Species Status Assessment Report for the Southern Rubber Boa (*Charina umbratica*)


Southern rubber boa (Photocredit Brian Hinds)

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EXECUTIVE SUMMARY

The southern rubber boa (*Charina umbratica*; boa) is a stout-bodied snake with a short, blunt tail and skin that folds in a way that resembles rubber. They are smaller "dwarfs" compared to the northern rubber boa (*Charina bottae*), measuring between 13–21 in (35–55 cm), and may live over 60 years in the wild. Optimal boa habitat is characterized as montane forest with relatively high humidity, well-developed soil, granitic rock formations, and woody canopy openings.

The southern rubber boa is historically and currently known from two mountain ranges in Southern California - the San Bernardino, and San Jacinto Mountains. It has declined in abundance at the most well-known and impacted site in the western San Bernardino Mountains, although estimates of population sizes anywhere are lacking. Significant habitat was lost to development historically; however, available scientific information indicates primary current threats are habitat degradation, rock formation (hibernacula/shelter) disturbance, and habitat drying due to increased drought, wildfire, and temperature associated with climate change.

For current conditions, we evaluated three analysis units (two sub-populations in the San Bernardino Mountains and one population in the San Jacinto Mountains). After evaluation of impacts from current threats on habitat and demographic needs, we determined that resiliency of these three units (western San Bernardino, Eastern San Bernardino, and San Jacinto) is medium-high, high, and medium, respectively. All three units are likely to be able to withstand stochastic events and are likely to contribute to the species' viability.

In projecting future species' viability of the southern rubber boa, four scenarios were considered with possible changes to impacts from habitat disturbance, development, habitat quality, climate, and wildfires (Table ES-1). Our analysis articulates the capability of populations to withstand stochastic disturbance (population resiliency), the number of and size of populations (species' redundancy), and the amount of habitat and genetic variability represented across the species' range (species' representation). Analysis of possible conditions 30 to 60 years into the future indicate the species will generally maintain viability in three out of four scenarios. One scenario indicates the San Jacinto Mountains population could lose resiliency, significantly reducing species' viability (Table ES-2). This analysis assumes that while species survey counts cannot provide density estimates, changes in the number of boas observed are indicative of changes in density.

Table ES-1. Change in primary impacts to southern rubber boa in four future scenarios.

Scenario #	Habitat Disturbance by Collectors	Development	Recovery of Impacted Western San Bernardino Mtn. Habitat	30-60 Year Temperatures	30-60 Year Precipitation	Wildfire Extent and Severity
1	Increased	Maximum development of both San Bernardino Mtn. sub-population vulnerable lands	No restoration effort	Warming trend accelerates; climate model realized	Trend continues; driest climate model realized	Trend continues; increased scope, intensity, and frequency
2	Unchanged	Some additional development of vulnerable lands	No restoration effort	Warming trend accelerates slightly; intermediate climate model conditions	Unchanged; intermediate climate model conditions	Trend continues, increases
3	Unchanged	Insignificant new development	Restoration somewhat successful	Warming trend continues; coolest climate model realized	Unchanged; intermediate climate model realized	Trend continues, increases
4	Reduced	No new development	Restoration fully successful	Warming trend continues; coolest climate model realized	Increases; wettest climate model realized	Unchanged; continued large wildfires but rate and size do not increase

Table ES-2. Southern rubber boa future scenarios viability analysis summary table.

Scenario #	Resiliency of analysis units (WSB Mtn, ESB Mtn, SJ Mtn)*	Representation	Redundancy	Overall Species Viability
Current	Medium-High, High, Medium	Maximum	Maximum	Relatively viable
1	Low, Low, Insufficient	Significantly decreased due to possible loss of genetically distinct SJ Mt population occupying unique habitat	Significantly decreased ability to withstand catastrophic event due to possible loss of SJ Mt "refuge" population	Significantly decreased
2	Medium, Medium-High, low	Slightly decreased due to population-level losses in genetic and habitat diversity	Slightly decreased due to reduced population sizes and distributions	Slightly decreased
3	Medium, High, Medium-low	Slightly decreased due to population-level losses in genetic and habitat diversity	Slightly decreased due to reduced population sizes and distributions	Slightly decreased
4	High, High, Medium-High	Slightly increased due to increased habitat diversity of the SJ Mt population	Slightly increased due to increased population sizes and distributions	Slightly increased

* Resiliency of Western and eastern San Bernardino Mountains sub-populations and San Jacinto Mountains population (in that order).

CHAPTER 1 - INTRODUCTION

1.1 Purpose of SSA

The Species Status Assessment (SSA) framework (Service 2016a, entire) is an in-depth review of a species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The SSA report is updated as new information becomes available to support all functions of the Endangered Species Program including: candidate assessment, listing, recovery planning, and consultation. As such, the SSA report is a living document that may inform decision making under the Endangered Species Act of 1973, as amended.

This SSA report is not a decisional document; rather, it is a science document that provides a review of available information related to the biological status of the southern rubber boa (*Charina umbratica*). Any decisions regarding the legal classification of the southern rubber boa are made after reviewing this document and all relevant laws, regulations, and policies. The results of a decision will be announced in the *Federal Register*, with appropriate opportunities for public input.

1.2 Species Basics – Taxonomy and Evolution

Rubber boas of the genus *Charina* are found throughout the northwestern and western United States in most of Washington, Oregon, Idaho, western Montana and Wyoming, northern and central Utah, and as far south as Riverside County, California. Klauber (1943, entire) recognized "dwarf" rubber boas from the mountains of Southern California (Figures 1.2-1 and 1.2-2) as distinguishable at the subspecies rank, describing the taxon as *Charina bottae umbratica*. Subsequently, Nussbaum and Hoyer (1974, entire) questioned the distinguishability of this and (at the time) a Utah subspecies of *C. bottae*; moreover, they questioned the value of recognizing the taxonomic rank of subspecies all together. In contrast, Erwin (1974, entire) reexamined multiple specimens of rubber boas from the mountains of Southern California and found them to be morphologically distinctive, even suggesting they may be distinguishable at the species rank. Subsequently, Rodríguez-Robles et al. (2001, entire) found the taxon to be morphologically, geographically, and genetically distinct, and elevated it to species rank, *C. umbratica*. This species-level rank is recognized by other authors in the scientific literature (such as Pyron et al. 2014, p. 252; Reynolds et al. 2014, p. 208; Reynolds and Henderson 2018, pp. 29–30), including the Committee on Standard English and Scientific Names, which establishes a standard list of names for taxa jointly recognized by five major North American herpetological societies (Crother et al. 2017, p. 60). Therefore, we recognize the southern rubber boa (*Charina umbratica*, also referred to herein as "boa" (Figure 1.1) as a full species occupying the San Bernardino and San Jacinto Mountains of Southern California (Figure 1.2).

The currently accepted classification is:

- Phylum: Chordata
- Class: Reptilia
- Order: Squamata
- Family: Boidae
- Genus: *Charina*
- Species: *umbratica*

Figure 1.1. ***Charina umbratica*, the southern rubber boa in typical habitat in the San Jacinto mountain range where the type specimen was collected (photo credit Brian Hinds 2020).**

Recent and advanced genetic analysis (Grismer et al. 2020, entire; Appendix A) sheds much light on the evolutionary relationships of known Southern California *Charina* sp. populations. There are at least six lineages corresponding with individual mountain tops that could be described as *Charina umbratica*, with the San Bernardino and San Jacinto lineages standing out as the most geographically isolated and genetically distinct (Grismer et al. 2020, p. 31; Appendix A). Despite their close geographic proximity, and being more closely related to each other than any other clades, the San Jacinto and San Bernardino Mountain populations also appear to have a significant amount of genetic divergence between them (Grismer et al. 2020, p. 16; Appendix A). The *C. umbratica* type specimen is from the San Jacinto Mountains, and the paratype from the San Bernardino Mountains (Klauber 1943, pp. 84 and 85). Therefore, the two populations would retain the name *C. umbratica* (*umbratica*) if future analyses and published taxonomic descriptions determine they are collectively a single subspecies.

While Grismer et al. (2020, entire) did not speak to how genetically diverse rubber boas are, there is some older data that address this. Analysis of electrophoretic samples of seven enzymes from the tissues of a small sample (21) of *Charina* sp. individuals from across California found a relatively high degree of homozygosity (Weisman 1988, entire). Such a low degree of heterozygosity and polymorphism, should it be characteristic of *Charina* sp. genomes, would mean populations are locally well-adapted with minimal ability to adapt to changing environmental conditions (Stewart 1991, p. 27).

1.3 Petition History

We, the U.S. Fish and Wildlife Service (Service), were petitioned by the Center for Biological Diversity to list the southern rubber boa as an endangered or threatened species under the Endangered Species Act. This request was part of a 2012 petition to list 53 amphibian and reptile species (Center for Biological Diversity 2012, pp. 190–540). On September 18, 2015, we found that the petition presented substantial scientific or commercial information indicating that listing the boa may be warranted (80 FR 56423–56432).

1.4 State Listing Status

The southern rubber boa was listed as a “Rare” species by the State of California June 27, 1971 (California Code of Regulations, Title 14, §670.5; CDFW 2020, p. 16). In 1984, the California Endangered Species Act was amended, at which time the “Rare” designation was changed to “Threatened,” and on January 1, 1985, all animal species previously designated as “Rare,” including the boa, were reclassified as “Threatened.” Threatened species are defined by the California Endangered Species Act as “a native species or subspecies of bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by this chapter” (Fish and Game Code, §2067). The same take prohibitions apply to threatened and endangered species, “No person shall import into this state, export out of this state, or take, possess, purchase, or sell within this state, any species, or any part or product thereof, that the commission determines to be an endangered species or a threatened species, or attempt any of those acts.” (Fish and Game Code, §2080; Cal. Code Regs., tit. 14, § 783.1)

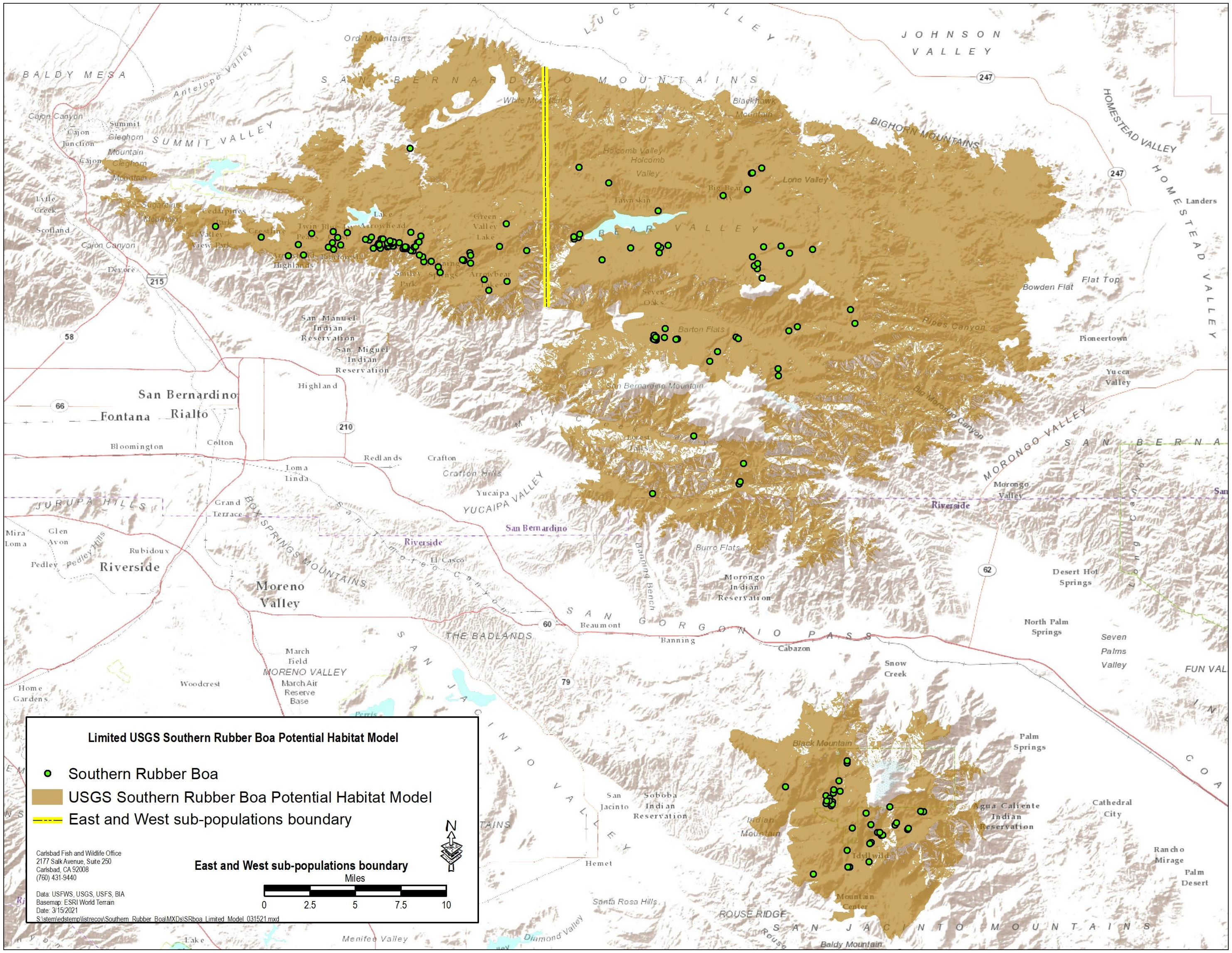


Figure 1.2. Distribution records for the southern rubber boa in the San Bernardino and San Jacinto Mountains, with a potential habitat model trimmed to occupied areas of the mountain ranges (USGS 2020).

CHAPTER 2 - METHODOLOGY AND DATA SOURCE

2.1 SSA Framework

This report is a summary of the SSA analysis, which entails three iterative assessment stages: species' (resource) needs, current species' condition, and future species' condition (Figure 2).

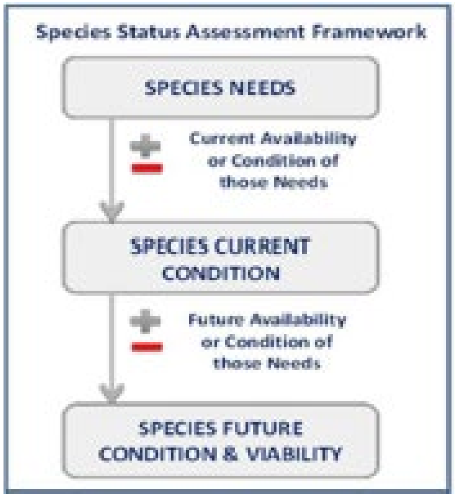


Figure 2. The three analysis steps in a Species Status Assessment (Service 2016a, entire).

To evaluate the biological status of the southern rubber boa both currently and into the future, we assessed a range of conditions to allow us to consider the species' needs and ultimately its resiliency, redundancy, and representation (3Rs). The following are working definitions of the 3Rs that are used throughout this document. They are derived from the SSA framework (Figure 2.2; Service 2016a, entire; Service 2018, entire):

- **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 (fire, floods, storms), and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity). Simply stated, resiliency is the ability to sustain populations through the natural range of favorable and unfavorable conditions. We can best gauge resiliency by evaluating population level characteristics such as: demography (abundance and the components of population growth rate -- survival, reproduction, and migration), genetic health (effective population size and heterozygosity), connectivity (gene flow and population rescue), and habitat quantity, quality, configuration, and heterogeneity. Also, for species prone to spatial synchrony (regionally correlated fluctuations among populations), distance between populations and degree of spatial heterogeneity (diversity of habitat types or microclimates) are also important considerations.

- **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 health and for which adaptation is unlikely (Mangal 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.

- **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 ever changing environments (Nicotra et al. 2015, p. 1,269). 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. 1,270). The latter (evolution) occurs via the evolutionary processes of natural selection, gene flow, mutations, and genetic drift (Crandall et al. 2000, pp. 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 the 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.

2.2 Species Needs

The SSA includes a compilation of the best available biological information on the species and its ecological needs at the individual, population, and species levels based on how environmental factors are understood to act on the species and its habitat.

- Individual level: These resource needs are those life history characteristics that influence the successful completion of each life stage. In other words, these are survival and reproduction needs that make the species sensitive or resilient to particular natural or anthropogenic influences.

- Population level: These components of the southern rubber boa's life history profile describe the resources, circumstances, and demographics that most influence **resiliency** of the populations.

- Species level: This is an exploration of what influences **redundancy** and **representation** for the boa. This requires an examination of the boa's evolutionary history and historical distribution to understand how the species functions across its range.

To assess the biological status of the southern rubber boa across its range, we used the best available information, including peer-reviewed scientific literature and academic reports, and survey data provided by the State of California and Federal agencies. Additionally, we consulted with several species experts who provided important information and comments on boa distribution, life history, and habitat. We researched and evaluated the best available scientific and commercial information on the boa's life history. To identify population-level needs, we used published literature, unpublished reports, information from field herpetologists, and data from current agency survey and taxonomic research projects. In some cases we draw conclusions from data collected on surrogate rubber boa populations of the same genus from the northwestern United States, taking into consideration similarities and differences in environmental and biological factors.

2.3 Current Species Condition

The SSA describes the current known condition of the southern rubber boa habitat and demographics, and the probable explanations for past and ongoing changes in abundance and distribution within areas representative of the geographic, genetic, or life history variation across the species range.

We consider the southern rubber boa's distribution, abundance, and factors currently influencing the viability of the species. We identified known historical and current distribution and abundance, and examined factors that negatively and positively influence the species. Scale, intensity, and duration of threats were considered for their impacts on the populations and habitat across life history stages. The population-level response from potential impacts to the boa or its habitat by a given threat are described using a High/Medium/Low category scale (see Chapter 6), which takes into consideration the intensity of effects on individuals and extent that the population distribution and threat overlap in space and/or time.

For the current condition analyses, a southern rubber boa occurrence (portion of a population distribution) was considered extant if a historical record location was in intact habitat. There has been no systematic sampling regime to monitor the boa's distribution, density, and status across its range. However, we gathered information from a large body of published and unpublished rangewide survey work. More recent published and unpublished distribution and status information was provided by biologists from the U.S. Forest Service (Forest Service), U.S. Geological Survey (USGS), other State and Federal agencies, academia, and individual researchers. Additional details on the current condition analysis methodology is presented in Chapter 5. Distinct populations were defined by mountain range because there is no information to indicate isolation within mountain ranges. Therefore, we assume that the boa species has two populations, one in the San Bernardino Mountains (consisting of two subpopulations, one in the eastern, and one in the western San Bernardino Mountains), and one in the San Jacinto Mountains (Figure 1.2). Both populations are considered extant.

2.4 Future Condition

The SSA forecasts a species' response to probable future scenarios of environmental conditions and conservation efforts. As a result, the SSA characterizes the species' ability to sustain populations in the wild over time (viability) based on our understanding of current and future abundance and distribution within the species' habitat. To examine the potential future condition of the southern rubber boa, we developed four future scenarios that focus on a range of conditions based on projections for habitat degradation or loss, collection, mortality sources, genetic isolation and displacement; beneficial conservation actions were also considered. The range of what may happen in each scenario is described based on the current condition and how resiliency, redundancy and representation, may change. We chose a time frame of 30 to 60 years for our analysis based on the availability of threats trend information, planning documents, and climate modeling that help inform future conditions; this is also the estimated reproductive lifespan of this long-lived species. Future scenarios consider the most probable threats with potential to influence the species at the population and rangewide scales, including potential cumulative impacts.

For this assessment, we define viability as the ability of the boa to sustain resilient populations in the wild long-term (i.e., approximately 30 to 60 years). Similar to current conditions (described above), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Service 2016a, entire; Wolf et al. 2015, entire).

To evaluate the current and future species' viability of the southern rubber boa, we assessed a range of conditions to characterize species resiliency, representation, and redundancy. Throughout this analysis, when data were lacking for the boa, we used information from closely related populations, such as northern rubber boas in California. Additionally, we evaluated all identified threats and attempted to assess how the cumulative impact of all threats acts on the viability of the species as a whole. That is, all the anticipated effects from both habitat-based and direct mortality-based threats are examined in total and then evaluated in the context of what those combined negative effects will mean to the future condition of the boa. However, for the vast majority of potential threats, the effect on the boa (e.g., total losses of individual boas or their habitat) cannot be quantified with available information. Instead, we use the available information to gauge the magnitude of each threat on the species, and then assess how those threat effects combined (and as may be ameliorated by any existing regulatory mechanisms or conservation efforts) will impact the boa's future viability.

