitat quantity/distribution, rainfall, and abundance together. A low condition was given a score of 1, a moderate condition was given a score of 2, and a high condition was given a score of 3. For categories that may fall in between conditions, a low-moderate condition was given a score of 1.5 and a moderate-high condition was given a score of 2.5. Each region was then assessed to determine the overall condition score. The only demographic category was weighted three times to equal the overall weight of the three habitat categories. The geometric mean (i.e., instead of the arithmetic mean) was used to calculate the overall condition so that categories with lower scores would contribute more to the overall score. This was used because if any one habitat or demographic category is low, other categories become less important. For example, if not enough rain occurs such that breeding does not take place, then the quality of grasslands becomes less significant. Regions with conditions with an overall average ≥2.5 received an overall high condition, regions with an average score between 2.25–2.5 received an overall condition of moderate-high, regions with an overall score between 1.75–2.25 received an overall condition of moderate, regions with a score between 1.5–1.75 received an overall condition of low-moderate and regions between 1–1.5 received an overall low condition. No one individual or population need was considered to have a higher weight in considering overall condition. Regions in high condition contain populations that are expected to persist into the future and have the ability to withstand stochastic events that may occur. Regions in moderate condition contain a majority of populations that are expected to persist into the future, but may be compromised by the lack of one or more need. Regions in low condition contain populations that are less likely to persist and will be less likely to withstand stochastic events that may occur. Table 3 and Table 4 outline the current conditions for the northern and southern clades of western spadefoot.

Western Spadefoot Regions

Figure 8: Map of western spadefoot regions. Regions in the northern western spadefoot clade are based on vernal pool mapping and align with the Service's Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon with a few species specific modifications for western spadefoot (Keeler-Wolf et al. 1998, entire; Service 2005, p. III18–III87; Neal 2019, p. 1, 14–15, 21, 108).Regions in the southern western spadefoot clade were developed by species experts to best represent the different habitat types of western spadefoot in southern California and Mexico (Fisher 2020, pers. comm.).

Table 2: Condition Category Table for Western Spadefoot

	Habitat Factors			**Demographic Factor**
Condition	Habitat Quantity/Distribution: Region has habitat to support X Number of Local Populations	Habitat Quality: Amount of Grassland or Grassland and Shrub/Scrub within Local Populations	Rainfall	Abundance
High	Region has the appropriate number of local populations as decided by experts	At least 80 percent grassland cover or grassland and shrub/scrub cover in the number of local populations as decided by experts	At least three average rain years within the past six years	The number of local populations as decided by experts has at least 500 Neb*
Moderate	Region has at least 65 percent of local populations as decided by experts	At least 60 percent grassland cover or grassland and shrub/scrub cover in the number of local populations as decided by experts	One average rain year within the past six years	At least 65 percent of local populations as decided by experts have 500 Neb
Low	Region has < 65 percent of local populations as decided by experts	Grassland cover or grassland and shrub/scrub cover is less than 60 percent in the number of local populations as decided by experts.	Extended drought of six or more years without average rain year	Less than 65 percent of local populations as decided by the experts have 500 Neb

*Neb Number of effective breeders

9.2 Regional Current Condition for Northern Western Spadefoot

9.2.1 Northwestern Sacramento Valley

The Northwestern Sacramento Valley vernal pool region extends from the Redding area of Shasta County south to the Williams area of Colusa County, also including parts of Glenn and Tehama counties. A full description of the Northwestern Sacramento Valley vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, pp. III-82–III-83). From expert feedback, the median number of local populations needed for the Northwestern Sacramento Valley region to be resilient is 4.5 local populations. Expert feedback ranged from three to five local populations needed for the region to be resilient. Using 2,000-m buffers, a total of seven local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the seven local population, only three local populations had greater than 80 percent grassland, and one that had greater than 60 percent grasslands, resulting in a low condition for habitat quality. For rainfall, there are four weather stations within the region including Redding, CA, Red Bluff, CA, Orland, CA, and Willows, CA. Of the four weather stations, three recorded at least average rainfall three of the last six years, resulting in a high condition for rainfall. Effective number of breeders was not calculated for the Northwestern Sacramento Valley region, but the closest region of Solano-Colusa calculated the effective number of breeders to be 3.7 individuals. To get to a local population with 500 breeders, a total of 135 occurrence points, or breeding populations, would be necessary within the local population (i.e., 135 occurrence points multiplied by 3.7 effective breeders per point is 500 individuals). The highest number of occurrences making up one local population in the Northwestern Sacramento Valley region is three, therefore the category of abundance was given a low condition. The overall condition of the Northwestern Sacramento Valley region is estimated to be low. Out of five pools that were surveyed in the Northwestern Sacramento Valley region in 2019, only one had western spadefoot present (USGS 2021, p. 28). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.2 Northeastern Sacramento Valley

The Northeastern Sacramento Valley vernal pool region extends from the Millville Plains to the Sutter Buttes, including parts of Butte, Shasta, Sutter, Tehama, and Yuba counties. It is adjacent to the Northwestern Sacramento Valley vernal pool region, but the two regions differ in soil type. A full description of the Northeastern Sacramento Valley vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, p. III-82). From expert feedback, the median number of local populations needed for the Northeastern Sacramento Valley region to be resilient is 6.5 local populations. Expert feedback ranged from five to ten local populations needed for the region to be resilient. Using

2,000-m buffers, a total of seven local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the seven local population, only two local populations had greater than 80 percent grasslands, and two more had between 60 to 80 percent grasslands, resulting in a low condition for habitat quality. For rainfall, there are two weather stations within the region including Chico, CA and Oroville, CA. Of the two weather stations, one recorded at least average rainfall three of the last six years and the other only recorded average rainfall in one year, resulting in a moderate-high condition of rainfall for the region. Effective number of breeders was not calculated for the Northeastern Sacramento Valley region, but the closest region of Southeastern Sacramento Valley calculated the effective number of breeders to be 12.7 individuals. To get to a local population with 500 breeders, a total of 39 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Northeastern Sacramento Valley region is three, therefore the category of abundance was given a low condition. The overall condition of the Northeastern Sacramento Valley region is estimated to be low. Out of eight pools that were surveyed in the Northeastern Sacramento Valley region in 2019, only one had western spadefoot present (USGS 2021, p. 28). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.3 Solano-Colusa

The Solano-Colusa vernal pool region includes substantial areas of Solano, Colusa, and Yolo counties, as well as small parts of Glenn, Butte, Sutter, and Contra Costa counties. A full description of the Solano-Colusa vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, p. III-84). From expert feedback, the median number of local populations needed for the Solano-Colusa region to be resilient is four local populations. Expert feedback ranged from three to seven local populations needed for the region to be resilient. Using 2,000-m buffers, a total of two local populations were identified for the region, resulting in a low condition for habitat quantity/distribution. Of the two local populations, none had at least 60 percent grasslands, resulting in a low condition for habitat quality. For rainfall, there are four weather stations within the region including Colusa, CA, Woodland, CA, Davis, CA, and Fairfield, CA. Of the four weather stations, two recorded at least average rainfall three of the last six years, and the other two only recorded average rainfall in two years, resulting in a moderate-high condition of rainfall for the region. Effective number of breeders was calculated to be 3.7 individuals in the Solano-Colusa region. To get to a local population with 500 breeders, a total of 135 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Solano-Colusa region is five, therefore the category of abundance was given a low condition. The overall condition of the Solano-Colusa region is estimated to be low. Out of six pools that were surveyed in the Solano-Colusa region in 2019, none had western spadefoot present (USGS 2021, p. 28). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.4 Southeastern Sacramento Valley

The Southeastern Sacramento Valley vernal pool region extends from southern Yolo County south to San Joaquin and Calaveras counties, incorporating most of Sacramento county and smaller areas of Amador, El Dorado, Nevada, Placer, and Sutter counties. A full description of the Southeastern Sacramento Valley vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, p. III-85). From expert feedback, the median number of local populations needed for the Southeastern Sacramento Valley region to be resilient is 8.5 local populations. Expert feedback ranged from five to ten local populations needed for the region to be resilient. Using 2,000-m buffers, a total of 24 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 24 local populations, five had at least 80 percent grasslands, and an additional ten with at least 60 percent grasslands, resulting in a moderate condition for habitat quality. For rainfall, there are three weather stations within the region including Olivehurst, CA, Sacramento, CA, and Acampo, CA. Of the three weather stations, two recorded at least average rainfall three of the last six years, and the other recorded average rainfall in two years, resulting in a high condition of rainfall for the region. Effective number of breeders was calculated to be 12.7 individuals in the Southeastern Sacramento Valley region. To get to a local population with 500 breeders, a total of 39 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Southeastern Sacramento Valley region is 11, therefore the category of abundance was given a low condition. The overall condition of the Southeastern Sacramento Valley region is estimated to be low-moderate. Out of 14 pools that were surveyed in the Southeastern Sacramento Valley region in 2019, three had western spadefoot present (USGS 2021, p. 28). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.5 Livermore

The Livermore vernal pool region straddles Alameda, Contra Costa, and Santa Clara counties. A full description of the Livermore vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, pp. III-80–III-81). From expert feedback, the median number of local populations needed for the Livermore region to be resilient is 3.5 local populations. Expert feedback ranged from three to four local populations needed for the region to be resilient. Using 2,000-m buffers, a total of three local populations were identified for the region, resulting in a moderate condition for habitat quantity/distribution. Of the three local populations, two had at least 80 percent grasslands, however with only two local populations the habitat quality is in low condition for the Livermore region. For rainfall, there are two weather stations within the region including Livermore, CA and Byron, CA. Of the two weather stations, one recorded at least average rainfall three of the last six years, and the other recorded average rainfall in two years, resulting in a moderate-high condition of rainfall for the region. Effective number of breeders was calculated to be 7.9 individuals in the Livermore region. To get to a local population with 500 breeders, a total of 63 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Livermore region is seven, therefore the category of abundance was given a low condition. The overall condition of the Livermore region is estimated to be low. The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.6 Southern Sierra Foothills

The Southern Sierra Foothills vernal pool region occupies high and low terrace landforms ranging from the junction of San Joaquin, Stanislaus, and Calaveras counties south to Tulare County. Portions of Fresno, Madera, Mariposa, Merced, and Tuolumne counties also are included in the region. A full description of the Southern Sierra Foothills vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, pp. III-85–III-86). From expert feedback, the median number of local populations needed for the Southern Sierra Foothills region to be resilient is ten local populations. Expert feedback ranged from eight to 20 local populations needed for the region to be resilient. Using 2,000-m buffers, a total of 40 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 40 local populations, 21 had at least 80 percent grasslands, and an additional four with at least 60 percent grasslands, resulting in a high condition for habitat quality. For rainfall, there are three weather stations within the region including Fraint, CA, Lemon Cove, CA, and Lindsey, CA. Of the three weather stations, one recorded at least average rainfall three of the last six years, and the other two recorded average rainfall in two years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be 4.5 individuals in the Southern Sierra Foothills region. To get to a local population with 500 breeders, a total of 111 occurrence points, or breeding ponds, would be necessary within the local population. The highest number of occurrences making up one local population in the Southern Sierra Foothills region is 32, therefore the category of abundance was given a low condition. The overall condition of the Southern Sierra Foothills region is estimated to be low-moderate. Out of 29 pools that were surveyed in the Southern Sierra Foothills region in 2019, five had western spadefoot present (USGS 2021, p. 31). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.7 San Joaquin Valley

The San Joaquin Valley vernal pool region occupies the long, narrow area that runs southward from San Joaquin County to Kern County, including parts of Fresno, Kings, Madera, Merced, Stanislaus, and Tulare counties. A full description of the San Joaquin Valley vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern

Oregon (Service 2005, p. III-83). From expert feedback, the median number of local populations needed for the San Joaquin Valley region to be resilient is ten local populations. Expert feedback ranged from five to ten local populations needed for the region to be resilient. Using 2,000-m buffers, a total of 26 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 26 local populations, only two local populations had at least 60 percent grasslands, resulting in a low condition for habitat quality. For rainfall, there are three weather stations within the region including Los Banos, CA, Hanford, CA, and Wasco, CA. Of the three weather stations, one recorded at least average rainfall three of the last six years, and the other two recorded average rainfall in one or two years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be 7.78 individuals in the San Joaquin Valley region. To get to a local population with 500 breeders, a total of 64 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the San Joaquin Valley region is 13, therefore the category of abundance was given a low condition. The overall condition of the San Joaquin Valley region is estimated to be low. Out of 53 pools that were surveyed in the San Joaquin Valley region in 2019, 11 had western spadefoot present (USGS 2021, pp. 29–30). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.8 Central Coast

The Central Coast vernal pool region includes several polygons distributed over portions of nine counties including Alameda, Fresno, Merced, Monterey, San Benito, San Mateo, Santa Clara, Santa Cruz, and Stanislaus. A full description of the Central Coast vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, pp. III-78–III-79). From expert feedback, the median number of local populations needed for the Central Coast region to be resilient is eight local populations. Expert feedback ranged from six to ten local populations needed for the region to be resilient. Using 2,000-m buffers, a total of 17 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 17 local populations, five had at least 80 percent grasslands, and an additional four with at least 60 percent grasslands, resulting in a moderate condition for habitat quality. For rainfall, there are four weather stations within the region including Gilroy, CA, Watsonville, CA, Carmel Valley, CA and Coalinga, CA. Of the four weather stations, one recorded at least average rainfall three of the last six years, and two recorded average rainfall in one or two years, and one recorded no average rainfall years in the past six years. The resulting condition for rainfall is moderate for the region. Effective number of breeders was calculated to be 7.2 individuals in the Central Coast region. To get to a local population with 500 breeders, a total of 69 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Central Coast region is 10, therefore the category of abundance was given a low condition. The overall condition of the Central Coast region is low-moderate. Out of nine pools that were surveyed in the Central Coast region in 2019, one had western spadefoot present

(USGS 2021, p. 32). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.9 Carrizo

The Carrizo vernal pool region is almost entirely in San Luis Obispo County, but does incorporate small areas of adjacent Kern and Monterey Counties. A full description of the Carrizo vernal pool region can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, p. III–78). From expert feedback, the median number of local populations needed for the Carrizo region to be resilient is seven local populations. Expert feedback ranged from five to ten local populations needed for the region to be resilient. Using 2,000-m buffers, a total of 21 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 21 local populations, ten had at least 80 percent grasslands, and an additional three with at least 60 percent grasslands, resulting in a high condition for habitat quality. For rainfall, there is one weather station within the region in Paso Robles, CA. The weather station recorded two of the past six years to have at least average rainfall, resulting in a moderate condition for rainfall. Effective number of breeders was calculated to be 6.1 individuals in the Carrizo region. To get to a local population with 500 breeders, a total of 81 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Carrizo region is 34, therefore the category of abundance was given a low condition. The overall condition of the Carrizo region is low-moderate. Out of six pools that were surveyed in the Carrizo region in 2019, three had western spadefoot present (USGS 2021, p. 32). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.2.10 Santa Barbara

The Santa Barbara modified vernal pool region includes the coastal plains of San Luis Obispo and Santa Barbara counties. This unit is modified from the original vernal pool region in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon due to known significant genetic differences between western spadefoot populations north and south of the Transverse Range. A description of the Santa Barbara vernal pool region, prior to the modification for western spadefoot, can be found in the Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon (Service 2005, pp. III-83–III-84). From expert feedback, the median number of local populations needed for the Santa Barbara region to be resilient is 6.5 local populations. Expert feedback ranged from five to nine local populations needed for the region to be resilient. Using 2,000-m buffers, a total of 15 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 15 local populations, only one had at least 60 percent grasslands, resulting in a low condition for habitat quality. For rainfall, there are three weather stations within the region including Santa Maria, CA, Lompoc, CA, and Santa Ynez, CA. Of the three weather stations, one recorded no years of average rainfall within the past six years, and the other two recorded average rainfall in one or two years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be 3.6 individuals in the Santa Barbara region. To get to a local population with 500 breeders, a total of 141 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Santa Barbara region is 74, therefore the category of abundance was given a low condition. The overall condition of the Santa Barbara region is low. Out of 32 pools that were surveyed in the Santa Barbara region in 2019, 13 had western spadefoot present (USGS 2021, p. 33). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and effects of climate change.

