



Protocol for the reintroduction of California Red-legged Frogs to Santa Monica Mountains National Recreation Area

Natural Resource Report NPS/SAMO/NRR—2023/2507





ON THIS PAGE

A California red-legged frog in a stream at night
NPS/SARAH WENNER

ON THE COVER

A California red-legged frog in hand
NPS/SARAH WENNER

Protocol for the reintroduction of California Red-legged Frogs to Santa Monica Mountains National Recreation Area

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Executive Summary

Once common and widespread in Southern California, California red-legged frogs (*Rana draytonii*) began declining sometime in the middle of the 20th century. They were listed as threatened under the Endangered Species Act in 1996. Three small and isolated populations remained in Los Angeles and Ventura Counties by the start of the 21st century. The nearest population of California red-legged frogs to Santa Monica Mountains National Recreation Area is critically small, located 15 km to the north, yet there is evidence of persistence, including successful reproduction each year it has been measured. A potential solution to alleviate small population size and isolation is to reintroduce a species back to habitable historical locations nearby. In 2011, we initiated a project to reintroduce California red-legged frogs back to the Santa Monica Mountains, where historical records showed they were once widespread. We developed a procedure to transfer partial egg masses into tadpole rearing pens located within streams determined to be suitable for the species. This translocation protocol outlines our procedure and results for the first five years of the project. It is our hope that this protocol will guide and inform similar conservation efforts for California red-legged frogs in other parts of their range as well as other amphibian conservation efforts throughout the world.

Acknowledgments

A project of this scale only comes to fruition and forges ahead with a large team of cooperators. We thank Chris Dellith, Cat Darst, Eric Morrisette, and Chris Kofron from the Ventura office of U.S. Fish and Wildlife Service for initial project planning and inspiration, permitting, expertise, support, and funding. We thank Mark Abramson and Jack Topel of California Water Boards for sharing expertise, providing water quality data for streams of interest, and generous funding. We thank Estelle Sandhaus, Devon Pryor, Nadya Seal Faith, Mark Huelly, Kelly Garner, Will Macias, Martin Hanson, and Cassie Funk from the Santa Barbara Zoo for invaluable expertise, enthusiasm, and many hours of volunteer field work. We thank Santa Monica Mountains NRA Superintendent David Szymanski and former Chief of Planning, Science, and Resource Management Christy Brigham for funding support. We thank California Coastal Conservancy for generous funding. We thank Chris Trumpy and Mountains Recreation and Conservation Authority for support and land access permission. We thank Suzanne Goode, Jamie King, and Danielle LeFer from California State Parks for support and land access permission. We thank all National Park Service wildlife interns who have helped the frog team throughout the project's planning and implementation. We thank Diane R. Elam and two anonymous reviewers for comments on earlier drafts of the protocol. We thank Keith Lombardo for comments on previous drafts and for acting as peer review manager to facilitate this protocol's publication.

Introduction

The worldwide decline of amphibian species has made headlines for over 40 years. In early 1990, a group of scientists from around the world met to discuss alarming trends in amphibian abundances in seemingly remote areas as well as in response to human disturbance. This meeting culminated in the publication of a review paper documenting amphibian declines and triggering widespread research and recovery efforts (Blaustein and Wake 1990). Among the earliest identified declines were the Southern California populations of the then-named red-legged frog (*Rana aurora*), now recognized as a distinct species, the California red-legged frog (*Rana draytonii*). Once common and widespread in Southern California, California red-legged frogs began declining sometime in the middle of the 20th century. The last known sighting was in the mid-1970s (De Lisle et al. 1987). They were listed as threatened under the Endangered Species Act in 1996 (U.S. Fish and Wildlife Service 1996). Three small and isolated populations remained in Los Angeles and Ventura Counties by the start of the 21st century (Richmond et al. 2013). One of these populations, in the Simi Hills region near Santa Monica Mountains National Recreation Area (SAMO), was discovered in 1999 and the surrounding open space was designated as park land by the State of California and protected under the Mountains Recreation and Conservation Authority. This population consists of around 100 adult frogs, with other life stages co-existing at various densities. It is critically small, yet there is consistent evidence of successful reproduction each year it has been measured (USGS unpublished data summaries available upon request).

