

California Red-Legged Frog
(Rana draytonii)

**5-Year Review:
Summary and Evaluation**



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**U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Sacramento, California**

December 2022

5-YEAR REVIEW

*California red-legged frog (*Rana draytonii*)*

I. GENERAL INFORMATION

PURPOSE OF 5-YEAR REVIEWS

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every five years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

SPECIES OVERVIEW

The California red-legged frog is the largest native frog in the western United States and typically exhibits red coloration on the abdomen and hind legs as an adult (Wright and Wright 1949, p. 417). The California red-legged frog predominately inhabits permanent fresh water sources such as streams, lakes, marshes, natural and manmade ponds, and drainages in valley bottoms and foothills (Jennings and Hayes 1994, pp. 64–65). The California red-legged frog also uses uplands near aquatic habitat for foraging, shelter, and dispersal to neighboring aquatic habitat up to 2.8 km away (Bulger *et al.* 2003, p. 90). The species currently is widespread in the nine-county San Francisco Bay area and is abundant along the Pacific Coast north of Ventura County. Isolated populations exist in the Sierra Nevada range and in Los Angeles, Mariposa, Ventura, and San Diego Counties. The northernmost range of the species is in Mendocino County and the southernmost range of the species is Baja California, Mexico (Peralta-García *et al.* 2016; p. 170).

METHODOLOGY USED TO COMPLETE THIS REVIEW

This review was prepared by the Sacramento Fish and Wildlife Office, following the Region 8 guidance issued in March 2008. We used information from the Service's 2002 Recovery Plan for the species (Service 2002), survey information from experts who have been monitoring various localities of this species, the California Department of Fish and Wildlife's California Natural Diversity Database (CNDDDB), and peer-reviewed publications as our primary sources of information used to update the species' status and threats. We also received information from the Center for Natural Lands Management, the US Forest Service, and Vandenberg Air Force Base in response to our Federal Notice initiating this 5-year review (Service 2018). This 5-year review contains updated information on the species' biology and threats, and an assessment of that

information compared to that known at time of listing. We focus on current threats to the species that are attributable to the Act's five listing factors. This review synthesizes all information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

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FEDERAL REGISTER (FR) NOTICE CITATION ANNOUNCING INITIATION OF THIS REVIEW

A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on June 18, 2018 (Service 2018). In response to this information request, we received information from the Center for Natural Lands Management, Vandenberg Air Force Base, and the US Forest Service.

LISTING HISTORY

Original Listing

FR Notice: 61 FR 25813 (Service 1996)

Date of Final Listing Rule: May 23, 1996

Entity Listed: *Rana aurora draytonii*, a subspecies

Classification: Threatened

ASSOCIATED RULEMAKINGS

Critical Habitat

FR Notice: 66 FR 14626 (Service 2001)

Date Designated: 3/13/2001

Revised Critical Habitat

FR Notice: 71 FR 19244 (Service 2006)

Date Revised: 4/13/2006

FR Notice: 75 FR 12816 (Service 2010)

Date Revised: 3/17/2010

4(d) Rule

FR Notice: 71 FR 19244 (Service 2006)

Date Finalized: 4/13/2006

REVIEW HISTORY

There are no previous 5-year reviews for the California red-legged frog.

SPECIES' RECOVERY PRIORITY NUMBER AT START OF 5-YEAR REVIEW

The recovery priority number for the California red-legged frog is 5C according to the Service's 2020 Recovery Data Call for the Sacramento Field Office, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Service 1983a; Service 1983b). This number indicates that the taxon is a species that faces a high degree of threat and has a low potential for recovery. The "C" indicates conflict with construction or other development projects or other forms of economic activity.

RECOVERY PLAN OR OUTLINE

Name of Plan or Outline: Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*)

Date Issued: May 28, 2002

II. REVIEW ANALYSIS

APPLICATION OF THE 1996 DISTINCT POPULATION SEGMENT (DPS) POLICY

The Endangered Species Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species act (Service and NOAA 1996) clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act.

No new information has come to light regarding the application of the DPS policy to the California red-legged frog.

INFORMATION ON THE SPECIES AND ITS STATUS

Species Biology and Life History

As discussed above, the California red-legged frog is the largest native frog in the western United States ranging from 1.5 to 5.1 inches in length (Stebbins 2003, p. 224). The abdomen and hind legs of adult California red-legged frogs are largely red and this coloration can extend throughout the body. The dorsum of adult California red-legged frogs contains prominent dorsolateral folds and adult coloration is typically brown, gray, olive, or reddish with small black flecks and larger irregular dark blotches with indistinct outlines (dorsal spots). The California red-legged frog is sexually dimorphic and females are larger than the males (Jennings *et al.* 1992, p. 3). Larvae (tadpoles) range from 0.8 to 8 cm in length and tadpole coloration is dark brown and yellow with darker spots (Storer 1925, p. 241). California red-legged frogs may live up to 10 years (Jennings *et al.* 1992, p. 3).

Breeding

California red-legged frogs are “irruptive” breeders where their breeding capacity is highly dependent on local environmental conditions, specifically the availability of cool water for egg deposition and larval maturation (Jennings and Hayes 1994, p. 62). California red-legged frogs breed from November to May and breeding activity typically begins earlier at southern coastal than northern coastal localities (Storer 1925, p. 2; Alvarez *et al.* 2013, pp. 547–548). Breeding may start as late as March or April in Sierra Nevada localities such as Hughes Pond, due to low temperatures at these sites in January and February (Tatarian and Tatarian 2008, p. 16). Breeding in Southern California localities may start as late as April, as exemplified in Matilija Canyon following the 2017 Thomas Fire (Patrick Lieske, US Forest Service, in litt. 2021). High water flows in the winter and spring also can delay breeding in streams and rivers (East Bay Regional Park District 2017, p. 29). During the breeding season, most non-dispersing frogs remain near the breeding site and do not move far into surrounding terrestrial habitat to forage (Wildlife Research Associates 2008, p. 11; Bulger *et al.* 2003, pp. 87–88).

California red-legged frogs typically breed at sites with a mix of open surface water and vegetated cover (Hayes and Jennings 1988, p. 151; Scott and Rathbun, 2006, pp. 14–15) but can breed at sites with dense shrubby riparian or emergent vegetation such as cattails (*Typha* spp.), tules (*Schoenoplectus acutus*) or overhanging willows (*Salix* spp.; Storer 1925, p. 239). Female California red-legged frogs lay only one egg mass in a breeding year and each egg mass contains between 300–4,000 eggs (Storer 1925, p. 240). Frogs typically deposit egg masses in relatively shallow water (less than 38 cm) on emergent vegetation within 1 meter of shore (Storer 1925, p. 239). However, the species can deposit eggs on a wide variety of substrates including boulders and cobbled substrate and submerged tips of overhanging branches (Alvarez *et al.* 2013, pp. 544–545). Additionally, frogs can deposit eggs up to 12 m from shore in water up to 3.2 m deep (Wilcox *et al.* 2017, p. 68) and successfully breed in ponds with water temperatures up to 30° C (Rathbun 2012, p. 9). Ponds or streams completely choked with emergent vegetation such as cattails or giant reed (*Arundo* sp.) are generally considered unsuitable for breeding because the dense vegetation can impede adult California red-legged frog movement (Giessow *et al.* 2011, p. 159).

Egg masses hatch after 6–14 days (Storer 1926, p. 241), depending on water temperature. Reis (1999, p. 46) found the greatest number of tadpoles occurred in study plots with water depths less than 0.75 m. Larval developmental and growth rate are variable and likely temperature dependent (Fellers 2005, pp. 552–554). In some areas, larvae may overwinter and then develop into metamorphs the following spring, a phenomenon observed in Santa Clara, Marin, Contra Costa, and San Luis Obispo Counties (Fellers *et al.* 2001, entire).

The metamorph life stage is defined as the time an individual loses its tail and becomes a small froglet, which typically occurs four to five months after hatching but can occur as early as three months (Storer 1925, p. 241; Wright and Wright 1949, p. 422). California red-legged frogs metamorphose at a size of 1.6–2.0 cm snout-urostyle length and a weight of 0.3–0.9 g (Fellers 2005, p. 552). In general, metamorphosis occurs between May and September (Storer 1925, p. 241; Wright and Wright 1949, p. 422). Immediately after metamorphosis, froglets shelter near the natal pond. However, these froglets soon disperse in the fall to nearby moist uplands or aquatic habitat to avoid predation by larger, older frogs.

The juvenile life stage of California red-legged frogs spans from the time a frog starts metamorphosis until the frog reaches adulthood and is able to breed. On average, this life stage is from about five months of age to two years in California red-legged frogs. California red-legged frog males begin breeding around two years of age and females begin breeding around three years (Jennings and Hayes 1985, p. 96).

Terrestrial feeding and sheltering

Adult and juvenile frogs frequently use terrestrial areas with cover features near water sources (i.e., upland habitat; Bulger *et al.* 2003, p. 87; Tatarian 2008, pp. 164–166) to feed and shelter. Typically, these cover features include dense riparian vegetation, wood or rock debris, small mammal burrows, or artificial features such as discarded wooden boards or tires. Terrestrial forays for feeding and sheltering occur most often in the late summer and early fall (Bulger *et al.* 2003, p. 87; Tatarian 2008, pp. 165–166). Bishop *et al.* (2014, p. 139) found that that upland habitat supports the majority of the prey base for adult and juvenile California red-legged frogs. Bulger *et al.* (2003, p. 87) observed that sheltering terrestrial California red-legged frogs were hidden from view 96 percent of the time. The frogs were hidden from view mainly by live plants (79 percent), followed by woody debris/rootballs, small recesses in vertical banks, and forest floor litter. We more fully discuss characteristics of upland habitat in the Habitat or Ecosystem section below.

Long Distance Dispersal

While most adult and juvenile California red-legged frogs remain at breeding sites with permanent water, a minority (10–30 percent) migrate or disperse to neighboring water features when breeding is finished and/or when breeding pools dry (Bulger *et al.* 2003, p. 92; Christopher 2004a, p. iii; Fellers and Kleeman 2007, p. 279; Tatarian 2008, p. 165). These long-distance dispersal events between watersheds provide gene flow between populations in nearby watersheds and therefore are essential for maintaining metapopulation connectivity at a regional scale (Bulger *et al.* 2003, p. 93; Fellers and Kleeman 2007, p. 285; Tatarian 2008, pp. 165–166; Keung 2015, p. 45; Richmond *et al.* 2013, p. 818; Richmond *et al.* 2014, p. 136). Long-distance

dispersal events typically are associated with rainfall (Bulger *et al.* 2003, p. 89; Tatarian 2008, pp. 159, 165), though California red-legged frogs may disperse in the absence of rainfall (Christopher 2004a, p. 50). Studies have observed both male-biased (Christopher 2004a, p. 21) and female-biased (Fellers and Kleeman 2007, p. 283) dispersal rates.