Table 3: Current Condition Table for Northern Western Spadefoot Regions

Northern Western Spadefoot Regions	Habitat Factors			Demographic Factors	Overall Condition
	Habitat Quantity/Distribution	Habitat Quality	Rainfall	Abundance (weighted three times)	
Northwestern Sacramento Valley	High (3)	Low (1)	High (3)	Low (1)	Low (1.44)
Northeastern Sacramento Valley	High (3)	Low (1)	Moderate-High (2.5)	Low (1)	Low (1.39)
Solano-Colusa	Low (1)	Low (1)	Moderate-High (2.5)	Low (1)	Low (1.16)
Southeastern Sacramento Valley	High (3)	Moderate (2)	High (3)	Low (1)	Low-Moderate (1.62)
Livermore	Moderate (2)	Low (1)	Moderate-High (2.5)	Low (1)	Low (1.31)
Southern Sierra Foothills	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
San Joaquin Valley	High (3)	Low (1)	Moderate (2)	Low (1)	Low (1.35)
Central Coast	High (3)	Moderate (2)	Moderate (2)	Low (1)	Low-Moderate (1.51)
Carrizo	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Santa Barbara	High (3)	Low (1)	Moderate (2)	Low (1)	Low (1.35)

9.3 Northern Western Spadefoot Clade Redundancy

To assess the current condition of redundancy, the species' current ability to withstand catastrophic events, this SSA considers the number of resilient regions in the northern western spadefoot range. We note that while more resilient populations are more likely to survive and rebound after a catastrophic even, numerous well-distributed populations with lower resiliency also contribute to redundancy. Resiliency is evaluated by assessing the condition of the individual and population needs for each region. There is a total of 10 regions in the northern western spadefoot range. Currently, four regions are in an overall low-moderate condition and six regions are in low condition with none of the regions in high or moderate condition. This may indicate that a majority of the regions have one or more individual or population needs that may be compromised. Of particular concern is that all the regions within the northern western spadefoot clade have a low condition for abundance which may make it difficult for them to withstand catastrophic events. However, the northern clade still occupies all regions throughout central and northern California. Environmental conditions throughout this areas varies greatly and most likely would still provide for the species needs, providing some redundancy even with regions in low condition.

9.4 Northern Western Spadefoot Clade Representation

As described in the Methodology section (2.0), representation is the ability of a species to adapt to changing environmental conditions. This factor is assessed at the species level. The western spadefoot occurs across a wide physical range that has different environmental conditions and as a result, western spadefoot could be considered to have a high level of environmental adaptability. We typically use the breadth of genetic or environmental diversity within and among populations as a surrogate for evolutionary adaptability. As noted in the Genetics section and Species Needs section above, there is some degree of genetic differences between regions within the northern western spadefoot range (Neal 2019, p. 115). However, the low effective number of breeders in all regions of the northern western spadefoot clade suggests that there is low genetic variability, which may reduce the representation. The northern western spadefoot clade still occupies all known regions, but six of the ten regions are in low condition. Currently the species still has some degree of representation since it occupies all its historically unique ecological settings. However, with all of the regions with low or low-moderate resiliency, the probability of persistence in those regions may be compromised by the lack of one or more needs. Habitat loss in the range and limited breeding years due to recent drought has likely reduced the species representation from historical levels (Jennings and Hayes 1994, p. 96; Witham *et al*. 2014, entire; Vollmar *et al*. 2017, entire; Neal 2019, p. 32). With the amount of land that is protected for vernal pool habitat within the northern clade, we predict that the species will likely maintain some level of representation even if there was a decline in populations in regions with low condition.

9.5 Regional Current Condition for Southern Western Spadefoot

9.5.1 Northwest Ventura and Los Angeles

The Northwest Ventura and Los Angeles region includes the coastal plains of Ventura County south of the Transverse Range. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Northwest Ventura and Los Angeles region to be resilient is five local populations. All experts agreed on five local populations needed for the region to be resilient. Using 1,000-m buffers from the recorded occurrences, a total of 32 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution because only five local populations were needed. Of the 32 local populations, three had at least 60 percent grasslands and shrub/scrub habitat, and an additional 17 local populations had 80 percent or greater grasslands and shrub/scrub habitat, resulting in a high condition for habitat quality. For rainfall, there is one weather station within the region in Camarillo, CA. Of the past six years, the weather station only has two years of data with precipitation available (2015 and 2019). Of those two years, there was at least one year with average rainfall, giving the region a moderate condition for rainfall. Effective number of breeders was calculated to be eight individuals in the Northwest Ventura and Los Angeles region. To get to a local population with 500 breeders, a total of 63 occurrence points, or breeding ponds, would be necessary within a local population. The highest number of occurrences making up 1 of the 34 existing local populations in the Northwest Ventura and Los Angeles region is 13. None of the existing local populations met the 63-occurrence threshold for a high condition, and again, this region needed 5. Therefore, the category of abundance was given a low condition. The overall condition of the Northwest Ventura and Los Angeles region is low-moderate. Out of 16 pools that were surveyed in the Northwest Ventura and Los Angeles region in 2020, two had western spadefoot present (USGS 2021, p. 34). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.2 Orange-Los Angeles Basin

The Orange-Los Angeles Basin region includes the areas surrounding the city of Los Angeles, CA. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Orange-Los Angeles Basin region to be resilient is eight local populations. Expert feedback ranged from three to 11 local populations needed for the region to be resilient. Using 1,000-m buffers, a total of 37 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution because only eight local populations were needed. Of the 37 local populations, eight had at least 60 percent grassland or shrub/scrub cover, and an additional 18 local populations had greater than 80 percent grassland or shrub/scrub cover resulting in a high condition for habitat quality. For rainfall, there are over 20 weather stations within the region, but only five were chosen to represent the range of precipitation averages in the area. The five weather stations that were chosen include Anaheim, CA, Culver City, CA, Newport Beach, CA, Pasadena, CA, and Torrance, CA. All five weather stations recorded average rainfall in one or two years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be four individuals in the Orange-Los Angeles Basin region. To get to a local population with 500 breeders, a total of 125 occurrence points, or breeding ponds, would be necessary within the local population. The highest number of occurrences making up one local population in the Orange-Los Angeles Basin region is 17, therefore the category of abundance was given a low condition. The overall condition of the Orange-Los Angeles Basin region is low. Out of 105 pools that were surveyed in the Orange-Los Angeles Basin region in 2016, 2019, or 2020, 36 had western spadefoot present (USGS 2021, pp. 35–37). There were 15 historical pools that no longer existed when surveys were attempted. The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.3 Inland Empire

The Inland Empire region includes the areas surrounding the city of Riverside, CA. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Inland Empire region to be resilient is eight local populations. Expert feedback ranged from eight to nine local populations needed for the region to be resilient. Using 1,000-m buffers, a total of 92 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 92 local populations, 35 had greater than 80 percent grasslands or shrub/scrub, and an additional 21 with at least 60 percent grasslands or shrub/scrub, resulting in a high condition for habitat quality. For rainfall, there are three weather stations within the region that recorded precipitation over the past six years including Lake Elsinore, CA, Redlands, CA and San Jacinto, CA. All three weather stations recorded average rainfall in one year over the past six years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be 4.2 individuals in the Inland Empire region. To get to a local population with 500 breeders, a total of 119 occurrence points, or breeding ponds, would be necessary within the local population. The highest number of occurrences making up one local population in the Inland Empire region is seven, therefore the category of abundance was given a low condition. The overall condition of the Inland Empire region is low-moderate. Out of 62 pools that were surveyed in the Inland Empire region in 2020, 14 had western spadefoot present (USGS 2021, pp. 38–39). There were five historical pools that no longer existed when surveys were attempted. The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.4 Inland Riverside-San Diego

The Inland Riverside-San Diego region includes the eastern areas of Riverside and San Diego County, CA. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Inland Riverside-San Diego region to be resilient is six local populations. Expert feedback ranged from four to eight local populations needed for the region to be resilient. Using 1,000-m buffers, a total of 32 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 32 local populations, 25 had greater than 80 percent grasslands or shrub/scrub, and an additional four with at least 60 percent grasslands, resulting in a high condition for habitat quality. For rainfall, there is one weather station within the region that recorded precipitation over the past six years in Warner Springs, CA. The weather station recorded average rainfall in one year over the past six years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was not calculated for the Inland Riverside-San Diego region. The closest regions of Inland Empire and Central San Diego calculated effective number of breeders to be 4.2 and 3.8 individuals respectively, therefore we used the average of the two closest regions to estimate four effective number of breeders in the Inland Riverside-San Diego region. To get to a local population with 500 breeders, a total of 125 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Inland Riverside-San Diego region is six, therefore the category of abundance was given a low condition. The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.5 Coastal Military Lands

The Coastal Military Lands region includes the areas surrounding Marine Corps Base Camp Pendleton. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Coastal Military Lands region to be resilient is three local populations. Expert feedback ranged from one to five local populations needed for the region to be resilient. Using 1,000-m buffers, a total of 30 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 30 local populations, 15 had greater than 80 percent grasslands or shrub/scrub, and an additional six had at least 60 percent grassland or shrub/scrub habitat, resulting in a high condition for habitat quality. For rainfall, there is one weather station in the region that recorded precipitation over the past six years in Oceanside, CA. The weather station recorded average rainfall in two years over the past six years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be 12 individuals in the Coastal Military Lands region. To get to a local population with 500 breeders, a total of 42 occurrence points, or breeding ponds, would be necessary within the local population. The highest number of occurrences making up one local population in the Coastal Military Lands region is 13, therefore the category of abundance was given a low condition. The overall condition of the Coastal Military Lands region is low-moderate. One pool was surveyed in 2016 in the Coastal Military Lands region and western spadefoot were present (USGS 2021, p. 40). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.6 Central San Diego

The Central San Diego region includes a majority of San Diego County, CA. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Central San Diego region to be resilient is 12 local populations. Expert feedback ranged from 10 to 17 local populations needed for the region to be resilient. Using 1,000-m buffers, a total of 110 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 110 local populations, 49 had greater than 80 percent grasslands or shrub/scrub, and an additional 24 had at least 60 percent grasslands or shrub/scrub habitat, resulting in a high condition for habitat quality. For rainfall, there are four weather stations within the region that recorded precipitation over the past 6 years including Escondido, CA, Alpine, CA, El Cajon, CA and Vista, CA. Of the four weather stations, one recorded 3 years with average rainfall, and the other three weather stations recorded average rainfall in 1 year or 2 years over the past 6 years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be 3.8 individuals in the Central San Diego region. To get to a local population with 500 breeders, a total of 132 occurrence points, or breeding ponds, would be necessary within the local population. The highest number of occurrences making up one local population in the Central San Diego region is 18, therefore the category of abundance was given a low condition. The overall condition of the Central San Diego region is low-moderate. Out of 39 pools that were surveyed in the Baja Northeast region in 2020, two had western spadefoot present (USGS 2021, p. 40). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.7 Baja Northwest

The Baja Northwest region includes southern tip of the west coast of California and the northwestern area of Baja California, Mexico. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Baja Northwest region to be resilient is ten local populations. Expert feedback ranged from 10 to 12 local populations needed for the region to be resilient. Using 1,000-m buffers, a total of 20 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of these 20 local populations, 5 had at least 60 percent grasslands or shrub/scrub, and an additional 4 local populations with greater than 80 percent grasslands or shrub/scrub habitat, resulting in a low condition for habitat quality. For rainfall, there are two weather stations within the region that recorded precipitation over the past six years including San Diego, CA, and Chula Vista, CA. Of the two weather stations, both weather stations recorded average rainfall in one year or two years over the past six years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was not calculated for the Baja Northwest region. The closest regions of Central San Diego and Baja

Northeast calculated effective number of breeders to be 3.8 and 4.6 individuals respectively, therefore we used the average of the two closest regions to estimate 4.2 effective number of breeders in the Baja Northwest region. To get to a local population with 500 breeders, a total of 119 occurrence points, or breeding populations, would be necessary within the local population. The highest number of occurrences making up one local population in the Baja Northwest region is 11, therefore the category of abundance was given a low condition. The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.8 Baja Northeast

The Baja Northeast region includes a small area in southern California and the northeastern area of Baja California, Mexico. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Baja Northeast region to be resilient is seven local populations. Expert feedback ranged from five to eight local populations needed for the region to be resilient. Using 1,000-m buffers, a total of 16 local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the 16 local populations, 10 had greater than 80 percent grasslands or shrub/scrub habitat, and one additional local population had at least 60 percent grasslands or shrub/scrub habitat, resulting in a high condition for habitat quality. For rainfall, there is one weather station within the region that recorded precipitation over the past six years in Campo, CA. The weather station recorded average rainfall in one year over the past six years, resulting in a moderate condition of rainfall for the region. Effective number of breeders was calculated to be 4.6 individuals in the Baja Northeast region. To get to a local population with 500 breeders, a total of 109 occurrence points, or breeding ponds, would be necessary within the local population. The highest number of occurrences making up one local population in the Baja Northeast region is three, therefore the category of abundance was given a low condition. The overall condition of the Baja Northeast region is low. Out of two pools that were surveyed in the Baja Northeast region in 2020, none had western spadefoot present (USGS 2021, p. 40). The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.9 Baja Central

The Baja Central region includes the centrally located inland areas of Baja California, Mexico. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Baja Northeast region to be resilient is five local populations. Expert feedback ranged from three to five local populations needed for the region to be resilient. Using 1,000-m buffers, a total of one local population was identified for the region, resulting in a low condition for habitat quantity/distribution. The one local population identified for the region had greater than 80 percent grassland or shrub/scrub cover, but with only one local population, the region still received a low condition for habitat quality. Data is not available for this region to assess rainfall or abundance. With so many of the categories unknown, the overall condition of the region is unknown. The threats that are likely impacting this region reducing the condition of individual and population needs include a combination of development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

9.5.10 Baja South

The Baja South region includes the southernmost portion of the western spadefoot range in Baja California, Mexico. This region was developed by species experts to best capture western spadefoot habitat in the area. From expert feedback, the median number of local populations needed for the Baja South region to be resilient is seven local populations. Expert feedback ranged from seven to eight local populations needed for the region to be resilient. Using 1,000-m buffers, a total of ten local populations were identified for the region, resulting in a high condition for habitat quantity/distribution. Of the seven local populations identified for the region, six had greater than 80 percent grassland or shrub/scrub cover, but the region received a low condition for habitat quality because it does not have seven local populations with high habitat quality. Data are not available for this region to assess rainfall or abundance. With so many of the categories unknown, the overall condition of the region is unknown. The threats that are likely impacting this region include development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and the effects of climate change.