The California red-legged frog (*Rana draytonii*) ranges from northern California to Northwest Baja California, Mexico, and was once widespread and abundant throughout its range (Jennings and Hayes 1985). The exact causes of their decline and disappearance from most of Southern California and the Santa Monica Mountains are unknown; however, several causes of decline have been identified in other parts of their range. California red-legged frogs have declined because of habitat destruction (De Lisle et al. 1987, Jennings and Hayes 1988, 1994), the amount of agricultural land upwind (Davidson 2004), the introduction of non-native species, particularly bullfrogs (*Rana catesbeiana*) (Hayes and Jennings 1986, Jennings and Hayes 1988, Fisher and Shaffer 1996, Lawler et al. 1999, Cook and Jennings 2007, D'Amore et al. 2009, 2010), and possible disease (Padgett-Flohr 2008, James et al. 2009, Peralta-García et al. 2018, Adams et al. 2020). Populations of California red-legged frogs were once exploited as food (Jennings and Hayes 1985). Bullfrogs are native to the eastern United States and were introduced possibly in response to California red-legged frog scarcity and documented harvest decline in the late 1800s (Jennings and Hayes 1985).

A potential solution to alleviate small population size and isolation is to reintroduce a species back to habitable historical locations nearby. Reintroduction, via translocations, is a common technique for the conservation of amphibian species, though its success and suitability for some species has been debatable (Germano and Bishop 2008). In 2011, we initiated a project to reintroduce California red-legged frogs back to the Santa Monica Mountains, where historical records showed they were once widespread (Figure 1, De Lisle et al. 1987). The U.S. Fish and Wildlife Service (USFWS) published a species recovery plan for California red-legged frogs in 2002 which defined actions “to reduce threats and improve the population status of the California red-legged frog sufficiently to warrant

delisting” (U.S. Fish and Wildlife Service 2002). Appendix G of the Recovery Plan specifically states that reintroduction should be considered in Recovery Unit #8, Southern Transverse and Peninsular ranges. This recovery unit includes SAMO.