CHAPTER 3 - SPECIES BACKGROUND AND ECOLOGY

3.1 Physical Description

The southern rubber boa is a stout-bodied snake with a short, blunt tail that resembles the head (Figure 1.1). The skin is smooth and shiny, and when the snake coils, the skin folds in a way that resembles rubber. Adult southern rubber boas are consistently light brown or tan in dorsal color, with an unmarked, yellow underside (Hoyer and Stewart 2000a, p. 351). They are morphologically distinct, smaller "dwarfs" compared to the currently recognized northern rubber boa (*Charina bottae*) (Grismer 2019a, pers. comm.). Based on measurements of 69 adults, male southern rubber boas measure approximately 13.8–18.5 in (35–48 centimeters (cm)) and weigh 0.6-1.3 ounces (oz) (18.3-36.3 grams (g)), while females measure approximately 12.2–21.5 in (44–55 cm) and weigh 1.0-2.6 oz (28.1-72.3g) (Hoyer and Stewart (2000a, p. 351). Average adult females are 20 percent longer and 93 percent heavier than adult males (Hoyer and Stewart 2000a, p. 352).

3.2 Life History

3.2.1 Reproduction and Sex Ratio

The typical reproductive life span of northern rubber boas is estimated to be at least 30 years in the wild, although data is limited to a few individuals repeatedly observed during surveys. One female taken into captivity mid-life produced a litter at the estimated age of between 49 to 69 years, and lived another 6 years after that (Ryan Hoyer 2011). Mating in southern rubber boas likely occurs almost immediately after emergence from hibernation in late March and early April, with the birth of live young (viviparous) primarily in late August through the first 3 weeks of September (Hoyer and Stewart 2000a, p. 351; Figure 3.1).

The sex ratio of southern rubber boas may vary depending on male versus female survival rates, and clutch frequency is also not known. For example, a sex ratio analysis among neonates appears biased toward females, as neonatal females outnumbered males 29 to 18 (Hoyer and Stewart 2000a, p. 351). Conversely, the sex ratio was reversed in a sample of 69 adults, with males outnumbering females 39 to 30, suggesting a higher male survival rate (Hoyer and Stewart 2000a, pp. 350, 353). A nearly 1:1 ratio of reproductive to non-reproductive females in a sample of 32 individuals suggests a biennial clutch frequency, though the sample was too small to be sure, and it is possible average clutch frequency is triennial or even quadrennial (Hoyer and Stewart 2000a, pp. 353).

Southern rubber boa clutch size varies from two to about six neonates in the lab depending on female size and nutrition, but averages in the field between three and four hatchlings (Stewart 2019a, pers. comm.; Hoyer and Stewart 2000a, p. 351).

3.2.2 Dispersal and Movement

Data on movement of southern rubber boas is limited, but informative. Recapture data from multiple studies provides a number of movement records. In one study, 18 of 21 recaptures occurred within 26 feet (ft) (8 meters (m)) of the original capture site, with two adult males found during the breeding season at a rock outcrop approximately 230–246 ft (70–75 m) from where they were first found (Hoyer and Stewart 2000a p. 352). One boa was recorded moving as far as 899 ft (274 m) over a season (Hesemann, pers. comm. *in* Keasler 1981, p. 6). After April, boa disperse out of the rock formations to shelter under fallen logs, needle piles, and fallen bark usually within a 900–1,200 ft (274–366 m) radius from rock formations (Stewart 2019a, pers. comm.). During warm summer weather boas may spend more time underground, or may move into canyons and along seeps where it is cooler (Keasler 1981, pp. 5–6; Stewart 1988, p. 137).

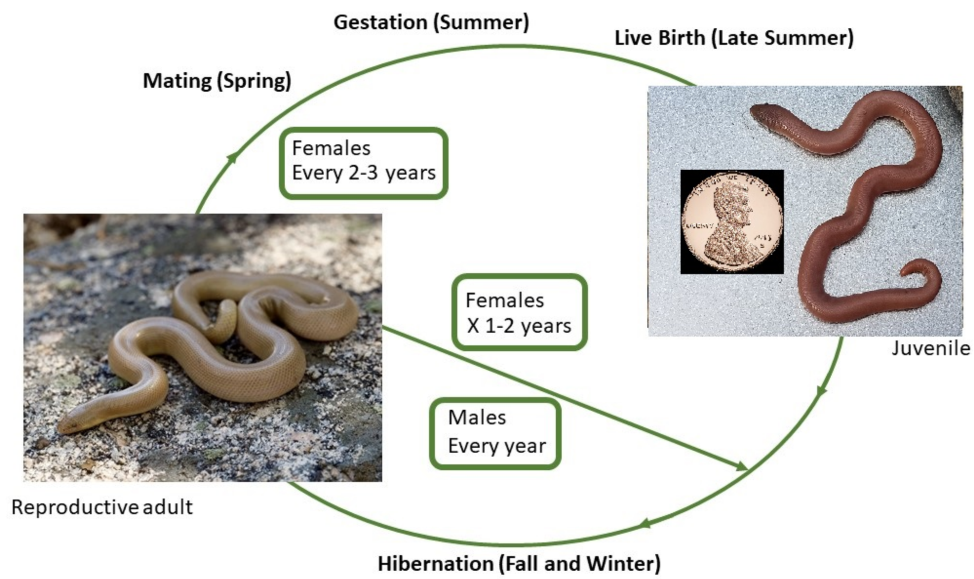


Figure 3.1. Life history diagram for the southern rubber boa (photo credit adult, Brian Hinds; juvenile, Ryan Hoyer).

3.2.3 Prey Base

The likely prey species of southern rubber boas are widespread and common throughout boa habitat. Known prey species observed in a laboratory setting include nestling mice (*Peromyscus* and *Microtus* sp.), nestling insectivores (*Sorex* and *Neurotrichus* sp.) and the eggs of lizards (Hoyer and Stewart 2000b, p. entire). Adults of most of these prey species are too large for most boas to consume; however, given how widespread mice, insects, and lizards are within the boa's range, the prey base is not expected to be a limiting factor for the species at this time (Stewart 2019a, pers. comm.).

3.2.4 Physiology and Thermoregulation

Southern rubber boas exhibit a unique temperature regulating characteristic. Northern and southern rubber boas are frequently observed at the surface basking, but rarely moving from place to place during the daytime. In a radiotelemetry tracking study of northern rubber boas, of 154 observed on the surface during the daytime, only 13 were actively crawling, but all boas found on the surface at night were actively crawling (Dorcas and Peterson 1998*,* p. 96). Data and incidental observations indicate all rubber boas move from place-to-place almost exclusively at night. Southern rubber boas typically maintain body temperatures similar to other snakes, around 86º F (30º C) (Dorcus and Peterson 1998, p. 95). However, at night when they are hunting, their temperature drops as low as 43º F (6º C), which is unusual for a snake (Dorcus and Peterson 1998, p. 94). This reduces the boa's crawling speed by more than half compared to other snake species, although their typical prey (see section 3.2.3, above) cannot evade them even at such low speeds. The boa's ability to hunt at night with a relatively low body temperature may help them minimize metabolic costs (Dorcus and Peterson 1998, pp. 100) and avoid contact with kingsnakes (*Lampropeltis* sp.)—a potential predator—that are typically active under warmer conditions (Hoyer 2015, pp. 37 and 38; Hinds 2020, pers. comm.).

Rubber boas have a range of optimal body temperatures they actively work to maintain. In the spring, southern rubber boas come up within rock outcrop hibernacula to warm themselves by lying under surface rocks (Keasler 1981, p. 5; Figure 3.1). For northern rubber boas tracked and monitored in Idaho, low body temperatures were typical of periods of activity, such as when hunting, and high temperatures typical of periods of inactivity, such as during digestion and gestation (Dorcas and Peterson 1998, p. 96). Pregnant northern rubber boa females maintained a relatively high and stable body temperature (from 81 to 93º F (27 to 34º C)) by moving into and out of cover during the day, and "basking" at night in deep rock crevices or beneath large rock outcroppings that retained heat (Dorcas and Peterson 1998, pp. 94, 95, 98, and 101). Northern rubber boas also exhibited optimal digestive performance at body temperatures between 68º F to 91º F (20 to 33º C) (Dorcus et al. 1997, p. 296). Northern rubber boas were typically active in the field at body temperatures from 50º F to 68º F (10 to 20º C) with a modal temperature of 57º F (14º C) (Dorcas and Peterson 1998 p. 96). Southern rubber boas have been documented to remain active at body temperatures of 55º F to 64º F (13º to 18º C), and could still return themselves to an upright position at body temperatures as low as 38º F (3º C) (Cunningham 1966, p. 299). Although unusually cold summer temperatures appear to cause gestation problems in northern rubber boas (Dorcas and Peterson 1998, pp. 98 and 99); historical air temperatures near Dorcas and Peterson's (1998) study site were cooler on average than in the San Bernardino and San Jacinto Mountains by approximately 4 and 2º F (7 and 4º C) respectively (Appendix B). Therefore, it is not likely southern rubber boas are similarly affected by low summer temperatures. Not all thermoregulation is achieved by behavior, heart rate adjustments and redirection of blood flow likely also play a role in rubber boa thermoregulation (Zhang et al. 2008, entire). Rubber boas appear to thermoregulate via a combination of behavior and physiological mechanisms.

Probably the most limiting factor for southern rubber boa survival and health is available moisture (precipitation and other water sources) and associated humidity (Loe 1985, p. 3; Stewart 1988, p. 133; Hoyer and Stewart 2000a, p. 350; Ryan Hoyer 2011; Hoyer 2019, pers. comm.; Grismer 2019a, pers. comm.; Grismer et al., 2020 pp. 4 and 24). The amount of moisture needed should depend on habitat structure, temperature regime, and the resulting humidity. Brian Hinds (2020, pers comm.), who has extensive southern rubber boa survey experience, summed up his personal expertise and opinions on habitat humidity in detail:

> *"Humidity is very important, because I have only ever found southern rubber boa in San Jacinto Mountains when humidity was above 50 [percent]. I look at humidity [during surveys] in San Bernardino Mountains too, but have found them under 50% [humidity] in that range. Think of it like this, the more humid the conditions, the more they can be on the surface, because they lose less water. This is the reason rubber boas are common on the coast in Northern California, because it's always humid, and they can afford to be out and up more. . . The most important aspect to surviving without water for this species is air and ground humidity, which is why they are rarely found …under objects that are dry. Those that are found in those dry conditions are digesting a meal, shedding, or gravid. Heaps Peak for example sits on the ridge of the mountains, and is subject to constant marine layers that usually hit dead on, which is [I think] the number one reason why that population was so dense. [Heaps Peak supported high] survival rate and maximum reproduction, while the eastern San Bernardino Mountains and the San Jacinto Mountains are rarely hit with that wet, cool air, leading to smaller densities."*

Habitat humidity has not been well characterized or quantified for southern rubber boa. It is clear hydration is key for this species, as the boas only occur at elevations in Southern California where moisture availability and humidity are relatively high and temperatures relatively low.

3.3 Habitat

Southern rubber boa habitat descriptions vary across its range; however, one near constant is the presence of rock outcroppings and rock piles with interstitial spaces used for thermoregulation and cover (e.g. Keasler 1981 p. 2; Stewart 1991, p. 5; Hoyer and Stewart 2000a, p. 350). Logs and other surface debris are also considered important for the boa for shelter and thermoregulation (e.g. Keasler 1981, p. 8).

Three typical rock formation associations for southern rubber boas have been described: a flat rock with a space and maybe a burrow underneath where the boa can move underground; a rock with a crack big enough for a boa to enter; and one where rocks are piled above and below-ground (Keasler 1981; see also Stewart 1991, p. 6). The factor of overriding importance in all habitats seem to be access to rocky hibernation sites and relatively damp soil (Keasler 1981, p. 7).

Vegetation associations noted by researchers are variable. Historically habitat vegetation has been described as transition forest dominated by ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), incense cedar (*Libocedrus decurrens*), and black oak (*Quercus kelloggi*) (Cunningham 1966, pp. 298 and 299), and as transitional woodlands dominated by Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), *A. concolor*, *Q. kelloggii*, *L. decurrens*, and sometimes manzanita (*Arctostaphylos* sp,), and California lilac (*Ceanothus* sp.) (Keasler

1981, p. 2). While the majority of occurrences are in habitat similar to the historical descriptions, recent boa observations in the unforested land east of Big Bear Lake (near Baldwin Lake and associated with Deadman's Ridge) have called into question the necessity of a woody forest canopy and well-developed forest soils (Service GIS database). These less-forested areas are similar to the location Stewart (1991, p. 5) described as "unusually arid" with great basin sage scrub vegetation ("Lake Williams Road," presumably Lake Williams Drive in the vicinity of Deadman's Ridge). Southern rubber boas collected on dry, south-facing slopes with little or no forest canopy are an indication that boa survival is not always dependent on cool, moist forests (Keasler 1981, p. 7), nevertheless, population resiliency is expected to be substantially bolstered by the presence of moist habitats.

The shape of the mountains where southern rubber boas are found may determine habitability. Grismer et al. (2020, pp. 34 and 35) hypothesized the difference in the shape of the mountains may be responsible for the smaller apparent population size and distribution of boas in the San Jacinto Mountains because the San Bernardino Mountains are longer, broader, have deeper soils, and accumulate more moisture from coastal weather systems; whereas the San Jacinto Mountains are further east and cone-shaped, and therefore overall drier except in deep canyons (see also Hind's explanation above). It may be that the only places in the San Jacinto Mountains that accumulate enough moisture and humidity are deep canyons with perennial streams (Grismer et al. 2020, p. 35).

In general, the ambient temperature of southern rubber boa habitat is relatively cool, with an average daily maximum temperature ranging from 61ºF to 75 ºF (16 ºC to 24 ºC) (Figure 3.2), and rainfall ranging from approximately 20 to 39 in (50 to 100 cm) total precipitation per year (Figure 3.2). It is likely that the boa's sensitivity to humidity and moisture limits their distribution to high altitudes in Southern California, which is the driest region within the ranges of northern and southern rubber boas (Grismer 2019a, pers. comm.). Soil moisture may be a limiting factor for boas during summer months given the species is often observed during this time period in damp draws near springs, seeps, and streams (Loe 1985, p. 3).

The likely factor minimizing southern rubber boa habitat suitability during high temperature periods is soil moisture loss. Generally, while moist micro-habitats hold more humidity in the short-term with increasing heat due to evaporation, at the landscape-scale habitats are likely to decrease in humidity long-term due to evaporation (near-surface) and evapotranspiration (plant roots pull moisture from deeper soils). Therefore, there is a logical limit to which boas can mitigate dryness in warmer areas by retreating underground; this is where environmental habitat suitability would be lost.

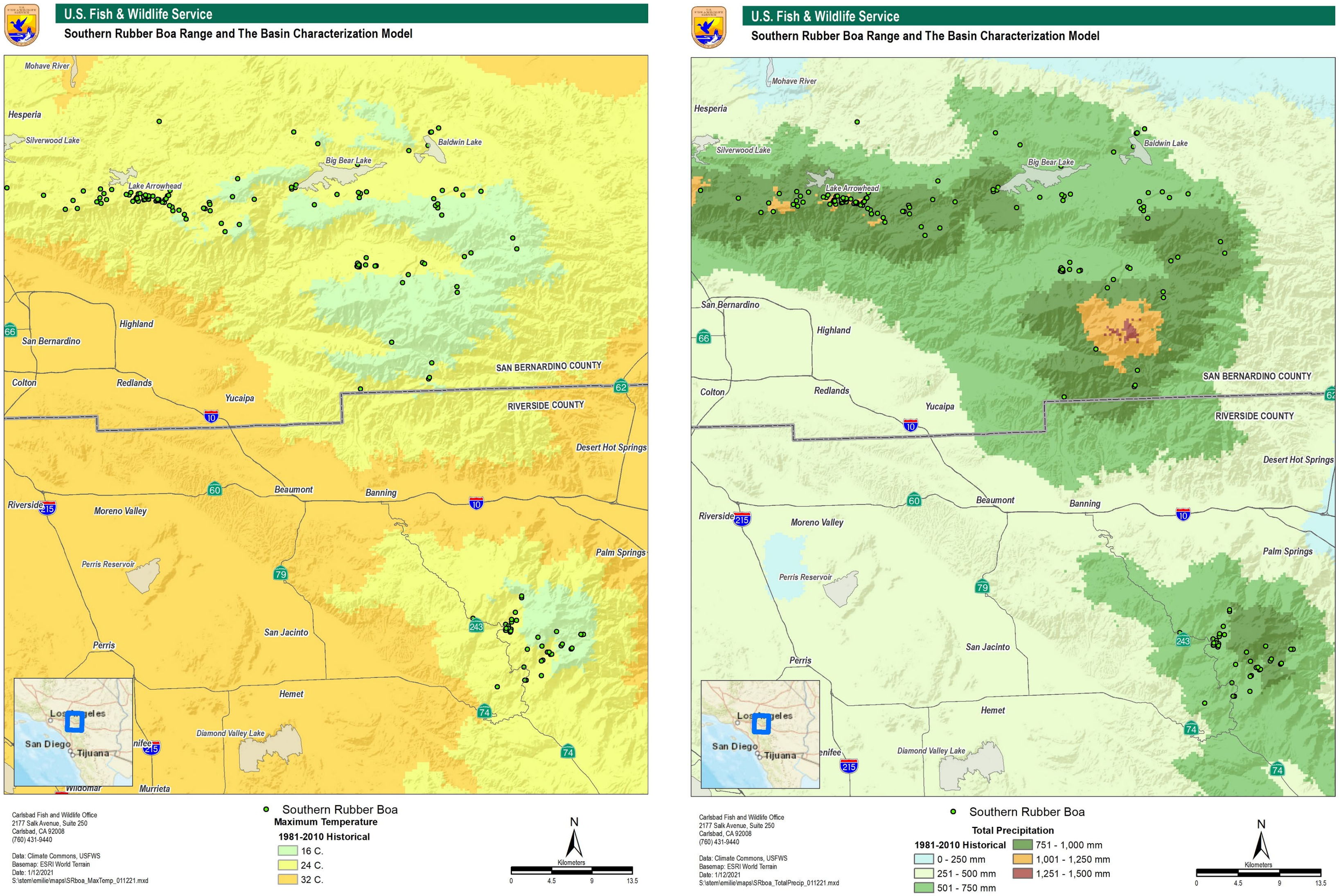


Figure 3.2. California Basin Characterization Model, historical climate maps within the range of the southern rubber boa.

CHAPTER 4 - ABUNDANCE AND DISTRIBUTION

4.1 Distribution

The southern rubber boa is known exclusively from the San Bernardino and San Jacinto mountains, each mountain believed to support a single population, as there are no clear separations in the species' distribution within each range (Figure 1.2). Boa observation records in the San Bernardino Mountains exist between 4,600 and 8,250 ft (1,402 and 2,515 m) in elevation (rounded to nearest 50 ft), and in the San Jacinto Mountains between 5,000 and 8,250 ft (1,524 and 2,515 m). The lowest elevation record is also the westernmost in the San Bernardino Mountains, possibly because of higher humidity due to higher precipitation within the species' acceptable temperature range (Figure 3.2).

4.1.1 Estimated Habitat Distribution

The USGS created a model to help determine all areas of potential occupancy outside known population distributions where surveys should occur (hereafter referred to as "USGS model" or "USGS-modeled area;" Appendix C). We used this model because it was the best available information when we started our analysis. An additional ecological niche model (Grismer et al. 2020, entire; Figure 41) became available after we had completed our geographic-based analyses, we present that information here, but did not use it for any quantitative analyses. The USGS-modeled area likely overestimates the area of suitable habitat; however, such a map drawn from occupancy records would likely underestimate it. Within the USGS-modeled areas, the boa can be locally abundant in prime micro-habitats, but uncommon and not continuously distributed in intervening habitats (Grismer et al. 2020, p. 35). We conducted this analysis assuming that not all areas within the USGS-modeled area are equally suitable or even habitable, but that it serves as a useful standard for potential impact to boa habitat.

4.1.2 San Bernardino Mountains Population

The San Bernardino Mountains extend approximately 60 miles (mi) (97 kilometers (km)) from Cajon Pass in the northwest (which separates them from the San Gabriel Mountains) to San Gorgonio Pass, in the southeast (which separates them from San Jacinto Mountains). The known southern rubber boa population is distributed throughout the majority of the range, from Cedarpines Park south of Silverwood Lake, east to Baldwin Lake and Onyx Peak, and southeast to the Riverside County line in the vicinity of Little San Gorgonio Peak (Figure 1.1). The total amount of habitat per the USGS-modeled area (Figure 1.2) in this mountain range is approximately 397,151 acres (ac) (160,721 hectares (ha)), which is assumed to be an over-estimate of available habitat. This analysis distinguishes east and west subpopulation "analysis units" based on expert opinion and general habitat differences, with a semi-subjective division of the USGS-modeled area running directly north from near the confluence of Bear Creek and the Santa Ana River (Figure 1.2). The total USGS-modeled area within the western and eastern subpopulations is approximately 100,332 ac (40,603 ha) and 296,818 ac (120,118 ha), respectively.