Table 4: Current Condition Table for Western Spadefoot Regions in the Southern Clade

Southern Western Spadefoot Regions	**Habitat Factors**			**Demographic Factors**	**Overall Condition**
	Habitat Quantity/ Distribution	Habitat Quality	Rainfall	Abundance (x3)	
Northwest Ventura and Los Angeles	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Orange-Los Angeles Basin	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Inland Empire	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Inland Riverside-San Diego	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Coastal Military Lands	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Central San Diego	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Baja Northwest	High (3)	Low (1)	Moderate (2)	Low (1)	Low (1.35)
Baja Northeast	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Baja Central	Low	Low	Unknown	Unknown	Unknown
Baja South	High	Low	Unknown	Unknown	Unknown

9.6 Southern Western Spadefoot Clade Redundancy

To assess the current condition of redundancy, the species' current ability to withstand catastrophic events, this SSA considers the number of resilient regions in the southern western spadefoot range. We note that while more resilient populations are more likely to survive and rebound after a catastrophic event, numerous well-distributed populations with lower resiliency also contribute to redundancy. Resiliency is evaluated by assessing the condition of the individual and population needs for each region. There are a total of 10 regions in the southern western spadefoot range. Currently, seven regions are in low-moderate condition, one region is in low condition, and none of the regions are in high or moderate condition. Two regions do not have enough information available to determine the current condition for the region. This may indicate that a majority of the regions have one or more individual or population needs that may be compromised which may make it difficult for the species to withstand a catastrophic event. However, the southern clade still occupies a majority of regions throughout a large portion of southern California and Baja Mexico. Environmental conditions throughout these areas varies greatly and most likely would still provide for the species needs, providing some redundancy even with regions in low condition.

9.7 Southern Western Spadefoot Clade Representation

As described in the Methodology section (2.0), representation is the ability of a species to adapt to changing environmental conditions. This factor is assessed at the species level. The western spadefoot occurs across a wide physical range that has different environmental conditions and as a result, western spadefoot could be considered to have a high level of environmental adaptability. We typically use the breadth of genetic or environmental diversity within and among populations as a surrogate for evolutionary adaptability. Neal (2019, pp. 114–115) found limited adaptive potential for both clades of western spadefoot, with the southern clade showing less genetic differentiation than the northern. Further, the low effective number of breeders in all regions of the southern western spadefoot clade suggests that there is low genetic variability, which may reduce representation. The southern western spadefoot clade still occupies all known regions. Currently the southern western spadefoot clade has some degree of representation since it occupies all of its historically unique ecological settings. However, with known habitat loss in the range and limited ability of the DPS to disperse, it likely has reduced representation from historical levels (Jennings and Hayes 1994, p. 96; Witham *et al*. 2014, entire; Thomson *et al*. 2016, p. 134; Vollmar *et al*. 2017, entire). With the amount of land that is protected for vernal pool habitat within the southern clade, we predict that the species will likely maintain some level of representation even if there was a decline in populations in regions with low condition.

Western Spadefoot Current Condition

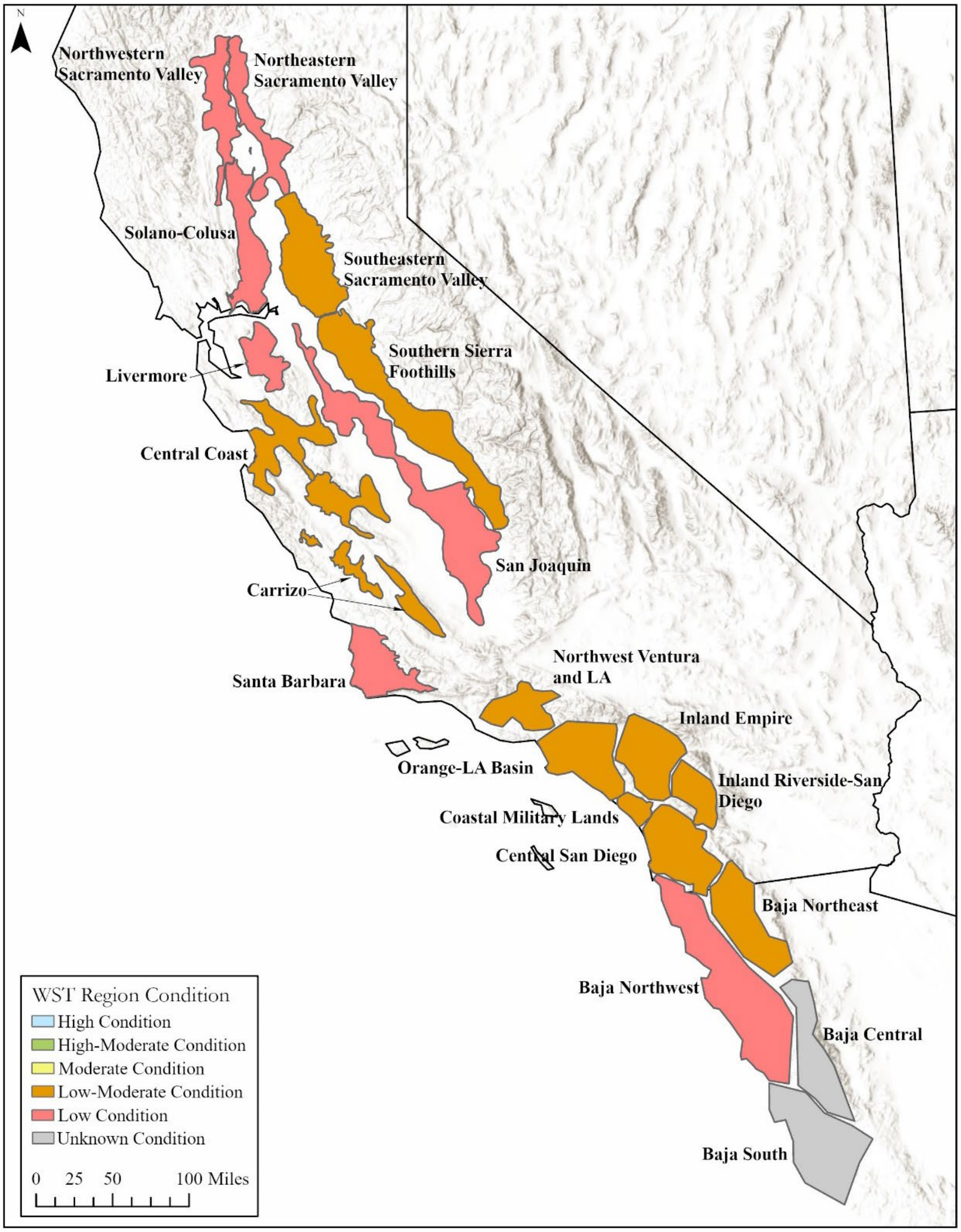

Figure 9: Western spadefoot regions displaying the current condition.

10.0 FUTURE CONDITIONS

In order to provide some insight into the future conditions for a particular species, we construct several plausible scenarios to assist in articulating how the species needs, threats, and habitat conditions may change in the future.

10.1 Scenario Planning and its Application

Scenario planning is a comprehensive exercise that involves the development of scenarios that capture a range of plausible future conditions. That development is then followed by an assessment of the potential effects of those scenarios on a given species. Scenarios are not predictions or forecasts of what will happen in the future for a species, but are projections or explorations into the range of conditions that may exist based on current information (Figure 10). The scenarios are intended to provide the "upper" and "lower" bounds of plausible conditions (Figure 11), outline uncertainties, and provide decision makers with a means for managing risk and maintaining flexibility in current and future decisions.

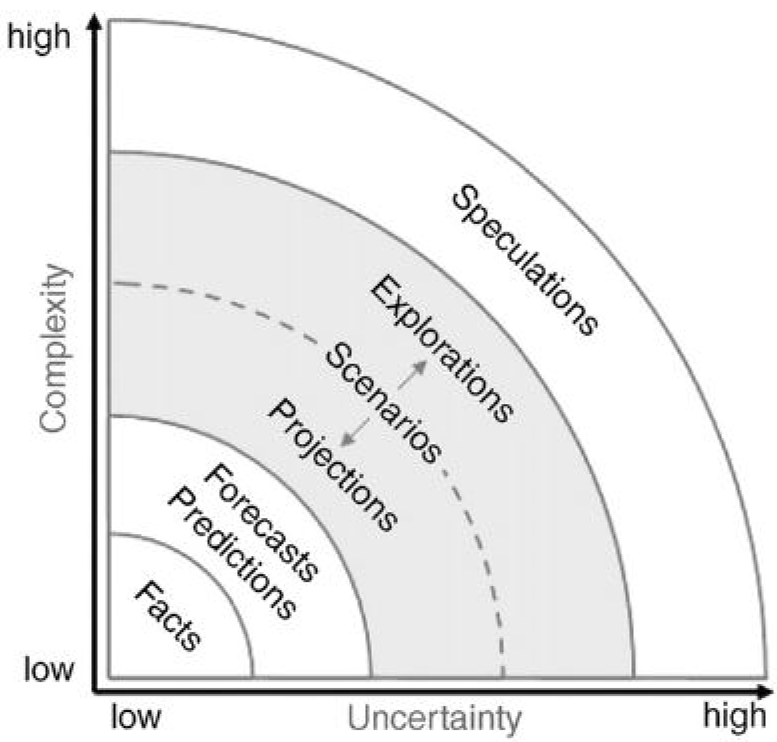

Figure 10. The levels of uncertainty and complexity in situations for which scenarios can be useful in considering future possibilities (adapted from Roland et al. 2014)

A range of time frames with a multitude of possible scenarios allows us to create a "risk profile" for the western spadefoot and its viability into the future. While we do not expect every condition for each scenario to be fully realized, we are using these scenarios as examples for the range of possibilities. For each scenario, we describe the stressors that would occur in each population and how they may change in the future. We used the best available science to predict trends in future threats facing the western spadefoot. Data availability varies across the range of the species and or individual populations. Where data on future threats or trends were not available, we looked to past threats and their trends and evaluate if it is reasonable to assume these trends will continue into future and to what degree.

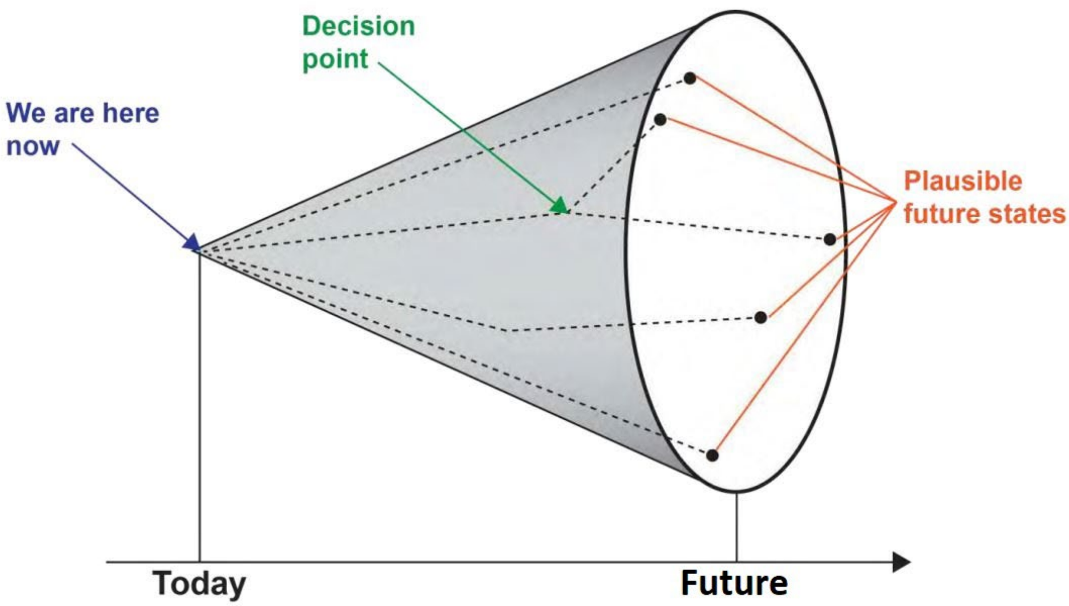

Figure 11. Conceptual diagram of the broadening range of plausible alternative futures as one moves farther away from the present and different events and decision points shift trajectories. (Roland et al. 2014, pp. 2–7 adapted from Timpe and Scheepers 2003, pp. 11–12).

10.2 Future Scenarios for the Western Spadefoot

This section of the SSA forecasts the species' response to a range of plausible future scenarios of environmental conditions and conservation efforts. The future scenarios project the threats discussed earlier in the SSA into the future and consider the impacts those threats would potentially have on western spadefoot viability. The concepts of resiliency, redundancy, and representation are applied to the future scenarios to describe the future viability of the northern and southern western spadefoot. Three future scenarios are described and future resiliency for each western spadefoot region was assessed. Scenario 1 assesses western spadefoot viability in a future with increased extreme climate events and anthropogenic impacts. Scenario 2 assesses the viability of the species under a continuation scenario future, defined as the continuing of the current trajectory of threats and conservation actions into the future. Scenario 3 assesses western spadefoot future viability with a lower emission scenario for climate change. Table 5 provides a comparison of the assumptions made for each scenario. By using three scenarios, it allows us to consider a range of future possibilities for predicting the future viability of the species. For this SSA, the future was assessed at approximately 30–40 years. This range represents estimates of mid-century climate projections and human population and development projections for California (The California Economic Forecast 2017, p. 2; Bedsworth *et al*. 2018, p. 23; California Department of Finance 2023, entire). We also considered lands that are currently protected within the local populations of both the northern and southern clade. Table 6 shows the number of local populations in each region that are either fully protected or have the amount of land protected such that it could support a population with a 2,000-meter buffer in the northern clade or a 1,000-meter buffer in the southern clade.

An overall high condition for a region is an indicator of high probability of persistence of individuals in the region, an overall moderate condition is an indicator that probability of persistence in that region may be compromised by the lack of one or more need, and a low overall condition indicates low probability of persistence of individuals in the region. Regions in high condition are expected to persist into the future and have the ability to withstand stochastic events that may occur. Regions in moderate condition are less resilient than those in high condition, but the majority of these regions are expected to persist beyond 30–40 years. Regions in moderate condition may have some declines in individual or population needs, but would likely still be able to support a population. Regions in low condition have low resiliency and may not be able to withstand stochastic events because of significant declines in individual or population needs. Regions in low condition are less likely to persist for 30–40 years, but a region in low condition does not automatically mean the region will become extirpated. For our future condition analysis, an additional condition of very low or extirpated was added for regions that are already low in current condition and may continue to see declines such that it may lead to extirpation in 30-40 years. When assessing the future, viability is not a specific state, but rather a continuous measure of the likelihood that the species will sustain populations over time.