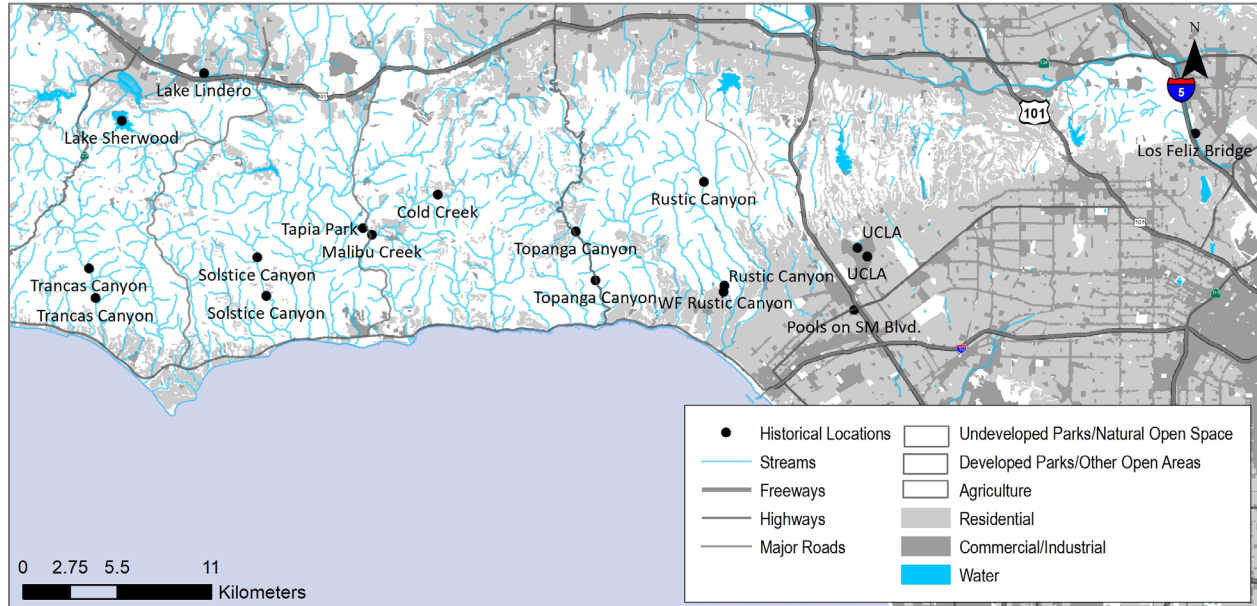


Figure 1. Documented historic locations of California red-legged frogs in the Santa Monica Mountains and surrounding regions. Note that some historical locations are approximate based on points taken from paper maps and some are museum records (see Table 1).

Table 1. The location, year collected, and collection locations of museum specimens of California red-legged frogs in the Santa Monica Mountains and surrounding regions.

Stream/Location Name	Year Collected	Individuals Collected
Trancas Canyon	1964	14
Solstice Canyon	1964	4
Tapia Park	1947	1
Topanga Canyon	1947	5
Rustic Canyon	?	2
UC Los Angeles	1937	1
UC Los Angeles	?	1
Pools on Santa Monica Blvd.	?	2
Los Feliz Bridge (LA River)	1925	2

Project Creation and Goals

We began the project by developing partnerships and collaborations with biologists and other local experts on streams, amphibians, and reintroductions. Some key partners are co-authors of this protocol, but others involved in the initial planning process are Chris Dellith (USFWS Ventura), Mark Abramson and Jack Topel (California Waterboards), and Suzanne Goode (California State Parks). In addition, we reached out to Paul Johnson who had successfully reintroduced California red-legged frogs to a historical location in Pinnacles National Park. Based on early meetings with this group and on Paul Johnson's successful protocol, we developed this protocol specific to the Santa Monica Mountains. After a literature review, museum record search (Table 1), meetings with local experts and partners, guidelines suggested by USFWS and the species recovery plan (U.S. Fish and Wildlife Service 2002), we developed a specific set of goals outlined below. With these, we could develop an associated yearly budget and determine personnel needs.

As a conservation action to reintroduce California red-legged frogs, the USFWS Recovery Plan for the species recommends translocation of eggs from an appropriate source population to suitable habitat. The goals of the project were to 1) determine fresh water bodies in Santa Monica Mountains NRA that would be suitable for reintroduction, 2) conduct egg mass translocations from the source population to all suitable reintroduction sites for five consecutive years, 3) feed tadpoles after hatching in protective pens and release when grown to a size likely to evade predation by the California newt (*Taricha torosa*), and 4) conduct day and nighttime surveys at reintroduction sites to look for California red-legged frogs of all life stages. The expected result of this effort was to create multiple self-sustaining, breeding populations of California red-legged frogs.

Methods

Source Population

Because there was no extant population of California red-legged frogs in the Santa Monica Mountains, we assumed that the nearest population would have been the closest genetically to the extirpated populations. The source population, located in the Simi Hills region, was less than 15 km from the center point of the mountains, although significant barriers to dispersal exist in between. This population shows persistence and successful reproduction each year despite its isolation and low genetic diversity (Richmond et al. 2013, 2014). A capture-mark-recapture analysis from 2013 estimated approximately 100 adults in the source population (USGS unpublished data). In addition, egg mass counts, used as a proxy to estimate adult population size (Crouch and Paton 2000, Campbell Grant et al. 2005, Fellers et al. 2017), consistently suggest an even higher number of adults (USGS data reports available upon request).

We obtained a recovery permit from the USFWS to work with California red-legged frogs in the study area. Our USFWS Recovery permit allows us to translocate up to 10% of the eggs found at the source population. Given the large number of egg masses (13-year average of 47 egg masses) and small amount of available habitat for frogs at the source site, this number does not impact source population persistence.