Dispersing California-red legged frogs typically travel less than 800 m between watersheds; however, a few individuals have been documented to move overland up to 3,200 m in wet coastal environments (Fellers and Kleeman 2007, p. 280; Bulger *et al.* 2003, p. 90). California red-legged frogs typically travel along riparian corridors (Fellers and Kleeman 2007, p. 280; Tatarian 2008, pp. 164–165) but are capable of dispersing through inhospitable habitats such as heavily grazed pastures or oak-grassland savannas (Bulger *et al.* 2003, pp. 91–92). Dispersal distances vary by local environmental conditions with much longer dispersal distances observed in cool, moist forested habitat in the northern coastal portion of the species range than in warmer, more arid habitat in the southern coastal portion of the species range. For example, Bulger *et al.* (2003, p. 92) observed that California red-legged frogs dispersed up to 500 m per day in the wet, cool habitat of the Santa Cruz Mountains whereas Christopher (2004a, p. 37) observed that California red-legged frogs moved up to 22 m per day in the warmer, more arid habitat of Santa Barbara County. Climate conditions in the Sierra Nevada region differ substantially from coastal areas and therefore long-distance dispersal behaviors of Sierra Nevada California red-legged frogs may also differ substantially and to date there have been few studies of dispersal by the species in this region. Notably, the National Park Service has conducted mark-recapture studies of California red-legged frogs in Yosemite National Park and found that at least one individual moved approximately 800 m overland between the Merced River and Ahwahnee Pond (Grasso, National Park Service, pers. comm. 2020.)

Diet

The diet of the California red-legged frog is highly variable and changes with age class. The diet of larvae is not well studied; however, their diet is likely similar to that of other ranid tadpoles, feeding on algae, diatoms, and detritus by grazing on the surface of rocks and vegetation (Kupferberg 1997, p. 431). For adult and juvenile frogs, Hayes and Tennant (1985, entire) analyzed the diets of California red-legged frogs from Cañada de la Gaviota in Santa Barbara County during the winter of 1981 and found invertebrates (comprising 42 taxa) to be the most common prey item consumed; however, they speculated that this was opportunistic and varied based on prey availability. They found that larger frogs consumed larger prey, including Pacific chorus frogs (*Pseudacris regilla*), three-spined stickleback (*Gasterosteus aculeatus*), and, to a limited extent, California mice (*Peromyscus californicus*), which were abundant at the study site (Hayes and Tennant 1985, p. 602; Fellers 2005, p. 554). Although larger vertebrate prey was consumed less frequently, it represented over half of the prey mass eaten by larger frogs suggesting that such prey may play an energetically important role in their diets (Hayes and Tennant 1985, p. 602). Bishop *et al.* (2014, p. 139) analyzed stomach contents of 98 frogs, and found that wet and dry season stomach content samples flushed from captured frogs had 90 percent terrestrial prey, and museum specimens contained 82 percent terrestrial prey. Spiders, aphids, froghoppers, and butterfly/moth larvae were the terrestrial invertebrate families consumed most. These data suggest that riparian and upland habitats adjacent to aquatic habitats support much of the prey base for California red-legged frogs.

Juvenile and adult frogs appear to vary in their feeding activity periods; juveniles feed for longer periods throughout the day and night, while adults feed nocturnally (Hayes and Tennant 1985, p. 604). Hayes and Tennant (1985, p. 605) noted that juveniles were significantly less successful at capturing prey, although all life history stages exhibited poor prey discrimination, feeding on several inanimate objects that moved through their field of view.

Spatial Distribution

The species historically occurred from sea level to approximately 1,600 m (Service 2002 p. 7) across 46 counties in California (Service 2002, p. 3). The species' historical coastal range extended along the Pacific Coast from its northern extent in central Mendocino County and western Tehama County through the California Coast Ranges to its southern extent in northern Baja California, Mexico (Jennings and Hayes, p. 63; Figure 1). The species' historical inland range included the western foothills of the Sierra Nevada and Cascade Ranges from Shasta County south to Madera County (Jennings and Hayes 1994, p. 63; Fellers 2005, p. 552). By the time of its listing in 1996, the distribution of the species had declined to only 243 streams or drainages within 22 counties, and we estimated that the species had lost 70 percent of its historical range (Jennings *et al.* 1992, p. 9; Service 1996, p. 25815) (Figure 1). Prior to listing, occurrence data for the species was limited to only 122 occurrences recorded in the California Natural Diversity Database (Service 1996, p. 25817).

Following listing in 1996, California red-legged observations recorded in the CNDDDB increased to 633 at the time of the Service's 2002 Recovery Plan for the species (CNDDDB 2022). Corresponding with this increase in number of records, in 2002 the species was known to occur in 256 streams or drainages within 28 counties (Service 2002, p. 1). As of January 2022, there are 1,667 occurrences across 34 counties, all below 1,430 m in elevation (CNDDDB 2022). This increase in California red-legged frog observations recorded in CNDDDB following its listing can likely be attributed to increased survey effort for the species during pre-project surveys in its suitable habitats rather than an increase in species distribution or abundance. With few exceptions, most novel occurrences are within a few miles of previously known localities and did not substantially increase the distribution of the species. A few notable exceptions are a new observation near Rincon Creek in Santa Barbara County (Sam Sweet, pers. comm. 2018); new translocated populations located within the Santa Monica Mountains Recreation Area in Los Angeles County, within Yosemite National Park in Mariposa County, on the Santa Rosa Plateau in Riverside County, and on private land in San Diego County; and identification of ten new localities in the Sierra Nevada mountain range (Barry and Fellers 2013, p. 481). The source of the translocated population in San Diego County was a newly observed locality near Whitewater in Riverside County (Backlin *et al.* 2017, p. 2). The Service and its partners translocated all California red-legged frogs from the Whitewater locality to the San Diego County translocation site following a wildfire and the Service no longer considers the Whitewater locality occupied.

Currently, the California red-legged frog is widespread in the San Francisco Bay nine-county area and abundant along the coast north of Ventura County (CNDDDB 2022). Isolated populations persist in several Sierra Nevada localities, in Ventura County, in Los Angeles County, as well as two recently translocated populations in Riverside and San Diego (Barry and Fellers 2013, pp. 456–457; CNDDDB 2022). Halstead *et al.* (2018, p. 15) used environmental DNA methods to investigate the putative northern extent of the species range in southern Mendocino County and

concluded that the species likely does not inhabit the sampled areas in southern Mendocino County. The southern extent of the species' current range remains in Baja California outside of the United States (Peralta-García *et al.* 2016, p. 170). However, the populations within the Service's purview are geographically and reproductively isolated from Baja California populations and aside from their use as donor populations for translocation in Southern California, we do not discuss these Baja California populations further in this review.

In 2020, the Service developed a species range map for the California red-legged frog based on watershed occupancy by the species (Figure 1). To reflect only the contemporary distribution of the California red-legged frog, the Service used only observations that occurred following the listing of the species in 1996. The Service combined data from 1,463 post-1996 records across 31 counties in the CNDDDB as of December 2019 and 3,168 post-1996 records from survey reports and other correspondence in Service files for a total dataset of 4,631 observations located across 40 counties. The Service's intent for the species range map was to identify areas where California red-legged frogs possibly could occur rather than only areas where the species is known to occur. Therefore, the Service considered the entire HUC10 watershed where a post-1996 record occurred as potentially occupied by the species because of the cryptic nature of the species and its capability to migrate long distances. Based on known differences in the natural histories of Southern California and Sierra Nevada populations of California red-legged frog, the Service reduced this approach to considering only the record's HUC12 watershed as occupied for watersheds located south of Ventura County and in the Sierra Nevada range. Additionally, for HUC12 watersheds in the Sierra Nevada range the Service imposed an upper altitudinal limit of 1,550 m for potential occupancy. The Service further refined this watershed-based range map through multiple rounds of expert review. The Service's final range map for the species (Figure 1) includes a total of 18,571,388 acres across 40 counties. We used the Bureau of Land Management's California land status layer (<https://navigator.blm.gov/api/share/1fca0357df7c87ae>) to calculate the proportionate ownership of land within these 18,571,388 acres and found that 22.6 percent of the species range is on federal lands, 2.9 percent of the species range is on State or local government lands, and the remaining 74.5 percent of the species range is on private lands. Notably, inhospitable areas such as heavily developed urban areas are included in this watershed-based range map and therefore not all 18,571,388 acres identified in the range map contain suitable habitat for the species.



Figure 1. Current and historical range of the California red-legged frog. We do not include populations in Baja California, Mexico in this figure.

Habitat or Ecosystem

California red-legged frogs predominately inhabit permanent fresh water sources with salinities less than 7.0 parts per thousand (ppt; Jennings and Hayes 1990, pp. 17) such as streams, lakes, marshes, natural and manmade ponds, and drainages in valley bottoms and foothills (Jennings and Hayes 1994, pp. 64–65) though the species is capable of temporarily using habitat with salinities up to 36 ppt (California Department of Fish and Wildlife 2011, pp. 3–70). Typically, aquatic habitat contains either riparian or emergent vegetation though California red-legged frogs also are known to inhabit ephemeral creeks, drainages, and ponds with minimal riparian and emergent vegetation. California red-legged frogs use these types of aquatic features for breeding and non-breeding activities. California red-legged frogs can occur in a wide range of water quality conditions, but Bobzien and DiDonato (2007, p. 61) found that they appear to prefer less turbid water relative to other co-occurring amphibian species. We describe below the varying habitats used by the California red-legged frog as categorized into Physical or Biological Features (PBFs) by the Service's 2010 final critical habitat rule for the species (Service 2010, pp. 12835-12836):

PBF 1: Aquatic breeding habitat

Aquatic breeding habitat is generally found in still or slow-moving water and can have a wide range of edge and emergent cover amounts. In streams and creeks, frogs have been documented in low, moderate, high, and extreme gradients ranging from 0.4 percent to 21.0 percent slopes; however, the most stable populations and the highest breeding densities occur in low and moderate stream gradient types (less than 4 percent) with minimal scouring flows (Bobzien and DiDonato 2007, pp. 32 and 58–59).

Depending on conditions, breeding sites typically retain water for a minimum of 20 weeks to allow for tadpole development and metamorphosis. Breeding sites typically also contain shelter such as vegetation, rocks, or other cover and water more than 0.7 m deep (Hayes and Jennings 1988, p. 147), though egg masses themselves are typically deposited on surfaces less than 38 cm deep (Storer 1925, p. 239). While California red-legged frogs typically use partially shaded pools and creeks with emergent vegetation as breeding habitat the species can deposit eggs in a large variety of habitats. For example, the California Department of Transportation (Caltrans) identified adults, tadpoles, and egg masses within a storm drainage system of a major cloverleaf intersection at Millbrae Avenue and State Route 101 in a heavily developed area of San Mateo County (Caltrans 2007, p. 17).