Table 5: Future Scenario Comparison Table

Threats	Scenario 1: Increasing Threats (RCP 8.5, plus extreme events such as drought)	Scenario 2: Continuation Scenario (RCP 8.5)	Scenario 3: Lower Emissions Scenario (RCP 4.5)
Development	Increases with population growth	Avoids Habitat	Avoids Habitat
Abundance of Vegetation	Increases due to lack of management	Increases	Slightly Increases
Nonnative Predators	Increases due to lack of management	Increases	Slightly Increases
Drought	Increases	Increases	Increases

Noise Disturbance	Increases with population growth	Remains the same	Remains the same
Wildfire	Increases due to drier conditions	Increases	Increases

Table 6: Number of Local Populations and Total Area Conserved in Each Region

Region	Number of Local Populations Conserved	Total Acreage in Region Conserved (acres)	Total Acreage in Region Not Conserved (acres)
Northern Western Spadefoot Clade			
Northwestern Sacramento Valley	0	1,149	15,563
Northeastern Sacramento Valley	1	5,407	10,836
Solano-Colusa	0	0	0
Southeastern Sacramento Valley	2	17,133	57,921
Livermore	1	3,780	11,600
Southern Sierra Foothills	2	17,479	195,332
San Joaquin Valley	7	33,429	59,135
Central Coast	1	4,109	53,376
Carrizo	3	21,084	112,519
Santa Barbara	0	3,317	130,587
Southern Western Spadefoot Clade			
Northwest Ventura and Los Angeles	3	5,497	22,757
Orange-Los Angeles Basin	18	25,412	9,912
Inland Empire	14	24,872	50,117
Inland Riverside-San Diego	10	10,984	10,791
Coastal Military Lands	22	30,359	3,626
Central San Diego	33	53,879	39,568
Baja Northwest	2	4,536	5,200
Baja Northeast	0	2,015	7,257
Baja Central	0	0	572
Baja South	0	0	6,367

10.3 Future Scenario Summary of Methods

Three plausible future scenarios were considered, and the viability of western spadefoot was assessed under each scenario using the western spadefoot condition category table (Table 2). For each scenario, a description is given of the scenario assumptions, and a table presents predicted changes in stressors/threats, how the threats would impact individual and population needs, the assumed magnitude of the impacts, and the current understanding of the likelihood of the prediction. Table 7 describes the definitions that were used for predicted change, magnitude, and likelihood of threats. The likelihood of the threat refers to the confidence from the scientific literature of how likely the prediction is to occur. The overall condition was determined as described in the current condition section of the SSA (section 11.1). Only categories that were given a condition in the current condition were assigned a condition for the future conditions.

For the future scenario analyses, we also considered lands that are currently protected within the local populations of both the northern and southern clade. Lands that are protected are unlikely to be impacted by development under any of the future scenarios, and some lands likely also have the benefit of being managed for natural conditions, reducing some of the threats such as overabundance of vegetation and non-native predators. Table 6 shows the number of local populations in each region that are either fully protected or have the amount of land protected such that it could support a population with a 2,000-meter buffer in the northern clade or a 1,000-meter buffer in the southern clade.

Data are not available to determine the condition of the individual need of small invertebrate prey for any region; therefore, we do not include it in our analysis. With no current condition basis, a future condition was not predicted for the unknown category. Each scenario only represents one possibility of an infinite number of future scenarios. The threats of chemical contaminants and potential disease were also not considered under the future scenarios because there is no evidence that these threats are impacting the species now or will in the future. The same predictions were made for both the northern and southern western spadefoot clades.

Table 7: Predicted Magnitude Definitions for Threats

Magnitude Term	Definition
Weak	Threat/stressor may have an impact, but not enough to impact the condition of the individual or population need
Strong	Threat/stressor will impact the condition of the individual or population need

10.4 Future Scenario 1: Increasing Threats Scenario

Scenario 1 considers future western spadefoot viability where some threats increase over the next 30–40 years, including extreme weather events of drought. This future scenario is based on the climate change prediction of Representative Concentration Pathway (RCP) 8.5, which is the upper bound of plausible climate change conditions in the future. In comparison to averages from 1976 to 2005, the projected average annual temperature increases under RCP 8.5 by mid-century (2040–2069) in California is approximately 5.8ºF (Bedsworth *et al*. 2018, p. 23). In addition, this scenario considers a future with more extreme weather events such as an extended multi-year drought. The bounds of the magnitude of each threat are based on the best available science and potential plausible increases in threats.

Under this scenario, development increases in California. Of the 37 counties within the western spadefoot range, 30 are predicted to have a population increase of at least 10 percent by 2050 (CalTrans 2016, entire). With a majority of counties predicted to have an increase in population, development will likely increase within the range of western spadefoot and may occur in vernal pool habitat that is not currently protected. Development would decrease the quality and quantity of aquatic breeding pools and underground burrows leading to declines in abundance, dispersal, and reproduction. There are five regions in the southern western spadefoot clade that will likely not be impacted by future development because enough land is conserved for the number of local populations needed for the region to be resilient. The regions include Orange-Los Angeles Basin, Inland Empire, Inland Riverside-San Diego, Coastal Military Lands, and Central San Diego. Overabundant vegetation that may be impacting western spadefoot needs to be properly managed or it can lead to the premature drying of aquatic breeding pools decreasing the ability of western spadefoot to disperse and reproduce. Even with protected vernal pool habitat, overabundance of vegetation can occur if the habitat is not properly managed (Vollmar *et al* 2017, pp. 2-8–2-15). Nonnative predators also have the potential to increase without management actions. There is evidence that non-native predators may increase with changing climate conditions (Sorte *et al*. 2012, p. 261). The increase of nonnative predators would likely cause declines of abundance and reproduction. Extreme events have the potential to either increase or decrease the number of nonnative predators. Not enough water would likely make the habitat less suitable for nonnative predators considering they prefer more permanent water sources, whereas an increase in storm events may produce aquatic breeding pools that are more hospitable for nonnative predators. An increase of extreme events has been predicted in California including both drought and flooding events (Bedsworth *et al*. 2018, p. 22). Drought would likely have the greatest impact on western spadefoot by reducing aquatic breeding pools available and reducing abundance, dispersal, and reproduction. Droughts are likely to be more frequent, longer, and more intense in the future (Bedsworth *et al*. 2018, p. 57). It is hypothesized that current effective population sizes may be low due to recent drought events (Neal 2019, p. 32). Although an extended drought period may minimize the number of nonnative predators, the negative impacts of drought on western spadefoot in limiting the number of western spadefoot individuals able to breed would likely outweigh benefit of fewer nonnative predators. With a lifespan of only 5-6 years, a multi-year drought would likely have significant consequences on the abundance of the species. Noise disturbance would likely increase as the human population and development increases. This disturbance could cause miscues for individuals to come out of burrows and breed when environmental conditions are not appropriate to support breeding or may cause individuals to not hear mating calls. It is possible that individuals could surface at times that may lead to mortality if high temperatures cause desiccation or if energy stores are used up to surface and prey is not available. Wildfires would likely increase due to warmer and drier conditions on the landscape.

Although some vernal pool habitat is currently protected, it is possible that under future climate scenarios and with extended drought periods that the protected vernal pool habitat may no longer be suitable for western spadefoot. If seasonal rains are compromised, then the aquatic breeding pools may no longer be available for western spadefoot. Upland habitat may still be present and protected, but if they are no longer within range of the aquatic breeding pools then they are not sufficient for the needs of western spadefoot. Small invertebrate prey would likely also be compromised by climate change and extreme weather conditions. With a decrease of both quality and quantity of all the individual needs, all the population needs would likely also decrease. Looking at the future threats under scenario 1, all the individuals needs will likely decrease in quality or quantity, but they each will only be impacted by some of the threats. The population needs will likely be impacted by all of the future threats. Table 8 provides a summary of the assumptions for Scenario 1, including how each threat is expected to impact the individual and population needs. All the regions with effective number of breeders data available had a low condition for abundance. Under Future Scenario 1, regions will likely have even lower number of effective number of breeders or potentially become extirpated. A "very low or extirpated" category was added for Future Scenario 1 since conditions would likely continue to worsen from a low condition. Table 9, Table 10, and Figure 12 provide the predicted condition for both northern and southern western spadefoot regions under Scenario 1.

Table 8: Future Scenario 1 Threat Projections

Threat	Scenario 1 Prediction	Impacts to Individual and Population Needs	Magnitude of Impact	Regions Impacted
Development	Increase with population growth	Aquatic Breeding Pools	Strong	All
		Upland Habitat	Strong	
		Seasonal Rains	No impact	
		Small Invertebrate Prey	Strong	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Overabundant Vegetation	Increase with lack of management	Aquatic Breeding Pools	Strong	All
		Upland Habitat	Weak	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	

Nonnative Predators	Increase with lack of management	Aquatic Breeding Pools	No Impact	All
		Upland Habitat	No Impact	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Strong	
		Dispersal	Weak	
		Abundance	Strong	
Drought	Increase; extended periods	Aquatic Breeding Pools	Strong	All
		Upland Habitat	No Impact	
		Seasonal Rains	Strong	
		Small Invertebrate Prey	Strong	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Noise Disturbance	Increase with population growth	Aquatic Breeding Pools	No Impact	All
		Upland Habitat	No Impact	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	No Impact	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Wildfire	Increase due to drier conditions	Aquatic Breeding Pools	Weak	All
		Upland Habitat	Weak	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Weak	
		Dispersal	Weak	
		Abundance	Strong	

Table 9: Northern Western Spadefoot Future Condition Scenario 1 Table (Conditions that are bolded indicate a change from the current condition table)

Northern Western Spadefoot Regions	**Habitat Factors**			**Demographic Factors**	**Overall Condition**
	Habitat Quantity/ Distribution	Habitat Quality	Rainfall	Abundance (x3)	
Northwestern Sacramento Valley	**Moderate (2)**	Low (1)	**Moderate (2)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.89)**
Northeastern Sacramento Valley	**Moderate (2)**	Low (1)	**Low-Moderate (1.5)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.85)**
Solano-Colusa	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.5)**	**Low-Moderate (1.5)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.60)**
Southeastern Sacramento Valley	**Moderate (2)**	**Low (1)**	**Moderate (2)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.89)**
Livermore	**Low (1)**	Low (1)	**Low-Moderate (1.5)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.76)**
Southern Sierra Foothills	**Moderate (2)**	**Moderate (2)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.89)**
San Joaquin Valley	**Moderate (2)**	Low (1)	**Low (1)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.79)**
Central Coast	**Moderate (2)**	**Low (1)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.79)**
Carrizo	**Moderate (2)**	**Moderate (2)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.89)**
Santa Barbara	**Moderate (2)**	Low (1)	**Low (1)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.79)**

Table 10: Southern Western Spadefoot Future Condition Scenario 1 Table (Conditions that are bolded indicate a change from the current condition table)

Southern Western Spadefoot Regions	**Habitat Factors**			**Demographic Factors**	**Overall Condition**
	Habitat Quantity/ Distribution	Habitat Quality	Rainfall	Abundance (x3)	
Northwest Ventura and Los Angeles	**Moderate (2)**	**Moderate (2)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.89)**
Orange-Los Angeles Basin	High (3)	**Moderate-High (2.5)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Low (0.99)**
Inland Empire	High (3)	**Moderate-High (2.5**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Low (0.99)**
Inland Riverside-San Diego	High (3)	**Moderate-High (2.5)**	**Low (1)**	Very Low or Extirpated (0.5)	**Low (0.99)**
Coastal Military Lands	High (3)	**Moderate-High (2.5)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Low (0.99)**
Central San Diego	High (3)	**Moderate-High (2.5)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Low (0.99)**
Baja Northwest	**Moderate (2)**	Low (1)	**Low (1)**	Very Low or Extirpated (0.5)	**Very Low or Extirpated (0.79)**
Baja Northeast	**Moderate (2)**	**Moderate (2)**	**Low (1)**	**Very Low or Extirpated (0.5)**	**Very Low or Extirpated (0.89)**
Baja Central	Low	Low	Unknown	Unknown	Unknown
Baja South	**Moderate**	Low	Unknown	Unknown	Unknown

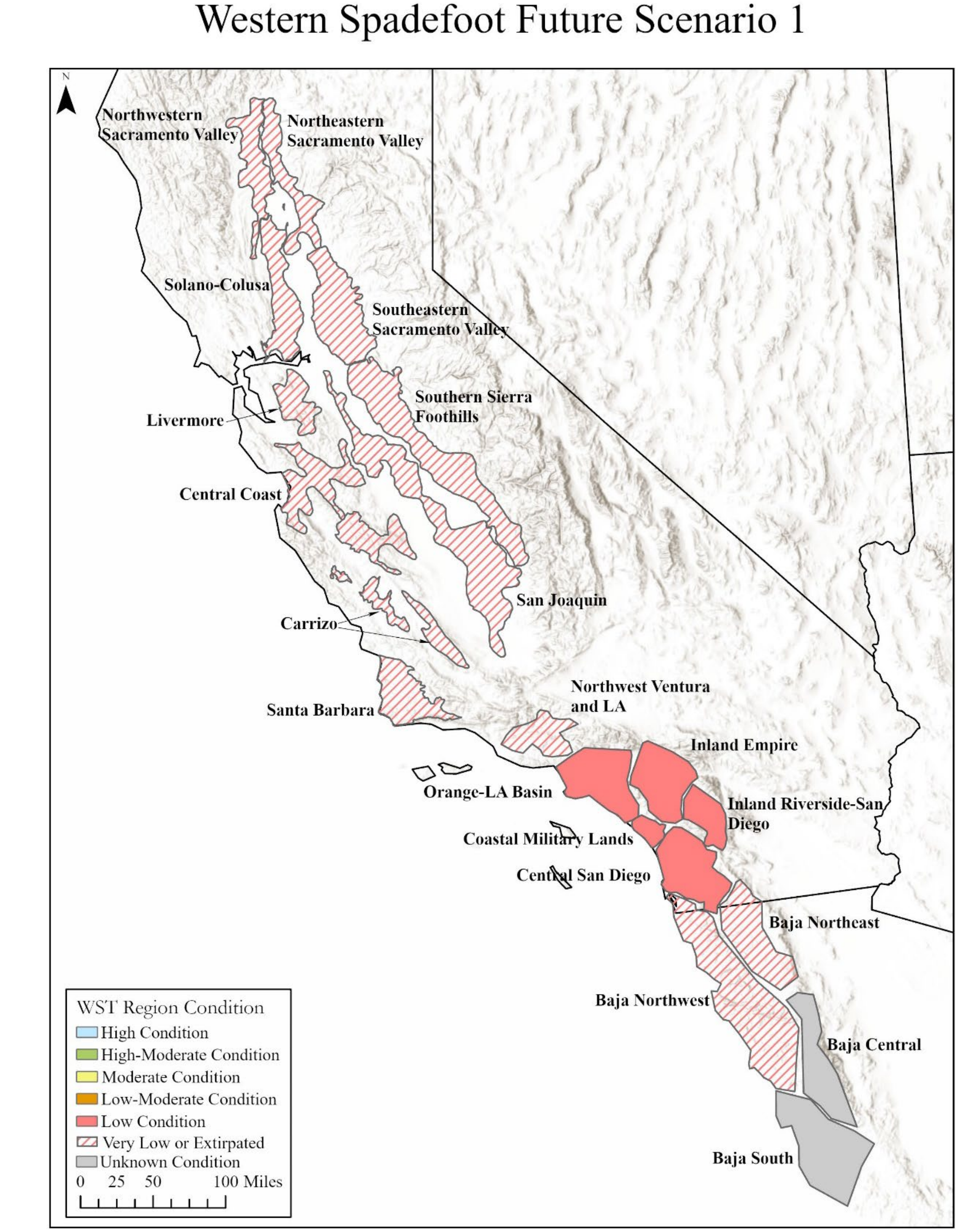

Figure 12: Map of western spadefoot regions and the overall viability projection under future Scenario 1.

10.4.1 Future Scenario 1 Northern Western Spadefoot Redundancy

Under Scenario 1, all ten regions are likely to be very low or potentially extirpated. Regions with a very low or low condition have a low probability of persistence in the future, and would likely not withstand a catastrophic event. Overall, the species would be less likely to withstand a catastrophic event than under current condition and would likely have a reduced number of regions in the future.