Translocation Site Selection

To find historical locations where California red-legged frogs were present in or near the Santa Monica Mountains, we accessed HerpNet.org in September 2010 (now VertNet.org). We used the information available at the time to inform our methods. We found 32 specimens collected between 1925 and 1964 (Table 1). These specimens are part of the Los Angeles County Natural History Museum's permanent collection.

California red-legged frogs are adapted to Southern California's Mediterranean climate and associated temporal and spatial changes in water flow and habitat quality. However, to maximize the success of the project, we sought re-introduction streams and stream segments that maintained water year-round, thus maximizing the potential for successful breeding, egg-laying, tadpole growth, froglet development, and sub-adult and adult survival. We sought aquatic habitat with deep (0.5-0.7 m), still or slow-moving, perennial water maintained this way through the entire tadpole rearing season (January to August) with good hiding places for escape cover such as bank overhangs (Hayes and Jennings 1988). Emergent vegetation provides cover and egg attachment sites (Alvarez et al. 2013). Habitat requirements for froglets or over-wintering larvae (very rare but present in the source population) during the non-breeding (dry season) include perennial water at least 0.5 m deep.

Upland habitat surrounding aquatic sites was an important factor in choosing translocation streams, given that the diet of California red-legged frogs consists mostly of terrestrial invertebrates (Hayes and Tennant 1985, Bishop et al. 2014). Aquatic habitats sometimes dry during the fall, making damp leaf litter or small mammal burrows important refugia for adults (Jennings and Hayes 1994). If habitat between streams is urbanized, it is unlikely that there can be dispersal of adult frogs, therefore potential dispersal routes between water bodies was taken into consideration when choosing

relocation sites. In the Santa Monica Mountains, however, few canyons remain connected by ridgetops lacking human development impacts.

The specific causes of California red-legged frogs extirpation in the Santa Monica Mountains are unknown, but the loss seems to have coincided with an increase in urban development and human population density during the mid-20th century. Increased human population meant habitat destruction, pesticides, non-native invasive species, and possibly chytridiomycosis (an infection caused by chytrid fungus, *Batrachochytrium dendrobatidis*). Non-native invasive species that represent a threat to a successful translocation of California red-legged frogs are non-native fish, bullfrogs (*Rana catesbeiana*), red swamp crayfish (*Procambarus clarkii*), and possibly New Zealand mudsnails (*Potamopyrgus antipodarum*). Non-native fish, bullfrogs, and crayfish are all known to depredate eggs and larvae of California red-legged frogs in other areas (Hayes and Jennings 1986, Lawler et al. 1999, Kiesecker et al. 2001, Davidson 2004, D'Amore et al. 2009). Habitat destruction continues to threaten potential sites for reintroduction of California red-legged frogs, where suitable upland stream habitat is important to provide cover and food for local and dispersing adults (Bulger et al. 2003, Fellers and Kleeman 2007). Diseases, pesticides, and declining water quality may also remain a threat (Berger et al. 1998, Davidson 2004, Padgett-Flohr 2008, Adams et al. 2020).

We met with local stream ecology experts and used information from Santa Monica Mountains NRA's aquatic amphibian long-term monitoring project, part of the NPS Inventory & Monitoring Program, to choose approximately 30 stream segments to assess suitability for California red-legged frogs (Riley et al. 2005, Delaney et al. 2011). We visited sites initially and took data on stream and habitat conditions to determine if a revisit was warranted (field forms available upon request). If the site was not eliminated as unsuitable, we visited the site two times per year (one wet season and one dry season) from spring 2012 to fall 2013. Although the process was generally subjective, we used a scoring system (Appendix A) to rank the suitability of stream sites based on stream and upland habitat as well as accessibility and land ownership. After two years, we compiled the stream scores and notes, and had discussions with our partners to rank and prioritize sites for reintroduction.

We determined that seven stream locations in the Santa Monica Mountains would be suitable for reintroduction. Two sites were on Federal property owned by the National Park Service. Five sites were outside of NPS-owned property, therefore we needed to work with property owners to obtain permission for the project. In support of our project USFWS and California State Parks signed a Safe Harbor Agreement allowing us to consider four of the five sites. One non-Federal property owner did not wish to be included in the project and was dropped.