4.1.3 San Jacinto Mountains Population

The San Jacinto Mountains extend approximately 30 mi (48 km) from San Gorgonio Pass (which separates them from the San Bernardino Mountains), southeast to the Santa Rosa Mountains (which separated by a valley and the Pines to Palms Highway). Within these mountains, the known southern rubber boa population distribution is clustered to the south and west of San Jacinto Peak, in the northern portion of the mountain range (Figure 1.2). It is possible the relatively inaccessible areas of apparently suitable habitat at higher elevations (9,101 ft (2,774 m)) could support more boas than known lower elevation locations near Idyllwild (Grismer et al. 2020, p. 35). The total amount of habitat per the USGS-modeled area (Figure 1.2) is approximately 56,106 ac (22,706 ha).

4.1.4 Other Possible Suitable Habitat Areas

The San Bernardino and San Jacinto Mountains are not the only areas where the southern rubber boa conceivably occurs. An ecological niche model (ENM) was developed by Grismer et al. (2020, pp. 29–30) to assess the extent and degree of habitat suitability for the six lineages of southern rubber boa under current climatic conditions and four different future projections of temperature and carbon dioxide concentrations over the next 50 years (see **6.1.5 Changing Climate Conditions**). The ENM predicted five areas of habitat suitability outside of the southern rubber boa's current known range: the San Gabriel Mountains; the Santa Rosas Mountains; Thomas Mountain; marginally in the Laguna Mountains (Figure 4.1); and the Sierra San Pedro Mártir in Baja California, Mexico.

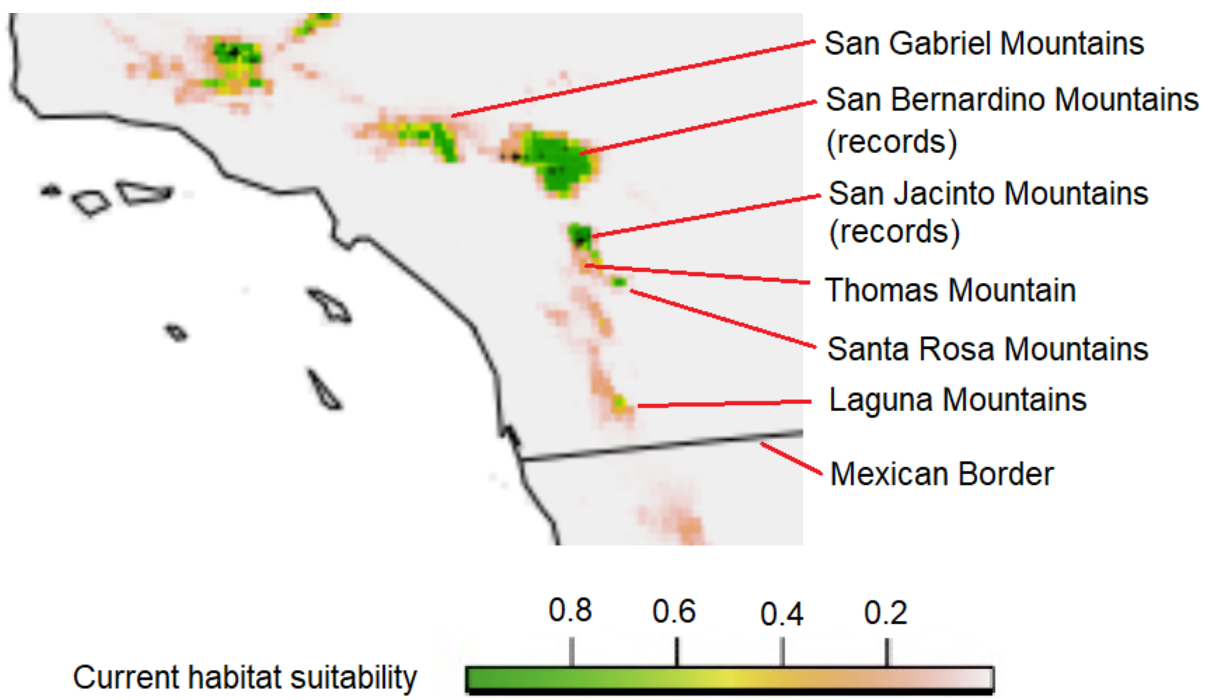


Figure 4.1. Ecological niche model of current southern rubber boa habitat suitability within the U.S. (Grismer et al. 2020, pp. 29–30).

Surveys for the southern rubber boa at Thomas Mountain did not yield any records, but Grismer et al.'s ENM (Figure 4.1) predicted areas of suitable habitat similar to the USGS-modeled area (Figure 1.2) (Grismer et al 2020, pp. 29–30). No confirmed *Charina* sp. records are known from the San Gabriel Mountains adjacent to the western edge of the species' range. Experts (Grismer 2019b, pers. comm.; Hoyer 2019, pers. comm.; Stewart 2019b, pers. comm.; Grismer et al. 2020, p. 29) believe it is possible, but unlikely, there is a *Charina* sp. population in the San Gabriel Mountains, and it is unclear if this would be considered southern rubber boa. Habitat in the San Gabriel Mountains is under-surveyed compared to the San Bernardino and San Jacinto Mountains, because the rugged topography makes them less accessible to field herpetologists, and most of those who search for them look at reported sites (Grismer 2019b, pers. comm.; Stewart 2019b, pers. comm.).

Reports of boas in the San Gabriel Mountains were described by Stewart (1976, p. 5), "Before he left the San Bernardino Forest in 1973, Wildlife Biologist Jerry Light told me he had seen a snake he believed to be a rubber boa in the South Fork of Lytle Creek. Independently, Micky Long, a herpetologist at the Whittier Narrows Nature Center, recently told me that a friend of his recalled seeing a rubber boa-like snake in the south fork of Lytle Creek several years ago. While far from being concrete evidence, the latter reports help to keep alive the idea that, somewhere in the San Gabriels, a small population of rubber boas may have managed to survive." Examination of satellite imagery indicates there is some potential habitat at higher elevations of Lytle Creek's south fork, and in areas immediately to the east (e.g., Big Tree Truck Trail and Penstock Ridge).

The San Gabriel Mountains rubber boa distribution "gap" was investigated most thoroughly in the 1970s (Stewart 1976, entire). Although this investigation did not include the south fork of Lytle Creek (dominated by vegetation not believed to be suitable at the time), the conclusion was the generally very steep, often dry topography with thin soils and scant leaf litter, provides only small isolated pockets of suitable habitat (Stewart 1976, entire). Expert opinion is that the San Gabriel Mountains are not likely to support a viable population because there is little contiguous suitable habitat, even in comparison to the San Jacinto Mountains, and some of the best historical habitats have been altered by resort development (Stewart 2019b, pers. comm.). The San Gabriel Mountains were likely occupied by the southern rubber boa during the Pleistocene, or even more recently, and provided a historical connection to northern rubber boa populations (Stewart 2019b, pers. comm.; Stewart 1976, p. 4), a hypothesis supported by Grismer *et al*.'s (2020, p. entire) genetic study. At this time, we do not consider the San Gabriel Mountains, or those in Mexico, to be habitat likely to support undiscovered populations.

4.2 Historical and Current Abundance

Perhaps the most difficult aspect of assessing southern rubber boa status is its unknown population size and local population densities. Population estimates are an important aspect of wildlife management and conservation, but can be difficult for fossorial and elusive species. Because boas are fossorial, nocturnal, and only infrequently active above-ground, it is especially difficult to estimate number of individuals in the field (Keasler 1981, p. 2). To date, there have been no studies to estimate detection probability of this boa, such as a mark-release-recapture, nor a genetic census based on pedigree reconstruction to identify populations and estimate size, such as single-nucleotide polymorphisms (e.g., Spitzer et al. 2016, entire). Therefore, it is not currently possible to estimate the density or abundance of this species based solely on field observations.

Relative differences in survey observation rates among habitat types, populations, and over time must be interpreted with caution. For the southern rubber boa, dry conditions or a declining amount of undisturbed cover reduces surface and near-surface activity, and therefore detectability; however, we cannot know how the density of snakes below-ground changes. Nevertheless, the best available information suggests that differences in boa survey observation rates within the species' range and over time may reflect population size differences. During longer periods of high temperature and dry habitat, reduced humidity and increased evaporation rates likely reduce habitat suitability and corresponding reproduction and survival rates.

Several factors suggest differences in boa observation rates consistent over a decade or more are reflective of density differences. Based on data collected by Hinds (2020, pers. comm.), southern rubber boas are not observed in the San Jacinto Mountains when humidity is below 50 percent and more boas are observed overall in the San Bernardino than the San Jacinto Mountains (Hinds 2020, pers. comm.). Finding more snakes under what appears to be less optimal conditions in the San Bernardino Mountains compared to better (i.e., higher humidity) conditions in the San Jacinto Mountains suggests higher survey numbers in the northern range are primarily due to higher densities of boas, and not an artifact of higher detectability. Therefore, long-term boa observation rate differences recorded between the San Jacinto and San Bernardino Mountain populations likely reflect density differences because reduced time spent by individuals at or near the surface (including where they bask under rock cover), should negatively affect population growth long-term. A second likely contributing factor to apparent abundance differences is the significantly smaller, isolated habitat area in the San Jacinto Mountains. The contiguous USGS-modeled area of the San Bernardino Mountains (397,151 ac (160,721(ha)) total) is approximately seven times larger than that of the San Jacinto Mountains (56,106 ac (22,706 ha) (Figure 1.2). Connectivity among a variety of habitat patches, including those supporting exceptionally productive local "source" populations or colonies, increases average abundance of local populations, as extirpated local populations are more likely to be recolonized frequently.

As discussed above, essential activities such as mate-finding, foraging, digestion, and gestation require above-ground activity, either to locate other individuals, or for required warmth. Foraging and mate-finding occur mostly on the surface at night when temperatures are low and boas are most active, and basking for digestion and gestation occur near the surface during the day in cracks or under rocks (Dorcas and Peterson 1998, pp. 94 and 95). The trade-off between the advantage of warmth and the disadvantage of moisture loss at the surface is illustrated by observations that only digesting, shedding, or gestating boas are found above-ground in dry conditions (Hinds 2020, pers. comm.). If cover sites are disturbed resulting in a loss of suitably humid basking sites, but temperatures remain unchanged, basking individuals could not move deeper underground to maintain humidity while still maintaining high enough body temperatures. Even if a warmer climate allowed adults such as gravid females to bask deeper below the surface, a shortened window of surface and near-surface activity would likely have a negative long-term population effect, as individuals would spend less time foraging and searching for mates. A shift in the seasonality of boa surface and near-surface activity to earlier times of year when surveys are not typically conducted would also explain differences in detectability; however, it would require significant life-history adjustments, such as a longer annual foraging period (and a larger prey base if that were limiting). If such alternate life history traits were advantageous and possible, the species would probably inhabit drier areas at lower altitudes, where it currently does not occur. Finally, as minimum nighttime temperatures increase, any adaptive advantages of foraging and searching for mates on the surface at night, such as low moisture loss, low metabolic cost, avoidance of predation by kingsnakes (*Lampropeltis sp.*), and avoidance of competition with rosy boas, would be reduced. Though there is a high level of uncertainty, areas that have sustained lower survey observation rates may have corresponding lower growth rates and population densities.

Overall, southern rubber boa observation rates and almost certainly abundance, are lower in the San Jacinto Mountains relative to the San Bernardino Mountains (Grismer 2019a, pers. comm.; Hansen 2019, pers. comm.; Grismer et al. 2020, p. 34). Prior to 2003, a single surveyor in the western sub-population of the San Bernardino Mountains (especially in the Heaps Peak area near Lake Arrowhead) could find approximately 20 boas in a single day. In comparison, a single surveyor in the eastern sub-population of the San Bernardino Mountains has always been able to find approximately zero to four boas per day (except near Barton Flat where abundance is approximately double), and one boa per 7 days of searching in the San Jacinto Mountains (Hinds 2020, pers. comm.). This equates to almost 140 times as many observations per unit effort in the western San Bernardino Mountains and 14 times as many in the eastern San Bernardino Mountains, as typically found in the San Jacinto Mountains. Currently, based on the best available information, the western sub-population (with most data from Heaps Peak) survey numbers for a single person in a single day’s survey effort has dropped dramatically to the same level as surveys conducted in the eastern sub-population; (0–3 boas per day), while similar drops have not been reported at any eastern sites (Hinds 2020, pers. comm.; Grismer et al. 2020, p. 34). Additionally, one field herpetology enthusiast (Lynum 2020, pers. comm.) claims there have been declines in the number of boas he could typically find in the San Jacinto Mountains compared to a similar amount of survey effort in the past.

CHAPTER 5 - RESOURCE NEEDS

In this section, we synthesize the information from the preceding sections to highlight the overall resource needs of the southern rubber boa at the individual, population, and species-levels. The resource needs are cumulative across levels. That is, if the needs of an individual cannot be met, then that individual would not likely survive, and it would not contribute to a population. Therefore, if the resource needs of a significant proportion of the individuals in a population are not met over time, the population may not be resilient in the future. Similarly, if the needs of a population cannot be met, that population may not be viable in the future, and it may not contribute to the species' overall viability. Thus, failure to meet individual-level or population-level needs (on a large enough scale) can ultimately lead to species extinction.

Conversely, if the resource needs of individuals in a population are being met, allowing for an adequate population size and with sufficient rate of growth, then that population will demonstrate resiliency. Furthermore, the number and extent of resilient populations, and their distribution and 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.

5.1 Individual-level Resource Needs

Basic Requirements for Juveniles and Adults

- Adequate humidity underground through dry months and years.
- Fractured granitic or similar rocky formation with existing rodent burrows (shelter/hibernacula).
- Adequate juvenile rodent and insectivore prey and lizard eggs (food).
- Open, sunlit areas that reach a minimum of 80 ºF (27 ºC) in the spring for gestation and in the summer for juvenile growth. Gestating females must maintain body temperatures between 77 ºF to 90 ºF (25 to 32 ºC) (Dorcas and Peterson 1998, pp. 94, 95, 98, and 101).

5.2 Population-level Needs

Resilient Populations

- Average daily maximum temperatures no greater than 75 ºF (24 ºC) (Figure 3.2).
- Greater than 20 inches (in) (50 centimeters (cm)) rainfall/year (Figure 3.2).
- Woody canopy with openings creating litter layer and well-developed soils within the population distribution (some individuals will survive in marginal habitat).
- Adequate number of individuals to recover from localized stochastic events to maintain genetic diversity, and adequate density to find mates.
- Adequate distribution encompassing sufficiently moist and diverse habitat types.
- Adequate connectivity and suitable corridor habitat for individuals to move among locations and find mates and recolonize previously occupied habitats.

5.3 Species-level Needs for Viability

5.3.1 Redundant Populations

Multiple populations and broad distribution help to ensure that a species is able to withstand catastrophic events. Loss of one population or subpopulation due to a catastrophic event would reduce species' redundancy by approximately one third, thereby significantly reducing species' viability. Although loss of the larger San Bernardino Mountains population is less likely to occur than loss of the San Jacinto Mountains population, a disease (such as snake fungal disease) epidemic could significantly affect one population without affecting the other (see **THREAT FACTORS INFLUENCING VIABILITY,** below). The same reasoning emphasizes the importance of maintaining both San Bernardino Mountains subpopulations.

5.3.2 Representative Populations

At least one population in each of the San Bernardino and San Jacinto Mountains help maintain the species' historical range of genetic and habitat diversity. Genetic divergence between the populations has been demonstrated (Grismer et al. 2020, entire; Appendix A), and there is likely some degree of local adaptation within populations. It is also likely important to maintain habitat diversity across the San Bernardino Mountains by retaining both east to west subpopulations, as this captures the variable range of elevations and vegetation types found within the species' range.

5.4 Summary of Resource Needs

Southern rubber boa resource needs reflect the species' reliance on moisture, their nocturnal habits, the importance of shelters for hibernation, gestation, basking under cover, and humidity (Figure 5.1). Habitat and demographic needs that are used in the resiliency analysis are described in more detail below and include: appropriate humidity, sufficient prey, appropriate gestation sites and shelter, mate availability and adult abundance, and adequate habitat diversity.

5.4.1 Appropriate Humidity

All life stages of the southern rubber boa depend on adequate humidity for health and growth (see **3.3 Habitat and 3.2.4 Physiology and Thermoregulation**). They maintain appropriate humidity levels by moving in and out of areas with higher humidity, and primarily limiting their active time above-ground to nighttime when temperatures and evaporation rates are low. Activities requiring above-ground movement include foraging, following moisture gradients to alternate micro-habitats when habitats start to dry, mate finding, and basking to elevate body temperature. Appropriate humidity is needed for adult and juvenile abundance and survival.

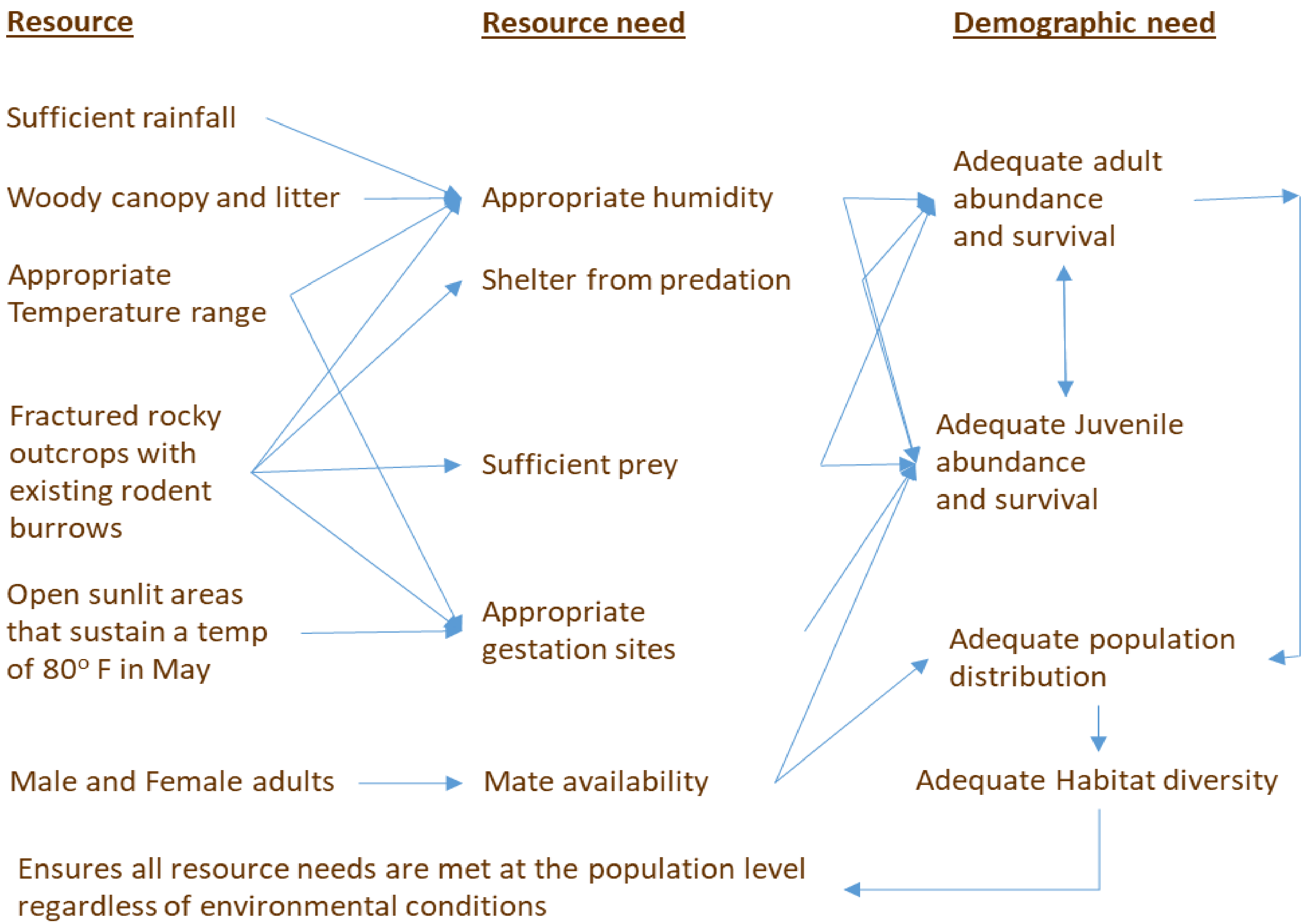


Figure 5.1. Conceptual model of Southern rubber boa's resource needs.

