



Bennett, Jesse &lt;jesse\_bennett@fws.gov&gt;

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## Peer Review of Draft Recovery Plan

2 messages

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**Bennett, Jesse** <jesse\_bennett@fws.gov>  
To: Jeff Lemm <jlemm@sandiegozoo.org>

Thu, Aug 9, 2018 at 10:02 AM

Dear Mr. Lemm

We recently completed a draft recovery plan for the conservation and recovery of the southern California distinct population segment of the mountain yellow-legged frog (*Rana muscosa*) and the notice of availability published in the *Federal Register* on July 19, 2018. Upon publication of the notice, a 60-day comment period was opened. This comment period closes on September 17, 2018. In order to assure that the U.S. Fish and Wildlife Service (Service) uses the best biological and commercial data available to recover threatened and endangered species, it is our policy to solicit reviews on recovery plans from the scientific community. We value your input and are seeking your comments as part of our evaluation process.

We understand that you have a considerable workload and invite you to review this document and associated documents including the (1) the species biological report, (2) the recovery implementation strategy, and (3) draft recovery plan. If you are unable to complete a comprehensive review we ask that you focus your attention on a few specific questions that are particularly germane to the recovery of this species:

1. Do you have comments or concerns regarding the proposed recovery criteria?
2. Do the recovery action priorities presented in the Implementation Schedule reflect a biologically sound conservation approach for mountain yellow-legged frog recovery?
3. Are there important recovery actions which have not been included?

Please forward your comments to our office by September 17, 2018. You may submit these comments by mail to the Carlsbad Fish and Wildlife Office or electronically to [Jesse\\_Bennett@fws.gov](mailto:Jesse_Bennett@fws.gov). If you would like to review the draft recovery plan, but are unable to complete your assessment during this time period, please let us know when we may anticipate receiving your comments.

On behalf of the U.S. Fish and Wildlife Service, I thank you in advance for your time and help in making this recovery plan a success. If you have any questions, please contact me at 760-431-9440, extension 305.

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U.S. Fish and Wildlife Service  
Carlsbad Fish and Wildlife Office  
2177 Salk Avenue, Suite 250  
Carlsbad, California 92008  
(760) 431-9440 ext 305

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### 3 attachments

**RPI MYLF RIS.pdf**  
504K

**RPI\_Draft MYLF RP.pdf**  
4163K

**RPI\_Draft MYLF SR.pdf**  
2259K

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**Jeff Lemm** <JLemm@sandiegozoo.org>  
To: "Bennett, Jesse" <jesse\_bennett@fws.gov>

Thu, Sep 13, 2018 at 12:18 PM

Hi Jesse-

Thanks for the opportunity to review. I think this is a fantastic document! I don't have much to say other than I didn't see Omaha listed as one of the zoos doing captive propagation (unless I missed that somewhere). Fine work on this, I have no other comments. Cheers!

Jeff

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**From:** Bennett, Jesse <[jesse\\_bennett@fws.gov](mailto:jesse_bennett@fws.gov)>

**Sent:** Thursday, August 9, 2018 10:02:02 AM

**To:** Jeff Lemm

**Subject:** Peer Review of Draft Recovery Plan

[Quoted text hidden]

## **Working Group Meeting held September 11, 2018 for the southern DPS of the Mountain yellow-legged frog**

### **Comments shared verbally from peer reviewer Debra Shier:**

Debra was in support of the plan and stated, "I think you did a great job with the draft and look forward to having a recovery plan for the species."

- (1) Add more information to the recovery plan to memorialize the partnerships in the working group. There is mention of the partners in the Recovery Implementation Schedule, but add a paragraph to the Recovery Plan.
- (2) Think about at least one refuge population in a pond or lake. This would be in the wild, rather than in captivity.
- (3) Need to perform modeling effort with and without removal of animals needed for translocation. Revise criteria and add action to perform PVA with and without animals removed from the wild.
- (4) Add language to action 4.3 in RIS to state: Continue barrier construction [and maintenance] where necessary to expand trout removal efforts and monitor for effectiveness of barriers (Priority 1).
- (5) Make recovery activities 1.2 and 6.1 more clear as they appear similar as stated. 6.2 should indicate that the captive population is managed to match the genetic diversity of the wild.
- (6) Add ICR as partnering agency for activity 1.3.
- (7) Add ICR as partnering agency for activity 5.3.1.

**Species Biological Report for the Southern  
California Distinct Population Segment of the  
Mountain Yellow-legged Frog  
(*Rana muscosa*)**



Photo courtesy of Adam Backlin (U.S. Geological Survey)

## ACKNOWLEDGEMENTS

The recovery planning process has benefitted from the advice and assistance of many individuals, agencies, and organizations. We thank our partners who play an active role in mountain yellow-legged frog conservation. Numerous agencies provided information through surveys and research, and these agencies helped manage habitat and implement recovery actions. Their support over the years has contributed to a better understanding of this species, which has subsequently helped develop this Species Biological Report.

In particular we thank: Robert Fisher, Adam Backlin, Elizabeth Gallegos, and Thierry Chambert (U.S. Geological Survey); Laura Patterson, Mike Giusti, Tim Hovey, John O'Brien, Claire Ingel, and Jennifer Pareti (California Department of Fish and Wildlife); Scott Quinnell (Caltrans); David Austin, Anne Poopatanapong, Kim Boss, Kathie Meyer, Ann Bowers, Nathan Sill, Anne Berkley, Kathleen Hemeon, Gar Abbas, and Leslie Welch (U.S. Forest Service); Ron Swaisgood, Jeff Lemm, Frank Santana, Debra Shier, Nicole Gardner, Natalie Calatayud, and Michelle Curtis (Institute for Conservation Research-San Diego Zoo); Ian Recchio and Marlowe Robertson (Los Angeles Zoo); Ethan Fisher (Santa Ana Zoo); and Jessi Krebs and Derek Benson (Henry Doorly Zoo) for their cooperation and collaboration. We appreciate these efforts and look forward to continued collaboration as we refine methodologies and implement actions that support mountain yellow-legged frog recovery.