Barry and Fellers (2013, p. 476) found 12 historical and three recent occurrences in the Sierra Nevada were located in permanent or ephemeral creeks, often in close proximity to the headwaters, and concluded that pools along streams, rather than natural ponds which are nearly absent in the Sierra Nevada, comprised the principal historical natural aquatic habitat for the species throughout much of its range in the Sierra Nevada. However, as noted by Barry and Fellers (2013, p. 476), at the present time California red-legged frogs in the Sierra Nevada are known to only use manmade and natural ponds as aquatic habitat.

PBF 2: Aquatic non-breeding habitat

Non-breeding habitat is found in similar aquatic features as breeding habitat but these features may not hold water long enough for the species to successfully complete its aquatic life cycle. While generally found in freshwater habitats, adult California red-legged frogs can survive in saline water for short periods. For example, URS Corporation observed dispersing adults and sub-adults in salinities of up to 36 ppt (California Department of Fish and Wildlife 2011, pp. 3–70).

Non-breeding aquatic features provide habitat for foraging, shelter, movement, and other essential behaviors. In addition to the aquatic features used for breeding, aquatic non-breeding habitat may include plunge pools within intermittent creeks, seeps, quiet water refugia during high water flows, and springs of sufficient flow to withstand the summer dry period. California red-legged frogs also readily use disturbed areas such as channelized creeks and drainage ditches as aquatic habitat.

PBF 3: Upland habitat

Upland habitat consists of terrestrial areas adjacent to breeding and non-breeding aquatic habitats. Juvenile and adult California red-legged frogs use upland habitat for foraging, shelter, and movement. Several studies have observed California red-legged frogs spending a significant amount of time in terrestrial habitats and consuming large amounts of terrestrial prey as adults (Bulger *et al.* 2003, pp. 87–88; Wildlife Research Associates 2008, p. 11; Halstead and Kleeman 2017, p. 134).

Suitable upland habitat for the California red-legged frog includes nearly any terrestrial area within 100 m of aquatic habitat that contains cover features such as dense riparian vegetation, wood or rock debris, burrows, or anthropogenic cover including discarded tires and wooden boards. The extent of upland habitat used by California red-legged frogs for feeding and sheltering varies substantially by habitat condition. In the wet, cool habitat of the Santa Cruz Mountains, Bulger *et al.* (2003, p. 87) observed 90 percent of terrestrial non-dispersing frogs within 60 m of water and 10 percent were found up to 130 m from water. The frogs in this study remained in the uplands for 20 to 30 days on average with a maximum duration of 63 days. Contrastingly, in the arid, warmer habitat of Vandenberg Air Force Base in Santa Barbara County, Christopher (2004a, p. 30) observed 65 percent of terrestrial non-dispersing frogs within 5 m of water and one individual 43 m from water. The frogs in this study typically remained in the uplands for 7 to 21 days with a maximum duration of 23 days. In the Sierra Nevada region Wildlife Research Associates (2008, p. 11) observed no upland movements further than 20 m from the study pond for a maximum duration of 7 days.

PBF 4: Dispersal habitat

Dispersal habitat consists of terrestrial areas up to 3.2 km away from breeding and non-breeding aquatic habitat used by adult and juvenile California red-legged frogs to move along and between watersheds during long-distance dispersal events. Only 10–30 percent of adult and juvenile California red-legged frogs perform long-distance dispersal each year. As described by Bulger *et al.* (2003, p. 85), California red-legged frogs may “move overland in approximately straight lines

to target sites without apparent regard to vegetation type or topography” and therefore California red-legged frogs may use almost any terrestrial area within dispersal distance as dispersal habitat. Notably, California red-legged frogs likely would not use areas delimited by significant passage barriers such as major roadways or walls as dispersal habitat.

Similar to upland habitat, the extent of dispersal habitat away from aquatic habitat is dependent on local conditions. Bulger *et al.* (2003, p. 90) observed that California red-legged frogs may disperse up to 2.8 km straight-line distance (3.2 km total distance traveled) away from their natal stream in the wet, cool environment of the Santa Cruz Mountains and spend up to 2 months dispersing between streams. Contrastingly, Christopher (2004a, p. 35) observed that California red-legged frogs dispersed a maximum of 209.3 m between ponds during the breeding season in the warm, arid environment of Vandenberg Air Force Base and frogs only spent up to 3 days dispersing between ponds. In the Sierra Nevada region Wildlife Research Associates (2008, pp.11–12) observed that California red-legged frogs dispersed a maximum of 208 m between the study pond and a neighboring seep area and stayed in the seep area for 62 days. The National Park Service observed a maximum dispersal distance of approximately 800 m overland (Grasso, pers. comm. 2020) during mark-recapture studies in Yosemite National Park.

Status of Habitat

To assess the status of the California red-legged frog’s habitat across its range, we analyzed the current species range map produced by the Service in 2020 as described above in the Spatial Distribution section. Briefly summarized, the Service used post-1996 California red-legged frog observations to identify 142 HUC10 and HUC12 watersheds as the current geographic range of the species. These 142 watersheds ranged in size from 25 km² to 1075 km² and comprised a total of 18,571,388 acres. For comparison, we digitized the historical range map presented in the Service’s 1996 listing rule for the species (Figure 1) and estimate that the historical geographic range of the species totaled approximately 43,206,623 acres. Based on a rough graphical comparison between the current species range map and the historical range map, we estimate the species has lost approximately 57 percent of its historical range rather than the previously estimated 70 percent (Service 1996, p. 25815). Primarily, the species has lost large portions of its historical range in the Central Valley and coastal areas south of Santa Barbara County.

In general, we expect range-wide habitat quality for the California red-legged frog to be degraded relative to the historical habitat quality of the species range as well as habitat quality at the time of the species’ listing. We expect habitat quality has degraded near developed areas from encroachment by development, reduced water availability because of water withdrawals, and the presence of invasive plant and animal species. Additionally, we expect that habitat within the species range in general has become warmer and drier during the past century because of regional climate change resulting from post-industrialization anthropogenic carbon inputs. A warmer and drier climate reduces the water available to the California red-legged frog for life cycle activities. We discuss these threats to the species’ habitat quality more fully in the Threats Assessment section below.

Connectivity

Historically, California red-legged frogs had a single contiguous species range which likely created a metapopulation dynamic where geographically separate populations maintained connectivity with one another through long-distance dispersal and subsequent gene flow. Such metapopulation dynamics foster population redundancy and resiliency by providing immigrants to extirpated or otherwise reduced populations and mitigating genetic drift between populations. As discussed above, the California red-legged frog has lost approximately 57 percent of its historical range, primarily in coastal areas south of Santa Barbara County and in the Central Valley. Populations in coastal areas south of Santa Barbara County currently are separated from one another by tens of kilometers and likely do not exchange migrants (Richmond *et al.* 2013, p. 818). Populations in the Sierra Nevada region are also currently geographically separate from one another and likely do not exchange migrants (Richmond *et al.* 2014, p. 134). Furthermore, these Sierra Nevada populations are genetically isolated from the rest of the species range by the formerly occupied Central Valley (Richmond *et al.* 2014, p. 134). Contrastingly, the California red-legged frog has retained much of its historical range in coastal areas north of Santa Barbara County and populations within this area have retained genetic connectivity with one another (Richmond *et al.* 2014, p. 134).

We expect that the status of connectivity within the species overall has decreased significantly relative to its historical status. At a regional scale, populations in the Sierra Nevada region have lost connectivity with the rest of the range of the species. Additionally, populations within the Sierra Nevada and coastal areas south of Santa Barbara County lack connectivity with other populations within these regions. Moreover, we expect that connectivity throughout the range of the species has decreased significantly as well, particularly with the placement of anthropogenic passage barriers such as major roadways or constructed walls between populations. Additionally, the observed and predicted overall trend of warmer and drier winters within the range of the California red-legged frog as a result of climate change may reduce the distance traveled by dispersing California red-legged frogs, which would further reduce connectivity within regions.

Abundance

Status of California red-legged frog abundance

To date, there has not been a range-wide survey of California red-legged frog abundance. It is difficult to reliably census California red-legged frogs in the field because of the cryptic habits of adults and juveniles and difficulties distinguishing larvae of the species from larvae of other ranid species. Currently, the most reliable census method for California red-legged frog is to perform repeated egg mass surveys during the breeding season (Wilcox *et al.* 2017, p. 70). Because female ranid frogs deposit only one egg mass a year (Wilcox *et al.* 2017, p. 66), the overall count of egg masses is a close approximation of the number of breeding adult female frogs using the survey area. While several egg mass survey efforts are ongoing, to date the only effort that has summarized abundance trends over time is the U.S. Geological Survey's study of 5 breeding areas in Southern California. Below, we present abundance over time from the U.S. Geological Survey's study (Gallegos *et al.* 2022, Table 3).

Site	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Aliso Canyon	–	0	3	1	1	0	2	3	5	0	0	0	0	0
San Francisquito Canyon	0	2	5	9	10	29	49	93	127	27	34	10	13	72
East Las Virgenes Canyon	–	8	28	35	13	22	19	31	37	76	61	86	55	59
Las Virgenes Canyon	–	–	–	–	–	3	0	0	0	2	0	0	0	0
Whitewater Canyon	–	–	–	–	–	–	–	–	–	0	2	1	0	0

Table 1. Egg mass survey results over time for five breeding locations in Southern California. Reproduced from Table 3 of Gallegos et al. (2022). A “–” entry indicates no survey was performed.

The data presented by Gallegos *et al.* (2022, Table 3) indicate differing trends in abundance as reflected in egg mass counts across the five Southern California survey sites. From 2009 to 2021 the San Francisquito Canyon and East Las Virgenes Canyon populations each consistently produced egg masses. However, annual increases or declines in egg mass counts were not consistent between these populations despite their relative proximity to each other (ca. 45 kilometers). For example, between 2018 and 2019 the San Francisquito Canyon population abundance decreased from 34 to 10 egg masses while the East Las Virgenes Canyon population abundance increased from 61 to 86 egg masses. The Aliso Canyon, Las Virgenes Canyon, and Whitewater Canyon populations were not able to consistently sustain breeding activity. From these egg mass survey data, we cannot infer a consistent regional trend in abundance over time for these Southern California populations.

In general, we expect that current overall abundance of the California red-legged frog has decreased from its historical abundance and its abundance at listing in 1996. The species has lost approximately 57 percent of its geographic range and areas of the species’ remaining habitat likely are degraded relative to their historical habitat quality. Nevertheless, local populations occasionally produce large numbers of California red-legged frogs, particularly in response to wet rainy seasons. For example, Padre Associates, Inc. detected hundreds of California red-legged frogs sheltering in an oil containment basin in Santa Barbara County (Padre Associates, Inc., 2017, p. 6). Similarly, VJS Biological Consulting (2013, p. 2) identified dozens of California red-legged frogs living in a small section of submerged concrete riprap along Tajiguas Creek in Santa Barbara County.