10.4.2 Future Scenario 1 Northern Western Spadefoot Representation

As identified above, northern western spadefoot has representation in the form of physiological adaptive potential, genetic differences throughout the range, and diversity of ecological settings throughout the range. Predictions for Scenario 1 are that many of the habitat characteristics identified as needs for northern western spadefoot will likely have a limited ability to withstand predicted changes and decrease the condition in the future. Under Future Scenario 1, northern western spadefoot populations will likely have even lower effective number of breeders than the already low effective number of breeders measured under current conditions. The continued decline in effective number of breeders will result in a loss of genetic diversity for the species, decreasing the representation. With all ten regions in very low condition, with the potential for extirpation, representation will be decreased under Scenario 1. There will likely be loss in genetic and ecological diversity within the northern western spadefoot clade.

10.4.3 Future Scenario 1 Southern Western Spadefoot Redundancy

Under Scenario 1, three regions would likely be in very low condition or potentially extirpated, and an additional five regions would likely be in low condition. Regions with a very low or low condition have a low probability of persistence in the future, and are more at risk of extirpation from a catastrophic event. Overall, the species would be less likely to withstand catastrophic events than under current condition, and would likely have a reduced number of regions in the future.

10.4.4 Future Scenario 1 Southern Western Spadefoot Representation

As identified above, southern western spadefoot has limited representation in the form of physiological adaptive potential, genetic differences throughout the range, and diversity of ecological settings throughout the range. Predictions for Scenario 1 are that many of the habitat characteristics identified as needs for southern western spadefoot will likely have a limited ability to withstand predicted changes and decrease the condition in the future. Under Future Scenario 1, southern western spadefoot populations will likely have even lower effective number of breeders compared to current conditions. The continued decline in effective number of breeders will result in a loss of genetic diversity for the species, decreasing the representation.

10.5 Future Scenario 2: Continuation Scenario

Scenario 2 considers western spadefoot viability under a continuation future where the threats continue at the current levels. This future scenario is based on the climate change prediction of RCP 8.5, which is the upper bound of plausible climate change conditions in the future. In comparison to averages from 1976 to 2005, the projected average annual temperature increases under RCP 8.5 by mid-century (2040–2069) in California is approximately 5.8ºF (Bedsworth *et al*. 2018, p. 23). However, in comparison to Future Scenario 1 above, Future Scenario 2 predictions are that even though droughts are likely to become more frequent in the future, there are enough rain days to allow successful reproduction to occur. The bounds of the magnitude of each threat are based on the best available science and the current trend of the threats.

Similar to Scenario 1, under Scenario 2 development increases in California. With projected increases in population in California, development will likely continue within the range of western spadefoot (The California Economic Forecast 2016, entire). However, there are several species listed as threatened and endangered under the Endangered Species Act that also occupy vernal pool habitat which may limit development in areas that would impact western spadefoot. Some habitat may be lost to development, but if protection of essential vernal pool habitat was to continue into the future, impacts would likely be minimal. Under Scenario 2, development would likely only have a weak impact on the quality and quantity of aquatic breeding pools and upland habitat leading to only minor declines in abundance, dispersal, and reproduction. Overabundant vegetation needs to be managed or it can lead to the premature drying of aquatic breeding pools decreasing the ability of western spadefoot to disperse and reproduce. Even with protected vernal pool habitat, overabundance of vegetation can occur if the habitat is not properly managed (Vollmar *et al* 2017, pp. 2-8–2-15). Overall, a majority of vernal pool habitat preserves are being managed adequately in regards to the maintenance of infrastructure (fences, gates, signs, and roads) and protection from nonranching human disturbance; however, looking at all preserves the amount of grazing, residual dry matter, and invasive weed control could be improved (Vollmar *et al*. 2017, p. 2-15). If management were to continue as it is currently into the future, there may be some impacts to western spadefoot aquatic breeding pools and population needs, decreasing the habitat quality from current condition. There is evidence that non-native predators may increase with changing climate conditions (Sorte *et al*. 2012, p. 261).

Extreme events such as drought are likely to increase into the future (Bedsworth *et al*. 2018, p. 22); however, Scenario 2 assumes that there would be adequate time in between drought events for western spadefoot populations to recover from the previous drought period. Noise disturbance would likely remain the same given the limited development within vernal pool habitats. Wildfire will likely continue to occur on the landscape, having some impacts on western spadefoot populations. Although there may be some decline in reproduction and abundance due to the shorter presence of aquatic breeding pools, given the adaptive potential of the species there will likely be some western spadefoot individuals likely to persist even with the shorter duration of seasonal pools, though they may have some decreased fitness.

Looking at the future threats under Scenario 2, aquatic breeding pools, upland habitat and small invertebrate prey would likely decrease from current condition, although not as significantly as predicted under Future Scenario 1. Under Scenario 2, the pattern of seasonal rains may change, but with the adaptive potential of western spadefoot it would likely only minorly impact the species. There will likely be some declines in western spadefoot habitat and demographic factors however they will be limited due to the continuation of current protections of vernal pool habitat and the adaptive potential of the species to withstand shorter vernal pool duration in the spring. Table 11 provides a summary of the assumptions for Scenario 2, including how each threat is expected to impact the individual and population needs. Table 12, Table 13, and Figure 13 provide the predicted condition for each region under Scenario 2.

Table 11: Future Scenario 2 Threat Projections

Threat	Scenario 2 Prediction	Impacts to Individual and Population Needs	Magnitude of Impact	Regions Impacted
Development	Increase, but avoid vernal pool areas	Aquatic Breeding Pools	Strong	All
		Upland Habitat	Strong	
		Seasonal Rains	No impact	
		Small Invertebrate Prey	Strong	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Overabundant Vegetation	Slightly Increase	Aquatic Breeding Pools	Strong	All
		Upland Habitat	Weak	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Nonnative Predators	Slightly Increase	Aquatic Breeding Pools	No Impact	All
		Upland Habitat	No Impact	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Strong	

		Dispersal	Weak	
		Abundance	Strong	
Drought	Increase	Aquatic Breeding Pools	Strong	All
		Upland Habitat	No Impact	
		Seasonal Rains	Strong	
		Small Invertebrate Prey	Strong	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Noise Disturbance	Remain the same	Aquatic Breeding Pools	No Impact	All
		Upland Habitat	No Impact	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	No Impact	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Wildfire	Increase	Aquatic Breeding Pools	Weak	All
		Upland Habitat	Weak	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Weak	
		Dispersal	Weak	
		Abundance	Strong	

Table 12: Northern Western Spadefoot Clade Future Condition Scenario 2 Table (Conditions that are bolded indicate a change from the current condition table)

Northern Western Spadefoot Regions	**Habitat Factors**			**Demographic Factors**	**Overall Condition**
	Habitat Quantity/ Distribution	Habitat Quality	Rainfall	Abundance (weighted three times)	
Northwestern Sacramento Valley	High (3)	Low (1)	**Moderate-High (2.5)**	Low (1)	Low (1.40)
Northeastern Sacramento Valley	High (3)	Low (1)	**Moderate (2)**	Low (1)	Low (1.35)
Solano-Colusa	Low (1)	Low (1)	**Moderate (2)**	Low (1)	Low (1.12)
Southeastern Sacramento Valley	High (3)	**Low-Moderate (1.5)**	**Moderate-High (2.5)**	Low (1)	Low-Moderate (1.50)
Livermore	Moderate (2)	Low (1)	**Moderate (2)**	Low (1)	Low (1.26)
Southern Sierra Foothills	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate(1.50)
San Joaquin Valley	High (3)	Low (1)	**Low-Moderate (1.5)**	Low (1)	Low (1.28)
Central Coast	High (3)	**Low-Moderate (1.5)**	**Low-Moderate (1.5)**	Low (1)	**Low (1.37)**
Carrizo	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Santa Barbara	High (3)	Low (1)	**Low-Moderate (1.5)**	Low (1)	Low (1.28)

Table 13: Southern Western Spadefoot Clade Future Condition Scenario 2 Table (Conditions that are bolded indicate a change from the current condition table)

Southern Western Spadefoot Regions	**Habitat Factors**			**Demographic Factors**	**Overall Condition**
	Habitat Quantity/ Distribution	Habitat Quality	Rainfall	Abundance (x3)	
Northwest Ventura and Los Angeles	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Orange-Los Angeles Basin	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Inland Empire	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Inland Riverside-San Diego	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Coastal Military Lands	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Central San Diego	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Baja Northwest	High (3)	Low (1)	**Low-Moderate (1.5)**	Low (1)	Low (1.28)
Baja Northeast	High (3)	**Moderate-High (2.5)**	**Low-Moderate (1.5)**	Low (1)	Low-Moderate (1.50)
Baja Central	Low	Unknown	Unknown	Unknown	Unknown
Baja South	High	Unknown	Unknown	Unknown	Unknown

Western Spadefoot Future Scenario 2

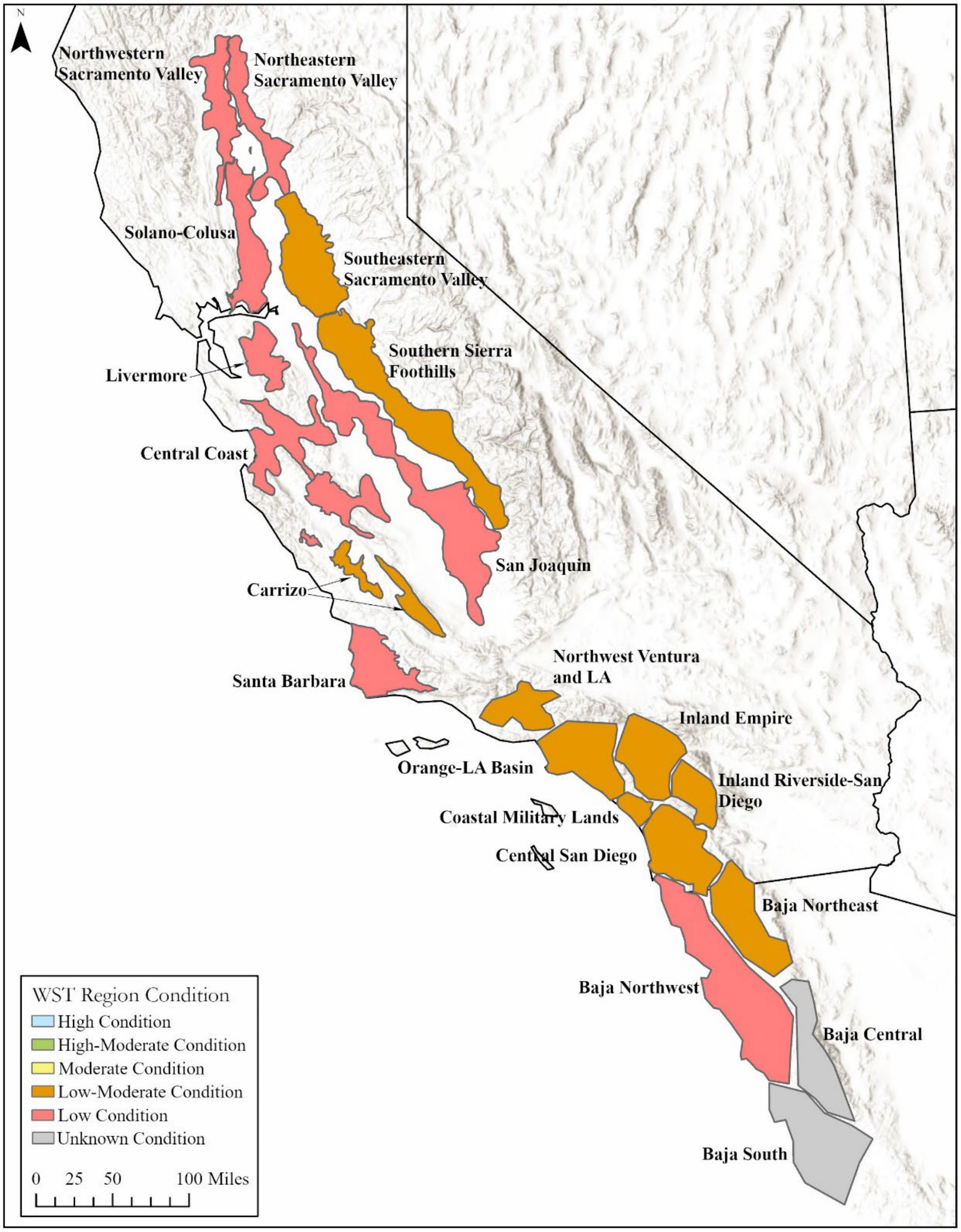

Figure 13: Map of western spadefoot regions and the overall viability projection under future Scenario 2.

10.5.1 Future Scenario 2 Northern Western Spadefoot Redundancy

Under Scenario 2, one of the regions would likely have reduced resiliency. None of the regions would be in high or moderate condition. Three regions are predicted to be in low-moderate condition, and seven regions are predicted to be in low condition. Overall, a majority of the regions are predicted to have low or low-moderate resiliency, which reduces the likelihood of persistence into the future. Under Future Scenario 2, the northern western spadefoot clade will be less likely to withstand a catastrophic event, reducing redundancy from the current condition.

10.5.2 Future Scenario 2 Northern Western Spadefoot Representation

As identified above, the northern western spadefoot clade has representation in the form of physiological adaptive potential, genetic differences throughout the range, and diversity of ecological settings throughout the range. Predictions for Scenario 2 are that there would be limited change in habitat characteristics and demographics identified as needs for western spadefoot. Although in low condition, there will likely be a variety of unique vernal pool habitats occupied throughout the northern western spadefoot clade into the future. The population need of reproduction will likely be particularly impacted by a generally warmer drier future, which is a concern due to current low western spadefoot effective number of breeders measured in vernal pool regions. Under Future Scenario 2, there will likely continue to be a loss in genetic diversity, reducing representation from the current condition. With the amount of land that is protected for vernal pool habitat within the northern clade, we predict that the species will likely maintain some level of representation even if there was a decline in populations in regions with low condition.

10.5.3 Future Scenario 2 Southern Western Spadefoot Redundancy

Under Scenario 2, regions in the southern western spadefoot clade would have similar overall resiliency as they do currently. None of the regions are predicted to be in high or moderate condition. Similar to current conditions, seven regions are predicted to be in low-moderate condition, and one region is predicted to be in low condition. Two regions have an unknown future condition. Overall, a majority of the regions are predicted to maintain a low-moderate resiliency. Under Future Scenario 2, the southern western spadefoot clade may be less likely to withstand a catastrophic event due to small declines in habitat quality and rainfall, reducing redundancy from the current condition.

10.5.4 Future Scenario 2 Southern Western Spadefoot Representation

As identified above, the southern western spadefoot clade has representation in the form of physiological adaptive potential, genetic differences throughout the range, and diversity of ecological settings throughout the range. Predictions for Scenario 2 are that there would be limited change in habitat characteristics and demographics identified as needs for western spadefoot. Although in low condition, there will likely be a variety of unique vernal pool habitats occupied throughout the southern western spadefoot clade into the future. The population need of reproduction will likely be particularly impacted by a generally warmer drier future, which is a concern due to current low western spadefoot effective number of breeders measured in vernal pool regions. Under Future Scenario 2, there will likely continue to be a loss in genetic diversity, reducing representation from the current condition. With the amount of land that is protected for vernal pool habitat within the southern clade, we predict that the species will likely maintain some level of representation even if there was a decline in populations in regions with low condition.