### **Literature Citation Should Read as Follows:**

U.S. Fish and Wildlife Service. 2018. Species Biological Report for the southern California distinct population segment of the mountain yellow-legged frog. U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. v + 32 pp.

An electronic copy of this biological report is available at:

<http://ecos.fws.gov/ecp0/profile/speciesProfile?sId=8037>

Additional copies may be obtained from:

Carlsbad Fish and Wildlife Office  
2177 Salk Avenue, Suite 250  
Carlsbad, California 92008  
Office Phone: 760-431-9440

# SPECIES BIOLOGICAL REPORT

## SOUTHERN CALIFORNIA DPS OF MOUNTAIN YELLOW-LEGGED FROG

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This Species Biological Report is a comprehensive review of the biology of the southern California distinct population segment (DPS) of mountain yellow-legged frog (*Rana muscosa*) (hereafter “southern *Rana muscosa*”) and provides a scientific assessment of the species’ status and viability, including those factors that impact or are likely to impact the species. This report informs the Draft Recovery Plan for Southern California Distinct Population Segment of Mountain Yellow-legged Frog (*Rana muscosa*) (U.S. Fish and Wildlife Service (Service) 2017) (<http://www.fws.gov/endangered/species/recovery-plans>), which presents our strategy for the conservation of the species. A Recovery Implementation Strategy, which provides an expanded narrative for recovery activities and an implementation schedule, is available at <https://ecos.fws.gov>. This Species Biological Report and the Recovery Implementation Strategy will be updated on a routine basis as necessary.

### EXECUTIVE SUMMARY

We, the U.S. Fish and Wildlife Service (USFWS), listed southern *Rana muscosa* as endangered in 2002 (USFWS 2002), under the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq.*). Critical habitat was designated for this species on September 14, 2006 (USFWS 2006). The recovery priority number for southern *R. muscosa* is 3, on a scale of 1C (highest) to 18 (lowest) (USFWS 1983a, pp. 43098–43105; USFWS 1983b, p. 51985). This number indicates the species faces a high degree of threat, has a high potential for recovery, and has taxonomic status as a DPS. *Rana muscosa* was State-listed as endangered in 2013 (USFWS 2014, p. 24277). Southern *R. muscosa* is restricted to the San Gabriel, San Bernardino, and San Jacinto mountains in southern California.

Southern *Rana muscosa*, which historically was widely distributed in at least 166 known populations across four mountain ranges in southern California, now occurs in 10 small populations distributed disproportionately across three mountain ranges. Most populations are isolated in the headwaters of streams or tributaries due to the extensive distribution of predatory nonnative trout in historical habitat; thus, it exists in a highly fragmented environment.

Southern *Rana muscosa* is impacted by the following threats: recreational activities (hiking, mountain climbing, camping, swimming, stocking of trout resulting in predation, and suction dredge mining for gold), dumping of trash and release of toxic or hazardous materials into occupied stream reaches, wildfire, predatory nonnative species (trout), the potential for disease, threats associated with small population size (genetic, demographic, and environmental stochasticity, and natural catastrophes), illegal marijuana cultivation, fire management activities, nonnative plants, climate change, and contaminants.

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## INTRODUCTION

We, the U.S. Fish and Wildlife Service (USFWS), listed the southern California distinct population segment (DPS) of mountain yellow-legged frog (*Rana muscosa*) as endangered in 2002 (USFWS 2002), under the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq.*). Critical habitat was later designated for this species on September 14, 2006 (USFWS 2006). A threats assessment and review of the biological status was conducted in a 5-year status review for the species in 2012 (USFWS 2012). The recovery priority number for southern *R. muscosa* is 3, on a scale of 1C (highest) to 18 (lowest) (USFWS 1983a, pp. 43098–43105; USFWS 1983b, p. 51985). This number indicates the species faces a high degree of threat, has a high potential for recovery, and has taxonomic status as a DPS. The high degree of threat is due to potential impacts associated with recreational activity; illegal marijuana plantations; impacts from road construction and maintenance; wildfire; fire management activities; trout predation; disease; the susceptibility of small populations to environmental, demographic, genetic stochasticity, and natural catastrophes; contaminants; and climate change. The high potential for recovery is due to the majority of habitat being protected and managed in two national forests, the significant and long-standing cooperative recovery efforts occurring amongst partners, a captive program currently operating at two zoo facilities, research, observed rebounds of populations upon habitat restoration, and the resilience of the remaining adults to the widespread presence of *Batrachochytrium dendrobatidis* (*Bd*).

The following discussion summarizes characteristics of southern *Rana muscosa* biology, distribution, population status, and threats that are relevant to recovery. Additional information is available in the 2012 5-year review (USFWS 2012). (<http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?sPCODE=I0LW>), and associated literature.

## BIOLOGY AND LIFE HISTORY

### Species description and taxonomy

Mountain yellow-legged frogs (*Rana muscosa*) are medium-sized amphibians in the family Ranidae (true frogs). Adult mountain yellow-legged frogs are about 40 to 80 millimeters (mm) (1.5 to 3 inches (in)) from snout to urostyle (the pointed bone at the base of the backbone) (Zweifel 1955, p. 230; Jennings and Hayes 1994a, p. 74). Females are slightly larger (up to 95 mm (3.75 in)) than males (up to 85 mm (3.35 in)) on average (Wright and Wright 1949, pp. 424–430).