Genetic abundance estimates

Richmond *et al.* (2014, Table 1) estimated the effective population size (N_e) of California red-legged frog populations across the range of the species using genetic microsatellite data. Richmond *et al.* calculated median N_e values between 7 and 40 for sampled populations throughout its range. We discuss the entirety of Richmond *et al.* (2013) and Richmond *et al.* (2014) in the genetics section below.

Survival

California red-legged frogs experience high mortality rates at each life stage until adulthood. Jennings *et al.* (1992, p. 3) estimated that around 1 percent of eggs reach metamorphosis and 0.1 percent of eggs reach adulthood (Scott and Rathbun 2006, p. 13). In coastal lagoons, the most significant mortality factor for eggs is water salinity with a survivable limit of 50 ppt salinity (Jennings *et al.* 1990, p. 17). In other environments, such as freshwater streams and ponds, predation of eggs is likely the most significant mortality factor particularly if voracious invasive predators such as bullfrogs (*Lithobates catesbeianus*) and crayfish are in the area. Additional sources of mortality for eggs and larvae are burial by siltation or desiccation from aquatic habitat drying out.

Longitudinal studies of California red-legged frog survival are infrequent. Scott and Rathbun (2006, p. 13) reported 9.9 percent survivorship from metamorphosis through the first juvenile year and subsequent annual adult survivorship of 25 percent to 39 percent on the Central Coast. Fellers *et al.* (2017, p. 670) estimated an annual survival rate of adult frogs of 26.3 percent at a pond in Point Reyes National Seashore while Halstead and Kleeman (2017, p. 133) estimated an annual survival rate of 70 percent for adult frogs in a nearby coastal dune area. Halstead and Kleeman (2017, p. 137) attribute this difference in estimated adult survivorship to a lower risk of predation and abundant prey (deer mice, *Peromyscus maniculatus*) in the coastal dune ecosystem. In general, we expect predation to be the most significant cause of mortality to juvenile and adult frogs. In particular, bullfrogs, centrarchid fish, crayfish, and raccoons (*Procyon lotor*) are known to prey on juvenile and adult California red-legged frogs. Additionally, near developed areas we expect mortalities of juvenile and adult California red-legged frogs resulting from vehicle strikes or crushing by equipment.

Overall, we expect that survival of California red-legged frogs at all life stages has decreased relative to historical survival rates. The general trend of a warming and drying climate within the range of the California red-legged frog has reduced the hydroperiod available for larval development and shelter for all life stages, though a reduced hydroperiod may also benefit the species in certain areas by reducing the abundance of invasive predators such as bullfrogs and crayfish. Additionally, relative to historical rates we expect additional mortality of California red-legged frogs near developed areas from vehicle strikes and predation from invasive species.

Sex Ratios

Of studies that report sex ratios in adults, most report female-biased sex ratios and survival (Russel *et al.* 2019, p. 11). Halstead and Kleeman (2017, p. 137) suggest that the sex ratio on their dune study system could be biased towards females because larger female frogs would be capable of preying on the *Peromyscus* deer mice that appear to be the main prey base for the species in their study system. We expect that contemporary sex ratios in California red-legged frogs are similar to historical sex ratios in the species.

Changes in Taxonomic Classification or Nomenclature

The California red-legged frog belongs to the family Ranidae (true frogs). As described by Storer (1925, p. 231), Baird and Girard first described the California red-legged frog (*Rana draytonii*) and the northern red-legged frog (*Rana aurora*) as two distinct species in 1852. In 1917, Camp

reclassified the frogs into two subspecies of the species *R. aurora*: the California red-legged frog was reclassified as *R. aurora draytonii* and the northern red-legged frog as *R. aurora aurora*.

In 1996, the Service listed the subspecies *R. aurora draytonii* as threatened under the Act (Service 1996, p. 25832). Subsequently, Shaffer *et al.* (2004, p. 2673) used genetic data to differentiate *R. aurora* into two distinct species: northern red-legged frog (*R. aurora*) and California red-legged frog (*R. draytonii*). In 2010, the Service formally recognized full species status for *R. draytonii* in its final rule designating critical habitat for the species (Service 2010, p. 12873).

Genetics

To date, the most comprehensive survey of genetic diversity within California red-legged frogs is Richmond *et al.*'s (2014) survey of microsatellite and mitochondrial DNA data from populations throughout the species range. Frequently, rapid frog species display high amounts of genetic structure between populations caused by philopatry to breeding sites and relatively limited ability to disperse long distances between breeding populations. Richmond *et al.* (2014, p. 134) identified corresponding patterns of strong genetic structure within California red-legged frogs. Specifically, Richmond *et al.* (2014, p. 136) found that Sierra Nevada populations no longer exchange immigrants with each other and are also no longer genetically connected with populations outside the Sierra Nevada. Similarly, Richmond *et al.* (2013, p. 818) found that populations south of Santa Barbara County no longer exchange immigrants with each other and are also no longer genetically connected with populations north of Ventura County. Contrastingly, Richmond *et al.* (2014, p. 134) found that populations in the Bay Area likely continue to retain genetic connectivity with one another.

Additionally, Richmond *et al.* (2014, p. 134) identified a pattern of genetic diversity indicating that Sierra Nevada populations shared most recent common ancestry with Southern California populations rather than Northern California populations. Richmond *et al.* (2014, p. 135) also found that populations in the Sierra Nevada possessed geographic patterns of genetic diversity indicating northwards expansion following the post-Pleistocene glacial retreat.

Overall, we expect that contemporary California red-legged frog populations have reduced genetic diversity relative to the species' historical genetic diversity. The approximately 57 percent reduction in species range likely reflects a proportionate decrease in abundance and a concordant reduction in the genetic diversity of the species. The large reduction in the species' range has severed genetic connectivity between Sierra Nevada populations and the rest of the species range. Similarly, almost all populations south of Santa Barbara County have lost genetic connectivity with the rest of the species range (the Matilija Creek/Ventura River population in Ventura County may be an exception). Accordingly, the coastal populations south of Santa Barbara County and Sierra Nevada populations now have separate evolutionary trajectories from coastal populations north of Ventura County. The loss of gene flow within and between regional populations has likely exacerbated the effect of genetic drift on populations. Accordingly, these populations likely have each suffered substantial stochastic loss of allelic diversity (including beneficial or otherwise adaptive alleles) over time. Artificial translocation of California red-legged frogs between isolated populations (i.e., assisted gene flow) would provide a powerful ameliorating effect on the loss of genetic diversity within these populations.

Species-specific Research and/or Grant-supported Activities

The Service has overseen many California red-legged frog research or other grant-supported activities since the time of the species' listing, we discuss these activities in the Significant Conservation Efforts section below.

THREATS ASSESSMENT (FIVE-FACTOR ANALYSIS)

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

The final listing rule for the California red-legged frog (Service 1996, pp. 25824–25830) listed the following factors as threats to the viability of the species: (1) urban encroachment, (2) construction of large and small reservoirs, water diversions and well development, (3) flood control maintenance, (4) road maintenance, (5) placer mining, (6) livestock grazing and feral pigs, (7) off-road vehicle use, and (8) introduction or presence of exotic predators and competitors. Below, we discuss these threats and other threats identified by the Service following the species' listing.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The Service's 2002 Recovery Plan for the species specifically identifies urbanization, agriculture, impoundments and water management, channelization and flood control, mining, livestock grazing and dairy farming, recreation and off-road vehicles, and timber harvesting activities as contributors to Factor A (Service 2002, pp. 17–23). The effects of timber harvest are largely similar to the effects of agriculture and therefore we have combined our discussion of these effects into a single category. Additionally, the effects of channelization and flood control activities are largely similar to the effects of water impoundments and management projects and therefore we have combined our discussion of these effects into a single category. Furthermore, we have generalized livestock grazing and dairy farming activities to livestock ranching activities. We discuss the status of each of these contributors to Factor A below.

Urbanization

The Service's 2002 Recovery Plan for the species identified urbanization as a significant threat to the California red-legged frog. Urban and suburban developments create isolated habitat fragments and barriers to dispersal (e.g., roads and walls) and consequently reduce connectivity between populations. Furthermore, urbanization can reduce the water available to frogs in the area, contaminate downstream habitat with pollutants and sediment, and facilitate the introduction of predators such as bullfrogs and raccoons. Urbanization remains a significant threat to the California red-legged frog. Urbanization of areas within California red-legged frog habitat continues to occur particularly along aquatic corridors containing suitable breeding habitat.

California red-legged frogs in the Sierra Nevada are under relatively low threat from urbanization because populations are located away from densely populated urban centers and many of these populations are located on protected land. California red-legged frogs in coastal areas north of Santa Barbara County are under moderate threat from urbanization. Some

populations in coastal areas north of Santa Barbara County are located near densely populated urban centers but the majority of the species range in coastal areas north of Ventura County (outside of the nine-county San Francisco Bay Area) are located away from urban centers. Additionally, the cooler, wetter climate of the species range north of Ventura County somewhat reduces the negative effect of urbanization on water availability for the species. Furthermore, the greater abundance and connectivity of California red-legged frogs in coastal areas north of Ventura County also somewhat reduces the negative effect of urbanization.

Contrastingly, populations south of Santa Barbara County are under intense threat from urbanization. Almost all known populations south of Santa Barbara County are within 20 miles of a major urban center. Populations south of Santa Barbara County (with the exception of the Matilija Creek/Ventura River population in Ventura County) are separated from neighboring populations by major urban development and roadways. Residential and agricultural use of surface water and groundwater resources in these areas reduces the availability and hydroperiod of suitable aquatic breeding habitat in these hot, dry areas. Similarly, the high human population density in coastal areas south of Santa Barbara County also facilitates introduction of invasive species such as crayfish and giant reed. For example, the sole breeding ponds of the Las Virgenes Creek population in Los Angeles County are on preserved land within 400 m of major urban development and invasive predators and water use issues continue to hinder re-establishment of California red-legged frogs in Malibu Creek.

The Service and its partners have attempted to address the effects of urbanization on the California red-legged frog by establishing conservation banks, permanently preserving areas, creating ponds, and restoring habitat (e.g., removing invasive predators and plants). Nevertheless, urbanization continues to be a threat to the California red-legged frog.