10.6 Future Scenario 3: Lower Emission Scenario

Scenario 3 considers western spadefoot viability under a future similar to the continuation scenario but with a lower increase in greenhouse gas emissions compared to business as usual. This future scenario is based on the climate change prediction of RCP 4.5, which is the lower bound of plausible climate change conditions in the future. The projected average annual temperature increases under RCP 4.5 by mid-century (2040–2069) in California is approximately 4.4ºF (Bedsworth *et al*. 2018, p. 23). The bounds of the magnitude of each threat are based on the best available science and the potential management improvements that could occur for the species within 30–40 years.

With projected increases in population in California, development will likely continue within the range of western spadefoot (The California Economic Forecast 2016, entire). However, there are several species listed as threatened and endangered under the Endangered Species Act that also occupy vernal pool habitat which may limit development in areas that would impact western spadefoot. Under Scenario 3, the assumption is that even with an increase in human population in California, the future development will avoid vernal pool habitat occupied by western spadefoot through protection of more vernal pool habitat than what is currently protected. Overabundant vegetation needs to be managed or it can lead to the premature drying of aquatic breeding pools decreasing the ability of western spadefoot to disperse and reproduce. Even with protected vernal pool habitat, overabundance of vegetation can occur if the habitat is not properly managed (Vollmar *et al* 2017, pp. 2-8–2-15). Overall, a majority of vernal pool habitat preserves are being managed adequately in regards to the maintenance of infrastructure (fences, gates, signs, and roads) and protection from nonranching human disturbance; however, looking at all preserves the amount of grazing, residual dry matter, and invasive weed control could be improved (Vollmar *et al*. 2017, p. 2-15). If management were to continue as it is currently into the future, there may be some impacts to western spadefoot aquatic breeding pools and population needs, but they would likely not further decrease western spadefoot needs from current condition. Under Scenario 3, nonnative predators would likely remain at the current trajectory having some impacts on reproduction and abundance.

Extreme events such as drought are likely to increase into the future (Bedsworth *et al*. 2018, p. 22); however, Scenario 3 assumes that there would be adequate time in between drought events or active management to ensure presence of pools for western spadefoot populations to recover from drought periods. Noise disturbance would likely remain the same given the limited development within vernal pool habitats. Wildfire will likely continue to occur on the landscape, having some impacts on western spadefoot populations.

Under Scenario 3, temperatures will likely increase in the future changing to some extent the time period of available vernal pools, but with the adaptive potential of western spadefoot it would likely only minorly impact the species. Under RCP 4.5, abundance and reproduction will likely remain steady under Scenario 3. Table 14 provides a summary of the assumptions for Scenario 3, including how each threat is expected to impact the individual and population needs. Table 15, Table 16, and Figure 14 provide the predicted condition for each region under Scenario 3.

Table 14: Future Scenario 3 Threat Projections

Threat	Scenario 3 Prediction	Impacts to Individual and Population Needs	Magnitude of Impact	Regions Impacted
Development	Remain the same	Aquatic Breeding Pools	Weak	All
		Upland Habitat	Weak	
		Seasonal Rains	No impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Weak	
		Dispersal	Weak	
		Abundance	Weak	
Overabundant Vegetation	Remain the same	Aquatic Breeding Pools	Strong	All
		Upland Habitat	Weak	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Nonnative Predators	Remain the same	Aquatic Breeding Pools	No Impact	All
		Upland Habitat	No Impact	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Strong	
		Dispersal	Weak	
		Abundance	Strong	
Drought	Remain the same	Aquatic Breeding Pools	Strong	All

		Upland Habitat	No Impact	
		Seasonal Rains	Strong	
		Small Invertebrate Prey	Strong	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Noise Disturbance	Remain the same	Aquatic Breeding Pools	No Impact	All
		Upland Habitat	No Impact	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	No Impact	
		Reproduction	Strong	
		Dispersal	Strong	
		Abundance	Strong	
Wildfire	Remain the same	Aquatic Breeding Pools	Weak	All
		Upland Habitat	Weak	
		Seasonal Rains	No Impact	
		Small Invertebrate Prey	Weak	
		Reproduction	Weak	
		Dispersal	Weak	
		Abundance	Strong	

Table 15: Northern Western Spadefoot Clade Future Condition Scenario 3 Table (Conditions that are bolded indicate a change from the current condition table)

Northern Western Spadefoot Regions	**Habitat Factors**			**Demographic Factors**	**Overall Condition**
	Habitat Quantity/ Distribution	Habitat Quality	Rainfall	Abundance (weighted three times)	
Northwestern Sacramento Valley	High (3)	Low (1)	High (3)	Low (1)	Low (1.44)
Northeastern Sacramento Valley	High (3)	Low (1)	Moderate-High (2.5)	Low (1)	Low (1.40)
Solano-Colusa	Moderate (2)	Low (1)	Moderate-High (2.5)	Low (1)	Low (1.31)
Southeastern Sacramento Valley	High (3)	Moderate (2)	High (3)	Low (1)	Low-Moderate (1.62)
Livermore	Moderate (2)	Low (1)	Moderate-High (2.5)	Low (1)	Low (1.31)
Southern Sierra Foothills	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
San Joaquin Valley	High (3)	Low (1)	Moderate (2)	Low (1)	Low (1.35)
Central Coast	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Carrizo	High (3)	Moderate (2)	Moderate (2)	Low (1)	Low-Moderate (1.51)
Santa Barbara	High (3)	Low (1)	Moderate (2)	Low (1)	Low (1.35)

Table 16: Southern Western Spadefoot Clade Future Condition Scenario 3 Table (Conditions that are bolded indicate a change from the current condition table)

Southern Western Spadefoot Regions	**Habitat Factors**			**Demographic Factors**	**Overall Condition**
	Habitat Quantity/ Distribution	Habitat Quality	Rainfall	Abundance (x3)	
Northwest Ventura and Los Angeles	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Orange-Los Angeles Basin	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Inland Empire	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Inland Riverside-San Diego	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Coastal Military Lands	High (3)	High (3)	Moderate (2)	Low (1)	Low-moderate (1.62)
Central San Diego	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Baja Northwest	High (3)	Low (1)	Moderate (2)	Low (1)	Low (1.35)
Baja Northeast	High (3)	High (3)	Moderate (2)	Low (1)	Low-Moderate (1.62)
Baja Central	Low	Low	Unknown	Unknown	Unknown
Baja South	High	Low	Unknown	Unknown	Unknown

Western Spadefoot Future Scenario 3

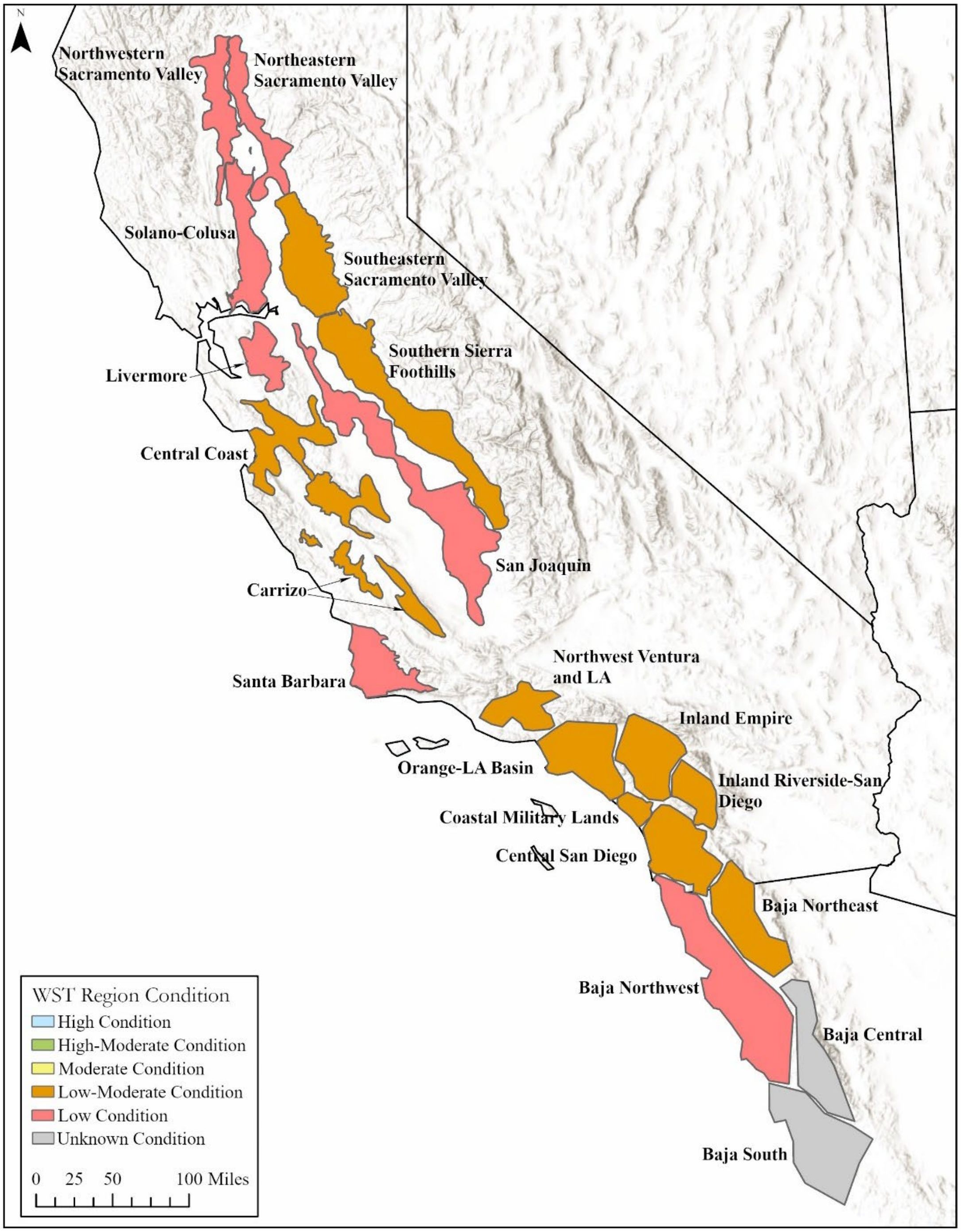

Figure 14: Map of western spadefoot regions and the overall viability projection under future Scenario 3.

10.6.1 Future Scenario 3 Northern Western Spadefoot Redundancy

Under Scenario 3, all of the northern western spadefoot regions would be similarly resilient compared to current condition. Four regions will likely have an overall low-moderate condition, and six regions will likely have a low condition. With a majority of the regions in low-moderate or low condition, it may be difficult for the northern western spadefoot clade to withstand a catastrophic event. Under Future Scenario 3, the likelihood of withstanding a catastrophic event is the same as the current condition.

10.6.2 Future Scenario 3 Northern Western Spadefoot Representation

As identified above, northern western spadefoot has representation in the form of physiological adaptive potential, genetic differences throughout the range, and diversity of ecological settings throughout the range. Effective number of breeders will likely remain low under Future Scenario 3, which reduces the representation due to lack of genetic diversity. It is possible under Future Scenario 3 there will be minor negative impacts to demography due to predicted changes in climate even under a future with decreased greenhouse gas emissions, but the species' physiological adaptive potential will likely allow the species to maintain representation similar to the representation discussed in the current condition.

10.6.3 Future Scenario 3 Southern Western Spadefoot Redundancy

Under Scenario 3, all of the southern western spadefoot regions would be similarly resilient compared to current condition. Seven regions will likely have an overall low-moderate condition, and one region will likely have a low condition. The condition of two regions is unknown. With a majority of the regions in low-moderate or low condition, it may be difficult for the southern western spadefoot clade to withstand a catastrophic event. Under Future Scenario 3, the likelihood of withstanding a catastrophic event is the same as the current condition.

10.6.4 Future Scenario 3 Southern Western Spadefoot Representation

As identified above, southern western spadefoot has representation in the form of physiological adaptive potential, genetic differences throughout the range, and diversity of ecological settings throughout the range. Effective number of breeders will likely remain low under Future Scenario 3, which reduces the representation due to lack of genetic diversity. It is possible under Future Scenario 3 there will be minor negative impacts to demography due to predicted changes in climate even under a future with decreased greenhouse gas emissions, but the species' physiological adaptive potential will likely allow the species to maintain representation similar to the representation discussed in the current condition.

11.0 OVERALL ASSESSMENT FOR SPECIES VIABILITY

The SSA describes the current condition as well as a range of plausible future scenarios that we considered important influences on the status of both the northern and southern western spadefoot clades. The results describe a range of possible conditions of where resilient populations may persist now and in the future. The goal of the SSA is to describe the viability of the species in a manner that will address the individual, population, and species needs in terms of resiliency, redundancy, and representation. Table 17 provides a summary of the overall current condition as well as the predicted future conditions under Scenario 1, 2, and 3 for each region. Figure 15 is a side by side comparison map showing western spadefoot regions and the current and predicted future scenario conditions.

11.1 Overall Assessment for Northern Western Spadefoot Clade Viability

Western spadefoot viability is characterized by summarizing population resiliency and species redundancy and representation. For resiliency, an overall high condition for a region is an indicator of high probability of persistence of individuals in the region, an overall moderate condition is an indicator that probability of persistence in that region may be compromised by the lack of one or more need, and a low overall condition indicates low probability of persistence of individuals in the region. Regions in high condition are expected to persist into the future and have the ability to withstand stochastic events that may occur. Regions in moderate condition are less resilient than those in high condition, but the majority of these regions are expected to persist beyond 30–40 years. Regions in moderate condition may have some declines in individual or population needs, but would likely still be able to support a population. Regions in low condition have low resiliency and may not be able to withstand stochastic events because of significant declines in individual or population needs. Regions in low condition are less likely to persist for 30–40 years, but a region in low condition does not automatically mean the region will become extirpated. We then use the number and distribution of resilient populations to assess redundancy and representation.

Under the current condition in the northern western spadefoot clade range, none of the regions are in high or moderate condition. Four regions are in low-moderate condition and six regions are in low condition. Currently, redundancy is limited in the northern western spadefoot clade because many of the regions are in low or low-moderate condition, compromising the species' ability to withstand a catastrophic event. The northern western spadefoot clade currently has some representation because the species exists throughout its historical range in unique vernal pool regions, providing for some habitat diversity needed to adapt to change. However, the low effective number of breeders measured in western spadefoot populations throughout the northern western spadefoot clades indicates low genetic diversity, reducing the representation of the clade. A combination of threats acting on the northern western spadefoot clade includes development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and climate change.

Under future Scenario 1, where threats increase in the future, including extreme weather events of extreme drought and flooding, all ten regions would likely be in very low condition with the potential to be extirpated. Both redundancy and representation would be reduced from current condition. Potential extirpations of western spadefoot from regions with very low or low resiliency would result in fewer populations to withstand catastrophic events. The further decrease in effective number of breeders would result in a loss of genetic diversity and presence in ecological settings reducing the representation of the northern western spadefoot clade. With three genetic clusters within the northern western spadefoot region, the genetic cluster north of the San Joaquin Delta has the highest probability of persistence, as the one region in low-moderate condition. There would likely be a loss of the two other genetic clusters that include south of the San Joaquin Delta and the central coast. The species may or may not persist across the unique vernal pool regions in the northern western spadefoot clade, but will most likely have reduced representation. Threats that will likely increase under Future Scenario 1 include development of unprotected habitat, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and climate change. The combination of these threats would reduce all the individual and population needs from current condition.