The skin pattern of mountain yellow-legged frogs is variable, ranging from discrete dark spots that can be few and large, to smaller and more numerous with a mixture of sizes and shapes, to irregular patches or a poorly defined network (Zweifel 1955, p. 230) (Figure 1). Body color is also variable, usually a mix of brown and yellow, but often with gray, red, or green-brown. The belly and ventral surface (underside) of the hind limbs range in hue from pale lemon yellow to an intense sun yellow.



**Figure 1. Adult mountain yellow-legged frog basking in the sunlight. Photo courtesy of Adam Backlin (USGS).**

taxonomy of mountain yellow-legged frogs after analyzing mitochondrial DNA, acoustic data, and morphological characteristics of museum specimens. The study recognized two distinct species representing the mountain yellow-legged frog complex: *R. sierrae* in the northern and central Sierra Nevada, and *R. muscosa* in the southern Sierra Nevada and southern California. Neither the taxonomy of southern *R. muscosa*, nor its status as a DPS is affected with recognition of two distinct mountain yellow-legged frog species. We hereafter refer to *R. muscosa* in the Sierra Nevada as northern *R. muscosa* and *R. muscosa* in southern California as southern *R. muscosa*.

Schoville *et al.* (2011, p. 2031) used mitochondrial and microsatellite data to examine patterns of genetic variation in multiple populations of northern and southern *Rana muscosa*. The study found low levels of genetic variation within each southern *R. muscosa* population compared to other montane ranid populations (Zhan *et al.* 2009, p. 2; Zhao *et al.* 2009, p. 270; Schoville *et al.* 2011, p. 71).

Populations were found to have diversified within the Pleistocene, with little gene flow during this divergence, indicating that unique evolutionary lineages of *R. muscosa* exist in each mountain range in southern California and that all but two populations (Bear Gulch and Vincent Gulch) are genetically distinct. Genetic bottlenecks were detected in all populations, and the

Tadpoles are generally mottled brown in dorsal coloration with a golden tint and a faintly-yellow venter (Stebbins 2003, p. 460) (Figure 2). Total tadpole length reaches 72 mm (2.8 in); the body is flattened, and the tail is wide, about 25 mm (1 in) or more, before tapering into a rounded tip (Wright and Wright 1949, p. 431).

At the time of their listing in 2002, mountain yellow-legged frogs occurring in the Sierra Nevada and southern California were classified as one species (*Rana muscosa*). Vredenburg *et al.* (2007, p. 361) revised the



**Figure 2. Mountain yellow-legged frog tadpole beginning to metamorphose. Photo courtesy of Adam Backlin (USGS)**

highest degree of inbreeding was found in the East Fork City Creek, Little Rock Creek, and Dark Canyon, although inbreeding in southern *R. muscosa* was not found to be strong overall (Schoville *et al.* 2011). Due to the small population size and the high probability that any catastrophic events will eliminate or reduce remaining populations, the study stated that loss of genetic diversity is likely to be rapid in the future. As a result, Schoville *et al.* 2011 (p. 2038) recommend that translocations between populations be considered to avoid inbreeding depression; however, because populations represent unique evolutionary lineages, care must be taken to avoid outbreeding depression that might result from mixing between locally-adapted populations.

### **Population Trends, Range, and Distribution**

Historically, southern *Rana muscosa* was widely distributed in rocky and shaded streams, creeks, and drainages on desert and coastal slopes from 370 to 2,290 m (1,200 to 7,500 ft) with cool waters originating from springs and snowmelt (Zweifel 1955, p. 237; Jennings and Hayes 1994b, p. 194; Jennings and Hayes 1994b, p. 74). Southern *R. muscosa* was known from an estimated 166 historical localities in the San Gabriel, San Bernardino, San Jacinto, and Palomar mountains of Los Angeles, San Bernardino, Riverside, and San Diego counties. By 1994, southern *R. muscosa* was thought to be extirpated from more than 99 percent of its historical range (Jennings and Hayes 1994b, p. 77), with only eight populations representing less than 100 individuals remaining (Jennings and Hayes 1994b, p. 78; USGS 1995, p. 2; USGS 1999, p. 30). BACKLIN ETAL 2013

At listing in 2002, southern *Rana muscosa* was known from only 7 of the 166 historical localities, including five small streams in the San Gabriel Mountains (Bear Gulch, Vincent Gulch, South Fork Big Rock Creek, Little Rock Creek, and Devil's Canyon), one stream in the San Bernardino Mountains (East Fork City Creek), and one stream in the upper reaches of the San Jacinto River system in the San Jacinto Mountains (Fuller Mill Creek) (USGS 2002, p. 1). Seventy-nine adult frogs were estimated to occur across five of the seven occupied localities (Little Rock Creek, South Fork Big Rock Creek, Vincent Gulch, Bear Gulch, and East Fork City Creek) (USFWS 2002, p. 44384) in addition to direct observations of four adults in Devil's Canyon and one adult in Fuller Mill Creek (USGS 2002, p. 5; USFWS 2002, p. 44384). All seven populations were in the small headwater sections of streams where barriers restricted upstream movement of predatory nonnative trout (USGS 2002, p. 5; USFWS 2002, p. 44388). At listing, all of the known localities of southern *R. muscosa* occurred on lands administered by the United States Forest Service (USFS), with the exception of Fuller Mill Creek, which occurs in USFS, Riverside County, and private lands. Since listing, southern *R. muscosa* has been detected at two additional waterways in the San Jacinto Mountains. In 2003, the Dark Canyon population was detected again after years of annual surveys at this site (USGS 2004, p. 6). Then in 2009, it was found at the Tahquitz Creek watershed (USGS 2010, p. 2). However, the Tahquitz Creek area was subject to the Mountain Fire in 2013 and despite surveys no individuals have been reported post-fire.