5.4.2 Sufficient Prey

Neonates subsist on stored yolk fat. Juveniles, subadults, and adults forage for lizard eggs, nestling mice and insectivores (see **3.2.3 Prey Base**). Rodent and lizard populations within the boa's habitat also support boa's potential predator populations, such as kingsnakes (*Lampropeltis* sp.) and owls (e.g., western screech owls (*Megascops kennicottii*) and great horned owls (*Bubo virginianus*). Therefore, sufficient prey population sizes to support boa populations may vary among habitats, depending on habitat characteristics and the density of competing predators. Seeds, insects, and other food items that support the boa's prey populations must also be in sufficient supply.

5.4.3 Appropriate Gestation Sites and Shelter

Southern rubber boas need shelter that provides shade during the day, warmth at night, sufficient humidity, and cover from predators (see **3.3 Habitat and 3.2.4 Physiology and Thermoregulation**), although the types of shelter vary throughout the year. Winter hibernacula typically consist of fractured granite rock piles with existing rodent burrows that allow boas to remain protected underground from predators and winter weather. During the spring time, adults regulate their body temperature on and near the surface by moving in and out of the sun, using logs, stones, and forest floor debris. Gravid females must maintain a steady, relatively high body temperature for weeks; and they achieve this at night by sheltering under rocks or deep in the crevices of rock outcrops that radiate heat absorbed during the day.

5.4.4 Mate Availability and Adult Abundance

As is the case with any population that requires mating for reproduction, densities of southern rubber boa must be high enough to find mates and reproduce in order to sustain a population long-term (see **3.2.1 Reproduction and Sex Ratio**). Rubber boas are relatively long-lived, and females only reproduce every 2 to 3 years; thus, for females, finding a mate is not an annual need, and a population can likely remain viable through several years of reduced mate availability without suffering a significant reduction in growth rate. Adult female boas appear to be less abundant than males, and it is their abundance that would be limiting for population growth.

5.4.5 Adequate Habitat Diversity

Habitat diversity is important on multiple scales. Individual southern rubber boas require cooler, wetter environments than are found in the vicinity of their hibernacula for summer survival (see **3.3 Habitat**). At a landscape scale, if a population is distributed throughout diverse habitat, some portion of individuals is likely to experience ideal humidity to support reproduction and survival. Prey availability is also likely to differ annually across the landscape, correlated with varying environmental conditions that support the prey's population growth.

CHAPTER 6 – THREAT FACTORS INFLUENCING VIABILITY

In this chapter, we examine existing factors that are negatively and positively influencing the population resilience and species viability of the southern rubber boa throughout its range, including threats and conservation efforts (Figure 6.1). We also identify those sources of negative and positive impacts that are not carried forward in our analysis because they are low-level threats and are not likely to increase the risk of extinction (recreation, infrastructure and forest management, resource extraction, and predation and disease). Threats are defined as any action or condition that is known to or is reasonably likely to negatively affect individuals of a species. This includes those actions or conditions that have a direct impact on individuals, and those that affect individuals through alteration of their habitat or required resources. A threat as described herein is a general term that describes the source of an action or condition, or the action/condition itself, that may negatively affect Southern rubber boa.

Impacts from each threat were evaluated to determine the intensity, exposure, and response of the southern rubber boa or its habitat. Threats may be affecting the species at all life stages or all individuals within a population, or possibly affecting all populations within the species' range. It is possible that a threat may be specifically affecting a single condition category, such as prey availability or humidity. Some threats, while present and acting on individuals of the species, may not rise to the level of affecting a population. The predominant threats are listed in Table 6.1 where intensity and exposure are evaluated to determine the overall response of southern rubber boa to impacts.

6.1 Recreation

Many off-highway vehicle (OHV) enthusiasts operate their vehicles within southern rubber boa habitat. (Stewart 1991, p. 16). Unauthorized OHV use negatively impacts boa habitat by destroying ground cover (leaf litter) and vegetation, changing (loosening or compacting) soil density, and disrupting riparian vegetation (Stewart 1991, p. 16; Forest Service/USFWS 2019, pp. 3 and 5). These impacts can lead to openings within the vegetation, drying of the habitat, and the loss of soil due to erosion (Stewart 1991, p. 16). In 1991, OHV activity was estimated to have a high- to moderate-level of impact on approximately 35 percent of all known and potential southern rubber boa habitat in the San Bernardino Mountains (about 29,200 of 82,660 acres) (Stewart 1991, p. 16). The San Bernardino National Forest specifically manages their lands and educates recreational users to minimize recreational impacts to southern rubber boas and their habitat (Forest Service 2019 pp. 1–4, 2005b. pp. 71, 126, and 128).

Currently, this threat is a low-level impact, affecting individual snakes based on minimally documented habitat degradation and direct mortality, but unlikely to result in significantly detrimental population effects.

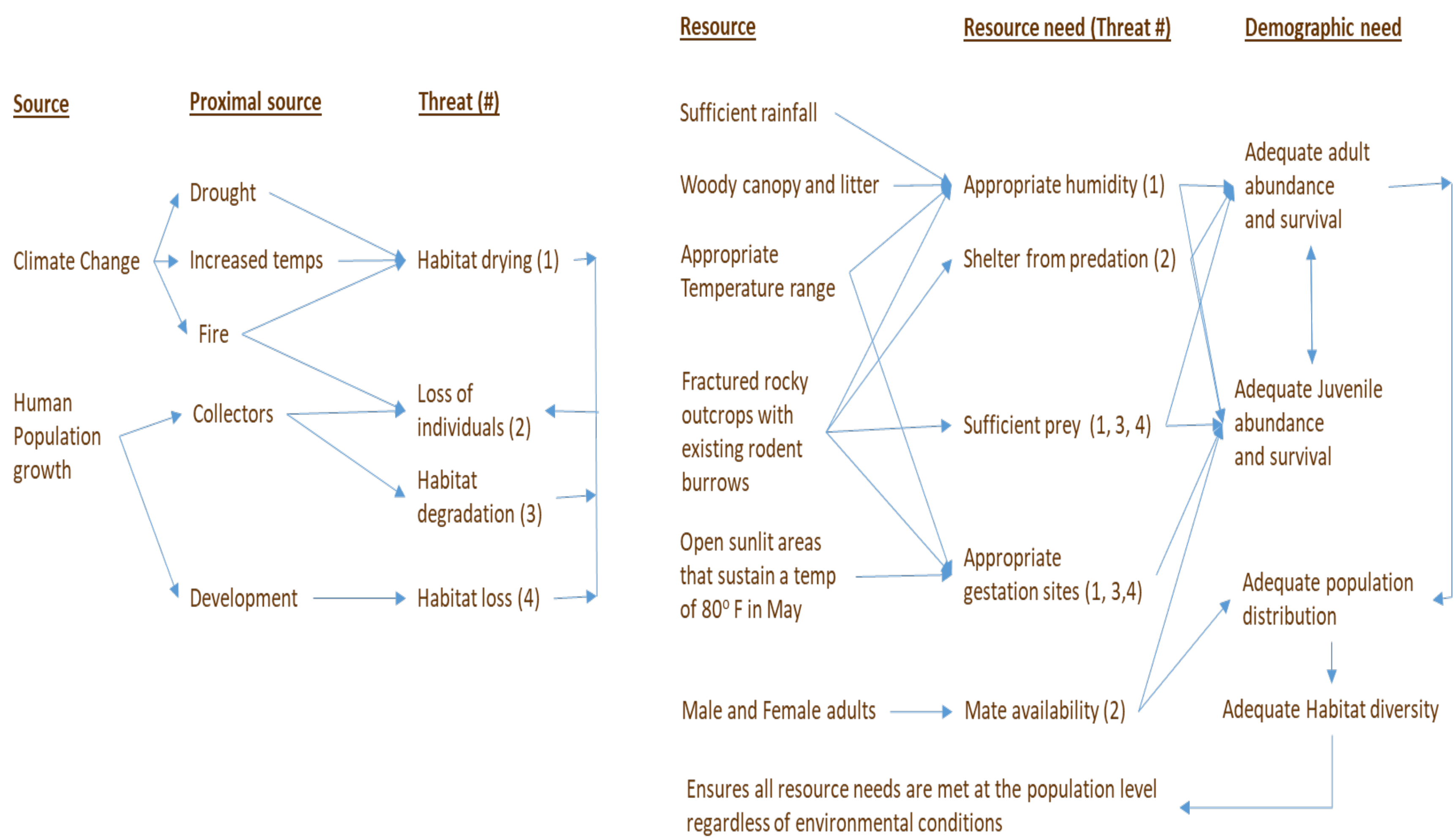


Figure 6.1. Conceptual model of southern rubber boa primary threat sources, threats, and resource needs. Other threat sources are not discussed further as they are low level threats that are not driving the status of species (infrastructure, forest management practices, resource extraction, recreational land use, and predation and disease).

Table 6.1. Predominant threats for southern rubber boa include: habitat drying from drought, increased temperature, and wildfire threat sources; loss of individuals from collectors and fire; habitat degradation from collectors; and habitat loss from development in each of the analysis units: (A) West San Bernardino Mountain sub-population, (B) East San Bernardino Mountain sub-population, and (C) San Jacinto Mountain population.

A. West San Bernardino Mountain Sub-Population: Threats (primary sources)	Intensity	Exposure	Response
Habitat drying (drought, increased temperatures and fire)	M	H	H
Loss of individuals (indirect effects of other threat sources)	M	UNK	UNK
Habitat degradation (rock pile disturbance by collectors)	M	M	m
Habitat loss (development)	H	L	L

B. East San Bernardino Mountain Sub-Population: Threats (primary sources)	Intensity	Exposure	Response
Habitat drying (drought, increased temperatures and fire)	M	H	H
Loss of individuals (indirect effects of other threat sources)	M	UNK	UNK
Habitat degradation (rock pile disturbance by collectors)	M	L	L
Habitat loss (development)	H	L	L

C. San Jacinto Mountain. Population: Threats (primary sources)	Intensity	Exposure	Response
Habitat drying (drought, increased temperatures, and fire)	M	H	H
Loss of individuals (indirect effects of other threat sources)	M	UNK	UNK
Habitat degradation (rock pile disturbance by collectors)	M	L	L
Habitat loss (development)	H	L	L

Column heading explanation

Intensity: Strength of the threat itself; the extent to which it affects individuals.
Exposure: Extent population distribution and threat overlap in space and/or time.
Response: Impact of threat in terms of portion of population impacted based on intensity and exposure (number of individuals vs population level impact).
Threat Category definitions
L = Low (intensity = few individuals at any given site affected; exposure = not more than one known site affected within each analysis unit); **M = Moderate** (intensity = 1/3 to ½ individuals at a site affected; exposure = multiple sites within each analysis unit affected); **H = High** (intensity = the majority of individuals at a site affected; exposure = the majority of sites within each analysis unit affected); **UNK =** Unknown.

6.2 Infrastructure and Forest Management

Roadways, both paved and unpaved, are relatively common in large areas of boa habitat. There are a number of accounts of accidental mortality associated with infrastructure, including road kill (Keasler 1981, p. 9; Stewart 1991, p. 22; Hoyer and Stewart 2000a, p. 350; Leatherman 2013, p. 4; Forest Service/USFWS 2019, p. 3). The higher the density of roads, and the more traffic on them at night, the more likely boa mortality is to occur. However, most boa movement above ground occurs at night, and most traffic occurs during the day. In a study assessing the susceptibility of 166 species of reptiles and amphibians to road mortality and habitat fragmentation, the southern rubber boa was judged to be at medium risk level on a scale of very low to very high (Broehme et al 2018, p. 13).

Controlled burning of brush and wood debris for fuel load reduction in the spring can cause boa mortality, and has been a subject of concern (Stewart 1991, p. 19; Grismer et al., 2020, pp, 32–33). As wildfire frequency increases, it is important to manage the forests to protect communities and vulnerable species, but controlled burns should be conducted after late May when most boas have dispersed (Grismer at al. 2020, pp. 32–33). The Forest Service is aware of this issue, and is working to minimize potential impacts (Forest Service/USFWS 2019, p. 4). The San Bernardino National Forest specifically manages their lands to minimize management impacts to southern rubber boas and their habitat (Forest Service 2019 pp. 1–4; Forest Service 2005, pp. 71, 99, 111, 126, and 128).

Overall, infrastructure and forest management activities are considered low-level impacts, affecting individuals and unlikely to detrimentally affect the populations based on low roadway mortality impacts and active management to minimize controlled burn impacts.

6.3 Resource Extraction

The resource extraction activity experts predominantly worry about is fuelwood collection (e.g. Stewart 1991, p. 13), which reduces the amount of shelter outside of rock formations. While fuelwood collection does occur and has the potential to affect southern rubber boa habitat, the best available information does not indicate it is a current threat to the species. This activity is managed and monitored through a Forest Service permit program, and helps reduce wildfire danger near communities (Forest Service/USFWS 2019 pp. 3 and 5). Another former concern was bracken fern harvesting, but like fuelwood collection, there seems to be consensus that this activity does not have significant impacts (Forest Service/USFWS 2019, p. 4). The San Bernardino National Forest specifically manages their lands to minimize fuelwood collection impacts to southern rubber boas and their habitat (Forest Service 2019 pp. 1–4; Forest Service 2005, pp. 71 and 99).

A recent concern, especially for a moisture-dependent species like the southern rubber boa, is water extraction and lowered water tables. There have been dramatic changes to seeps, wetlands, and riparian areas on the forest likely due to drinking water extraction (Forest Service/USFWS 2019, p. 4). Water extraction and lowered water tables can cause habitat drying, potentially reducing the amount of micro-habitats with appropriate humidity levels. Project proponents access boa habitat through horizontal wells. Ongoing water extraction is a state water rights issue that the Forest Service has no control over (Forest Service/USFWS 2019, p. 4). On September 16, 2014, the Governor of California signed a package of bills that established a California groundwater regulation framework for the first time. Together Senate Bill (SB) 168, Assembly Bill (AB) 1739, and SB 1319 (which amends AB 1739) of the 2013-2014 legislative session, form the Sustainable Groundwater Management Act. The Legislature intends that AB 1739 (in part) provide groundwater sustainability to agencies (as created by SB 1168) with authority to regulate groundwater extraction through measures such as well spacing rules, extraction allocation transfers within the watershed, and accounting rules (Abbott and Kindermann, LLP 2014, pp. 1 and 4). This legislation should require regulation of spring and ground water removal and implementation of these regulations is still evolving. So far, there has not been any resulting decrease in water extractions in boa habitat reported, however we anticipate this legislation could minimize the potential impacts from groundwater extraction in the future.

Overall, this threat is likely a low-level impact based on management of fuel wood collection and minimally documented water extraction impacts, thus likely affecting individuals and unlikely to affect the species at the population level.

6.4 Predation and Disease

While the likelihood of an epidemic is unknown, it is possible such an event could infect one or both southern rubber boa populations. While no such diseases have been documented in southern rubber boas, an example of a possible future epidemic threat is snake fungal disease, similar to white-nose syndrome in bats (Yates 2015, entire), and an emerging threat to wild snakes including boas (Lorch et al. 2016, p. 3; Allendar et al. 2019, pp. 21 and 23). The effects of this pathogen on individual snake health remains unknown, and the true impact on fitness needs to be evaluated (Allendar et al. 2019, pp. 13). Should an epidemic occur, it could also remain isolated to a single mountain range or subpopulation long enough to be managed before a population is lost, or for assisted recolonization to occur. Such a situation occurred with the Catalina Island Fox (*Urocyon littoralis catalinae*), where the population on the larger portion of the island (connected by a narrow isthmus) was decimated due to canine distemper, and had to be repopulated by captive individuals from the smaller, relatively isolated portion of the island (Service 2015, pp. 19 and 32). While disease epidemics in wildlife have clearly become more prevalent and of conservation concern (e.g., white-nose syndrome in bats and chytrid fungus pandemic in frogs), at the present time we are not aware of any specific diseases found in, or likely to threaten, boa populations. Therefore, disease is currently considered a non-existent threat to the species.

There are scattered references to southern rubber boa predation in the literature. Some small mammalian carnivores are potential predators, including raccoons (*Procyon lotor*) and long-tailed weasels (*Mustela frenata*). It can be assumed that common snake predators such as kingsnakes, and especially nocturnal predators such as owls prey on southern rubber boas. In urbanized areas, domestic dogs and cats also are potential predators (Stewart 2019a, pers. comm.). Residents in the Lake Arrowhead area reported that domestic cats are bringing southern rubber boas home (Loe pers. comm. in Keasler 1981, p. 7), but no numbers have been reported.

Predation by domestic pets does not appear to be frequent or widespread and is therefore not likely to be a threat to the species. However, data is sparse, and we recognize as the wildland-urban interface continues to increase, both populations may be subject to added predation pressure from domesticated pets.

6.5 Development and Land Use Change

To evaluate past impacts of development on southern rubber boa populations and habitat, we quantified and evaluated development within the USGS-modeled area (i.e., potentially suitable habitat) for each mountain range. The majority of modeled habitat occurs on Federal land with 397,151 ac (160,721 ha) within the San Bernardino Mountains (Figure 6.3), and 56,106 ac (22,706 ha)within the San Jacinto Mountains (Figure 6.4, Table 6.2).

We analyzed the amount and rate of recent development in the USGS modeled-area from 2006 to 2018. We can identify areas of highest certainty regarding habitat suitability based on southern rubber boa historical records, and therefore areas of greatest concern regarding vulnerability to development. These areas are: (1) north of Heaps Peak and east of the community of Lake Arrowhead in the western San Bernardino Mountains; (2) between the City of Big Bear Lake and the community of Sugarloaf; and (3) east of Sugarloaf in the eastern San Bernardino Mountains (Figure 6.3). Boas are more likely to be found near development because of ease of access for surveyors and others increases the survey effort in these areas, but the best available information suggests that development is not a primary threat.

In the western San Bernardino Mountains, approximately 11 percent of the USGS southern rubber boa potential habitat model area (USGS Model area) is developed, of which 2 percent (<1 percent of the USGS model area) has been developed in the past 15 years (Table 6.2). More development has occurred in the larger eastern San Bernardino Mountains sub-population area, but this comprised only 5 percent of the total USGS model area developed; 2.3 percent (<1 percent of the total) was developed between 2006 and 2018 (Table 6.2)). Furthermore, 89 percent of the remaining undeveloped western San Bernardino Mountains USGS model area is publicly-owned and likely to receive some level of protection, and 88 percent is publicly-owned in the eastern analysis unit and likely to receive some level of protection. In the San Jacinto Mountains approximately 5 percent of the USGS model area is developed (1 percent of this was developed in the past 15 years); 84 percent of undeveloped land is publicly owned (Table 6.2). Therefore, the majority of the USGS model area has not been developed and remains largely conserved. The risk of losing significant amounts of habitat in the next 30 years is unlikely.

Beyond the direct effects of habitat loss through land use change, the most significant concern related to human encroachment may be clearing of surface debris (Keasler 1981, p. 7) that contributes to habitat degradation and fragmentation. Degradation of high quality habitat is a concern in areas such as Heaps Peak, where the highway, SkyPark at Santa's Village resort, Heaps Peak Arboretum, a heliport, Heaps Peak Disposal Site and Transfer Station (landfill), and the KBON FM Lake Arrowhead radio transmitter station all increase human impacts through enhanced access and edge effects. Connectivity among areas north and south of Lake Arrowhead has also been greatly restricted by development, which has the potential to isolate individuals and potentially reduce gene flow within the sub-population.