Pre-translocation Egg Mass Surveys at Source Site

The goal of these surveys was to determine how many egg masses were laid to determine how many partial egg masses could be translocated. Beginning in 2009 and continuing every year since then, egg mass surveys were conducted during the daytime, every 10 days to 3 weeks, beginning in early February, which is the typical start of breeding at the source site. Egg mass surveys began at the same starting point in the stream each time and 1 – 3 observers moved upstream slowly looking for egg masses on emergent vegetation, sticks, and other substrate, looking carefully to avoid stepping

on larvae or disturbing egg masses. Within the season, we continued to conduct surveys until no more (or only few) new egg masses were found, which usually fell around late March.

We placed a numbered flag near each egg mass found and noted the substrate upon which it was laid. Using a meter stick, we measured (in cm): 1) the width of the egg mass at the widest place; 2) the depth of the water below the egg mass; 3) the depth that the egg mass rested below the water's surface; and 4) the distance from the egg mass to the nearest bank or shore. We took photos of each egg mass and determined the approximate date it was laid. Upon subsequent surveys, the approximate hatching date (typically 10–14 days) could be determined by using the laying date that was recorded on previous surveys.

Egg masses were chosen for translocation based on large size and appropriate level of development for the time we chose to complete the translocation. Egg masses that were designated for translocation were typically moved after 7–10 days since laying.

Translocation Procedure

Pen construction

We transferred partial egg masses to tadpole rearing pens that we constructed out of common materials. We constructed cubes using approximately 6–8 m of $\frac{3}{4}$ inch PVC pipe and 8 Side Outlet Elbow $\frac{3}{4}$ inch PVC Fittings. Each side of the cube was approximately 50–60 cm long. Each cube was covered completely with pet resistant fiberglass screen mesh. The mesh screening was tightly zip-tied to the PVC cube. We sewed a Velcro-enclosed flap door on the top of each cube. Two empty sealed water bottles were secured with zip-ties to the inside top of the pen so that it would float on the surface of the stream. The tadpole rearing pen must be well-closed so that aquatic macroinvertebrate and other predators cannot enter, and tadpoles cannot escape. Pens were placed in the water at translocation sites several weeks before egg mass transfer to allow for algal growth that tadpoles could feed on after hatching.

Egg mass collection

We located egg masses flagged during earlier surveys and determined their suitability for harvest. We considered the approximate age of the egg mass, which was based on the size and Gosner stage of embryos, and the date of detection. Ideally, egg masses should be harvested and transferred several days before hatching, in Gosner stage 18 or 19. If egg masses are harvested too close to hatching, they may hatch prematurely from vibrations and agitation during egg separation and transfer.

Partial egg masses (approximately half of the mass) were collected, usually from mid-February to mid-March, by gently separating clumps of eggs by hand (Figure 2). The part of the egg mass not attached to any substrate (e.g., willow roots, cattails, emergent sticks) can be pulled away and clumps of eggs separated. We placed eggs in a disposable Tupperware container filled with stream water. Once the eggs were harvested, the container was labeled and immediately placed into a small cooler with ice packs and packing material for stabilization. We noted the temperature of the stream water (°C) at the time of harvest using handheld thermometers. Approximately every 30 minutes, we took

the temperature of the water in the Tupperware container, making sure it was similar to the temperature of the source stream water.



Figure 2. California red-legged frog egg masses with nearby flagging marking the date of detection and a unique number. Partial egg masses are harvested by gently pulling clumps of eggs apart by hand (NPS)

Egg Mass Translocation

It was important to minimize the travel time between source and translocation sites. Travel between our sites was a combination of driving and hiking and took 2–4 hours. Upon arrival at the translocation site, we took the temperature of the stream water. Each Tupperware container was placed in the stream for approximately 15 minutes to allow for temperature equilibration.

One partial egg mass was placed into each pen. To position the egg mass near the top of the tadpole rearing pen, we placed it in a mesh bag (“intimates wash bag”) (Figure 3). The mesh bag was zip-tied to the inner top of the tadpole rearing pen to mimic the egg mass’s original position near the water surface. One partial egg mass was added to each tadpole rearing pen.