Although population trends are difficult to discern and some population increases have occurred, all populations are still considered small and are at risk from a number of factors as discussed below. Determining accurate population estimates has been difficult due to low numbers at almost all extant localities (A. Backlin, 2012, pers. comm.) (Table 1). In 2014, four populations

had either no individuals or no adult individuals detected (Vincent Gulch, Devil's Canyon, East Fork City Creek, and Tahquitz Canyon).

Increased restrictions on recreation and trout removal at Dark Canyon may have reversed the decline of this population, as evidenced by an increase in abundance (A. Backlin, 2012, pers. comm.). Little Rock Creek experienced a dramatic and substantial increase of individuals since 2001, which is correlated with trout removal efforts and a creek closure by the USFS at this location (USGS 2012, p. 18). In 2015, southern *Rana muscosa* was reported at seven geographically-separate occurrences located in the San Gabriel, San Bernardino, and San Jacinto Mountains (Figure 3, Table 1). An "occurrence" is defined simply as a location at which the species has been detected. In 2017, adults were reported from six occurrences in the San Gabriel, San Bernardino, and San Jacinto Mountains. The number of occupied occurrences has fluctuated from 4 to 9 from 2001 to 2017.

Mountain yellow-legged frogs are currently presumed to be extant at 10 occurrences (5 in the San Gabriel Mountain, 1 in the San Bernardino Mountains, and 4 in the San Jacinto Mountains). Extensive surveys have been performed by USGS at over 200 additional locations in all four mountain ranges within the historical distribution of the species. No other occupied areas have been identified since 2009. However, because survey intensity has varied between sites and areas still have not been surveyed, there may be additional occupied sites.

BACKLIN  
ET AL  
2013

Southern *Rana muscosa* are successfully reared in captivity and are currently held at three facilities, the San Diego Zoo Institute for Conservation Research (ICR), Los Angeles Zoo (LAZ), and Henry Doorly Zoo (HDZ). Eleven adults from Dark Canyon, San Jacinto Mountains and seven adults from City Creek, San Bernardino Mountains are held at ICR (J. Bennett, 2017, pers. comm.); 13 adults from Little Rock Creek, San Gabriel Mountains and 20 adults from Big Rock Creek, San Gabriel Mountains are held at the LAZ (J. Bennett, 2017, pers. comm.); and 27 adults from Dark Canyon, San Jacinto Mountains are held at the HDZ. The HDZ also has 56 juveniles that are the result of breeding an individual from City Creek with one from Dark Canyon (J. Bennett, 2017, pers. comm.). In 2010, an experimental reestablishment effort began at Indian Creek in Hall Canyon. Progeny (egg masses, tadpoles, and juveniles) of captive-bred and reared animals were placed there from 2010 to 2013. In addition, releases of captive-bred juveniles and tadpoles occurred in Fuller Mill Creek from 2013 to 2015.

Finally, a translocation effort occurred in 2013 from Devil's Canyon to a reestablishment site in Dorr Canyon, San Gabriel Mountains. Seventy-five juveniles were translocated. However, surveys in 2014 did not detect any southern *Rana muscosa* in Dorr Canyon, suggesting that this effort was not successful (USGS 2014).