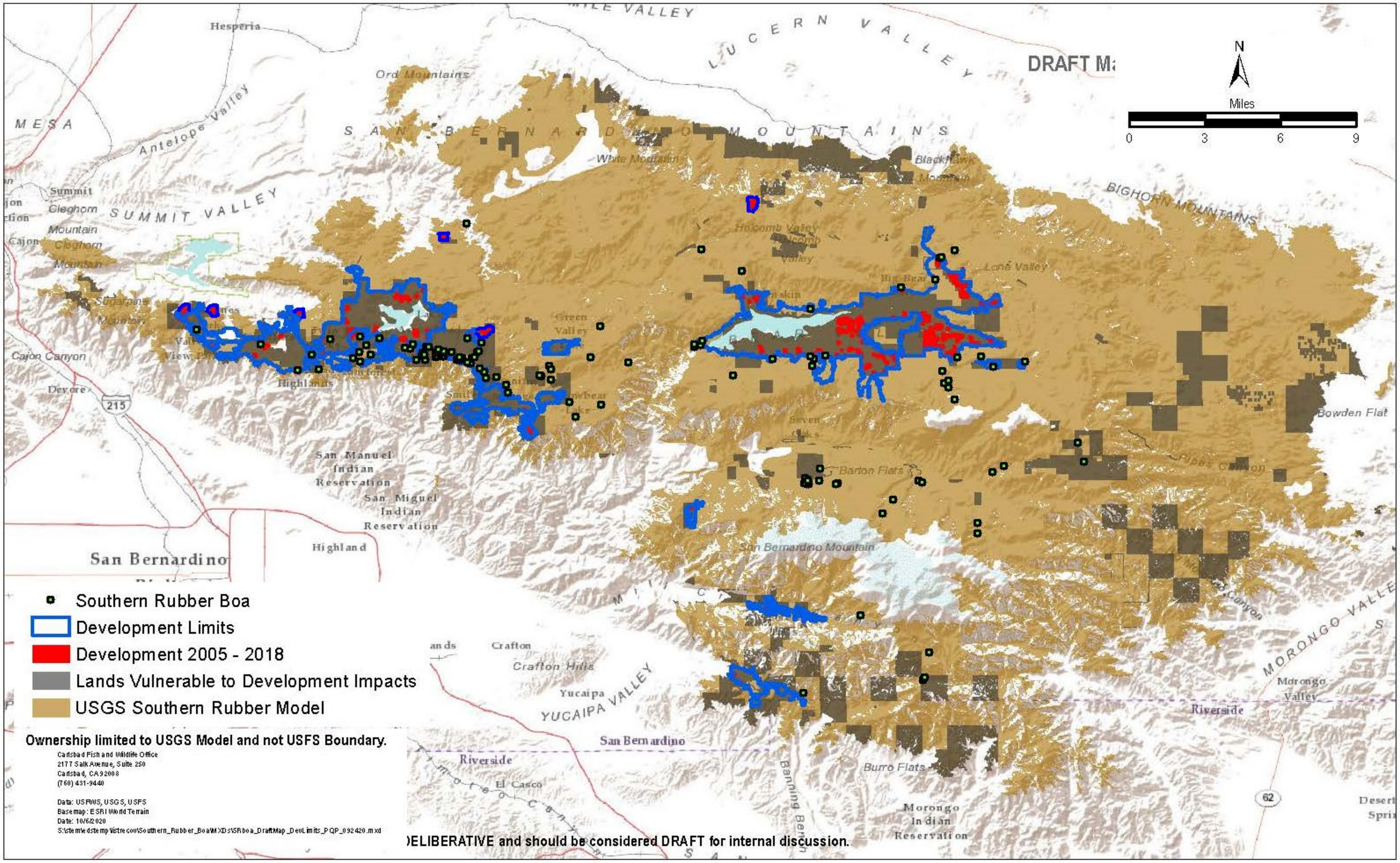


Figure 6.3. USGS southern rubber boa potential habitat model in the San Bernardino Mountains, including losses to land use change (general and recent specific areas), and relatively unprotected/vulnerable lands (not publicly-owned, including Tribal trust lands).

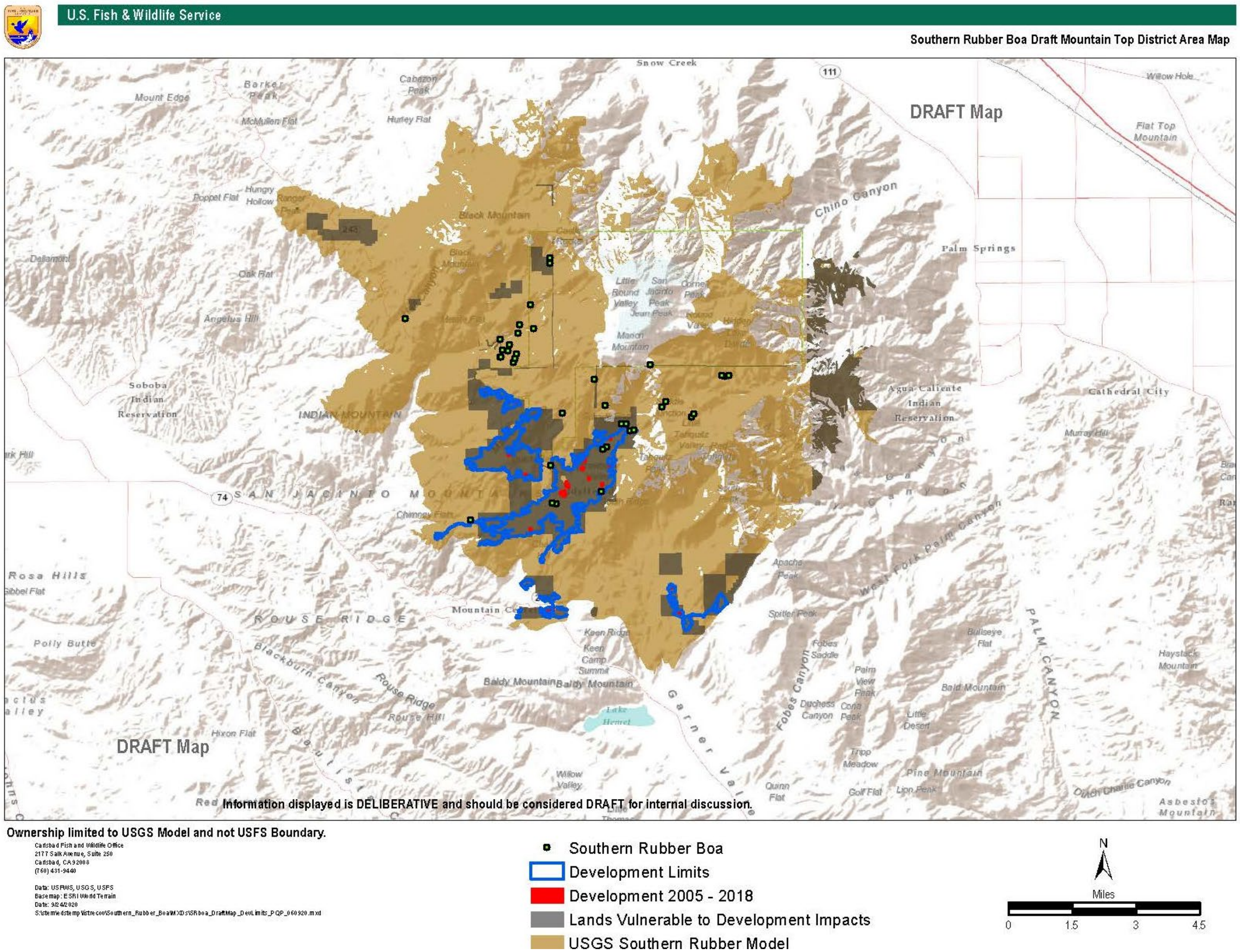


Figure 6.4. USGS southern rubber boa potential habitat model in the San Jacinto Mountains, including losses to land use change (general and recent specific areas), and relatively unprotected lands (not publicly-owned, including Tribal trust).

Table 6.2. Areas within USGS-modeled survey area for the southern rubber boa, by status assessment analysis unit.

Analysis Unit	Total ac (ha)	Total DL[1] ac (ha)	DL 2006-2018 ac (ha)	Total UL[2] ac (ha)	UL Non-public ac (ha)[3]	UL Federal[4] ac (ha)	UL State ac (ha)	UL Local government and conservancy ac (ha)
West San Bernardino Mountains sub-population	100,333 (40,603)	10,594 (4,287)	161 (65)	89,739 (36,316)	9,488 (3,840)	80,226 (32,385)	225 (91)	0
East San Bernardino Mountains sub-population	296,818 (120,118)	14,620 (5,917)	332 (134)	282,198 (114,201)	33,827 (13,689)	229,200 (92,754)	1,093 (442)	18,078 (7316)
San Jacinto Mountains population	56,106 (22,706)	2,904 (11,75)	30 (12)	53,203 (21,530)	6,157 (2,492)	39,635 (16,040)	7,034 (2,846)	377 (153)

[1] DL – Developed lands
[2] UL – Undeveloped lands
[3] Includes a total of 3,100 ac (1,254 ha) of Tribal trust land.
[4] Includes 284,736 ac (86,703 ha) of National Forest/ U.S. Forest Service lands.

While the southern rubber boa is listed as threatened under the California Endangered Species Act and take is prohibited, we are not aware of any State or local regulations specifically protecting southern rubber boa habitat where the species' has not been detected. Nevertheless, to the extent it discourages habitat disturbance by collectors, protection provided by State listing, does reduce damage to southern rubber boa habitat. Overall, existing State (such as the California Environmental Protection Act) and local regulatory mechanisms do not provide a comprehensive level of protection for the southern rubber boa on non-conserved lands.

Though development impacts are not likely throughout the majority of the southern rubber boa's range, the intensity of this threat is high where these impacts do occur. Overall, the threat of development currently has a low-level impact, and affects individual southern rubber boas, not the species as a whole. Past development may have somewhat detrimentally affected the San Bernardino Mountains population based on minimal rates of habitat loss, degradation, and fragmentation.

6.6 Wildfire

Wildfires in California have become five times as frequent over the past almost 30 years due to human-induced climate change (Westerling et al. 2003, entire; 2006, entire; 2004, entire; 2011, entire; Westerling and Bryant 2008, entire; Westerling 2016, entire; 2018, entire; Kitzberger et al. 2017 entire; Holden et al. 2018, entire; Williams et al. 2019, entire; see Section 6.1.5 below for further discussion of warming temperatures and drought). Some of these wildfires have heavily impacted forested and montane habitats in Southern California (Williams et al. 2019, entire).

Concerns regarding the impacts of wildfire are limited to habitat modification, as southern rubber boas are believed to typically retreat underground as fire approaches. Immediately after a fire, loss of woody canopy and forest floor debris is likely to cause habitat drying and reduced microhabitat humidity. Longer-term, replacement of more open woodlands with closed-canopy shrublands is thought to shade rock outcrops so they do not warm as quickly, or as much, in the spring (Stewart 2019a, pers. comm.). Such conditions are less than optimal for adults basking under or in the cracks of warm rocks in order to digest food or during gestation. This phenomenon is hypothesized to have contributed to the apparent decline in southern rubber boa abundance in the Heaps Peak area of the western San Bernardino Mountains (Stewart 2019a, pers. comm.). Wildfires may, but are not likely to significantly affect boa prey populations (West 2009, p. iv; Brehme et al. 2011, entire). Over time, forests usually recover from wildfire; however, more frequent and high temperature wildfires can delay or prevent forest recovery, and larger fires affect larger portions of a population.

Vegetation change resulting from the effects of forest canopy loss due to fire is thought to affect southern rubber boa habitat quality and population densities (Stewart 1991, pp. 7–8). There is an "approximately 2 square mi" (mi^2) (5.2 square ha (ha^2) area near Heaps Peak that burned in 1922 and again in 1956 (Figure 6.5); in the early 1980s and 90s it was dominated by recovering vegetation consisting of extensive bracken fern (*Pteridium aquilinium*), clumps of lilac (*Ceanothus* sp.), manzanita (*Arctostaphylos* sp.) shrubs, and scattered trees (Stewart 1991, pp. 7–8). While the habitat appeared relatively "barren and dry," there were more than 30 historical post-fire boa records there, and together with six adjacent localities, they yielded as many boa records during surveys from 1988-90 as all other 31 surveyed localities (Stewart 1991, p. 8). Therefore, more than 20 years after the 1956 fire, boa population densities appeared relatively high and recovered from any effects. Abundance does not, however, appear to have similarly recovered in the Heaps Peak area in the almost 20 years since the 2003 Old Fire (Hinds 2020, pers. comm.; Figure 6.3).

While climate change (see Section 6.7**,** below) and habitat degradation by collectors (see Section 6.8**,** below) have likely contributed to the decline in the southern rubber boa survey observation rate at Heaps Peak, there is reason to believe wildfire is also a significant factor. The 2003 wildfire footprint was centered (east/west direction) on Heaps Peak, and burned all of the 1922/1956 fire footprint overlap area, including habitat to the east and west where the footprints do not overlap (Figure 6.5). There were occupied areas closer to Heaps Peak on the eastern burn edge after the 1922 fire, and on the western burn edge after the 1956 fire, than there were in either direction after the 2003 fire (Figure 6.5). This would have delayed recolonization of Heaps Peak from areas unaffected by the 2003 fire compared to the two earlier wildfires. In addition, 4 years later in 2007, the Slide Fire burned almost 13,000 ac (5,261 ha) within the USGS-modeled area up to, and partially within, the eastern boundary of the 2003 fire near Heaps Peak (Forest Service 2008, entire). In both 2003 and 2007, the majority of forested areas within the fire footprints were deforested from the wildfires (Forest Service 2004, entire; Forest Service 2008, entire). One argument is that the 2003 and 2007 wildfires were hotter and more intense than prior wildfires due to a warmer climate and the dry, dead wood caused by bark beetle infestation (Hinds 2020, pers. comm.).

It is generally accepted that wildfires have gotten larger, hotter, and more frequent in Southern California due to past fire suppression practices and climate change (see Section 6.7, below). To understand how past wildfires may affect southern rubber boa populations currently and into the future (see discussion on potential future conditions in Chapter 8, below), we analyzed the total area burned per 10 year period over the past 60 years within the USGS-modeled area (Figures 6.6 and 6.7) This analysis revealed wildfire has been more prevalent over the past 20 years compared to the 40 years prior (Table 6.3, Figure 6.6). The total area burned from 1999 to 2009 alone (132,167 ac (53,486 ha)) surpassed the area burned in all four prior 10 year periods combined (111,213 ac (45,006 ha)) by almost 21,000 ac (8,498 ha). Additionally, 21,000 ac is approximately the total area burned in the earliest period analyzed (1959–1969), which was also the smallest total area burned/decade. While the total area burned this past 10 years from 2009 to 2019 (57,685 ac (23,344 ha)) was less than half that of the previous decade, it was still significantly greater than any decade in the 1900's, and close to double the average for the 1900's (27,803 ac (11,251 ha)). A pattern of increasing total burned area per 10 year period is visually obvious within the individual mountain ranges (Figure 6.6). The greatest total area burned during the last 10 year period analyzed was in the San Jacinto Mountains (2009–2019; Figure 6.7). In 2020, the majority of the 33,211 ac (13,440 ha) Apple Fire burned within USGS modeled-habitat in the eastern San Bernardino Mountains, including the four southernmost boa observation locations south of San Gorgonio Mountain (Service GIS database).

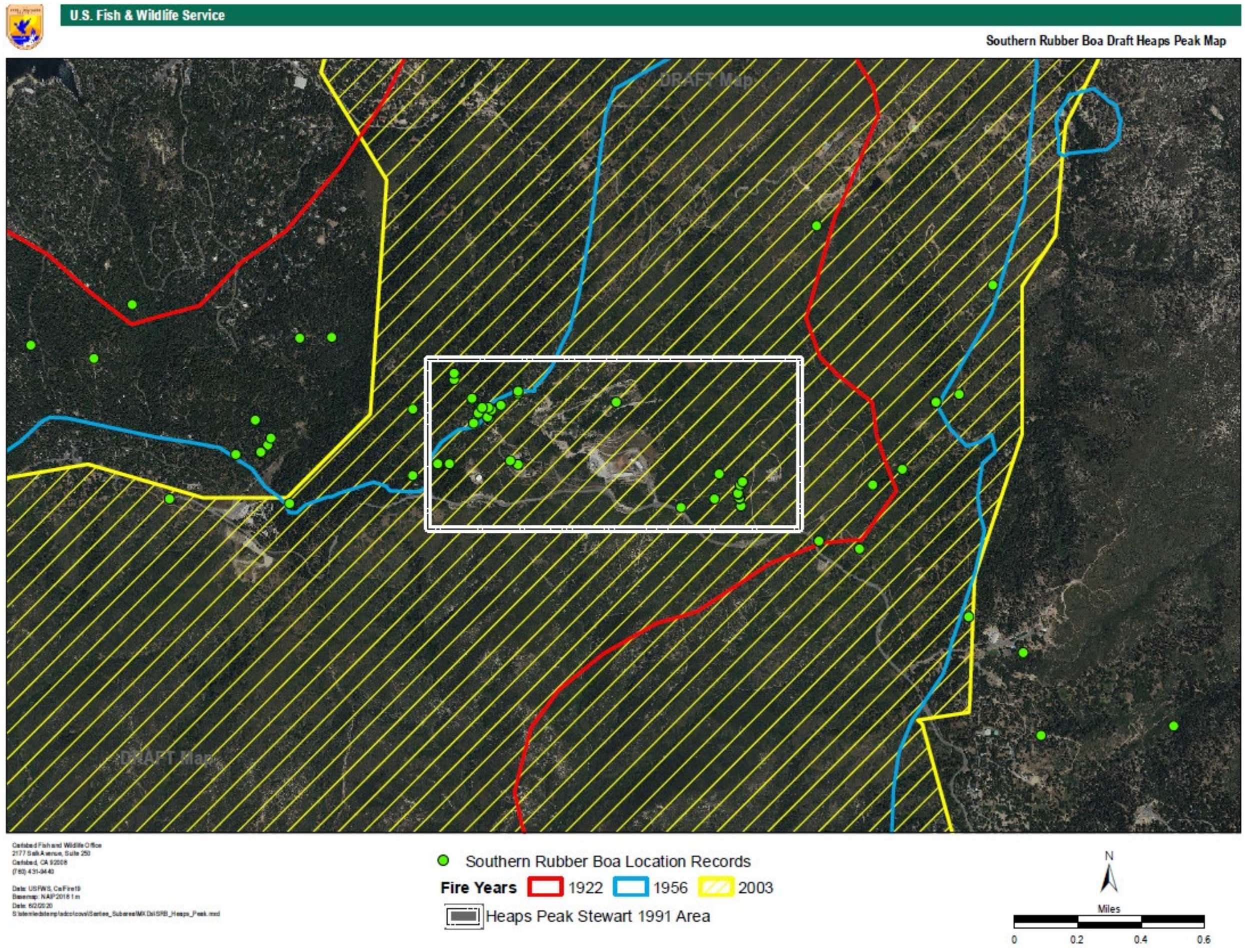


Figure 6.5. Historical southern rubber boa observation records and wildfire history in the Heaps Peak area of the western San Bernardino Mountains.

Table 6.3. Total USGS southern rubber boa potential habitat model area burned per 11-year period (including Santa Rosa and Thomas Mountain south of the San Jacinto Mountains, total model areas 498,723 ac (201,826 ha)).

11 Year period	Acres burned	Hectares burned	Percent Total
1954–1964	21,308	8,623	4.3
1965–1975	36,700	14,852	7.4
1976–1986	29,048	11,755	5.8
1987–1997	24,157	9,776	4.8
1998–2008	132,167	53,486	25
2009–2019	57,685	23,344	11.6

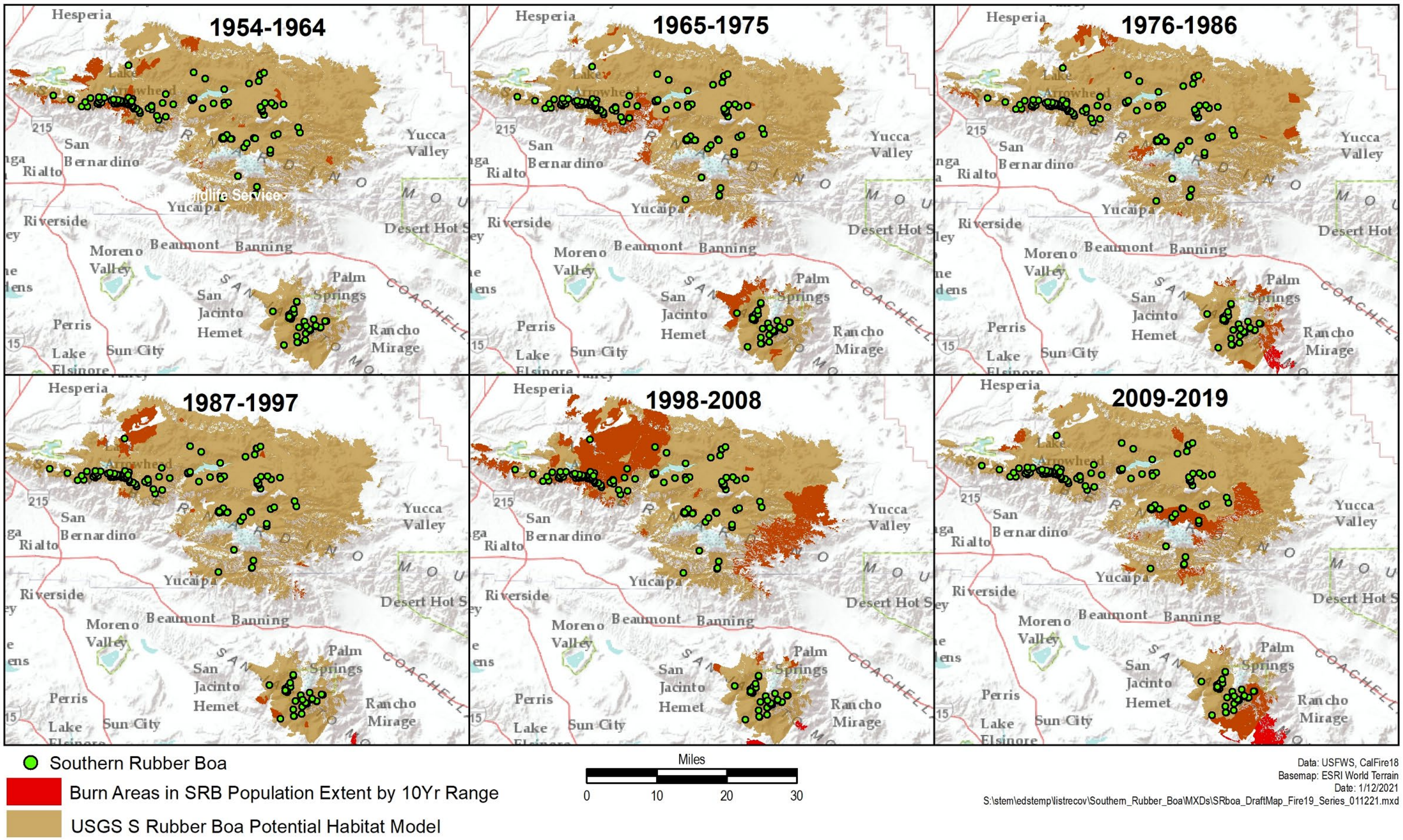


Figure 6.6. Areas burned within USGS southern rubber boa potential habitat model, over 11 year periods.