Figure 3. California red-legged frog eggs being poured into the mesh bag before it was placed within the tadpole rearing pen (NPS)

Tadpole Rearing and Release

Tadpoles usually hatched within a week of the translocation. The mesh of the bag was wide enough to allow newly hatched tadpoles to swim out into the enclosed tadpole-rearing pen. After a few days, we opened the mesh bag and left it attached to avoid trapping the growing tadpoles within the secondary bag. For about 7–14 days, tadpoles fed on the remnants of the egg mass and algae growing on the pen itself.

After egg mass transfer, each pen was checked 2–3 times per week until tadpoles were released several months later. Each visit, we assessed growth and health of tadpoles and removed any

deceased individuals. Dead tadpoles were collected and placed in 1.7 mL microcentrifuge tubes filled with 95% ethanol. We took 4 – 6 photos of tadpoles within each pen as well as keeping general notes on activity and growth. Immediately after hatching and for a week or two, tadpoles were small and fed solely on algae that had grown on the inside of the tadpole rearing pens. As the tadpoles grew, we supplemented their diet during each visit. Based on the size and number of tadpoles, we fed each pen 20–200 algae rounds (Hikari brand and similar), 1–2 Tbsp of tadpole food (Zoo Med Aquatic Frog and Tadpole Food), and 1–3 leaves of organic romaine lettuce that we crushed by hand for easier consumption by tadpoles.

Tadpoles were released when we deemed most of them large enough to avoid predation by California newts (*Taricha torosa*). Due to the differential growth and development of tadpoles within a rearing pen, some tadpoles were still very small at the time of release. At the time of release, 10–20 tadpoles were measured using a clear plastic ruler. We measured in mm the length of the head and total tadpole length, and we evaluated Gosner stage. All tadpoles were counted and released in the pool with the pen or pools adjacent within the same stream segment.

Surveys

After release of tadpoles from the rearing pens, we conducted weekly visual encounter surveys. We conducted the surveys during the day, starting several hundred meters downstream of tadpole release sites. Upon entering, we walked up the stream corridor searching for amphibians in water and on the banks. We used dip nets if needed to identify tadpoles and took photographs of habitat and amphibians occasionally. We reduced the frequency of surveys throughout the late summer, fall, and winter. During the later months we surveyed for metamorphosing tadpoles, over-wintering tadpoles, and metamorph froglets. Location data, counts of frogs at each life stage, other notable species, and general habitat notes were recorded during each survey.

Frogs were assumed to be breeding age at two years old; therefore, egg mass surveys at each site were initiated two years after the first translocation at each site and were conducted yearly thereafter. Weekly or biweekly egg mass surveys were conducted at the source and translocation sites from February through April of each year. At irregular intervals, we also conducted night surveys to measure and mark (PIT-tag) adult and subadult frogs at each site and to swab individuals for Bd (*Batrachochytrium dendrobatidis*), the causative agent of the amphibian disease chytrid fungus.

Measures of Progress

The project's goals are to increase the number of frogs, increase the number of sites where frogs are found, and to establish self-sustaining breeding populations of California red-legged frogs at Santa Monica Mountains NRA. The USFWS Recovery Plan for this species recommends at least five years of translocations per site if possible. We have completed the five years at two of our four sites (Table 2). After the November 2018 Woolsey fire, the largest wildfire ever recorded in the Santa Monica Mountains, we made adjustments to the project because of habitat changes, as well as compensations for the worldwide Covid-19 pandemic since 2020. Since November 2018, we have adapted our translocation schedule and process in ways that are beyond the scope of this protocol.

Table 2. Yearly summary of the Santa Monica Mountains California red-legged frog translocation project showing total number of creeks used as translocation sites, total number of tadpole rearing pens, number of tadpoles released in each creek, and whether froglets, subadults, adults, and wild egg masses were found in each creek.