↓  
2015, AND 2017

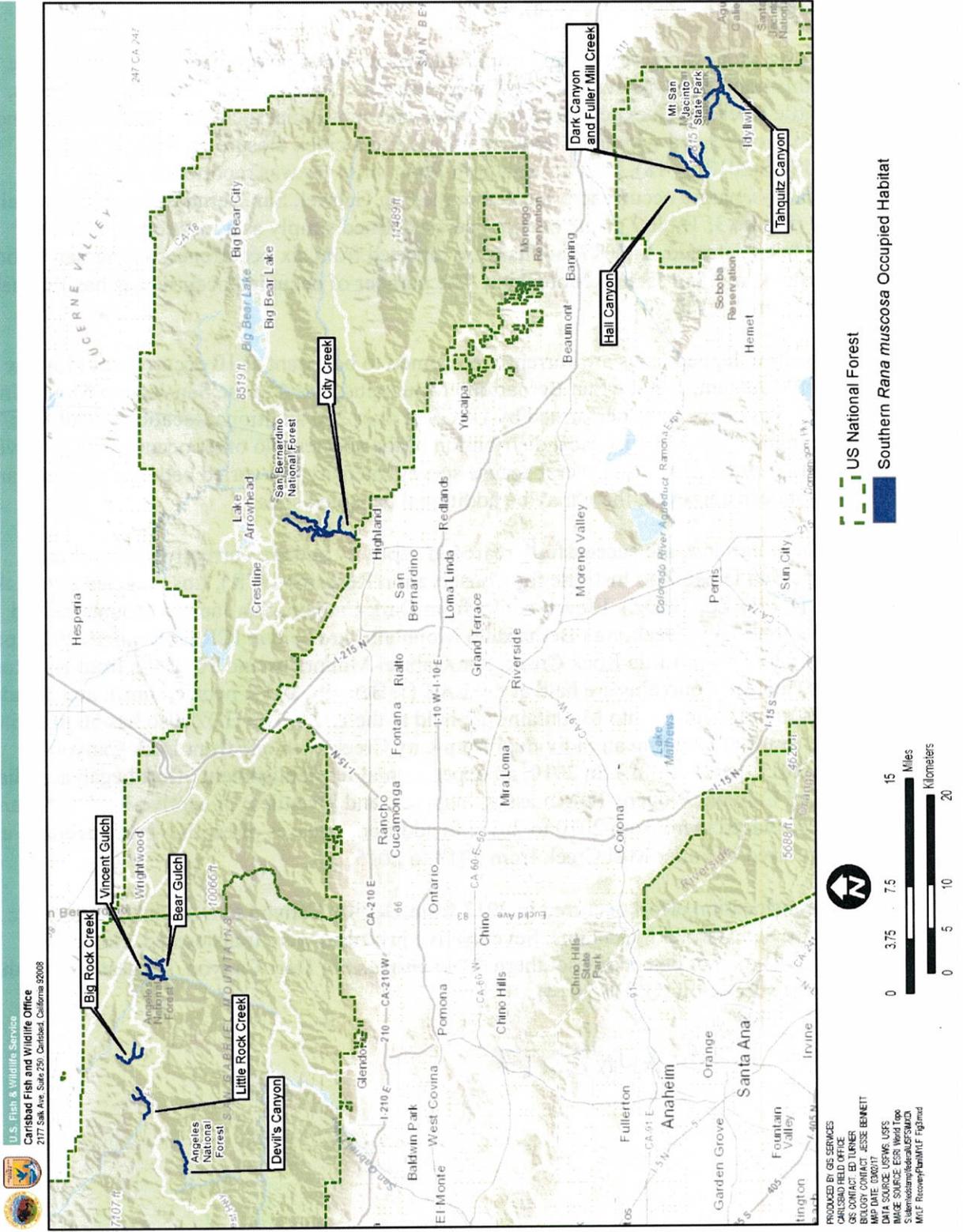


Figure 3. Mountain yellow-legged frog occupied habitat.

Table 1. Number of unique adult mountain yellow-legged frogs (*southern Rana muscosa*) observed in southern California from 2001 to 2017 at each occurrence. Survey effort (number of days surveyed) varied over time.\*

|  | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>San Gabriel Mountains</b>                                 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Devil's Canyon   | 3    | 5    | 4    | 0    | 4    | 8    | 3    | 8    | 11   | 12   | 4    | 25   | 45   | 0    | 0    | 0    | 0    |
| Little Rock Creek  | 5    | 8    | 7    | 3    | 6    | 10   | 15   | 15   | 24   | 48   | 51   | 108  | 112  | 137  | 151  | 134  | 84   |
| South Fork Big Rock Creek                                    | 4    | 22   | 25   | 17   | 14   | 20   | 15   | 12   | 11   | 12   | 26   | 46   | 44   | 47   | 30   | 12   | 9    |
| Vincent Gulch  | 4    | 2    | 1    | 1    | 2    | 3    | 2    | 1    | 2    | 7    | 3    | 16   | 18   | 3    | 2    | 0    | 1    |
| Bear Gulch   | 21   | 14   | 17   | 0    | 1    | 1    | 1    | 1    | 1    | 0    | 1    | 0    | 0    | 0    | 0    | 0    | 1    |
| <b>San Bernardino Mountains</b>                              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| East Fork City Creek   | 11   | 18   | 4    | 0    | 1    | 8    | 12   | 2    | 1    | 1    | 7    | 2    | 1    | 0    | 1    | 0    | 1    |
| <b>San Jacinto Mountains</b>                                 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Fuller Mill Creek  | 3    | 3    | 6    | 0    | 8    | 5    | 9    | 14   | 9    | 6    | 1    | 3    | 9    | 15   | 6    | 6    | 4    |
| Dark Canyon  | 1    | 1    | 11   | 23   | 20   | 14   | 17   | 16   | 14   | 9    | 14   | 39   | 38   | 28   | 22   | 25   | 27   |
| Tahquitz-Willow Creek  | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 4    | 0    | 1    | 1    | 0    | 0    | 0    | 0    |
| Hall Canyon**  | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 0    | 0    | 0    | 0    | 0    | 14   | 3    | 0    |
| Total  | 48   | 72   | 75   | 44   | 55   | 69   | 74   | 69   | 74   | 99   | 107  | 240  | 268  | 230  | 233  | 189  | 126  |
| Number of occurrences occupied by southern <i>R. muscosa</i> | 7    | 7    | 8    | 4    | 7    | 8    | 8    | 8    | 9    | 8    | 8    | 8    | 8    | 5    | 7    | 5    | 6    |

SHOULD BE PART OF SAN JACINTO MOUNTAINS  
 BECAUSE THEY ARE IN THE SAN JACINTO MOUNTAINS

\*Data from Backlin 2017.

\*\* Individuals reintroduced from captive-bred mountain yellow-legged frogs in 2010 and 2011.

## *Metapopulation Structure*

Under natural circumstances, mountain yellow-legged frogs appear to operate under a metapopulation structure (Bradford *et al.* 1993, p. 886; Drost and Fellers 1996, p. 424), whereby populations are spatially structured in assemblages of local breeding populations and migration among the local populations has some effect on local dynamics, including the possibility of population reestablishment following extinction (Hanski and Simberloff 1997, p. 6). Both genetic and demographic factors are important to ensure the long-term viability of individual populations and the metapopulation as a whole. A small amount of genetic exchange among subpopulations via movements by adults, juveniles, or dispersal of tadpoles downstream, can counteract inbreeding and associated decreases in genetic diversity that might otherwise develop within small isolated populations. If geographic distance between populations is not great, gene flow via dispersing individuals occurs readily. However, in the absence of an operable metapopulation structure, isolated subpopulations may benefit from genetic enrichment via translocations (Lande and Barrowclough 1987, pp. 111–113). Another important long-term process in metapopulation dynamics is the need for rates of colonization to exceed rates of natural extinction among constituent populations, thereby ensuring the persistence of the metapopulation as a whole (Hanski and Gilpin 1991, p. 5).

A metapopulation structure of southern *Rana muscosa* is not currently functional because populations are highly isolated. Populations occupy the headwaters of tributaries above barriers that prevent the upstream movement of predatory nonnative trout. Trout dominate the downstream habitat below barriers at the majority of occupied localities and act as barriers to dispersal and recolonization by tadpoles. Surveys performed by USGS have shown that with very little exception, nonnative trout and southern *R. muscosa* do not currently coexist in the same reach of a stream or creek, likely due to predation of southern *R. muscosa* by trout. The disruption of natural metapopulation dynamics diminishes natural recovery options and can increase the extinction risk of species that exhibit this population structure (Noss and Cooperrider 1994, p. 61–62), including southern *R. muscosa*.