Agriculture

As in the Service's 2002 Recovery Plan, we distinguish monotypic agricultural activities (e.g., viticulture, row farming, or timber harvest) from ranching and grazing activities. Similar to urbanization, agriculture creates isolated habitat fragments and barriers to dispersal for California red-legged frog. Agriculture can reduce water available to the species in the area, introduce contaminants such as pesticides and sediment into suitable habitat, and facilitate the presence of predators such as raccoons and bullfrogs. Illegal, unpermitted cannabis cultivation sites in particular are known to degrade habitat by converting habitat on protected lands and drafting water from neighboring aquatic habitat. Notably, the habitat fragmentation produced by agriculture is of a lesser magnitude than the fragmentation produced by urbanization because agricultural lands generally remain permeable for dispersing California red-legged frogs and individuals can use water impoundments on agricultural lands such as frost ponds for shelter during movements.

The effect of agriculture on the species can be seen in the near extirpation of the species from the Central Valley region following a century of intense agricultural activities. Fisher and Shaffer (1996, p. 1395) suggested that the declines of native amphibians in the Central Valley and other agricultural regions were due to intense farming practices that rendered the few remaining ponds and pools on these valley floors uninhabitable for native species. The Service's Recovery Plan for the species (2002, p. 18) in particular singles out the practice of heavy use of fertilizers and

pesticides in the region and Davidson (2004, p. 1897) notes a correlation between California red-legged frog population declines and upwind pesticide use. Nevertheless, California red-legged frogs are known to live and breed adjacent to agricultural fields (e.g., near Santa Maria in Santa Barbara County) so the precise effect of heavy use of fertilizers and pesticides on the species in the wild remains unknown.

California red-legged frogs face differing magnitudes of effects from agriculture throughout their range. Many coastal populations north of Ventura County occur nearby agriculture. In particular, populations in Santa Barbara, San Luis Obispo, Monterey, and Santa Cruz Counties occur nearby intensive agricultural activities such as hoop-house row crop farming. Populations south of Santa Barbara County are located away from agriculture with the exception of the Matilija Creek/Ventura River population in Ventura County.

In the Sierra Nevada region, multiple populations are located in close proximity to areas subject to timber harvest operations. Timber harvest operations vary in type and magnitude, from occasional clearcuts of large contiguous areas of forest to removal of individual trees during selective harvest or fuels reduction operations. Timber harvest operations can reduce and degrade California red-legged frog habitat by building and maintaining roads to accommodate vehicle traffic and generating erosion and sedimentation of downstream habitat.

The Service and its partners have attempted to address the effects of agriculture on the California red-legged frog by avoiding, minimizing, and mitigating effects through activities such as establishing conservation banks, permanently preserving areas that contain suitable habitat for the species, creating ponds, and restoring habitat (e.g., removing invasive predators). Nevertheless, agriculture continues to be a threat to the California red-legged frog.

Impoundments and water management projects

As described in the Service's 2002 Recovery Plan, water impoundment and management projects affect California red-legged frog habitat by removing suitable habitat and altering watershed hydrology and the hydroperiod available to California red-legged frogs. Water impoundment and management projects can also create impassible barriers such as large dams which limit connectivity within watersheds. Additionally, water impoundments can facilitate the presence of invasive predators such as bullfrogs and crayfish. Water impoundment and management projects frequently occur in service to urbanization and agricultural development to ensure year-round water availability for these developments and thus effects on the California red-legged frog from urbanization and agricultural development are frequently compounded by additional effects from water impoundment and management projects.

The range of the California red-legged frog typically has a "Mediterranean" climate characterized by dry summer and mild, wet winters. The life histories of California red-legged frogs align with this "Mediterranean" climate pattern by breeding and dispersing during wet winter weather and sheltering in or near pools during the dry summer. Therefore, the propensity of water impoundment and management projects to alter hydroperiods away from natural patterns can further reduce habitat quality for the species. To date, studies have identified patterns of habitat loss and degradation for California red-legged frogs following construction of water management projects (Hayes and Jennings 1988, p. 154; Kupferberg *et al.* 2012, p. 517).

Nevertheless, water management projects and impoundments may also alter natural hydroperiods for the benefit of the species. For example, the species uses a large artificial pool at the former St. Francis dam site for breeding and shelter in hot, dry Los Angeles County.

The effects of channelization and flood management projects largely are similar to other water management projects in general. However, as noted by the Service's 2002 Recovery Plan, channelization and flood management activities such as dredging channels, placing erosion controls, or applying herbicides typically occur within stream channels and uplands where California red-legged frogs breed and shelter. Therefore, the magnitude of direct effects from channelization and flood management projects on California red-legged frogs may be relatively greater than other types of water management projects.

California red-legged frogs are currently affected by water impoundment and management projects throughout their range. Many of the known remaining populations in the Sierra Nevada region are located at artificial water impoundments created for historical logging or mining activities. Similarly, many of the populations south of Santa Barbara County are located nearby dams and other impoundments. Many coastal populations from north of Ventura County also are located near water impoundment or management projects. In particular, many populations in the nine-county San Francisco Bay Area are located near large reservoirs and other water management projects constructed to service urban and agricultural development. The Service's 2002 Recovery Plan (p. 19) lists these reservoirs near known California red-legged frog populations.

It is likely that agencies will continue to install water management projects (e.g., flood control basins) within the range of the California red-legged frog particularly near areas with urban or agricultural development. Therefore, it is likely that effects on the California red-legged frog from water impoundment and management projects will continue to increase, though at a less rapid pace than seen in the early 20th century.

The Service and its partners have attempted to address the effects of water impoundment and management projects on the California red-legged frog by working with agencies to avoid, minimize, and mitigate effects to natural hydrology and hydroperiod from such projects during the design and permitting processes. Nevertheless, water impoundment and management projects continue to be a threat to the California red-legged frog.

Mining

The Service's 2002 Recovery Plan for the species identifies habitat degradation from gold, sand, and gravel mining as well as oil and gas production activities as a threat to the species. These activities can remove suitable habitat, alter natural stream courses and hydroperiods, and introduce contaminants such as chemicals or sediment into species habitat. Historical mining and quarrying activities have also created artificial ponds on California red-legged frog habitat which can facilitate the presence of predators such as bullfrogs and crayfish. Relative to the other threats to the species discussed in this section, effects from mining and oil and gas production are limited geographically to a few areas. However, effects from these activities can be locally intense.

The Service is aware of no active suction dredge gold mining occurring near California red-legged frog populations. The Service is aware of ongoing sand and gravel mining occurring near California red-legged frog populations at the Sisquoc River and near Lompoc in Santa Barbara County. The Service is aware of ongoing oil and gas production activities occurring within California red-legged frog habitat in San Luis Obispo, Santa Barbara, and Ventura Counties.

The Service and its partners have attempted to address the effects of mining and oil and gas production projects on the California red-legged frog by working with agencies to avoid, minimize, and mitigate effects to natural hydrology and hydroperiod from such projects during the design and permitting processes. Nevertheless, mining and oil and gas production projects continue to be a threat to the California red-legged frog.

Livestock ranching activities

As described in the Service's special rule (Service 2006, p. 19285) exempting routine livestock ranching activities from prohibitions against take under Section 4(d) of the Endangered Species Act (4(d) rule), livestock ranching activities such as grazing and dairy farming can be both detrimental and beneficial to the California red-legged frog (Bobzien *et al.* 2000, p. 18). Specifically, while routine livestock ranching activities can degrade habitat by removing vegetation, introducing contaminants, and facilitating the presence of predators such as bullfrogs these activities also can enhance habitat by removing emergent vegetation that would otherwise overwhelm aquatic habitat. In many areas, livestock stock ponds are used as aquatic breeding habitat by the species.

California red-legged frog populations exist where livestock ranching activities occur throughout their range with the exception of coastal areas south of Santa Barbara County. We expect that these livestock ranching activities in these areas will continue to occur in proximity to California red-legged frog populations. As stated by the Service's 4(d) rule (Service 2006, p. 19286), the Service believes that continued livestock ranching activities near California red-legged frog populations is beneficial for the species.

The Service has worked with its partners to avoid, minimize, and mitigate the effects of livestock ranching activities on the California red-legged frogs. As indicated by the Service's 4(d) rule, there are numerous methods to manage ranching practices for the benefit of the California red-legged frog. To this end, conservation banks for the species frequently include livestock grazing and dairy farming activities to enhance habitat on bank lands for the benefit of the species.

Recreation

As discussed in the Service's Recovery Plan for the species (2002, p. 22), outdoor recreation and its associated infrastructure are known to degrade California red-legged frog habitat quality when occurring in proximity to California red-legged frog populations. Specifically, recreational activities can directly injure or kill California red-legged frogs, introduce contaminants and erosion into suitable habitat, facilitate the presence of predators, and alter hydroperiods in aquatic habitat.

California red-legged frogs exist where recreational activities occur in many locations throughout their range. Populations north of Santa Barbara County frequently occur in recreation

areas such as the Golden Gate National Recreational Area, East Bay Regional Parks lands, and Marin County recreational lands. Notably, all populations in coastal areas south of Santa Barbara County and in the Sierra Nevada are on federal lands or are otherwise publicly accessible for recreational activities, other than the Big Gun, Lake of the Cross, and Sailor Flat populations in the Sierra Nevada. For example, the only breeding ponds for the Las Virgenes Creek population in Los Angeles County are located on Los Angeles County lands within 40 m of heavily-used recreational trails. Accordingly, populations in coastal areas south of Santa Barbara County and the Sierra Nevada may be particularly affected by recreation. We expect that recreational activities will continue to affect the species as human populations increase within the range of the species.

The Service has worked with its partners to avoid, minimize, and mitigate effects of recreation on the California red-legged frog. For example, federal agencies consider the presence of the species when siting and managing recreational trails and campgrounds. In general, populations vulnerable to effects from recreation are located on publicly accessible lands managed by governmental agencies. The Service has worked with many of these agencies to develop programs to manage the effects of recreation on the species. Nevertheless, recreation continues to be a threat to the California red-legged frog.

Fire management activities

The Service has not previously identified fire management activities as a threat to the California red-legged frog. The range of the California red-legged frog has suffered a regional drought for the past decade. During this period the frequency and magnitude of wildfires within the range of the species (i.e., coastal areas and the Sierra Nevada range) has increased accordingly (Li and Bannerjee 2021, p. 12). For example, the 2017 Thomas fire burned large portions of the species range in Ventura and Santa Barbara Counties, the 2017 Tubbs fire burned large portions of the species range in Napa and Sonoma Counties, and the 2018 Woolsey fire burned the sole remaining breeding ponds for the species in the Santa Monica Mountains in Los Angeles County. Accordingly, over time both preventative fire management activities such as mechanical thinning or prescribed burns and fire response activities such as cutting dozer lines and aerial retardant drops have likely increased in frequency within the range of the California red-legged frog.