Location or Action Taken	2014	2015	2016	2017	2018
Creeks	2 ^a	2 ^a	4 ^b	4 ^b	4 ^b
Pens	4	5	7	7	7
Tadpoles Released	849	1301	2036	3819	2618
Froglets	✓	✓	✓	✓	✓
Subadults	–	✓	✓	✓	✓
Adults	–	–	✓	✓	✓
Wild egg masses	–	–	–	✓	✓

^a Sites 1 and 2.

^b Sites 1, 2, 3, and 4.

^c A checkmark (✓) indicates that action took place that year and an endash (–) indicates that it did not.

Monitoring of translocated animals is valuable to evaluate the success of translocations and protocols used. We conducted regular daytime surveys to detect tadpoles after release. During these surveys we learned when metamorphs were first detected (August) within the season. Nighttime surveys were done to conduct simple counts of subadults and adults. Estimates of population size at each translocation site are informative, either through capture-mark-recapture or egg mass surveys, which can serve as a proxy for adult reproductive female population size.

After two years, if adults were present, we conducted egg mass surveys at each translocation site. Egg mass surveys were conducted every 10–14 days from early February until mid-April at each of our sites. California red-legged frogs at one site bred on their own three years after the first translocation, while frogs at another other site reached the same milestone after four years. This

suggests that California red-legged frogs at our site reach sexual maturity as early as three years after hatching but that it may take up to a year longer.

Additional Considerations

Many implementing amphibian translocation projects have partnered with zoos which can provide a range of support, including species expertise, field work help, and captive breeding programs. After the Woolsey fire, our partners at the Santa Barbara Zoo provided a space to house egg masses and rear tadpoles for release. In 2019, we feared that habitat degradation due to the Woolsey fire and subsequent debris flows would severely limit the success of California red-legged frog breeding at the source population. Therefore, in March 2019, we harvested 4 partial egg masses according to this protocol and transported them to two aerated, temperature-controlled tanks in a clean room at the Santa Barbara Zoo. The egg masses hatched, and the tadpoles were fed by Santa Barbara Zoo staff for approximately 6 weeks. Two of our four translocation sites that had recovered minimally from the fire were selected as the release sites for these tadpoles. We transferred tadpoles from the Santa Barbara Zoo water tanks to food-safe 5-gal buckets with lids. An aeration stone and portable motor were added because of longer travel times and the large number of tadpoles. Because of the large volume of water, we did not have to adjust temperature during transport, however, if during travel time the temperature was likely to increase by several degrees, a cooler would have been employed to maintain water temperature. Zoo-reared tadpoles were released into two sites, and subsequent surveys confirmed that some survived into the summer to morph into froglets.

Biosafety Precautions

To reduce potential spread of invasive New Zealand mudsnails, we follow a cleaning procedure that involves freezing all gear (nets, pants, Texas, and socks) for 36 hours prior to washing. To reduce risk of spreading Bd, gear was rinsed with a 10% Bleach solution prior to washing and reuse (an example of the protocol can be found here:

https://www.fws.gov/sites/default/files/documents/MYLF%20Attachment%204_Decon%20Protocol.pdf).

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Appendix A

Scoring streams as breeding habitat for California red-legged frogs (*Rana draytonii*) in Santa Monica Mountains NRA and Simi Hills.

Based on N. J. Scott and G. B. Rathbun's "Management guidelines for the California red-legged frog", Elkhorn Slough Training Program, February 2009.

http://www.elkhornsloughctp.org/reference/subissue_detail.php?SUBISSUE_ID=37

The scoring system is based on experience of N. J. Scott, G. B. Rathbun, and others, and literature reviews. Although this is a number-based scoring system, it is generally subjective (Table A1).

Table A1. The California red-legged frog breeding habitat scoring system used at Santa Monica Mountains National Recreation Area.