Although southern *Rana muscosa* faces significant obstacles, recovery actions initiated in the last decade have demonstrated that the DPS has a promising ability to rebound and metapopulation dynamics could be restored. Trout eradication and recreational closures adjacent to two populations have resulted in an increase in abundance and area occupied by each population. In addition, trout eradication between the Dark Canyon and Fuller Mill Creek populations has allowed for the movement of southern *R. muscosa* between these populations. In the future, similar threat abatement measures can be strategically planned and implemented to help additional populations.

## Life History and Ecology

Southern *R. muscosa* spend the coldest winter months in hibernation, probably underwater or in crevices in the streambanks (Zweifel 1955, p. 242; Bradford 1983, p. 1171; Matthews and Pope 1999, p. 615). Tadpoles may survive overwintering better than juveniles and adults (Bradford 1983, p. 1171). A recent *ex situ* study of the dormancy requirements of adult southern *R. muscosa* found that captive *R. muscosa* require a hibernation period for successful reproduction, as only hibernated females produced eggs and only hibernated males successfully fertilized eggs (Santana *et al.* 2015). Individuals may also become dormant during especially dry periods of late summer (Mullally 1959, p. 79).

Individuals emerge from overwintering (hibernation) sites immediately following snowmelt in early spring and breeding begins soon after. Breeding activity typically occurs from April (at lower elevations), to June or July (at higher elevations) and continues for approximately a month (Zweifel 1955, p. 243).

Adults deposit their eggs in globular clumps (masses) in shallow waters of inlet streams where they may attach to rocks, gravel, vegetation, under banks, or similar substrates (Figure 4) (Wright and Wright 1949, p. 431; Zweifel 1955, p. 243; Pope 1999, p. 30; Vredenburg *et al.* 2005, p. 565). Egg masses are somewhat flattened, roughly 25 to 50 mm (1 to 2 in) across (Stebbins 2003, p. 444), and vary in size from as few as 15 eggs to 350 eggs per mass (Livezey and Wright 1945, p. 703; Vredenburg *et al.* 2005, p. 564), which is considered low relative to other ranids. Eggs have three firm jelly-like transparent envelopes surrounding a grey-tan or black vitelline (egg yolk) capsule (Wright and Wright 1949, pp. 431–433). Egg hatching time *ex situ* ranges from 18 to 20 days at 5 to 13.5°C (41 to 56°F) (Zweifel 1955, p. 265; Pope 1999, p. 31). Eggs masses and tadpoles are difficult to detect due to their cryptic nature.



Figure 4. Mountain yellow-legged frog egg mass submerged among vegetative debris. Photo courtesy of Adam Backlin (USGS).

Time to develop from fertilization to metamorphosis (transformation from tadpole to frog) is variable and dependent upon temperature. In the wild, southern *Rana muscosa* tadpoles typically metamorphose at the end of the second summer, at approximately 1.5 years of age (A. Backlin, 2012, pers. comm.). Southern *R. muscosa* have a long aqueous phase and complete metamorphosis after spending 2 years as tadpoles. Juveniles develop over another 2 years and reach reproductive maturity by age 4 (Zweifel 1955, p. 245). Little is known about the lifespan of southern *R. muscosa*, however, they are presumed to be long-lived due to high adult survivorship from year to year (Pope 1999, p. 619).

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The U.S. Geological Survey (USGS) (2004, p. 27) noted that when southern *Rana muscosa* tadpoles are detected, they tend to be found further and further downstream as the season progresses. This indicates that streamflow may contribute to tadpole dispersal, especially after summer rains (USGS 2004, p. 27). Outside of southern California, mountain yellow-legged frog tadpoles have been observed more than one kilometer (0.62 mile) downstream from the initial point of observation (R. Knapp, 2012, pers. comm.). The successful dispersal downstream may be limited by the presence of predators, such as nonnative trout (R. Knapp, 2012, pers. comm.). Almost no data exist on the dispersal of juveniles, although in the Sierra Nevada juveniles from small intermittent streams are thought to disperse to permanent water (Bradford 1991, p. 176).

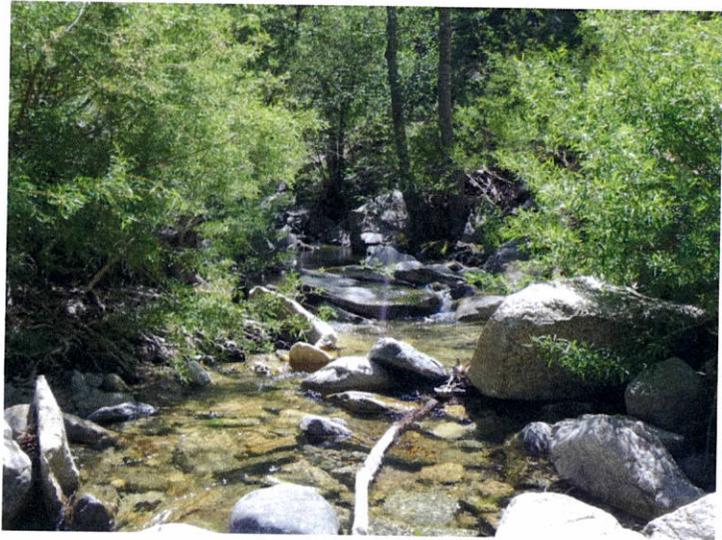
Adult southern *Rana muscosa* appear to be highly philopatric, but may travel long distances (i.e., longer than one kilometer (0.62 mile)), perhaps in search of new territories and mates (USGS 2004, p. 26). Movement patterns suggest that longer dispersal events occur just after emergence from hibernation in the spring and just before returning to hibernacula in the winter, with high site fidelity occurring during the middle of the active season (Matthews and Pope 1999, p. 615). In a study of displaced mountain yellow-legged frogs, Matthews (2003, p. 621) indicated that stress due to a homing response in adults may preclude translocation as an effective conservation tool. However, other research in the Sierra Nevada suggests that if translocations occur an adequate distance from the source population, the homing mechanism will not function (R. Knapp, 2012, pers. comm.).