Preventative fire management activities such as mechanical thinning may have some direct effects on California red-legged frog through trampling or crushing of individuals but the intensity of these effects is likely low and relatively small in scale. Contrastingly, large-scale use of aerial retardant for fire response activities may have much broader effects on entire watersheds. According to Pilliod *et al.* (2003, pp. 24–25), there is little evidence for direct effects on amphibians from toxic exposure to aerial retardant. Nevertheless, aerial retardant is primarily nitrogenous and this nitrogen input can cause algal blooms, alter water chemistry, and facilitate the establishment of invasive plants (Zouhar *et al.* 2008, p. 11). We anticipate that use of aerial retardant will continue if not increase over time throughout the species range.

The Service has worked extensively with its agency partners to avoid and minimize the effects of fire response activities on the California red-legged frog. For example, prior to fire season the Service will identify changes to the distribution of listed species (e.g., California red-legged frog)

for fire agencies to avoid effects on listed species from fire management activities. Nevertheless, fire response agencies' activities are directed by many State and federal laws and occasionally fire management activities must take place in areas where listed species occur. Following fire response activities, federal agencies evaluate the effects of these activities on listed species in areas of federal responsibility and request consultation on these actions under Section 7(a)2 of the Endangered Species Act. Nevertheless, fire management activities are likely to remain a threat to the California red-legged frog.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The Service evaluated threats to the species from overutilization in its 2002 Recovery Plan for the species and concluded that overutilization in any form was not a threat to the species at that time (Service 2002, p. 23). The status of these threats from overutilization has not changed in the time following the Service's 2002 Recovery Plan and therefore overutilization for any purpose does not appear to be a threat at this time.

FACTOR C: Disease or Predation

Disease

The Service's 2002 Recovery Plan for the species identified disease as a potential threat to the California red-legged frog (Service 2002, pp. 23–24). To the Service's knowledge, *Batrachochytrium dendrobatidis* (chytrid) fungus is the only disease-causing pathogen that could be considered a threat to the California red-legged frog as a species. At the time of the Service's 2002 Recovery Plan for the species, little was known about the extent of chytrid infestation within the range of the species and the effects of chytrid infection on individuals. In the following years, research has shown that chytrid infestation is widespread in California red-legged frog habitats, with few exceptions. Additionally, research has indicated that California red-legged frogs can survive high fungal loads with little apparent effect, especially relative to other ranid frog species such as foothill yellow-legged frog (*Rana boylei*; Adams *et al.* 2020, p. 2). Furthermore, researchers have found that California red-legged frogs have both innate and adaptive immune responses to chytrid fungi. Nevertheless, recently researchers have identified patterns of reduced survival amongst infected California red-legged frogs (Russell *et al.* 2019, p. 8) and an instance of direct mortality of a subadult frog caused by chytrid infection (Adams *et al.* 2020, p. 4).

At present, chytrid fungi is an endemic, range-wide pathogen that appears to have minimal direct effects on California red-legged frogs. However, chytrid fungi are not monotypic and possess substantial genotypic and phenotypic diversity. Accordingly, California red-legged frogs may be vulnerable to introduced chytrid variants from other areas. Introduction of a new chytrid variant may have contributed to mortality of adult California red-legged frogs in Las Virgenes Canyon in Los Angeles County in 2021 (Santa Monica Mountains National Recreational Area 2021, p. 2). Therefore, chytrid fungus may be a potential threat to the California red-legged frog and the Service should continue to monitor the effects of chytrid fungus on the species, particularly from introduced chytrid variants.

Predation

The Service's 2002 Recovery Plan for the species identified predation as a significant threat to the California red-legged frog (Service 2002, p. 24). Predation of California red-legged frogs by invasive bullfrogs and swamp crayfish (*Procambarus clarkii*) is known to extirpate populations and hinder colonization of otherwise suitable habitat by California red-legged frogs (Hayes and Jennings 1986, pp.154–155; Jennings and Hayes 1990, pp. 19–21; DePalma-Dow *et al.* 2020, p. 45). Accordingly, the presence of these predators in particular can challenge translocation efforts intended to fulfill Recovery Task 10 (i.e., re-establishment of existing populations) described in the Service's 2002 Recovery Plan for the species. Notably, it is possible for California red-legged frogs to coexist with these predators for some period of time (Jennings and Hayes 1990, p. 19; Christopher 2004b, p. 97); however, the presence of these predators should nevertheless be viewed as a significant threat to populations. It remains difficult to remove these predators from California red-legged frog habitat because of their invasive life history traits and continued introduction to habitat near urban areas as sport fishing bait. Raccoons, garter snakes (*Thamnophis* spp.), centrarchid fish species such as bass (*Micropterus* spp.) and sunfish (*Lepomis* spp.), mosquitofish (*Gambusia affinis*), signal crayfish (*Pacifastacus leniusculus*), great blue herons (*Ardea Herodias*), cattle egrets (*Bubulcus ibis*), Sierra newt (*Taricha sierrae*), cats (*Felis domesticus*), red and grey foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*), African clawed frogs (*Xenopus laevis*), and coyotes (*Canis latrans*) also are known to prey on the California red-legged frog.

Predation on California red-legged frogs occurs throughout the species range. Bullfrogs and swamp crayfish in particular are present near almost all populations located near human development. The isolated populations in coastal areas south of Santa Barbara County may be particularly vulnerable to effects of predation because of continued introduction of predators from nearby urbanized areas and the lack of connectivity between populations to allow for re-colonization following extirpation. For example, following years of exhaustive crayfish removal trapping the California red-legged frog population in Las Virgenes Creek in Los Angeles County was able to extend its range 4 km downstream (Mountains Restoration Trust 2018, p. 26). However, following a lapse in trapping from June 2019 to May 2020, crayfish re-infested the formerly trapped areas and the California red-legged frog population's range has receded 400 m upstream (Kirby Bartlett, U.S. Fish and Wildlife Service, pers. comm. 2021).

Predation by bullfrogs is more common in coastal populations north of Ventura County. Bullfrogs have adapted readily to the pond habitat available to California red-legged frogs in this region. Notably, bullfrog tadpoles have a multi-year maturity cycle that can be disrupted by artificially managing hydroperiod of ponds. Bullfrogs also are present in the Sierra Nevada region as well as native predators such as rough-skinned newt (Calef and Waller 1973, p. 751) and centrarchid fish (Alvarez *et al.* 2002, p. 11) which also can voraciously consume California red-legged frogs. However, predator removal in the Sierra Nevada region can be successful. For example, following an extensive multiyear effort, the National Park Service was able to eradicate bullfrogs from Yosemite Valley in Mariposa County and successfully reintroduce California red-legged frog to the Valley (Kamoroff *et al.* 2020, pp. 623–634).

The Service has worked extensively with its partners to address the effects of predation on the California red-legged frog, in particular focusing on threats from bullfrog and swamp crayfish. The Service has worked with partners to eradicate bullfrog and crayfish from California red-legged frog habitat by managing hydroperiods (Jody McGraw Consulting 2020, pp. 7–8) and extensive capture and trapping efforts (Kamoroff *et al.* 2020, p. 618; Mountains Restoration Trust 2018, p. 21). Despite this progress, predation of California red-legged frogs, particularly by bullfrogs and crayfish, continues to be a significant threat to the California red-legged frog.

Competition

The Service's 2002 Recovery Plan for the species identified competition with bullfrogs as a threat to the California red-legged frog (Service 2002, p. 65). Prior to the introduction of bullfrogs, California red-legged frogs were the largest frogs in the Western United States. Therefore, there are few native competitors to the California red-legged frog (e.g., western toads (*Anaxyrus boreas*)). However, bullfrogs are significant competitors to the California red-legged frog. American bullfrogs are larger, more generalized predators, have longer potential breeding seasons, produce around 4 times more eggs than California red-legged frogs per breeding season (up to 20,000), and are unpalatable to predatory fish as tadpoles (Service 1996, p. 25828). Accordingly, D'Amore *et al.* (2009, pp. 538–540) observed direct and indirect effects on California red-legged frogs from competition in addition to predation by bullfrogs. Therefore, competition with bullfrogs continues to threaten the California red-legged frog, though the magnitude of this threat on the species is likely lower than the threat from predation by bullfrogs.

Invasive species

The Service's 2002 Recovery Plan for the species identified threats to the California red-legged frog from habitat degradation by invasive plant and animal species (Service 2002, pp. 24-27, 65-66). Multiple invasive species are known to degrade California red-legged frog habitat quality by ecosystem modification rather than direct predation. Feral pigs (*Sus scrofa*) can degrade habitat by rooting and wallowing in riparian areas and wetlands. The invasive water fern (*Azolla pinnata*; hereafter *Azolla*) is a freshwater floating fern found in suburban and rural ponds and can degrade habitat for the species. An *Azolla* infestation in Ledson Marsh in Sonoma County created anoxic conditions and reduced invertebrate populations to the point that California red-legged frogs abandoned breeding sites in areas of the marsh most invaded by *Azolla* (D. Cook, pers. comm. 2018). Giant reed (*Arundo donax*) is an invasive marsh plant that forms thick, resilient stands in riparian habitat and readily spreads downstream through cane fragments. Giant reed stands can impede California red-legged frog movement in riparian areas and reduce the amount of aquatic habitat available in an area by infilling pools with vegetation. Additionally, giant reed may reduce surface water in infested streams through its relatively high rate of evapotranspiration (Giessow *et al.* 2011, pp. 48 and 56). Therefore, invasive species continue to threaten the California red-legged frog and we anticipate that this threat likely will increase as human populations increase near California red-legged frog populations.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At the time of listing, regulatory mechanisms thought to have some potential to protect the California red-legged frog included: (1) Section 404 of the Clean Water Act; (2) the California Environmental Quality Act (CEQA) and the National Environmental Quality Act (NEPA); and

(3) multiple land use management as practiced by national, state, and local land management agencies. The listing rule (Service 1996, pp. 25828–25829) provides an analysis of the level of protection that was anticipated from those regulatory mechanisms. This analysis appears to remain valid.

Aside from the Endangered Species Act (Act), Section 404 of the Clean Water Act remains the primary protective mechanism for the California red-legged frog under Federal law. The U.S. Army Corps of Engineers (Corps) reviews individual and nationwide permit applications under Section 404 of the Clean Water Act that may affect Waters of the United States, which in California frequently are used by the California red-legged frog. The Corps then determines if the permit application's proposed activities may affect the California red-legged frog. If the Corps determines that proposed activities are likely to adversely affect the species, the Corps initiates consultation with the Service on the proposed activities under Section 7(a)(2) of the Act. During this consultation process, the Corps and the Service coordinate on appropriate measures to avoid, minimize, and off-set effects from the proposed activities on the California red-legged frog.