Metric	Conditions	Points Available
Pool duration (through July or August) ¹	Pools with tadpole habitat present through August	5
	Pools do not hold water through July most years	0
Distance to other breeding areas ¹	Two or more breeding sites within 500 m	5
	No other breeding sites within 2 km	0
Water Flow ¹	No flow (ponds or pools in creek)	5
	Yearly flushing flows	0
Pool depth	Pools >0.7 m	3
	Pools <0.7 m	0
Pool persistence	Dries up in fall at least every 2-4 years ²	2
	Never dries up	0
Summer water temperature ³	Around 70°F (surface temp may be higher)	5
	Below about 60°F	0
Egg and tadpole rearing area	Greater than 0.1 ha (1000 m ³)	5
	Less than 0.01 ha (100 m ³)	0

¹If any of these criteria are consistently scored 0, frogs will probably not breed in these habitats.

² Periodic drying allows for eradication bullfrogs or crayfish.

³ Water temperature sensitivity was shown in a population of CRLF in Pescadero Marsh between San Francisco and Monterey (D. K. Reis, M.S. thesis, 1999). Sensitive to temperatures > 70°F.

⁴ Refuges include emergent bank vegetation, undercut banks, semi-submerged root balls, nearby small mammal burrows, and grassland seeps or springs.

⁵ It is unknown how important this factor is for Santa Monica Mountains locations where we will probably not be surveying "ponds".

Table A1 (continued). The California red-legged frog breeding habitat scoring system used at Santa Monica Mountains National Recreation Area.

Metric	Conditions	Points Available
Summer/juvenile refuges ^{1,4}	Summer/juvenile refuges at site or within 200 m	2
	Summer/juvenile refuges >2 km away	0
Metamorph habitat ¹	Aquatic micro-habitat with good cover ⁴ and few adult CRLF or bullfrogs	3
	No cover and abundant adults or other predators	0
Pond nutrients ^{1, 5}	High level of nutrient input (livestock, sewage, fertilizer)	5
	Low level of nutrient input (deep well, spring water)	0
Aquatic vegetation	Mosaic of open and vegetated water (a rocky cobble substrate can substitute for vegetation in a stream)	5
	Choked with vegetation	2
	No vegetation	0
Exotic fish present, cover for frog escape from fish ¹	No fish	5
	Mosquitofish or crayfish	3
	Fish present, little cover for tadpoles	0
Bullfrogs	No bullfrogs	3
	Bullfrogs abundant and reproducing	0
New Zealand mudsnails	NZMS absent	1
	NZMS present	0
Urban proximity	Urban development further than 1 km	1
	Urban development closer than 200 m	0
Urbanization in watershed	0-8% upstream urbanization	2
	9-100% upstream urbanization	0

¹If any of these criteria are consistently scored 0, frogs will probably not breed in these habitats.

² Periodic drying allows for eradication bullfrogs or crayfish.

³ Water temperature sensitivity was shown in a population of CRLF in Pescadero Marsh between San Francisco and Monterey (D. K. Reis, M.S. thesis, 1999). Sensitive to temperatures > 70°F.

⁴ Refuges include emergent bank vegetation, undercut banks, semi-submerged root balls, nearby small mammal burrows, and grassland seeps or springs.

⁵ It is unknown how important this factor is for Santa Monica Mountains locations where we will probably not be surveying "ponds".

Table A1 (continued). The California red-legged frog breeding habitat scoring system used at Santa Monica Mountains National Recreation Area.

Metric	Conditions	Points Available
Accessible to public	Far from trails, unlikely that people would go near site	5
	Close to trail, busy parkland, etc.	0
Agriculture proximity (pesticide exposure)	Agriculture or winery not upstream within 2 km	2
	Agriculture or winery upstream/near watershed within 2 km	0

¹If any of these criteria are consistently scored 0, frogs will probably not breed in these habitats.

² Periodic drying allows for eradication bullfrogs or crayfish.

³ Water temperature sensitivity was shown in a population of CRLF in Pescadero Marsh between San Francisco and Monterey (D. K. Reis, M.S. thesis, 1999). Sensitive to temperatures > 70°F.

⁴ Refuges include emergent bank vegetation, undercut banks, semi-submerged root balls, nearby small mammal burrows, and grassland seeps or springs.

⁵ It is unknown how important this factor is for Santa Monica Mountains locations where we will probably not be surveying “ponds”.

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