Juveniles and adults of southern *Rana muscosa* appear to be principally insectivorous, feeding on a wide variety of invertebrates, including beetles (*Coleoptera*), ants (*Formicidae*), bees (*Apoidea*), wasps (*Hymenoptera*), flies (*Diptera*), true bugs (*Hemiptera*), and dragonflies (*Odonata*) (Long 1970, p. 7). Tadpoles graze on benthic detritus and algae along rocky bottoms in streams (Bradford 1983, p. 1171; Zeiner *et al.* 1988, p. 88).

## Habitat Characteristics/Ecosystem

Streams utilized by adults vary from those having steep gradients with numerous pools, rapids, and small waterfalls, to those with low gradients with slow flows, marshy edges, and sod banks (Zweifel 1955, p. 237; Mullally 1959, p. 78).

Aquatic substrates vary from bedrock to fine sand, rubble, rocks, and boulders (Zweifel 1955, p. 237), any of which may serve as basking areas for thermoregulation (Zweifel 1955, p. 237) (Figure 5). USGS (2004, p. 21) reported creeks occupied with southern *Rana muscosa* were generally narrow (1 to 3 meter (m) (3 to 10 feet (ft))), and highly variable in length (250 to over 5,000 m (820 to 16,400 ft), with pools typically 1 to 10 m (3 to 32 ft) long, 0.5 to 7 m (2 to 23 ft) wide, and 1 to 180 cm (0.4 to 71 in) deep. Pools usually had some type of structure that could function as refugia (cover from predators) such as bank overhangs, rocks, and downfall logs or branches, although aquatic vegetation was minimal (USGS 2004, p. 21).



**Figure 5. Southern *Rana muscosa* habitat. Photo courtesy of Adam Backlin (USGS).**

Individuals are most often found in creeks with permanent (perennial) water in at least some portion of the reach (A. Backlin, 2012, pers. comm.). Mountain yellow-legged frogs are rarely found more than 1 m (3 ft) away from water (Stebbins 2003, p. 233). Perennial flows are needed for reproduction, larval growth and survival, and hydration of juveniles and adults (Vredenburg *et al.* 2005, p. 564). Water depth, persistence, and configuration (i.e., gently sloping shorelines and margins) are important factors for overwintering, thermoregulation (regulation of body temperature through behavior), reproduction and development, foraging, and protection from predation (Jennings and Hayes 1994b, p. 77). Individuals seem to be absent from the smallest creeks, probably because these have insufficient depth to provide for adequate refuge and overwintering habitat (Jennings and Hayes 1994b, p. 77).

Southern *Rana muscosa* historically ranged between 370 to 2,300 meters (1,214 to 7,546 feet) in elevation. At lower elevations, the streamside habitat is characterized by common species such as seep willow (*Baccharis viminea*), white alder (*Alnus rhombifolia*), big-cone spruce (*Pseudotsuga macrocarpa*), and cottonwood (*Populus spp.*) (Zweifel 1955, p. 237; Jennings and Hayes 1994b, p. 195). At higher elevations, the streamside habitat is dominated by species such as lodgepole pine (*Pinus contorta*), Jeffery pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), yellow pine (*Pinus ponderosa*), white fir (*Abies concolor*), and incense cedar (*Calocedrus decurrens*) (Zweifel 1955, p. 237). USGS (2004, p. 21) reported that in occupied habitat, riparian zone widths ranged from 8 to 25 m (26 to 82 ft), with canyon walls typically rising steeply on

either side. The riparian zone, with the associated vegetation canopy, is necessary to maintain the prey base needed for the nutritional requirements of the mountain yellow-legged frog. An open or semi-open canopy (not exceeding 85 percent of riparian vegetation) is needed to ensure that adequate sunlight reaches the stream to allow for basking behavior and for photosynthesis of benthic algae (USFWS 2006, p. 54351).

## **Critical Habitat**

On September 14, 2006 (USFWS 2006), 8,283 acres (ac) (3,352 hectares (ha)) of occupied and unoccupied critical habitat was designated for southern *Rana muscosa* on Federal, State, and private lands in Los Angeles, San Bernardino, and Riverside counties, California. Three units were designated (Unit 1: San Gabriel Mountains, Unit 2: San Bernardino Mountains, and Unit 3: San Jacinto Mountains). Designated areas that were occupied by southern *R. muscosa* at the time of listing contain the physical and biological features essential to the conservation of southern *R. muscosa* and may require special management considerations or protection. Certain areas were designated that were not known to be occupied by southern *R. muscosa* at the time of listing that are essential to the conservation of the species. These areas are essential because they were occupied in recent history and habitat quality is unchanged, indicating the potential for occupancy remains (USFWS 2006, p. 54358). Management and protections are necessary in critical habitat to minimize habitat destruction associated with (1) recreational activities including camping, hiking, fishing, and recreational mining and (2) watershed management activities including forest thinning or clearing for public safety or fire prevention (e.g., fuel load management), water diversion, application of herbicides, use of fire retardants, and inadvertent spills of hazardous chemicals (USFWS 2006, p. 54354). The critical habitat designation identifies areas that are considered essential for the recovery of the species and without them, recovery would not be achievable.