Under future Scenario 2, the continuation scenario, there would likely be a decrease in resiliency in the regions. Three regions would likely have low-moderate resiliency, and seven regions would likely have low resiliency. With reduced redundancy, the species will likely have difficulty withstanding a catastrophic event. Low effective numbers of breeders measured in western spadefoot populations throughout the northern western spadefoot clade would continue to decline, reducing the representation of the clade. The threat that will likely have the most significant impact on the northern western spadefoot clade in the future under Scenario 2 is climate change. Under warmer and drier conditions, reproduction will likely be impacted, which could exacerbate the already low effective number of breeders in the future.

Under future Scenario 3, with lower greenhouse gas emissions under RCP 4.5 in comparison to business as usual, the northern western spadefoot regions would be similarly as resilient as they are under the current condition. Of the ten regions, four would likely be in low-moderate condition, and six would likely be in low condition. Under Scenario 3, the northern western spadefoot clade would likely have similar redundancy to the current condition. The northern western spadefoot clade also would have representation because the species would exist throughout its historical range, within all three genetic clusters, in unique vernal pool regions, providing for some habitat diversity needed to adapt to change. However, low effective number of breeders measured in western spadefoot populations throughout the northern western spadefoot clade would remain, reducing the representation of the clade. The threat that will likely have the biggest impact on the species under future Scenario 3 is the climate projection of RCP 4.5.

11.2 Overall Assessment for Southern Western Spadefoot Clade Viability

Under the current condition in the southern western spadefoot clade range, none of the regions are in high or moderate condition. Seven regions are in low-moderate condition, one is in low condition, and two regions are unknown. Redundancy is limited in the southern western spadefoot clade because many of the regions are in low-moderate condition, compromising the species' ability to withstand a catastrophic event. The southern western spadefoot clade currently has some representation because the species exists throughout its historical range in unique vernal pool regions, providing for some habitat diversity needed to adapt to change. However, the low effective number of breeders measured in western spadefoot populations throughout the southern western spadefoot clade indicates low genetic diversity. A combination of threats acting on the southern western spadefoot clade includes development on unprotected areas, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and climate change.

Under future Scenario 1, where threats increase in the future, including extreme weather events of extreme drought and flooding, three of the ten regions would likely be in very low condition with the potential to be extirpated. Five regions are predicted to be in low condition due to the amount of habitat that is currently protected which reduces the likelihood of extirpation. Two regions would have unknown resiliency. Both redundancy and representation would be reduced from current condition. Potential extirpations of regions with very low or low resiliency would result in fewer populations to withstand catastrophic events. The further decrease in effective number of breeders would result in a loss of genetic diversity and presence in ecological settings reducing the representation of the southern western spadefoot clade. The species may or may not persist across the unique vernal pool regions in the southern western spadefoot clade, but will most likely have reduced representation. Threats that will likely increase under Future Scenario 1 include development of unprotected habitat, overabundant vegetation, nonnative predators, drought, noise disturbance, wildfire, and climate change. The combination of these threats would reduce all the individual and population needs from current condition.

Under future Scenario 2, the continuation scenario, there would likely be a decrease in resiliency in the regions. Seven regions would likely have low-moderate resiliency, one region will likely have low resiliency, and two regions would have unknown resiliency. With reduced redundancy due to low effective population sizes and a predicted warmer/drier future, the species will likely have difficulty withstanding a catastrophic event. Low effective numbers of breeders measured in western spadefoot populations throughout the southern western spadefoot clade would continue to decline, reducing the representation of the clade. Since much of this vernal pool habitat is protected and regions are likely to remain occupied, representation, though low, is not likely to change much over the next 30-40 years in Future Scenario 2. The threat that will likely have the most significant impact on the southern western spadefoot clade in the future under Scenario 2 is climate change. Under warmer and drier conditions, reproduction will likely be impacted, which could exacerbate the already low effective number of breeders in the future.

Under future Scenario 3, with lower greenhouse gas emissions under RCP 4.5 in comparison to business as usual, the southern western spadefoot regions would be as resilient as they are under the current condition. Of the ten regions, seven would likely be in low-moderate condition, and one in low condition. Two regions have unknown resiliency. Under Scenario 3, the southern western spadefoot clade would likely have similar redundancy to the current condition. The southern western spadefoot clade also would have representation because the species would exist throughout its historical range in unique vernal pool regions, providing for some habitat diversity needed to adapt to change. However, low effective number of breeders measured in western spadefoot populations throughout the southern western spadefoot clade would remain, reducing the representation of the clade. The threat that will likely have the biggest impact on the species under future Scenario 3 is the climate projection of RCP 4.5.

Table 17: Regional Current and Future Resiliency Comparisons

Region	Current Condition	Future Scenario 1	Future Scenario 2	Future Scenario 3
Northern Western Spadefoot Regions				
Northwestern Sacramento Valley	Low	Very Low or Extirpated	Low	Low
Northeastern Sacramento Valley	Low	Very Low or Extirpated	Low	Low
Solano-Colusa	Low	Very Low or Extirpated	Low	Low
Southeastern Sacramento Valley	Low-Moderate	Very Low or Extirpated	Low-Moderate	Low-Moderate
Livermore	Low	Very Low or Extirpated	Low	Low
Southern Sierra Foothills	Low-Moderate	Very Low or Extirpated	Low-Moderate	Low-Moderate
San Joaquin	Low	Very Low or Extirpated	Low	Low
Central Coast	Low-Moderate	Very Low or Extirpated	Low	Low-Moderate
Carrizo	Low-Moderate	Very Low or Extirpated	Low-Moderate	Low-Moderate
Santa Barbara	Low	Very Low or Extirpated	Low	Low
Southern Western Spadefoot Regions				
Northwestern Ventura and Los Angeles	Low-Moderate	Very Low or Extirpated	Low-Moderate	Low-Moderate
Orange-Los Angeles Basin	Low-Moderate	Low	Low-Moderate	Low-Moderate
Inland Empire	Low-Moderate	Low	Low-Moderate	Low-Moderate
Inland Riverside-San Diego	Low-Moderate	Low	Low-Moderate	Low-Moderate
Coastal Military Lands	Low-Moderate	Low	Low-Moderate	Low-Moderate
Central San Diego	Low-Moderate	Low	Low-Moderate	Low-Moderate
Baja Northwest	Low	Very Low or Extirpated	Low	Low
Baja Northeast	Low-Moderate	Very Low or Extirpated	Low-Moderate	Low-Moderate
Baja Central	Unknown	Unknown	Unknown	Unknown
Baja South	Unknown	Unknown	Unknown	Unknown

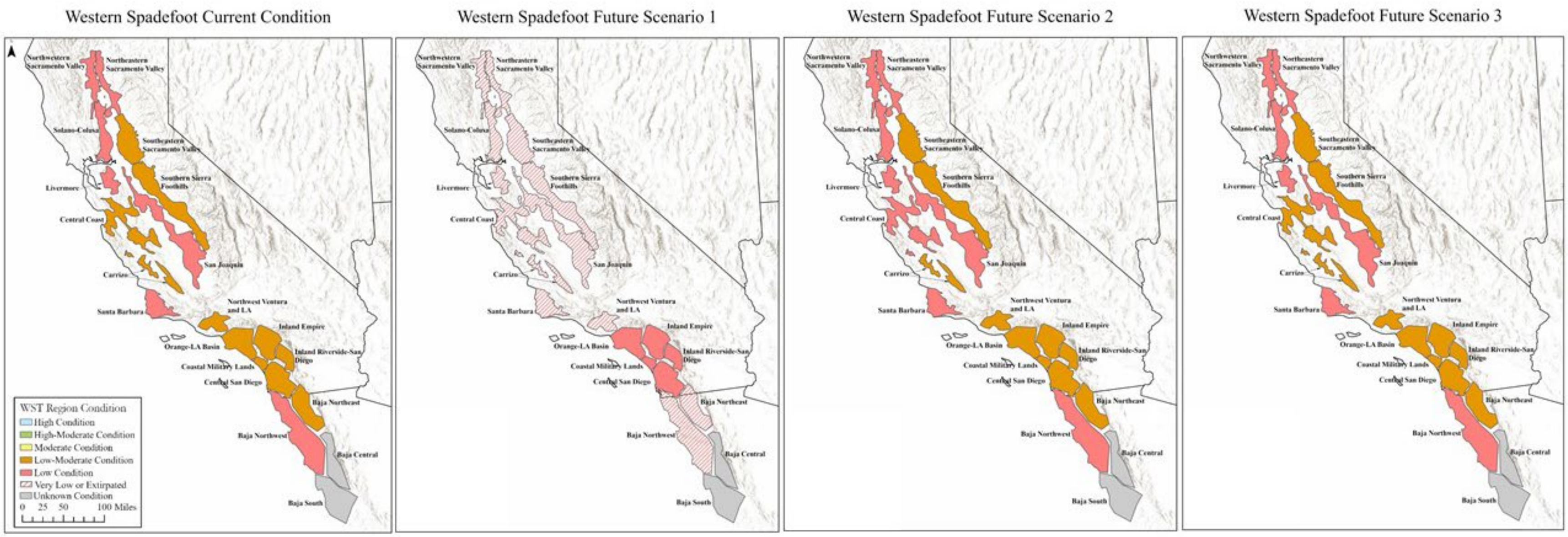

Figure 15: Maps showing the current condition of the western spadefoot regions in comparison to projections for western spadefoot regions under future Scenarios 1, 2, and 3.

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Appendix A: Habitat Conservation Plans that Include Conservation Measures for Western Spadefoot

Title	Title_url	Status	Regions	Lead Office	Impacts and Conservation for WST	Document and Notes	In ECOS for WST?
Fieldstone/La Costa & City of Carlsbad	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=184	plan completed and permit issued	Region 8	CFWO	1,040 acres affected; 565 acres conserved	City of Carlsbad HCP 1995; HCP Volume 1 page 76	Y
Assessment District 161	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=674	plan completed and permit issued	Region 8	CFWO	1,230 acres affected; 723 acres conserved	USFWS BO 2000; page 51	Y
Western Riverside MSHCP (One permit w/ 22 permittees)	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=983	plan completed and permit issued	Region 8	CFWO	289,001 acres affected; 375,357 acres conserved	BO for Western Riverside MSHCP 2004; page 403. Details: 985 acres breeding habitat and 297,016 upland habitat affected; 6,090 acres wetland and 369,267 acres upland conserved. All based on modeled habitat.	Y
Orange County Central/Coastal NCCP/HCP	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=99	plan completed and permit issued	Region 8	CFWO	12,000 acres taken; 9,500 acres conserved	County of Orange NCCP/HCP 1996; Page II-244. 3 breeding sites	Y

						taken; 10 breeding sites conserved	
El Sobrante Landfill	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=1026	plan completed and permit issued	Region 8	CFWO	645 acres affected; 1,305 acres conserved	BO for Western Riverside MSHCP 2004; page 67. No documents could be located from this project. Acres are estimates from Western Riverside MSHCP BO	Y
Lake Mathews	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=148	plan completed and permit issued	Region 8	CFWO	882 acres affected; 2,544 acre mitigation bank created	BO for Western Riverside MSHCP 2004; page 67. No documents could be located from this project. Acres are estimates from Western Riverside MSHCP BO. Mitigation bank is not specific to spadefoot	Y
Orange County Southern Subregion NCCP/HCP	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=612	plan completed and permit issued	Region 8	CFWO	2 locations impacted; 18 locations conserved	USFWS BO 2007; page 167	Y
San Diego Gas & Electric	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=53	plan completed and permit issued	Region 8	CFWO	Little analysis directly related to spadefoot. Effects deemed insignificant	SDG&E Subregional NCCP 1995; Table 3.1 unpaginated	Y

North Peak Development Project	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=383	plan completed and permit issued	Region 8	CFWO	608 acres affected	USFWS BO for AD161 in 2000; page 51. No documents could be located from this project. Conserved acres were not provided in AD161 BO	Y
Rancho Bella Vista (Pacific Bay Properties)	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=537	plan completed and permit issued	Region 8	CFWO	4.4 acres riparian and 97.8 acres uplands affected; conservation of 115 acres of upland and 6.2 acres of riparian habitat	USFWS BO 2000, page 37	Y
San Diego County Water Authority	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=1486	plan completed and permit issued	Region 8	CFWO	258.2 acres affected; 59,874 conserved	USFWS BO 2011; page 292	No- In ECOS but did not include WST as a covered species (error)
San Diego Multiple Habitat Conservation Plan (MHCP)		plan completed and permit issued	Region 8	CFWO	Spadefoot is a covered species with species specific conditions. No acreage estimates are provided because they	SANDAG MHCP 2003; page 4-215. The Orange County Southern Subregion HCP estimated this plan would affect 0 acres and conserve 3,768 acres for	No- Not included in ECOS

					are calculated at the subarea plan level when each subplan is completed. The MHCP has a no-net loss of wetlands requirement that should help conserve spadefoot within jurisdictions that complete subarea plans, whether or not each subarea plan elects coverage for spadefoot	spadefoot (page 525 of the BO)	
MHCP, City of Carlsbad Habitat Management Plan	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=610	plan completed and permit issued	Region 8	CFWO	See discussion regarding San Diego MHCP. The City of Carlsbad HMP is a subarea plan under the MCHP. The Carlsbad subarea plan does not include		

					spadefoot as a covered species, but because it is implementing the broader MHCP with its no-net loss of wetland policy, spadefoot receives some conservation from development under the MHCP		
City of Fontana	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=3616	plan in progress/pending/serious discussion is involved	Region 8	CFWO	N/A	N/A	Y
Joint Water Agencies Subregional HCP/NCCP, Santa Fe Irrigation Water District Subarea Plan	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=1509	application withdrawn	Region 8	N/A	N/A	N/A	Y
Natomas Basin, City of Sacramento	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=114	permit revoked	Region 8	N/A	N/A	N/A	Y

Yolo Natural Heritage Program	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=558	plan completed and permit issued	Region 8	SFWO	Not a covered species. Plan loss of grassland habitat is 1,734 acres, with 4,430 acres of grasslands conserved.	USFWS Findings and Recommendations 2018, p. 22; USFWS Record of Decision 2018, p. 22	Y
Kern Water Bank	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=149	plan completed and permit issued	Region 8	SFWO	Deliberate introductions to permanently managed wetlands.	USFWS BO 1997, p. 43	Y
San Joaquin County Multi-Species Habitat Conservation and Open Space Plan	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=52	plan completed and permit issued	Region 8	SFWO	Estimated 385 acres of habitat lost, and 955 preserved.	USFWS BO 2001, p. 131	Y
Natomas Basin Revised HCP and Litigation Resolution - City of Sacramento, Sutter County, and Natomas Basin Conservancy	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=113	plan completed and permit issued	Region 8	SFWO	Very low likelihood of impacts, if they are found, avoidance and minimization efforts will be implemented.	N/A	Y

South Sacramento Habitat Conservation Plan (SSHCP)	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=554	plan completed and permit issued	Region 8	SFWO	23,065 acres of habitat effected, 23,207 preserved, and an additional 1,069 re-established.	USFWS BO 2019, p. 220	Y
Tracy Hills	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=557	plan in progress/pending/serious discussion is involved	Region 8	SFWO	N/A	N/A	Y
Unocal Sargent-Fee Property	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=3140	application withdrawn	Region 8		N/A	N/A	Y
Carnegie SVRA & OHV Park (Calif. Dept. of Parks and Recreation)	https://ecos.fws.gov/ecp0/conservationPlan/plan?plan_id=631	application withdrawn	Region 8		N/A	N/A	Y