Notably, the jurisdiction of the Corps is limited to the Waters of the United States and occasionally nearby uplands and therefore the Corps cannot require avoidance, minimization, or compensation measures for effects to listed species that occur outside Corps jurisdictional areas. Despite this limitation, the Service and the Corps currently are implementing a “small federal handle” policy that allows the Service to include analysis of incidental take of listed species outside of Corps jurisdiction in biological opinions issued to the Corps under Section 7(a)(2) of the Act. Consequently, under the “small federal handle” policy the Corps can exempt take of listed species from penalties under Section 9 of the Act in areas outside of federal jurisdiction, an exception formerly reserved for permittees under Sections 10(a)1(a) and 10(a)1(b) of the Act. This new exception may encourage development activities on non-federal lands that were formerly inhibited by the presence of California red-legged frogs.

The National Environmental Policy Act (NEPA) is the remaining federal law with the potential to protect the California red-legged frog. Both NEPA and the State of California's California Environmental Quality Act (CEQA) require an intensive environmental review of projects' environmental effects including effects on listed and non-listed wildlife species. However, project proponents are not required under NEPA or CEQA to avoid, minimize, or mitigate effects on wildlife species if the project's effect on a species is not “significant”.

The State of California has taken various regulatory steps to protect the California red-legged frog. The California Fish and Game Commission amended its sport fishing regulations in 1972 to prohibit take or possession of California red-legged frog. Additionally, the California Department of Fish and Wildlife banned importation of bullfrogs, a voracious predator of California red-legged frogs, as a food product in 2010 though enforcement of this regulation appears infrequent. The Service has provided the California Department of Forestry and Fire Protection with guidelines to avoid effects on California red-legged frogs during the Department's implementation of Timber Harvest Plans. The State of California designated the California red-legged frog as a “Species of Special Concern” and the species may not be taken without an approved scientific collecting permit from the California Department of Fish and

Wildlife. However, designation as a Species of Special Concern provides no legally mandated protection of the species or its habitat.

Multiple land use management, as currently practiced by federal agencies, does not necessarily provide long-term protection for the California red-legged frog because protection of the species under the Endangered Species Act is balanced alongside other coequal federal laws. For example, the U.S. Forest Service has created breeding ponds for the species on its lands, but still permits timber harvest, recreational, and infrastructure activities that may affect the California red-legged frog. State, County, and Regional Park lands provide some protection from some threats, however, these parks are also managed for multiple uses. Multiple land use management by local governmental agencies can also threaten local populations of California red-legged frogs. For example, food safety standards promulgated by the US Department of Agriculture and agricultural industry groups recommend removal of riparian vegetation in the vicinity of leafy green (e.g., spinach) production areas in an effort to reduce vectors for *E. coli* contamination. Producers in the Salinas River Valley, which produces 70 percent of all leafy greens grown in the United States, removed approximately 13 percent (2000 hectares) of riparian habitat in the Valley to conform to these guidelines between 2005 and 2009 (Gennet *et al.* 2012, p. 6) including occupied California red-legged frog habitat. Similarly, County ministerial pest control programs, such as the Northern Salinas Valley Mosquito Abatement District, can threaten California red-legged frog populations by introducing mosquitofish and applying pesticides both of which reduce the insect prey available to California red-legged frogs. Mosquitofish are known to attack California red-legged frog tadpoles and delay metamorphosis of tadpoles through behavioral changes and competition for invertebrate prey (Lawler *et al.* 1999, p. 621).

In summary, the Endangered Species Act is the primary Federal law that provides protection for this species since its listing as threatened in 1996. Other Federal and State regulatory mechanisms may provide some discretionary protections for the species but do not guarantee protection for the species absent its status under the Act. Additionally, multiple land use management policies such as food safety regulations or mosquito vector control policy can contribute to threats to local California red-legged frog populations. Therefore, other laws and regulations continue to have limited ability to protect the species in absence of the Endangered Species Act.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

Pesticides

The Service's 2002 Recovery Plan for the species described pesticide use as a potential significant threat to the species and attributed in part the species' decline in the Central Valley to heavy use of pesticides in the area (Service 2002, pp. 28 –30). Biologists have continued to observe persistence and breeding of California red-legged frog populations in areas of heavy agricultural pesticide use such as near Santa Maria in Santa Barbara County and Watsonville in Santa Cruz County (CNDDB 2022). Laboratory experiments have observed strong negative effects on amphibians from exposure to glyphosate-based herbicides, a specific class of pesticides with polyethoxylated tallowamine surfactant (e.g., Roundup herbicide; Govindarajulu 2008, pp. 3–8). Nevertheless, California red-legged frogs persist in areas of heavy herbicide use such as recreational parks and golf courses and it appears that nearby pesticide use, including

herbicides, do not preclude the presence of California red-legged frogs. However, pesticides may still degrade habitat quality in general by causing algal blooms, reducing the prey base for the species in an area, altering the natural composition of vegetation, or decreasing the cover available to California red-legged frogs. Consequently, the U.S. Environmental Protection Agency has issued regulations prohibiting the application of certain pesticides in and around California red-legged frog habitat (<https://www.epa.gov/endangered-species/how-comply-requirements-protect-california-red-legged-frog-pesticides>). Accordingly, pesticide use remains a potential threat to the California red-legged frog.

Climate Change

The Service's 2002 Recovery Plan for the species specifically identifies drought as a threat to the species (Service 2002, p. 28) and we have incorporated drought into our more general discussion below of threats to the species from climate change. The scientific consensus is that anthropogenic inputs of carbon dioxide and other greenhouse gases are the primary cause of observed rapid global warming over the past century (i.e., climate change). Rapid global warming over the past century also has changed evaporative patterns which can alter patterns of humidity, the amount of rainfall and snowpack, the frequency of severe storms, and the likelihood of severe drought. Scientists expect higher temperatures and more frequent drought conditions to increase the frequency and intensity of wildfires as well.

To date, scientists have observed over the past century an increase in mean annual temperature between 0.5 and 3 degrees Fahrenheit within the range of the California red-legged frog, with a maximum increase of 3 degrees in coastal areas south of San Luis Obispo County (EPA 2016, p. 1). Swain *et al.* (2018, p. 431) predict that climate change will decrease total statewide precipitation only modestly but will increase the frequency of extreme wet and dry years, particularly in Southern California. Additionally, higher temperatures will increase evaporation rates and reduce the amount of surface water available. McHarry *et al.* (2019, pp. 11–12) studied the potential future effects of climate change on species phenology and survival using a latitudinal gradient of field sites and found that climate influenced all life stages of the species including a correlation between maximum temperature and egg mortality.

We expect that ongoing climate change will continue to reduce and degrade available habitat for the species by inducing generally warmer and drier climate conditions throughout the range of the species. Warmer and drier climate conditions will reduce available habitat for the species by reducing water availability and altering hydroperiods of suitable aquatic habitat. Reduced water availability will reduce the number and extent of areas suitable for breeding and development. Thorne *et al.* (2016, Table S4) expect freshwater marsh habitat in California to decrease by up to 64 percent by 2099 as a result of climate change. Additionally, reduced water availability and less frequent precipitation will limit the distance and frequency of long-distance dispersal events by individuals. These long-distance dispersal events are necessary to maintain genetic connectivity between populations and to recolonize areas of suitable habitat following population extirpation. Changes in precipitation patterns may cause higher flows in stream habitats during egg-laying periods and result in more frequent scouring of egg masses and vegetative cover.

Additionally, climate change likely will increase the frequency and severity of wildfires within the range of the California red-legged frog (Bedsworth *et al.* 2018, p. 30). California red-legged

frog populations appear to be resilient to direct effects from wildfire, with populations immediately returning to successful breeding in heavily burned areas following the 2017 Thomas Fire, 2018 Camp Fire, 2018 Woolsey Fire; and 2020 North Complex Fire (P. Lieske, pers. comm. 2021; James Johnson, U.S. Forest Service, pers. comm. 2019; Santa Monica Mountains National Recreational Area 2019, p. 2; James Johnson, pers. comm. 2021). However, habitat degradation from post-fire sedimentation and accumulation of fire-retardant chemicals within inhabited watersheds is likely. We expect these wildfire-related habitat degradation effects on the California red-legged frog will increase over time throughout the species range. Overall, we expect that the threat of habitat degradation from climate change will increase over time on the California red-legged frog throughout the species range.

Combined Effects

The California red-legged frog has suffered wide-scale loss of aquatic, upland, and dispersal habitat as a result of urban, agricultural, rangeland, and water development. The once widespread species is now restricted to isolated stock ponds, wetlands, and creeks frequently located near urban or agricultural areas. Urbanization of land within and adjacent to California red-legged frog habitat threatens populations by introduction of predators and reduction of riparian cover (Hayes and Jennings 1988, p. 152). The spread of invasive predatory species has degraded the quality of many remaining areas of breeding habitat. Concurrently, regional climate warming and drying caused by climate change likely will further reduce the amount and quality of suitable aquatic habitat over time.

Significant Conservation Efforts

Conservation Plans

Habitat Conservation Plans (HCPs) permitted under Section 10(a)(1)(b) of the Act exempt take of listed species in exchange for implementation of sufficient avoidance, minimization, and mitigation measures to provide a conservation benefit to the species as a project outcome. Currently, there are 33 HCPs and one General Conservation Plan that include the California red-legged frog as a covered species. The areas covered by these Conservation Plans total approximately 1,965,493 acres and are located throughout the range of the species including large portions of San Diego, San Joaquin, and Santa Clara Counties. However, large portions of the areas covered by these Conservation Plans, particularly multi-species Conservation Plans in Southern California and the San Joaquin Valley, do not contain suitable habitat for the species. Therefore, these plans together protect some amount less than 1,965,493 acres of the species range.

The Safe Harbor Policy provides incentives for property owners to restore, enhance and maintain habitats for listed species. Because many endangered and threatened species occur exclusively, or to a large extent, on non-Federally owned property, the involvement of non-Federal property owners in the conservation and recovery of listed species is critical to the eventual success of these efforts. There are currently 11 safe harbor agreements that include the California red-legged frog.

The Service's Sacramento Fish and Wildlife Office has developed and implemented the *East Alameda County Conservation Strategy* (EACCS) (EACCS 2011). The EACCS is intended to provide an effective framework to protect, enhance, and restore natural resources in eastern Alameda County, while improving and streamlining the environmental permitting process for impacts resulting from infrastructure and development projects. The EACCS not only addresses project-level mitigation for potential impacts to the California red-legged frog and its habitat throughout the eastern part of the county, but also provides a broader, coordinated approach for local conservation efforts beyond those required by mitigation.

Habitat Restoration

The Service worked with its partners on numerous habitat restoration projects for the California red-legged frog ranging from removal of invasive predators from Las Virgenes Creek in Los Angeles County (Mountains Restoration Trust 2018, p. 26) to construction of ponds on the Eldorado National Forest (US Forest Service 2014, p. 4), Plumas National Forest (US Forest Service 2019, p. 2), Tahoe National Forest (US Forest Service 2020, p. 3), and Bureau of Land Management lands (Service 2004, p. 2; US Bureau of Land Management 2016, p. 3) in the Sierra Nevada. The Service continues to focus its efforts on habitat restoration, particularly as part of translocation projects, and will continue to do so in the future.