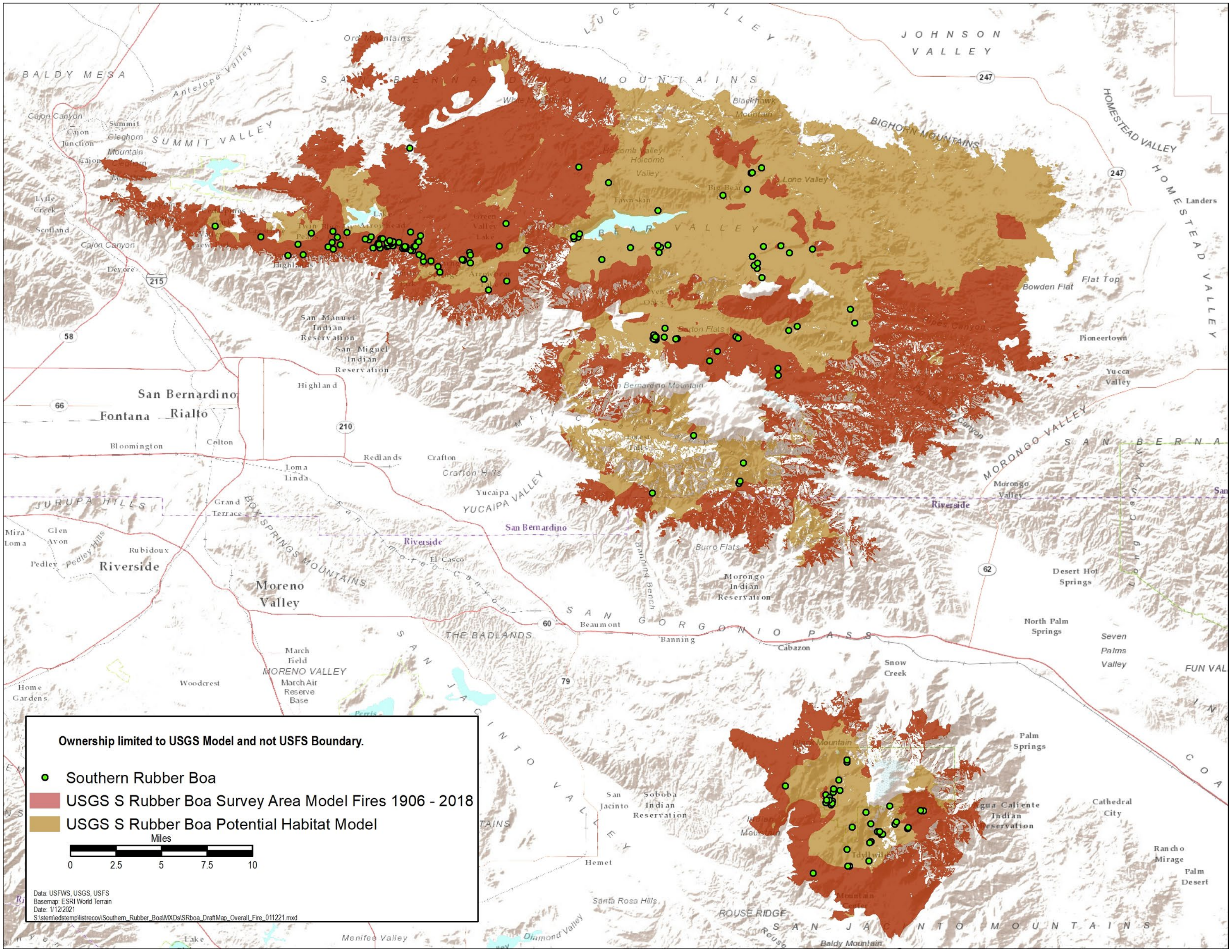


Figure 6.7. Historically burned areas within USGS southern rubber boa potential habitat model.

While the pattern of increasing area affected by wildfires is concerning, it is also noteworthy that wildfire has never affected the majority of USGS-modeled area and southern rubber boa observations in the San Jacinto and eastern San Bernardino Mountains (Figure 6.8). The portion of the species' range that has received the most significant impacts from wildfire is the western San Bernardino Mountains, in particular the historically significant habitat east of Lake Arrowhead from Heaps Peak north, which appears to be particularly prone to wildfire (Figures 6.7 and 6.8).

During a wildfire, human health and safety are the priority for State, Federal, and local governments in California. However, in the future there are no feasible means to control or minimize impacts from mega-fires to wildlands in southern California (Temple 2020, entire). The state is investing in long-term changes to wildland management, however it is unclear how long these will take to be realized, or how successful they will be (Helvarg, 2019, entire). Therefore we do not believe there are any counter-balancing or beneficial measures to discuss with regard to this threat.

Overall, wildfire is considered a moderate-level threat across the southern rubber boa's range, reaching a high level locally due to the potentially greatest effect on habitat humidity in the western San Bernardino Mountains subpopulation (see Appendix E for discussion of uncertainty and assumptions).

6.7 Changing Climate Conditions

There is general concern by experts (Sawyer et al. 2014, entire; Hansen 2019, pers. comm.) regarding the recent warming and drying trend in the San Bernardino National Forest area (including San Jacinto Mountains), and the current and future effects on wildlife. Global climate projections are informative, and, generally provide the best available scientific information. However, projected changes in climate and related impacts can vary across and within different regions of the world (IPCC 2013, pp. 15–16). We use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick et al. 2011, pp. 58–61, for a discussion of downscaling). To assess the vulnerability of southern rubber boa to the effects of climate change, we relied primarily on the high-resolution downscaled California Basin Characterization Model (Appendix D) to evaluate past and projected changes in climate factors that affect habitat suitability. The primary environmental variables affecting boa populations are temperature and precipitation, which affect snake behavior, soil moisture retention, and vegetation structure.

Generally, temperature and precipitation interact to effect southern rubber boa activity levels and development rates. Increased precipitation should generally increase the micro-habitat humidity essential for boa molting and health, which all else being equal, could expand the amount of suitable habitat; however, like all primarily exothermic animals, boa metabolism increases with increasing temperature which increases energy requirements. Increased precipitation and temperature, if not entirely offsetting, could increase or decrease the area of suitable micro-habitat humidity. The water in humid air has a high specific heat, which allows heat to accumulate in collective molecules. Evaporation is a cooling process, reducing humidity and allowing heat to escape. Cloud cover reduces evaporation, so if rainfall and cloud cover increase, the temperature would drop even less at night when boas are active, because humidity retains the heat.

Comparison of the average annual temperature between 30-year intervals (past and present 60-year periods) using the California Basin Characterization Model (Figures 6.8 and 6.9) indicates precipitation may increase or decrease in southern rubber boa habitat, but temperatures will increase, perhaps substantially. Furthermore, the historical trend over the past 60 years (through 2010) has been one of decreasing precipitation (Figure 6.10). To the extent increased precipitation does not offset increased warming, southern rubber boa survival and reproduction could be adversely affected, given the best available information suggests that higher temperatures may be a factor that limits the species' southernmost distributions. California's climate has been getting progressively warmer since the 1970s, with record high temperature and low precipitation statistics in the past decade (NOAA 2014, pp. 1, 4, and 7).

Climate change has exacerbated the drought cycle, to the extent that experts have recently expressed concerns related to its potential impact on southern rubber boa habitat:

- Williams et al. (2020, p. 314) concluded "The megadrought-like trajectory of 2000–2018 soil moisture was driven by natural variability superimposed on drying due to anthropogenic warming." Anthropogenic-driven trends in temperature, humidity, and precipitation estimated from climate models accounted for 47 percent of drought severity, "pushing" an otherwise moderate drought on track to become the worst southwestern megadrought in north American since 800 AD (in 1,220 years).

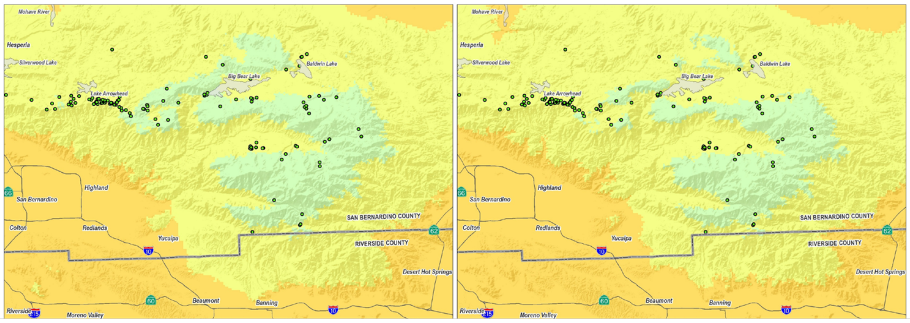
- Stewart (2019, pers. comm.) expressed concern that cycles of more extreme drought and precipitation are likely to occur in the future, and the current state of climate science does not permit accurate predictions about the resulting balance between them. Stewart also stated: "Extended periods (say 10+ years) of drought could be disastrous for SR [boa] populations, and even the beneficial effects of increased monsoonal flows could be countered by an increased frequency of lightning-caused fires. SR [boa] populations obviously have survived with fire up to now, but fire impact to SR [boa]s probably varies with fire intensity, and increased frequency of fires, associated with droughts or monsoons, could curtail habitat recovery, including the prey base, and result in population losses."

- Grismer (2019, pers. comm.) noted that "there is a litany of studies demonstrating that high altitude and latitude populations are at the highest risk of extinction. Additionally, previous studies have shown that populations on the fringe of a species' larger distribution are also at the highest risk of extinction. …. Given this species is so sensitive to soil moisture and humidity it's very possible that if these mountains continue to experience higher than normal temperatures, drought, and higher number of wild fires, these populations could [be extirpated] in the future."

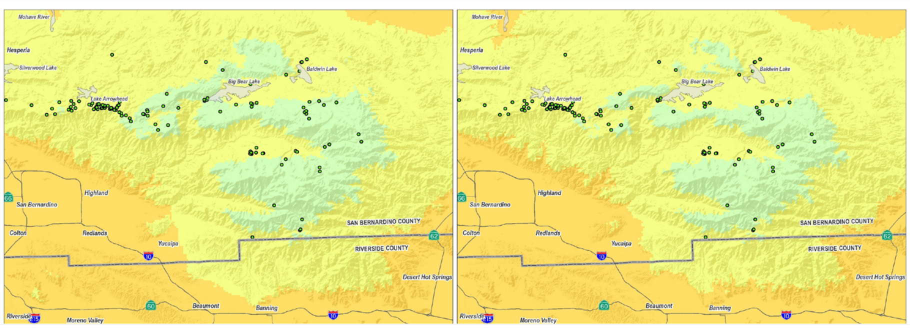
Fortunately, ENM models (Appendix D) also indicate the San Jacinto and San Bernardino Mountains may be large enough to retain suitable habitat over the next 50 years (Grismer et al. 2020, p. 31). Regardless, the estimate of reduction in habitat quality modeled for these lineages does not take into account wildfire, drought, or other indirect anthropogenic impacts related to climate change. Even though the San Jacinto and San Bernardino Mountains habitat areas may be large enough to retain suitable boa habitat over the next 50 years with respect to changing climate conditions, Grismer et al. (2020, p. 31) noted all locally endemic *Charina* sp. lineages on isolated mountains could lose nearly all their available habitat. While the taxa are different biologically in many ways, their ecological communities are the same, therefore parallels, can be drawn to the San Bernardino flying squirrel subspecies, another rare species endemic to the San Bernardino and San Jacinto Mountains. The San Bernardino flying squirrel is an example of a high-altitude taxon with populations on the fringe of a species' larger distribution that apparently experienced extirpation of its historical San Jacinto Mountains population (Service 2016b, p. 22).

While Federal, State, and local governments are beginning efforts to reduce greenhouse gas emissions and planning for social adjustments to promote climate change resilience and adaptation, it is unclear how successful these measures will be long-term to reduce climate change and minimize ecological effects. Therefore, we do not believe there are any counter-balancing or beneficial measures to discuss with regard to this threat.

Overall, changing climate conditions are considered a high-level threat across the southern rubber boa's range, potentially having the greatest effect to reduce habitat humidity (see Appendix E for discussion of uncertainty and assumptions).



Baseline
Historical data



Baseline
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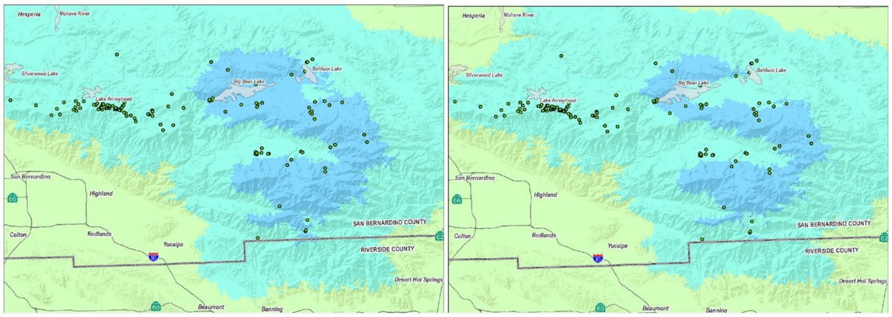
Figure 6.8. California Basin Characterization Model average maximum temperature historical maps and future scenarios for the San Bernardino and San Jacinto Mountains.



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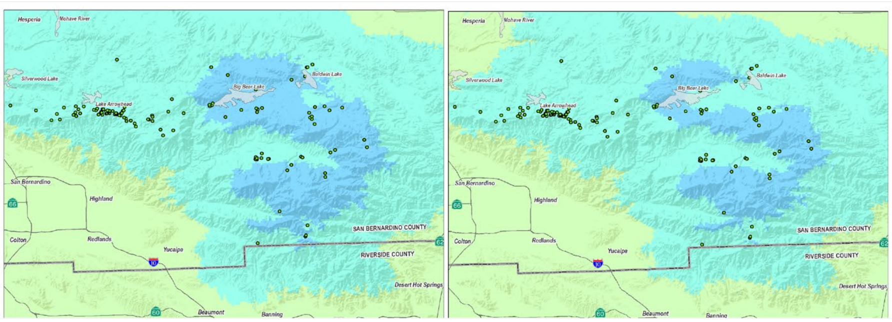
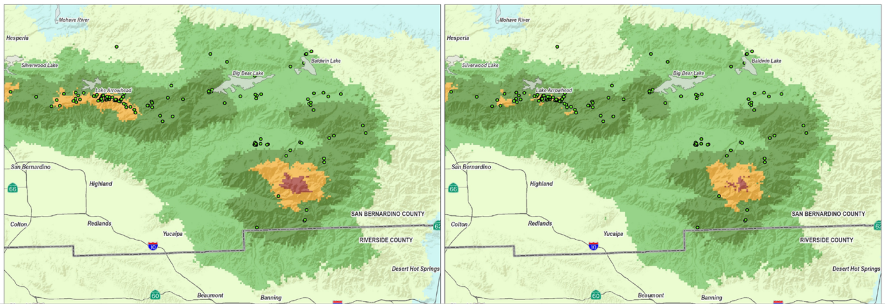


Baseline
Historical data

Figure 6.9. California Basin Characterization Model average minimum temperature historical maps and future scenarios for the San Bernardino and San Jacinto Mountains.



Baseline
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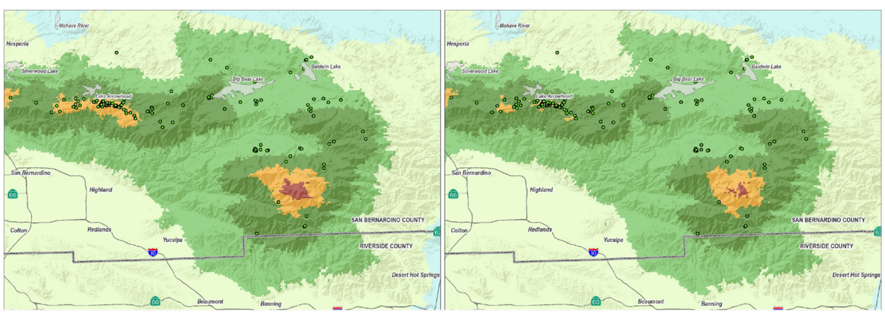

Baseline
Historical data

Baseline

Figure 6.10. California Basin Characterization Model precipitation historical maps and future scenarios for the San Bernardino and San Jacinto Mountains.

6.8 Collectors and Field Hobbyists

The degradation of southern rubber boa rock pile shelters/hibernacula habitat by collectors is one concern shared by most experts (e.g. Devitt et al. 2013, p. 10; Grismer 2019a, pers. comm.; Hinds 2020, pers. comm.). While Grismer et al. (2020, p. 33) stated they do not believe collection of boas is a threat to the species, Forest Service staff familiar with the species and its habitat disagreed, expressing significant concerns about poachers and hobbyists that search and disturb habitat without removing snakes (Forest Service/USFWS 2019, p. 1). Overall, the primary concern of species experts appears to be habitat disturbance and degradation, mostly caused by unauthorized collectors searching for other species of snakes such as mountain kingsnakes (*Lampropeltis parvirubra*) (Stewart 2019a, pers comm.; Devitt et al. 2013, p. entire; Grismer 2019a, pers. comm.; Hinds 2020, pers. comm.). How experts believe hobbyists and collectors cause boa habitat degradation was described in detail by Grismer et al. (2020, p. 5 and 6):

> *…many illegal collectors come to the San Jacinto and San Bernardino Mountains in early Spring to collect Mountain King Snakes (Lampropeltis parvirubra) …as they emerge from hibernation which are sold in the United States and European pet trade. These snakes also use the same rock piles that Rubber Boas do for hibernacula and collectors usually scour through these rock piles, not putting large rocks back where they were originally found, or replacing the leaf-litter around them, and in between the rocks. These disturbances can have a major impact on Rubber Boas because they are incredibl[y] site specific and dependent on soil humidity among the rocks and moisture in the soil. When rocks and leaf litter are not put back correctly, it can release moisture from the soil beneath rendering these microhabitats unsuitable.*

As an example of the magnitude of this issue, three individuals were recently convicted of unauthorized collection and trafficking hundreds of kingsnakes to or from 12 states, including California (Service 2017, entire). We are not aware of any targeted regulatory or physical efforts to minimize the effects of collectors and hobbyists on southern rubber boa habitat, other than State listing and general U.S. Forest Service regulations and enforcement as much as possible per staff availability. The U.S. Forest Service is aware of this issue, and will likely act in the near future to further reduce impacts.

Habitat degradation by collectors is not prevalent throughout the range of southern rubber boas, but rather has localized impacts at a few important locations. The intensity and exposure of impacts to the boa is moderate such that overall, impacts to habitat associated with collectors and field hobbyists is considered a medium-level threat across the species range. This is due to targeted impacts in the highest quality habitat sites (e.g., the Heaps Peak area of the western San Bernardino Mountain subpopulation distribution) that reduce appropriate shelter/hibernacula rock formation structure, and likely micro-habitat humidity.