State of California NCCPs for Western Spadefoot (2015) (CDFW 2015)

NCCP Name
Kern Water Bank
Western Riverside County MSCP
Natomas Basin
San Diego County Water Authority
South Sacramento
Central/Coastal Orange County
Butte Regional Conservation Plan
San Diego MSHCP
San Joaquin County HCP
Bakersfield Regional HCP
San Diego North County MSCP
Yuba/Sutter HCP
San Diego Gas & Electric Subregional HCP
San Diego East County MSCP
Orange County Southern Subregion

Appendix B: Expert Feedback on Number of Local Populations Needed for Each Region to be Resilient

Northern Western Spadefoot Regions	Number of Local Populations from Expert A	Rationale from Expert A	Number of Local Populations from Expert B	Rationale from Expert B	Number of Local Populations from Expert C	Rationale from Expert C	Number of Local Populations from Expert D	Rationale from Expert D
Northeastern Sacramento	3	Based on discussions in workshop and Fig. 1 in Rose *et al*. 2020, I expect few metapopulations (historical or extant) in this region. I consider three metapopulations to be the absolute minimum to offer some resiliency.	8	lots of habitat, 8 MP (vs 6 target minimum) compensates for reduced MP number in NW Sac Valley	10	This is a large region with abundant vernal pool habitat. For this whole region to be resilient would require a several metapopulations, given increasing pressure from human development.	5	uncommon in region, 5 is minimum for recovery
Northwestern Sacramento	3	Based on discussions in workshop and Fig. 1 in Rose *et al*. 2020, I expect few metapopulations (historical or extant) in this region. I consider three metapopulations to be the absolute minimum to offer some resiliency.	4	reduced from 6 MP minimum due to limited habitat blocks and WSF occurrences; likely common genetics w NE Sac Valley	5	This region has less vernal pool habitat than the eastern edge of the Sacramento Valley and fewer recent spadefoot observations, as far as I know.	5	uncommon in region, 5 is minimum for recovery

Solano-Colusa	3	Based on discussions in workshop and Fig. 1 in Rose *et al*. 2020, I expect few metapopulations (historical or extant) in this region. I consider three metapopulations to be the absolute minimum to offer some resiliency.	3	very limited opportunity; all/nearly all WSF occurrences are not on mapped VP habitat; each conserved VP block per MP may be below target minimum block size (2000 ac?) for metapopulation; assumes WSF doesn't occur in southern end of region (greater Jepson Prairie region) where the bulk of remaining vernal pool habitat occurs in the region	5	This region has less vernal pool habitat than the eastern edge of the Sacramento Valley and fewer recent spadefoot observations, as far as I know. The part of this region that overlaps with the delta might also not be climatically favorable for spadefoots.	7	habitat in very serious decline, need multiple units for protection
Southeastern Sacramento	7	Based on Fig. 1 in Rose *et al*. 2020, I expect several metapopulations in this region. This area is rapidly urbanizing, and metapopulations might become fragmented or extirpated.	10	sufficient habitat and WSF occurrences to ID/conserve 10 metapopulations; key conservation area	10	This is a large region with abundant vernal pool habitat and many recent spadefoot occurrence records. For this whole region to be resilient would require a several metapopulations, given increasing pressure from human development.	5	habitat in very serious decline, but populations more common, possibly protected in a few sites already

Livermore	4	Based on Fig. 1 in Rose *et al*. 2020, I expect few metapopulations (historical or extant) in this region, but more than in the first three regions.	3	very limited opportunity; all/nearly all WSF occurrences outside of mapped VP habitat; each conserved VP block per MP may be below target minimum block size (2000 ac?	3	This is a smaller area with fewer recent spadefoot occurrences. This region has less and seems unlikely to support a large number of metapopulations.	4	smaller area, heavy development, maybe all one can hope for
Southern Sierra Foothills	10	Based on Rose *et al*. 2020, this region is likely the remaining stronghold for the species, and also covers a large area.	20	numerous large, extant habitat blocks, highest density of WSF occurrences; key conservation area	10	Large parts of the foothills in this region are predicted to be suitable for spadefoots, vernal pool habitat is available, and populations have been documented in recent years.	8	vast area with the best habitat opportunities left. This should be the core area for genetic unit #2

San Joaquin Valley	5	Based on Rose *et al*. 2020, although this region covers a large area, much of the habitat has been lost to agricultural development. The remaining metapopulations are likely isolated. This number is a wild guess at how many metapopulations might remain extant.	10	abundant habitat and WSF occurrences; key conservation area; bring in the mapped vernal pool habitat just outside the SW boundary; high habitat variation north half vs. south half so aim to have 5 MPs in northern portion, 5 MPs in southern portion	10	This is a large region with abundant vernal pool habitat and many recent spadefoot occurrence records, including records from ecological reserves and wildlife refuges. For this whole region to be resilient would require a several metapopulations, especially given the fragmented nature of vernal pool habitat in the San Joaquin Valley.	10	5 in the northern section, 5 in the south captures the ecologically different southern San Joaquin "desert" from the more central region from Stockton to around Fresno.
Central Coast	7	Based on Rose *et al*. 2020, much suitable habitat and likely many metapopulations remain in this area.	6	most occupied pools likely sag ponds along San Andreas fault and other faults; each conserved habitat block per MP may be below target minimum block size (2000 ac?)	10	There is suitable habitat including vernal pools and stock ponds in the less developed parts of this region, particularly in San Benito County. Still some areas with habitat and spadefoots (e.g., Fort Hunter Liggett) are isolated.	9	region has two quasi-isolated areas, possibly have 4 in each north and south, with one interconnecting them

Carrizo	7	Based on Rose *et al*. 2020, much suitable habitat and likely many metapopulations remain in this area.	10	a lower target number may be warranted (6 MPs?) but the region is biologically unique with strong conservation interest; numerous WSF occurrences, widely dispersed; many occupied pools likely sag ponds along faults	7	Although this region is smaller than some others, the habitat is likely less fragmented and could support several spadefoot metapopulations. There are also a fair number of recent records documenting spadefoot breeding in this region, and large areas with highly suitable spadefoot habitat according to Rose *et al*. (2020) *Biological Conservation* 241:108374.	6	I suggest three each in the northern and southern isolates
Santa Barbara	7	Based on Rose *et al*. 2020, much suitable habitat and likely many metapopulations remain in this area.	6	occurrences likely in a mix of sag ponds, maybe some vernal pool like features, and lots of man-made stock ponds (?); numerous evenly distributed occurrences, many likely now extirpated (?); each conserved habitat block per MP may be below target minimum block size (2000 ac?)	5	Currently suitable habitat is more fragmented and restricted in this region, but several populations of spadefoots are extant. This region seems unlikely to be able to support 10 metapopulations or more.	9	This is a unique genetic area under heavy development pressure; note that many pools are shared with CTS and the dynamics of the two mean that often it works poorly for Spea. I would like to see three sets of 3 metapopulations spread across the region.

Southern Western Spadefoot Regions	Number of Local Populations from Expert A	Rationale from Expert A	Number of Local Populations from Expert B	Rationale from Expert B	Number of Local Populations from Expert C	Rationale from Expert C
Northwest Ventura and LA	5	natural breaks in the landscape and artificial breaks due to freeway and urban barriers	5	area is in poor shape for Spea, requires substantial protection, modest size	5	
Orange-LA Basin	8	based on extant populations two in the Chino-Puente Hills, One in the northwest Santa Ana Mtn foothills. Central Tustin Plains - Santa Ana Mtn Pop, Southern SA Mtn, two in San Joaquin Hills split by 73. One south of 74. Justification natural breaks in landscape and human made breaks. Different habitats also.	11	Based on the genetics work, I would put five metapopulations in the coastal genetic unit and 3 each in the inland parts of genetic region 1 in OC and further to the northwest in LA county	3	LA basin is essentially all unsuitable. Orange County has some areas with suitable habitat, but only enough to support a few metapopulations.

Inland Empire	8	San Andreas Faultline population, Edge of San Jacinto Mtns from Bautista to Banning, Middle Santa Ana River Complex including Reche Canyon, 215 - 15 complex north of 74, Santa Rosa Plateau-Tenaja Complex, Santa Margarita Tributaries - Temecula Valley (3 complexes).	9	this is a large area with remnant populations still occurring in many areas. I base this on three regions, each with three metapopulations	8	Large area with abundant putatively suitable habitat and recent records of spadefoot occurrence
Inland Riverside-San Diego	4	Anza - Aguanga Valley (2 complexes), Dameron Valley - Chichuhua Valley, Warner Basin,	8	smaller area, fewer known sites than the inland empire. I base this on two large metapopulation clusters each with 4 metapops, one in the north and one in the south.	6	Slightly smaller area than Inland Empire, but still has with a large area of putatively suitable habitat and recent records of spadefoot occurrence
Coastal Military Lands	1	Landscape is highly porous to western spadefoot currently and will potentially remain that way through the land use mission of the landscape	5	biologically this is the minimum I really recommend, and this is possible given the military land status	3	Small region with abundant habitat. Habitat is likely more continuous than other regions, due to land ownership

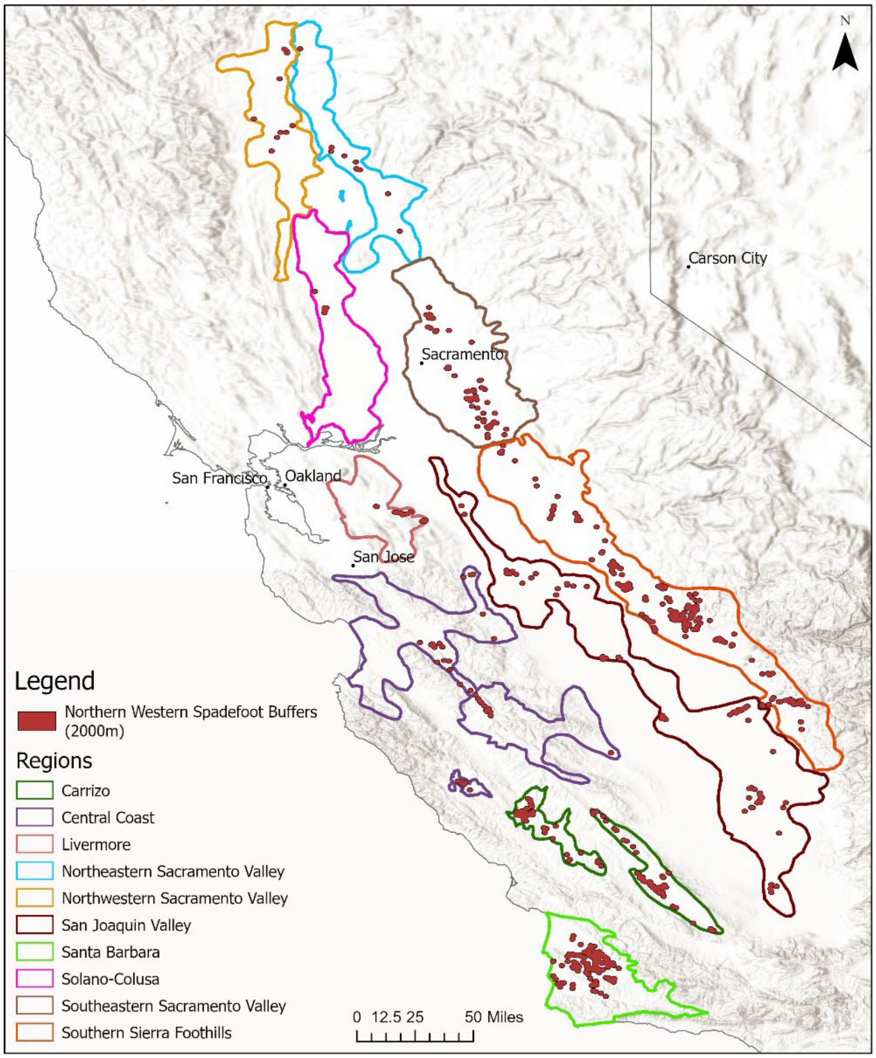
Central San Diego	17	San Luis Rey upper and lower River split by 15 (2), San Deiguito River (4), Central county mesa complexes (6), El Monte Valley, San Diego refuges complex (3), inland Cleveland NF.	12	I base this on identifying and protecting 4 regional metapopulation clusters each with three functional metapopulation units in the NW, NE, SW and SE quadrats of the county	10	Large region with a large area of predicted suitable habitat (USGS unpublished data).
Baja Northwest	12	scattered across Tijuana Watershed (5), more poorly known south.	10	There is so little knowledge that I simply base this on acreage.	10	Large region with lots of records, do not know much about Baja populations or habitat otherwise.
Baja Northeast	7	patchy in valleys, three in US and rest in northern Baja.	5	as above	8	Large region with lots of records, do not know much about Baja populations or habitat otherwise.
Baja Central	5	patches in valleys	5	as above	3	Few records. Have little information on habitat in Baja.
Baja South	7	Xeric landscape, in washes, poorly know, probably different biology	7	as above	8	Large region with lots of records, do not know much about Baja populations or habitat otherwise.

Appendix C: Summary of Metrics Used in Current Condition for Each Region

Northern Western Spadefoot Regions	Median Number of Local Populations form Experts	Number of Current Local Populations in Region	Number of Local Populations with 60-80 percent grasslands	Number of Local Populations with >80 percent grasslands	Average Neb Calculation for Region	Number of Ponds Needed to get 500 Neb	Highest Estimated Number of Breeding Ponds in a Local Population
Northwestern Sacramento	4.5	7	1	3	Used Solano-Colusa Neb		3
Northeastern Sacramento	6.5	7	2	2	Used Southeastern Sacramento Valley Neb		3
Solano-Colusa	4	2	0	0	3.7	135	5
Southeastern Sacramento	8.5	24	10	5	12.7	39	11
Livermore	3.5	3	0	2	7.9	63	7
Southern Sierra Foothills	10	40	4	21	4.5	111	32
San Joaquin Valley	10	26	2	0	7.8	64	13
Central Coast	8	17	4	5	7.2	69	10
Carrizo	7	21	3	10	6.1	81	34
Santa Barbara	6.5	15	1	0	3.6	141	74

Southern Western Spadefoot Regions	Median Number of Local Populations form Experts	Number of Current Local Populations in Region	Number of Local Populations with 60-80 percent grasslands or shrub/scrub	Number of Local Populations with >80 percent grasslands or shrub/scrub	Average Neb Calculation for Region	Number of Ponds Needed to get 500 Neb	Highest Estimated Number of Breeding Ponds in a Local Population
Northwest Ventura and Los Angeles	5	32	3	17	8	63	13
Orange-Los Angeles Basin	8	37	8	18	4	125	17
Inland Empire	8	92	21	35	4.2	119	7
Inland Riverside-San Diego	6	32	4	25	Used average Neb of Inland Empire and Central San Diego		6
Coastal Military Lands	3	30	6	15	12	42	13
Central San Diego	12	110	24	49	3.8	132	18
Baja Northwest	10	20	5	4	Used average Neb of Central San Diego and Baja Northeast		11
Baja Northeast	7	16	1	10	4.6	109	3
Baja Central	5	1	0	1	N/A	N/A	1
Baja South	7	7	0	6	N/A	N/A	2

Northern Western Spadefoot Local Populations



Southern Western Spadefoot Local Populations