Habitat Protection

To calculate the proportion of the species range on protected lands, we compared the species range to areas identified as protected in the California Protected Areas Database (CPAD; GreenInfo Network 2021a) or under a conservation easement in the California Conservation Easement Database (CCED) (GreenInfo Network, 2021b). The CPAD includes national, state, or regional parks forests, preserves, and wildlife areas; large and small urban parks that are mainly open space; land trust preserves; and special district open space lands. CPAD specifically excludes military lands, tribal lands, private golf courses, and public lands not intended for open space such as waste facilities or administrative buildings. The CCED includes easements held by land trusts, nonprofit organizations, local jurisdictions, and State and national governmental agencies. 6,057,310 acres (32.6%) of the total 18,571,388 acres in the species range are on protected lands or lands under a conservation easement. From comparison to the Bureau of Land Management's Land Status Management database (U.S. Bureau of Land Management 2021) an additional 373,740 acres (2.0%) of the species range are on military lands where the species is still protected by the Endangered Species Act Section 7 consultation process to avoid and minimize effects on the species (Cheryl Hickam, U.S. Fish and Wildlife Service, pers. comm. 2022).

Reintroductions

The Service and its partners have reintroduced California red-legged frogs to four localities in the Santa Monica Mountains in Los Angeles and Ventura Counties, to Yosemite Valley in Mariposa County, to two localities on the Santa Rosa Plateau in Riverside County, and one locality in San Diego County. The Santa Monica Mountains and Yosemite Valley populations have successfully bred following reintroduction (Santa Monica Mountains National Recreational Area 2021, p. 12; Kamoroff *et al.* 2020, p. 624). Additionally, the Santa Monica Mountains

populations have persisted despite the catastrophic 2018 Woolsey fire burning all four reintroduction sites (Santa Monica Mountains National Recreational Area 2019, p. 2). In 2020 and 2021, the Service used egg masses from Baja California and Riverside County populations of the species to establish two adjacent reintroduction sites on State and County lands on the Santa Rosa Plateau in Western Riverside County and another reintroduction site on private land in San Diego County (Simonsen, pers. comm. 2021). The Service is also preparing to reintroduce California red-legged frogs to Gravel Pit and Swamp Lakes in Tuolumne County as well.

III. RECOVERY CRITERIA

The Service completed a recovery plan for the California red-legged frog on May 28, 2002. Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to eliminate or reduce threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. For such instances, we may determine that, overall, the threats have been sufficiently addressed, and the species is robust enough to downlist or delist. In other cases, new recovery approaches and/or opportunities unknown at the time a recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

The 2002 Recovery Plan for the California red-legged frog provided the following criteria for consideration of species delisting:

- 1) *Suitable habitats within all 35 core recovery areas designated by the 2002 Recovery Plan are protected and/or managed for the California red-legged frog in perpetuity, and the ecological integrity (e.g., water quality, uplands condition, hydrology) of these areas is not threatened by adverse anthropogenic habitat modification (including indirect effects of upstream/downstream land uses). **This criterion addresses listing factors A, C, and E.***

This criterion has not been met. To calculate the proportion of the core recovery areas on protected lands, we compared the 35 core recovery areas to areas identified by CPAD (GreenInfo Network, 2021a) as protected or identified by CCED (GreenInfo Network, 2021b) as under a conservation easement. 2,741,278 acres (38.6%) of the 7,087,001 acres within all 35 core recovery areas designated by the 2002 Recovery Plan are identified as protected or under conservation easement. From comparison to the Bureau of Land Management's Land Status Management database (U.S. Bureau of Land Management 2021) an additional 111,066 acres (2.0 %) of the 7,087,001 acres within all 35 core recovery areas are on military lands where the species is protected by the Endangered Species Act Section 7 consultation process to avoid and minimize effects on the species

(Hickam, pers. comm. 2022). The Recovery Plan did not define the amount of suitable habitat that would need protection or management in perpetuity in order to assure the ecological integrity of each core area. To assess this criterion, we would likely need further population viability and habitat modeling analyses which also account for projected climate change effects.

- 2) *Existing populations, throughout the range, are stable (i.e., reproductive rates allow for long term viability without human intervention). Because population numbers do not necessarily indicate stability, long term evidence of successful reproduction (e.g., presence of juveniles) and survivorship into different age classes provides a better indication of stability, persistence, and population resilience. Therefore, population status will be documented through establishment and implementation of a scientifically acceptable population monitoring program for at least a 15-year period (four to five generations) that includes an average precipitation cycle (a period when annual rainfall includes average to 35 percent above-average through greater than 35 percent below-average and back to average or greater; the direction of change is unimportant in this criterion). **This criterion addresses listing factors A, C, D and E.***

This criterion has not been met. As described above, demonstrating population stability to meet the criterion requires long-term population monitoring programs and the few population monitoring programs currently in place have not yet met the 15-year monitoring period requirement. Fortunately, the introduction of egg mass surveys (Wilcox *et al.* 2017, p. 70) as a less difficult alternative to visual encounter surveys for determining population abundance likely will facilitate implementation of new and existing long-term monitoring programs.

- 3) *Populations are geographically distributed in a manner that allows for the continued existence of viable metapopulations despite fluctuations in the status of individual subpopulations (i.e., when populations are stable at each core area). **This criterion addresses listing factors A, C, and E.***

This criterion has not been met. Coastal populations south of Santa Barbara County are isolated from one another by impassible distances and therefore cannot exchange migrants with neighboring populations and maintain a metapopulation dynamic (Richmond *et al.* 2013, p. 818). Populations in the Sierra Nevada region also are isolated from one another by impassible distances and cannot maintain a metapopulation dynamic (Richmond *et al.* 2014, p. 134). However, populations in the Bay Area region have retained some amount of genetic connectivity and could potentially maintain a metapopulation structure (Richmond *et al.* 2014, p. 134).

- 4) *The subspecies is successfully reestablished in portions of its historical range such that at least one reestablished population is stable/increasing in each core area where frogs are currently absent. **This criterion addresses listing factors A and E***

This criterion has not been met. Following listing the Service and its partners have successfully re-introduced the species to core recovery area 32 in San Diego County and the species currently occurs in 30 of 35 core recovery areas. The species remains absent

in core recovery area 30 located in San Bernardino County; 31 located in Orange and Riverside Counties; and 33, 34, and 35 all located in San Diego County.

- 5) *The amount of additional habitat needed for population connectivity, recolonization, and dispersal has been determined, protected, and managed for the California red-legged frog. There will be varying scales of connectivity needed including at the level of a local population (i.e., connectivity of habitat within a drainage) up to the needs of a metapopulation (many linked drainages over large regions such as recovery units). This will provide dispersal opportunities for population viability, genetic exchange, and recolonization. **This criterion addresses listing factors A, C, and E.***

This criterion has not been met. Populations in coastal areas south of Santa Barbara County remain isolated from one another and the areas necessary for population connectivity are not protected or managed for the California red-legged frog. The Recovery Plan did not define the amount of population connectivity necessary to maintain a metapopulation structure across many linked drainages. Quantifying the required level of connectivity to maintain a metapopulation structure would require population viability analyses and further field study of long-distance dispersal and subsequent gene flow between drainages.

IV. SYNTHESIS

Over the past century, the California red-legged frog has lost 57 percent of its historical range and its remaining range is threatened by anthropogenic development, invasive predators, and climate change effects. Additionally, the formerly contiguous species range is now reduced to three genetically distinct, geographically disjunct areas (coastal areas north of Ventura County, coastal areas south of Santa Barbara County, and the Sierra Nevada region). Coastal populations south of Santa Barbara County and Sierra Nevada populations have lost genetic connectivity among themselves and may be particularly vulnerable to species threats. Climate change effects will reduce habitat quality and quantity throughout the species' range, and further impede connectivity between populations. To date, the species has not met any of the delisting criteria presented in the Service's 2002 Recovery Plan though the species has proven resilient to numerous potential threats such as chytrid fungus and catastrophic wildfires. Approximately 32.6 percent of the species range are in protected areas or land under conservation easement and an additional 2.0 percent of the range is on military lands where activities must undergo a Section 7 consultation process to avoid or minimize effects on the species. Additionally, numerous habitat restoration efforts are underway and translocation efforts have proven consistently successful.

After reviewing the best available scientific information, we conclude that the California red-legged frog continues to meet the definition of a threatened species and recommend no change in its status at this time.

V. RESULTS

RECOMMENDED LISTING ACTION

Downlist to Threatened

Uplist to Endangered

Delist (indicate reason for delisting according to 50 CFR 424.11):

Extinction

Recovery

Original data for classification in error

No Change

NEW RECOVERY PRIORITY NUMBER AND BRIEF RATIONALE

No change in recovery priority number.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

The following are recommended actions to promote the recovery of the California red-legged frog over the next five years.

1. Develop a range-wide long-term monitoring plan to evaluate if populations are stable and increasing, including specific long-term study sites.
2. Conduct studies to determine population sizes and locations sufficient to maintain metapopulation structures within core recovery areas.
3. Continue to remove non-native predators such as American bullfrog and other invasive species such as giant reed from California red-legged frog habitat throughout the species range.
4. Continue to promote habitat restoration and reintroduction efforts to restore population redundancy and metapopulation structure particularly in coastal populations south of Santa Barbara County to northern Baja California as well as populations within the San Joaquin Valley and adjacent foothills.
5. Work with private landowners to further conservation of California red-legged frog on private lands in the Sierra Nevada. This may include recording conservation easements on non-protected lands that support populations, acquiring occupied private lands from willing landowners, and increasing surveying efforts on private lands to better understand species distribution and recovery opportunities.
6. Continue to research habitat use and movement of California red-legged frog in the Sierra Nevada.
7. Continue to promote habitat protection and conservation in Mendocino County at the northern extent of the species range, and formally standardize a Service-approved protocol for eDNA surveys so the species status can be accurately studied and distinguished from the similar sympatric species, Northern red-legged frogs (*Rana aurora*).

8. Investigate “food safety” policies implemented by agricultural commodity buyers, and subsequently farmers, that result in the removal of natural riparian or terrestrial vegetation adjacent to farm fields for the purpose of stemming contaminate outbreaks.

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**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW**

California Red-Legged Frog (*Rana draytonii*)

Current Classification: Threatened


Recommendation Resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Review Conducted By: Sacramento Fish and Wildlife Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Sacramento Fish and Wildlife Office

Approve **MICHAEL FRIS**  Digitally signed by MICHAEL FRIS
Date: 2022.12.01 13:20:45 -08'00' _____ Date _____