6.9 Summary of Factors Influencing Viability

Factors affecting the southern rubber boa discussed in this section include those that contribute to the greatest threats to the species throughout its range: habitat drying; physical habitat degradation; habitat loss, and direct mortality and loss of individuals (Figure 6.1; Table 6.1). The topics discussed in this chapter are reflective of the best available information as it pertains to the boa; there may be other factors we are unaware of, or for which data are currently lacking.

Threats that alone may not significantly affect populations and reduce species viability have at least additive, if not synergistic, effects on species viability. For example, development of homes and resorts cause direct mortality and irreversible loss of habitat, but also indirectly increase local recreation and transportation-related impacts, reduce local shelter availability, increase fire ignition sources, increase potential disease transmission due to accidental or intentional pet release, and increase mortality due to domestic cat predation. Habitat degradation, pollution, inbreeding, stress from human encroachment, and severe weather may all worsen snake health, making isolated populations more susceptible to disease and extirpation (Yates 2015, p. 3; Clark et al. 2010, entire).

The current resiliency, redundancy, and representation of southern rubber boa is directly tied to sub-population and habitat connectivity and habitat humidity levels. Factors associated with climate change such as increased scope, intensity, and frequency of wildfires, and increased length, intensity, and frequency of drought, and increased temperatures and heat wave frequency can reduce habitat humidity at a landscape-scale, and decrease habitat suitability long-term (Figure 6.1). Cumulative impacts to populations on a smaller scale caused by habitat disturbance and individual mortality can also contribute to a loss of population resiliency, and reduced species viability (Figure 6.1).

CHAPTER 7 – CURRENT CONDITIONS

To assess current population conditions for the southern rubber boa, the species' range was divided into three regional analysis units. There are two analysis units in the San Bernardino Mountains (subpopulations) and one in the San Jacinto Mountains (population). Each of the analysis units are representative of the range of biotic and abiotic features of boa habitat. A rating of high, medium, or low condition was developed for each condition category (Table 7.1). A high overall resiliency condition score means all population resource needs are clearly adequate in the analysis unit; a medium overall resiliency condition score means some population resource needs are minimally present in the analysis unit; and an overall low current resiliency condition means that one or more population needs are not adequate in the analysis unit.

Table 7.1. Southern rubber boa population needs-based condition category definitions.

Resiliency Category	Appropriate Humidity	Sufficient Prey	Appropriate Gestation Sites and Shelter	Mate Availability/Adult Abundance	Adequate Population Distribution and Habitat Diversity
Low	Little rock cover, minimal soil litter and woody canopy. Rainfall below average for species range and historical levels; temperatures above average.	Little prey species available; few burrows to hunt for immature rodents. Little insect, fruit, or seed food for prey.	Closed woody canopy with few small openings. Few intact fractured rock piles with cracks to maintain heat.	Mate encounters less than once every 5 years. Density low enough that experts can find less than one adult per week.	Total estimated habitat area less than 50,000 ac. Climate and topography relatively uniform across distribution.
Medium	Disturbed or diffuse rock cover. Rainfall and temperature at least average for species range and historical levels.	Mixed prey species available, including reproductive rodents and lizards; and some occupied burrows to hunt in. Typical insect, fruit, and seed abundance.	Woody canopy with scattered openings. Forest tree cover recovering from fire within past 20 years. Disturbed or diffuse fractured rock piles with cracks to maintain heat.	Mate encounters at least every 5 years. Density high enough that experts can find at least one adult per day.	Total estimated habitat area between 50,000 and 150,000 ac. Climate and topography vary across distribution.
High	Abundant rock cover. Rainfall and temperatures above average for species range and historical levels.	Abundant reproductive rodents and lizards. Many occupied rodent burrows. Abundant food for prey.	At least one large woody canopy opening associated with each occupied hibernaculum/rock pile. Older-growth forest canopy. Abundant intact fractured rock piles with cracks to maintain heat.	Mate encounters annually. Density high enough that experts can find 10 or more adults per day.	Total estimated habitat area greater than 150,000 ac. Climate and topography diverse across distribution.

7.1 Current Population Resiliency

We ranked the population resiliency level of each analysis unit based on our best assessment of resource conditions within each region (Table 7.2). The western San Bernardino Mountains sub-population's resiliency is currently considered medium-high. Condition of appropriate humidity and mate availability are both high with the condition of gestation sites and adequate distribution at moderate, due to habitat degradation caused by collectors, recreation, and wildfire in the highly-accessible and well-known habitat areas from Heaps Peak north, and the total USGS-modeled area (estimated undeveloped habitat) area is 89,813 ac (36,346 ha). The eastern San Bernardino Mountains sub-population's resiliency is considered high primarily because the 282, 226 ac (114,213 ha) of estimated habitat is highly diverse with numerous hibernacula and gestation sites; there is also good mate availability within this unit. The San Jacinto Mountains population's resiliency is considered medium primarily because the population is distributed across less than 53,203 ac (21,530 ha) of habitat that is not very diverse with low mate availability. Though there are sufficient gestation sites, humidity is also at a moderate level.

Table 7.2. Southern rubber boa population resiliency current conditions.

Population Analysis Unit	Appropriate humidity	Sufficient prey	Appropriate hibernacula and gestation sites	Mate availability	Adequate population distribution and habitat diversity	Overall current condition (resiliency)
West San Bernardino Mountains	High	Unknown	Medium	High	Medium	**Medium-High**
East San Bernardino Mountains	Medium	Unknown	High	High	High	**High**
San Jacinto Mountains	Medium	Unknown	High	Low	Low	**Medium**

7.2 Current Species Redundancy

To assess the current level of redundancy we considered the number of resilient populations throughout the southern rubber boa's range. Boas currently occur among three historical population analysis units spread out across the San Bernardino and San Jacinto Mountains. The San Bernardino subpopulations are medium-high and high condition and the San Jacinto Mountain population has a resiliency condition of medium. The San Bernardino Mountains population is more widely distributed than believed historically. Occupancy on each of these isolated mountain ranges provide refugia that appear sufficient to withstand catastrophic events.

7.3 Current Species Representation

The southern rubber boa occupies three separate population analysis units that capture unique habitat diversity and provide adaptive capacity to changing environmental conditions. The western San Bernardino Mountains sub-population has the highest precipitation and relatively low temperature variability. The eastern San Bernardino Mountains sub-population is relatively dry, but has the lowest temperatures and highest habitat diversity. The San Jacinto Mountains has precipitation levels intermediate to the two San Bernardino sub-populations, but the warmest temperatures, and the topography uniquely traps humidity in deep canyons. The two mountaintop populations are genetically distinct and appear locally adapted.

CHAPTER 8 - FUTURE CONDITIONS

8.1 Future Scenario Considerations

Scenario planning is a comprehensive exercise that involves the development of scenarios that capture a range of plausible future conditions, which 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 8.1). The scenarios are intended to provide the “upper” and “lower” bounds of plausible conditions (Figure 8.2), outline uncertainties, and provide decision makers with a means for managing risk and maintaining flexibility in current and future decisions.

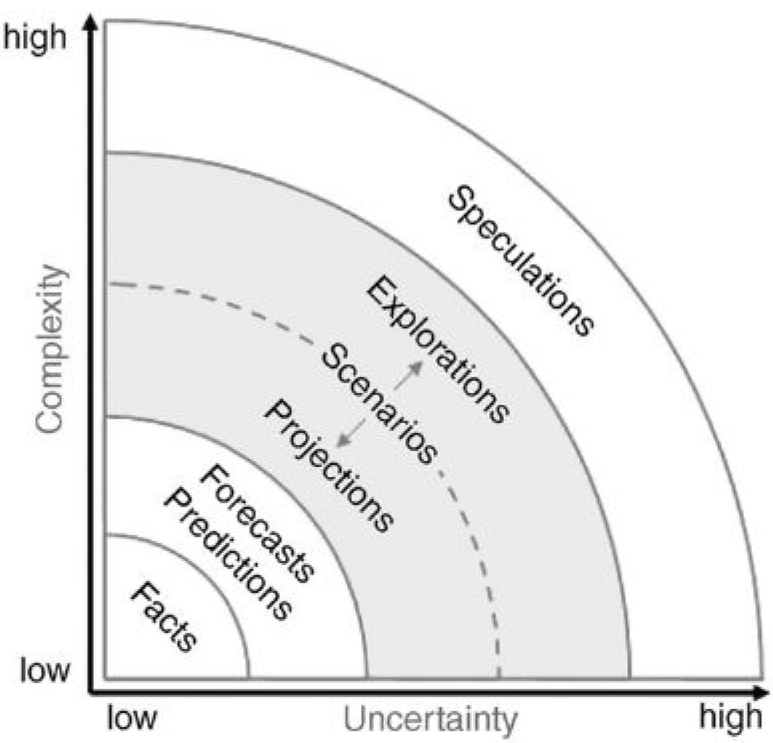

Figure 8.1. The levels of uncertainty and complexity in situations for which scenarios can be useful in considering future possibilities (adapted from Roland et al. 2014).

A range of time frames with a multitude of possible scenarios allows us to create a “risk profile” for the southern rubber boa 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 threats 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 boa. Data availability varies across the range of the species and individual populations. Where data on future threats or trends are not available, we look to past threats and their trends. We evaluate if it is reasonable to assume these trends will continue into future and to what degree.

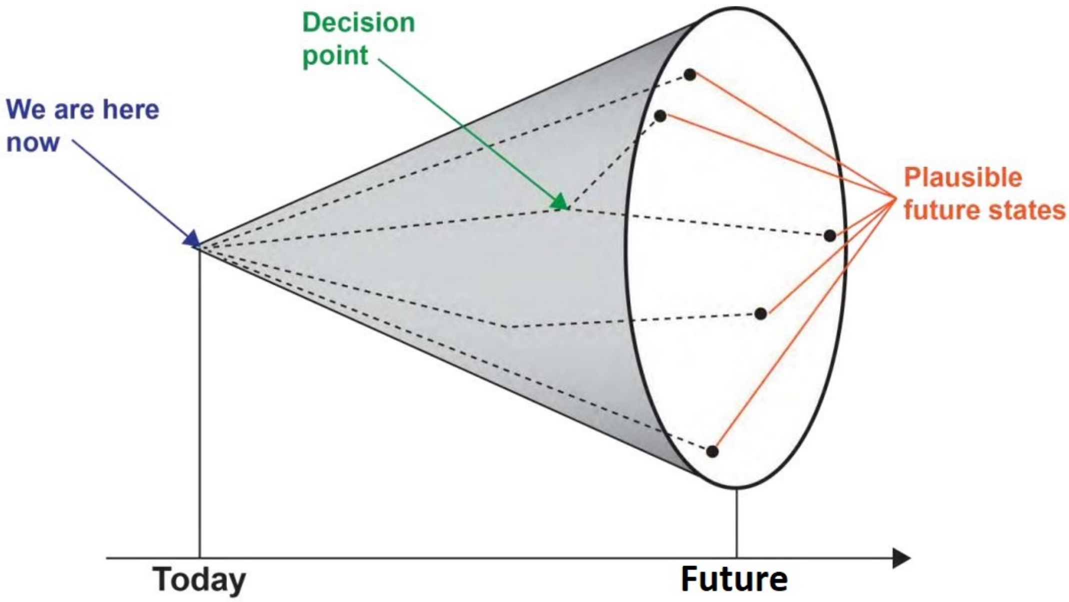

Figure 8.2. Conceptual diagram of the broadening range of plausible alternative futures as one moves farther away from the present and different events and decision points shift trajectories. (Rowland et al. 2014).

In order to analyze future conditions, we developed four plausible scenarios to assess how the species needs, threats, and habitat conditions may change over the next 30–60 years. Changes to habitat drying and degradation, and loss of individuals are ongoing threats analyzed below. Plausible changes in threats impacting southern rubber boa analysis units are illustrated in Table 8.1 and discussed in each of the four scenarios below. Due to the lack of information related to prey availability, the condition category "sufficient prey" was not carried through in the resiliency analysis for each of the future scenarios.

8.2 Scenario 1

Under Scenario 1, impacts from unauthorized OHV and collection activities increase and expand within the western and eastern San Bernardino Mountains sub-populations because of human population growth and continued (increased) demand, and difficulty enforcing protective regulations (Table 8.1). Humidity significantly decreases across the species' range at both macro- and micro-levels as climate change, wildfire, and direct habitat impacts cause habitat drying. Important habitat (e.g., hibernacula) is lost to development in the San Bernardino Mountains, and past habitat impacts have not been reversed by beneficial management activities.

Table 8.1. Change in impacts from the predominant threats to southern rubber boa analyzed in the four future scenarios.

Scenario #	Habitat Disturbance by Collectors	Development	Recovery of Impacted Western San Bernardino Mtn. Habitat	30-60 Year Temperatures	30-60 Year Precipitation	Wildfire Extent and Severity
1	Increased	Maximum development of both San Bernardino Mtn. sub-population vulnerable lands	No restoration effort	Warming trend accelerates; climate model realized	Trend continues; driest climate model realized	Trend continues; increased scope, intensity, and frequency
2	Unchanged	Some additional development of vulnerable lands	No restoration effort	Warming trend accelerates slightly; intermediate climate model conditions	Unchanged; intermediate climate model conditions	Trend continues, increases
3	Unchanged	Insignificant new development	Restoration somewhat successful	Warming trend continues; coolest climate model realized	Unchanged; intermediate climate model realized	Trend continues, increases
4	Reduced	No new development	Restoration fully successful	Warming trend continues; coolest climate model realized	Increases; wettest climate model realized	Unchanged; continued large wildfires but rate and size do not increase

8.2.1 Resiliency

Under Scenario 1, habitat loss is accelerated with increased development and increased collector presence. Habitat drying is also increased from a changing climate (elevated temperatures) and fires. Impacts to the species under these conditions leads to a reduced population resiliency of all three analysis units would likely decrease significantly over the next 30–60 years due to a significant drop in habitat suitability and corresponding reductions in population sizes and distributions (Table 8.2). Both San Bernardino Mountains southern rubber boa sub-populations decrease in resiliency to low condition, suggesting low resiliency in the future. While there is also elevation variability in the San Jacinto Mountains population distribution, it would be unlikely to shift and retain humidity due to the shape of the mountain range, and thus likely lose resiliency entirely and be extirpated.

Table 8.2. Southern rubber boa population resiliency under future scenario 1.

Population Analysis Unit	Appropriate Humidity	Appropriate Hibernacula and Gestation Sites	Mate Availability	Adequate Population Distribution and Habitat Diversity	Overall Condition (resiliency)
West San Bernardino Mountains	Low	Low	Low	Low	**Low**
East San Bernardino Mountains	Low	Low	Low	Medium	**Low**
San Jacinto Mountains	Low	Low	Insufficient	Insufficient	**Insufficient**

8.2.2 Redundancy

Under Scenario 1, resiliency in two of the analysis units in the San Bernardino Mountains would decrease to low condition. Resiliency of the San Jacinto population would also likely decrease and could become extirpated. As a result, the southern rubber boa is less likely to withstand catastrophic events, compared to current conditions, with only the San Bernardino Mountains sub-populations possibly remaining resilient, although experiencing drops in sub-population distributions and sizes.

8.2.3 Representation

Under Scenario 1, adaptive potential would be significantly reduced because of a loss of genetic and habitat diversity throughout the range resulting from extirpation of the San Jacinto Mountains population. While the species would still likely occur in the San Bernardino Mountains, habitat diversity would be reduced, and there could be some associated loss of genetic diversity. Additionally, low resiliency in the San Bernardino Mountains sub-populations would possibly lead to further losses. These losses would likely result in reduced representation, reducing the ability of southern rubber boas to adapt to changing environmental conditions in the future.

8.3 Scenario 2

Under Scenario 2, impacts from unauthorized OHV and collection activities neither increase or decrease within the two San Bernardino Mountains sub-populations because enforcement of protective regulations offset human population growth and continued (increased) demand. Humidity decreases across the species' range at both macro- and micro-levels as climate change, wildfire, and direct habitat impacts cause some habitat drying. Threats appear less significant as compared to current conditions. However collectively cumulative impacts, such as habitat is lost to development could continue to result in death or loss of individuals, and past habitat impacts would not have been reversed by beneficial management activities.

8.3.1 Resiliency

Under Scenario 2, population resiliency of all three sub-populations analysis units would likely decrease over the next 30-60 years due to a drop in habitat suitability and corresponding reductions in population sizes and distributions. Resiliency under scenario 2 for the western San Bernardino sub-population, eastern San Bernardino sub-population, and San Jacinto population would likely decrease to medium, medium-high, and low, respectively (Table 8.3)

Table 8.3. Southern rubber boa population resiliency under future scenario 2.

Population Analysis Unit	Appropriate Humidity	Appropriate Hibernacula and Gestation	Mate Availability	Adequate Population Distribution	Overall Condition (resiliency)
West San Bernardino Mountains	Medium	Low	Medium	Low	**Medium**
East San Bernardino Mountains	Medium	High	High	Medium	**Medium-High**
San Jacinto Mountains	Low	Medium	Low	Low	**Low**

8.3.2 Redundancy

Under Scenario 2, all three analysis units would likely remain viable. However, the southern rubber boa would be slightly less likely to withstand catastrophic events than currently, due to decreased population sizes and distributions. Resiliency among the analysis units would likely decrease to medium, medium-high, and low condition; this could increase the risk of losing a population or sub-population, particularly in the San Jacinto Mountains.

8.3.3 Representation

Under Scenario 2, all three analysis units would likely remain viable. However, adaptive potential would decrease slightly compared to current conditions because of loss of genetic and habitat diversity throughout the range resulting from decreased population sizes and distributions.

8.4 Scenario 3

Under Scenario 3, impacts from unauthorized OHV and collection activities neither increase nor decrease within the two San Bernardino Mountains sub-populations because enforcement of protective regulations offset human population growth and continued (increased) demand. Humidity decreases slightly across the species' range at both macro- and micro-levels as climate change, wildfire, and direct habitat impacts cause some habitat drying. Less significant threats compared to current conditions are controlled, and past habitat impacts have been slightly reversed by beneficial management activities.

8.4.1 Resiliency

Under Scenario 3, population resiliency of the western San Bernardino sub-population and the San Jacinto population would likely decrease over the next 30-60 years due to a drop in habitat suitability and corresponding reductions in population sizes and distributions. However, the change in resilience for the eastern San Bernardino Mountains sub-population would not be significant because of the variability in elevation (potential for upward shift elevation distribution) and relatively extensive amount of estimated habitat; therefore, it would retain a relatively extensive population distribution, and therefore high resource quality, quantity, and diversity. Resiliency under scenario 3, for the western San Bernardino sub-population, eastern San Bernardino sub-population, and San Jacinto population would be medium, high, and medium-low, respectively (Table 8.4).

Table 8.4. Southern rubber boa population resiliency, future Scenario 3.

Population Analysis Unit	Appropriate Humidity	Appropriate Hibernacula and Gestation Sites	Mate Availability	Adequate Population Distribution and Habitat Diversity	Overall Condition (resiliency)
West San Bernardino Mountains	Medium	Low	High	Medium	**Medium**
East San Bernardino Mountains	Medium	High	High	High	**High**
San Jacinto Mountains	Medium	Medium	Low	Low	**Medium-Low**

8.4.2 Redundancy

Under Scenario 3, all three analysis units would remain viable with conditions of medium, high, and medium-low resiliency. The southern rubber boa would be slightly less likely to withstand catastrophic events than it currently is, resulting from decreased population sizes and distributions (decreased resiliency of multiple populations, and therefore increased likelihood of analysis unit loss).

8.4.3 Representation

Under Scenario 3, all three analysis units would likely remain viable. Adaptive potential would decrease slightly compared to current conditions because of the potential for loss of genetic and habitat diversity throughout the range resulting from decreased population sizes and distributions.

8.5 Scenario 4

Under Scenario 4, impacts from unauthorized OHV and collection activities are reduced within the two San Bernardino Mountains sub-populations because enforcement of protective regulations more than offset increased demand. Humidity increases slightly across the species' range at both macro- and micro-levels as climate changes are offset, and average wildfire frequency, size, and intensity do not worsen compared to current conditions. Less significant threats (i.e., recreation and collectors impacts to habitat) are controlled, and past habitat impacts have been reversed by beneficial management activities.

8.5.1 Resiliency

Under Scenario 4, population resiliency of all three analysis units would likely increase over the next 30-60 years due to an increase in habitat suitability and corresponding increases in population sizes and distributions (Table 8.5). The increase in resilience of the eastern San Bernardino sub-population would not change its ranking, as it is already highly resilient. However, the western San Bernardino subpopulation would increase to high condition and the San Jacinto population would increase to medium-high condition.

Table 8.5. Southern rubber boa population resiliency under future scenario 4.

Population Analysis Unit	Appropriate Humidity	Appropriate Gestation Sites	Mate Availability	Adequate Population Distribution and Habitat Diversity	Overall Condition (resiliency)
West San Bernardino Mountains	High	High	High	Medium	**High**
East San Bernardino Mountains	High	High	High	High	**High**
San Jacinto Mountains	High	High	Medium	Medium	**Medium-High**

8.5.2 Redundancy

Under Scenario 4, all three analysis units would likely remain viable with two high and one medium-high condition of resiliency. The southern rubber boa would likely be slightly more able to withstand catastrophic events than it currently is, resulting from increased population sizes and distributions (increased resiliency of multiple populations, and therefore decreased likelihood of analysis unit loss).

8.5.3 Representation

Under Scenario 4, all three analysis units would likely remain viable. Adaptive potential could increase slightly compared to current conditions because of the potential for increased habitat diversity throughout the range. Specifically, there could be expansion of the San Jacinto Mountains population distribution into areas identified in the ENM (Grismer et al. 2020, p. 30), such as dispersal into higher elevations.

CHAPTER 9 - OVERALL 3R SYNTHESIS AND SPECIES VIABILITY ANALYSIS

This SSA for the southern rubber boa describes the current conditions and a range of plausible future scenarios that we considered were most likely in the next 30–60 years. The results describe a range of possible conditions for each of the boa populations, and their likelihood of resiliency under these conditions (Table 9.1). Although typically the hierarchical levels of population and species are distinct, the fewer populations there are, and the geographically closer they are, the more these hierarchical levels collapse and the more analogous phenomena at different levels converge. With fewer populations, the geographical scale of species range is strongly influenced by population distributions, and species survival time depends more on population resiliency. Redundancy depends on population size and distribution, species representation depends more on population-level genetic and habitat diversity. Species viability relies more on individual population resilience especially with a species like southern rubber boa that has just two populations; therefore, maintaining the resilience of both populations is crucial to maintaining species viability (Table 9.2). Under scenario 1 viability is likely to decrease significantly due to potential loss of the San Jacinto population (Table 9.1). Scenarios 2 and 3 would likely yield a slight decrease in viability due to a reduction of population size and distribution. Under scenario 4 viability of southern rubber boa would increase slightly.

The greatest obstacle to evaluating species' viability (likelihood to survive for 30–60 years) for southern rubber boa is the amount of uncertainty inherent in data inference and expressed by experts (e.g. Stewart 2019a, pers. comm.; Appendix E). We can estimate how viability is likely to change given our assumptions, but how viable the species is currently depends largely on how resilient the populations are, which depends in large part on their actual and effective sizes, values we cannot yet estimate. What does seem clear from our analysis is the importance of the San Jacinto Mountains population, and that there is reason to be concerned about its long-term resilience and how that might affect species' viability.

Table 9.1. Southern rubber boa future scenarios population resiliency summary table.

Population Analysis Unit	Current	Scenario 1	Scenario 2	Scenario 3	Scenario 4
West San Bernardino Mountains	Medium-High	Low	Medium	Medium	High
East San Bernardino Mountains	High	Low	Medium-High	High	High
San Jacinto Mountains	Medium	Insufficient	Low	Medium-Low	Medium-High

Table 9.2. Southern rubber boa future scenarios viability analysis summary table.

Scenario #	Resiliency (WSB Mtn, ESB Mtn, SJ Mtn)*	Representation	Redundancy	Overall Species Viability
Current	Medium-High, High, Medium	Maximum	Maximum	Relatively viable
1	Low, Low, Insufficient	Significantly decreased due to possible loss of genetically distinct SJ Mt population occupying unique habitat	Significantly decreased ability to withstand catastrophic event due to possible loss of SJ Mt "refuge" population	Significantly decreased
2	Medium, Medium-High, low	Slightly decreased due to population-level losses in genetic and habitat diversity	Slightly decreased due to reduced population sizes and distributions	Slightly decreased
3	Medium, High, Medium-low	Slightly decreased due to population-level losses in genetic and habitat diversity	Slightly decreased due to reduced population sizes and distributions	Slightly decreased
4	High, High, Medium-High	Slightly increased due to increased habitat diversity of the SJ Mt population	Slightly increased due to increased population sizes and distributions	Slightly increased

* Resiliency of western and eastern San Bernardino Mountains sub-populations and San Jacinto Mountains population (in that order).

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APPENDIX A – FIGURES FROM RECENT GENETIC STUDY

There are at least six lineages corresponding with individual mountain tops that could be described as *Charina umbratica*, with the San Bernardino and San Jacinto lineages standing out as the most geographically isolated and genetically distinct (Grismer et al. 2020, p. 31; Figures A- 1 and 2). Despite their close geographic proximity, and being more closely related to each other than any other clades, the San Jacinto and San Bernardino Mountain populations appear to have a significant amount of genetic divergence between them (Grismer et al. 2020, p. 16; Figures A-1 and 2)

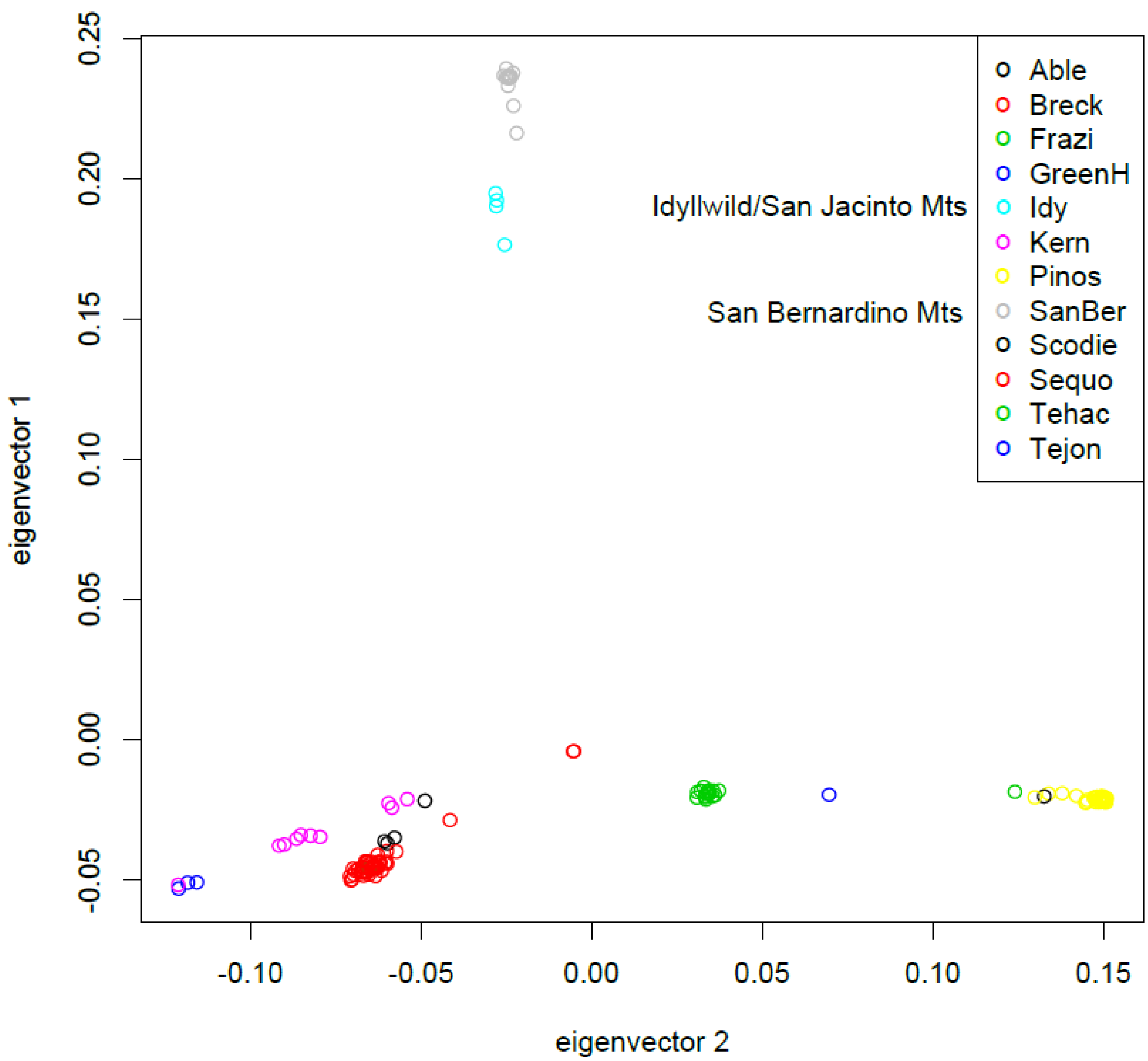

Figure A-1. Statistical clustering analysis of southern rubber boa genetic data (Grismer 2020).

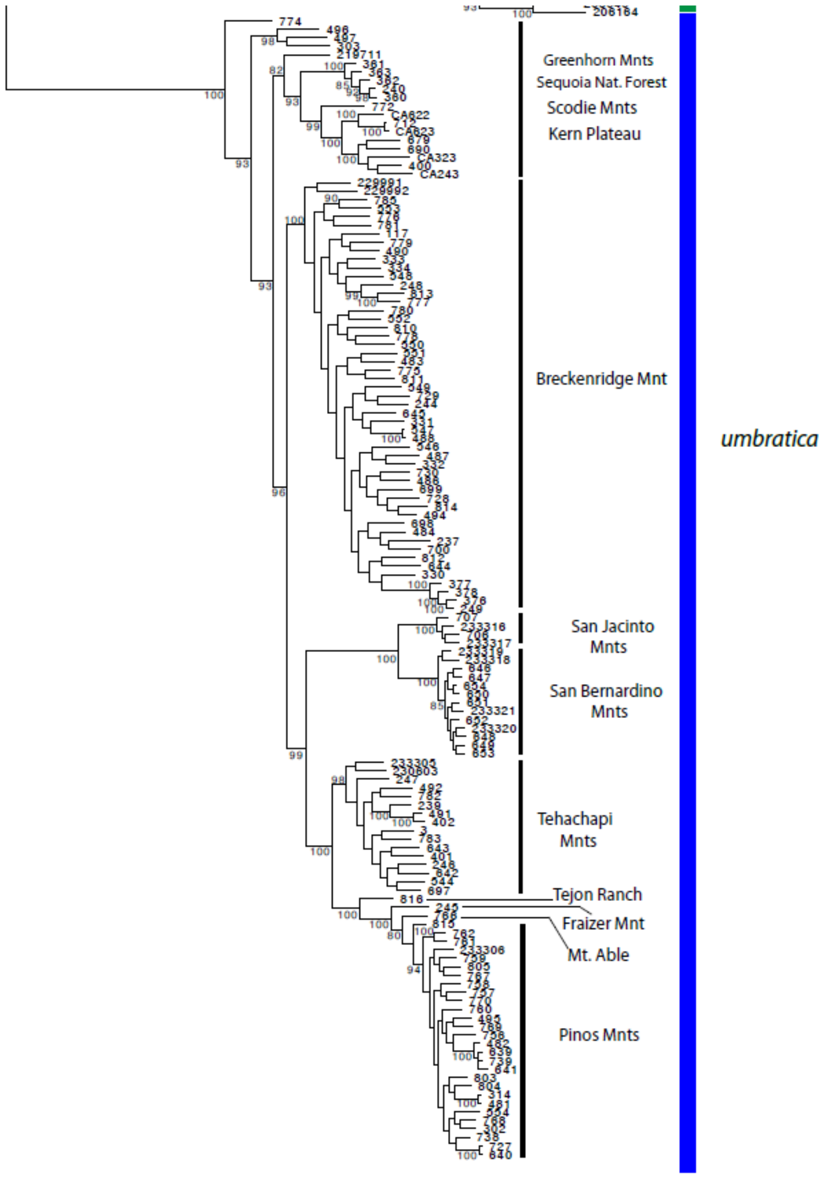

Figure A-2. Phylogenetic species tree analyses of southern rubber boa (*Charina* sp. Found in San Bernardino and San Jacinto mountain ranges) genetic data.

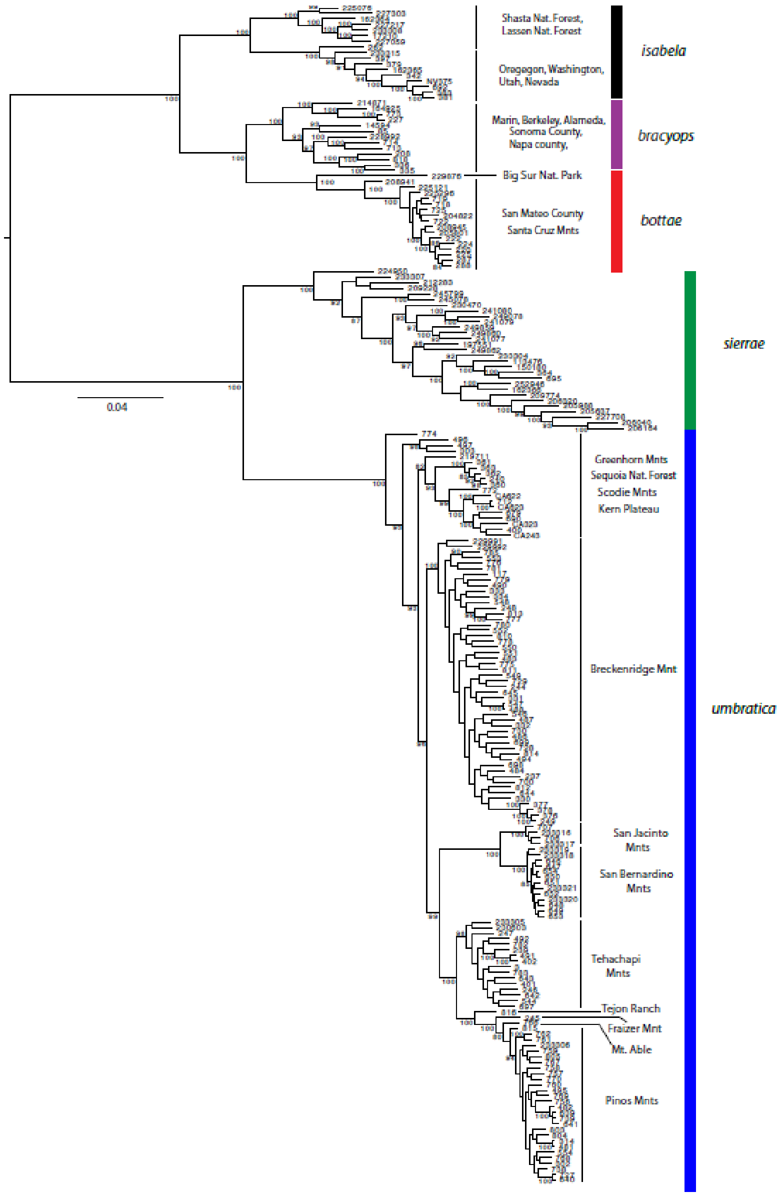

Figure A-3. Phylogenetic species tree analyses of rubber boa (genus *Charina*) genetic data.

APPENDIX B – WEATHER STATION DATA

Weather station data used to determine similarity of temperatures in southern rubber boa habitat to those at those of habitat in Idaho where Dorcas and Peterson (1998, entire) and Dorcas et al. (1997, entire) studied northern rubber boas. This comparison indicates how environmental conditions experienced by that surrogate northern rubber boa population are similar, and how they are not.

Table B-1. Comparison of rubber boa habitat mean monthly normals climate data 1981-2010 for July (units are meters and °F).

Weather Station	Elevation ft (m)	Difference in elevation from 1710 m Dorcus site ft (m)	Daily max temp °F (°C)	Daily min temp °F (°C)	Daily mean temp °F (°C)	Standard deviation long term avg mean temp °F
Grace Idaho	5551 (1692)	-59 (-18)	n/a	46.2 (7.9)	66.4 (19.1)	3.5
Idaho Falls SE	5827 (1776)	217 (66)	n/a	48.9 (9.4)	64.7 (18.2)	3.2
Palisades Idaho	5384 (1641)	226 (-69)	n/a	51.8 (11)	67.2 (19.6)	3.5
Lake Arrowhead	n/a	n/a	80.9 (27.2)	56.8 (13.8)	68.8 (20.4)	2.8
Big Bear	n/a	n/a	81.2 (27.3)	48.2 (9)	64.7 (18.2)	2.4
Idyllwild	n/a	n/a	85.8 (29.9)	54.2 (12.3)	70 (21.1)	2.5
Idaho avg				49.0 (9.4)	66.1 (18.9)	3.4
California avg				53.1 (11.7)	67.8 (19.9)	2.6
difference in avg				-4.1 (-2.3)	-1.7 (-1)	0.8

Note: Idaho stations used were the 3 closest in elevation to Dorcus' study site, within 100 km.

APPENDIX C – U. S. GEOLOGICAL SURVEY GEOGRAPHIC INFORMATION SYSTEM SOUTHERN RUBBER BOA SURVEY AREA MODEL METHODS

A generalized boundary for San Jacinto, San Bernardino, Santa Rosa, and San Gabriel Mountains was created. Granitic and metamorphic rock were selected from the ca_geology layer and clipped to the mountain range boundaries. Using the ca_ned30m raster, elevation data was extracted for the southern rubber boa observations. The elevation ranged from 5,174–8,409 ft (1,577–2,563 m). The elevation values were buffered to create a target elevation range of 4,516–9,065 ft (1,377-2,763 m). The ca_ned30m raster was then reclassified and converted to a polygon to create a layer of the target elevation range for the species. Slope was calculated in degrees from the ca_ned30m raster. The slope was then extracted for the species observations. Species was found at the highest slope value of 34.6 degrees (69 percent slope), so the slope raster was reclassified and converted to a polygon to create a layer of all areas with a slope of 34.6 degrees or less. The final three layers (geology, elevation, and slope) were overlaid to create a polygon of the target area to look for southern rubber boa (CAgeol_target_ele_slope).

APPENDIX D- CALIFORNIA BASIN CHARACTERIZATION MODEL

The California Basin Characterization Model 2014 (CA-BCM 2014) dataset provides historical and projected climate and hydrologic surfaces for the region that encompasses the state of California and all the streams that flow into it (California hydrologic region). The CA-BCM 2014 applies a monthly regional water-balance model to simulate hydrologic responses to climate at the spatial resolution of a 270-meter (m) grid.

Model outputs are intended for watershed-scale evaluation. Use of the data for analyses at a scale smaller than the planning watershed could yield misleading results.

Creator: Lorraine and Alan Flint, USGS
Contributor: Jim Thorne, Ryan Boynton, UC
Davis **Publisher:** California Climate Commons

Spatial Resolution: 270m
Temporal Coverage: 1921-2099
Date Issued: July, 2014

Source of above and for more information: http://climate.calcommons.org/dataset/2014-CA-BCM. We reviewed future scenarios from six different General Circulation models for three future time periods (30 year averages) and two historical time periods for climatic water deficit (CWD: potential minus actual evapotranspiration; a measure of soil moisture level or plant drought stress). We examined future scenarios from four different General Circulation models for three future time periods (30 year averages) and two historical time periods for total annual precipitation.

APPENDIX E- UNCERTAINTIES AND ASSUMPTIONS MADE IN THE SERVICE'S SOUTHERN RUBBER BOA (*CHARINA UMBRATICA*) ANALYSIS

Assumptions:

1. The amount of southern rubber boa habitat is equal to the area of the USGS-modeled area.

    - It is probable the polygons we are using overestimate the areas of southern rubber boa population distributions and associated habitat because the USGS modeled-area (see Appendix C above) polygon is simplistic and based on an elevation threshold and course geology description.

    - It is possible the southern rubber boa exists in the surrounding mountains but has yet to be observed. In that case, the polygons we are using underestimate the areas of southern rubber boa population distributions and associated habitat because the USGS modeled-area (see Appendix C) polygons were cut to eliminate areas outside of the known occupied mountains.

2. Declining southern rubber boa observation rates are the result of a decline in southern rubber boa abundance.

    - It is possible that southern rubber boa numbers have remained stable, and declining observations are the result of decreased detection probabilities. Detection probabilities for fossorial species like the southern rubber boa could theoretically decline as a result of a declining amount of undisturbed cover sites, which are often damaged or destroyed by people looking for this species or other commonly sought species like the California mountain kingsnake (*Lampropeltis zonata*). Detection probabilities can also change for certain periods of the year as a result of local drought or long-term climate change, which could shorten or shift the window of surface and near-surface activity.

3. The species is not adapted to tolerate increased fire frequency, extent, and severity.

    - It is probable that this species has some adaptations to cope with fire, as the southern and northern rubber boas inhabit many fire-adapted ecosystems—the San Bernardino Mountains, for instance, which have a relatively short fire return interval, particularly pre-fire suppression.