The principal benefit of critical habitat designation is the requirement under the Act for Federal agencies to ensure actions they fund, authorize, or carry out are not likely to result in the destruction or adverse modification of any designated critical habitat. There are also significant educational and ancillary benefits to designating critical habitat within areas occupied and unoccupied by southern *Rana muscosa* (USFWS 2006, pp. 54361–54364). We anticipate that a Federal nexus for section 7 consultation under the Act exists for most activities within the designated critical habitat areas, which enables us to review proposed activities that may affect designated southern *R. muscosa* critical habitat in the San Gabriel, San Bernardino, and San Jacinto mountains to ensure that it is not destroyed or adversely modified.

## REASONS FOR LISTING AND CURRENT THREATS

The final listing rule (USFWS 2002, pp. 44382–44392) identified the following threats to southern *Rana muscosa*: recreational impacts (hiking, mountain climbing, camping, swimming, stocking of trout for fishing, and suction dredge mining for gold), dumping of trash and release of toxic or hazardous materials into occupied stream reaches, wildfire, predatory nonnative species (trout and bullfrogs), disease, and threats associated with small population size (genetic, demographic, and environmental stochasticity, and natural catastrophes). Each threat is classified according to the five listing factors identified in section 4 of the Act. The 2012 5-year review for southern *R. muscosa* (USFWS 2012, pp. 1–78) identified five additional threats since listing including illegal marijuana cultivation, fire management activities, nonnative plants, climate change, and contaminants. ~~Bullfrogs are no longer considered a threat.~~ The 2012 5-year review provides a detailed evaluation of all threats (USFWS 2012), which are re-evaluated and described below. (see Table 2).

### **Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range**

The Angeles and San Bernardino National Forests have conserved and managed the majority of southern *Rana muscosa* habitat since before listing (USFWS 2002, p. 44383). As such, individual threats to the habitat do not generally impact populations on a rangewide scale, but taken together, all extant populations are at risk from at least one threat to the habitat. **Factor A** threats include: (1) recreational activity, (2) illegal marijuana plantations, (3) spills, (4) wildfire, and (5) fire management activities.

Human use in and along streams (hiking, mountain climbing, camping, swimming, and suction dredge mining for gold) can disrupt the development, survivorship, and recruitment of eggs, larvae, and adult frogs (Jennings 1995, p. 5; Rodriguez-Prieto and Fernandez-Juricic 2005, p. 1), and can change the character of a stream and its banks and associated vegetation in ways that make whole sections of a stream less suitable habitat for southern *Rana muscosa*. Amphibians may suffer mortality due to trampling or dislodging of egg masses and may alter their behavior resulting in a decline in the spatial and temporal use of habitat.

The USFS is implementing protective measures for the benefit of southern *Rana muscosa* at some locations, including signs, fencing, and monitoring. A formerly popular recreation area at Little Rock Creek has been closed since December 2005 and streamside closures are also being implemented at City Creek, Fuller Mill Creek, and Dark Canyon to minimize or eliminate impacts from recreational activities.

Suction dredge mining is a method of extracting minerals, commonly gold, from water bodies and may affect habitat suitability by altering substrates and drafting water away from a source (Harvey 1986, p. 407). Additional impacts include alteration of stream channel morphology, turbidity, sedimentation, and impacts to the benthic community. Impacts to southern *Rana muscosa* could also result from behavioral changes, physical entrainment or excavation, and exposure to contamination (toxicological effects). The California Department of Fish and Wildlife (CDFW) currently enforces a moratorium on suction dredge mining (CDFW 2011, p. 1), although illegal mining continues to be a problem in the more accessible parts of East Fork

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Table 2. Current status and threats impacting the Mountain yellow-legged frog.

| Occurrence*                                      | Detected at Listing | Last Detected        | Current Status  | Current Threats  |
|--|---------------------|----------------------|-----------------|--|
| <b>San Gabriel Mountains</b>                     |                     |                      |                 |  |
| Devil's Canyon                                   | Yes                 | 2015 (tadpoles only) | presumed extant | Factor A: Illegal marijuana cultivation<br>Factor C: Bd<br>Factor E: Small population size; climate change. ← WILDFIRE                                 |
| Little Rock Creek                                | Yes                 | 2017                 | extant          | Factor C: Bd<br>Factor E: Small population size; climate change ← WILDFIRE   |
| South Fork Big Rock Creek                        | Yes                 | 2017                 | extant          | Factor A: Wildfire<br>Factor C: Bd<br>Factor E: Small population size; climate change  |
| Vincent Gulch                                    | Yes                 | 2017                 | extant          | Factor A: Illegal marijuana cultivation; wildfire<br>Factor C: Nonnative trout; Bd<br>Factor E: Small population size; climate change ← WILDFIRE       |
| Bear Gulch                                       | Yes                 | 2011                 | presumed extant | Factor A: Illegal marijuana cultivation; wildfire<br>Factor C: Nonnative trout; Bd<br>Factor E: Small population size; climate change ← WILDFIRE       |
| <b>San Bernardino Mountains</b>                  |                     |                      |                 |  |
| East Fork City Creek                             | Yes                 | 2013<br>2017         | extant          | Factor A: Illegal marijuana cultivation; habitat impacts during roadwork<br>Factor C: Bd<br>Factor E: Small population size; climate change ← WILDFIRE |
| <b>San Jacinto Mountains</b>                     |                     |                      |                 |  |
| Fuller Mill Creek                                | Yes                 | 2012<br>2017         | extant          | Factor A: Recreation; wildfire<br>Factor C: Nonnative trout; Bd<br>Factor E: Small population size; climate change                                     |
| Dark Canyon (Upper North Fork San Jacinto River) | No                  | 2013<br>2017         | extant          | Factor A: Recreation; wildfire<br>Factor C: Nonnative trout; Bd<br>Factor E: Small population size; climate change                                     |
| Tahquitz/Willow Creeks                           | No                  | 2013                 | presumed extant | Factor C: Nonnative trout; Bd<br>Factor E: Small population size; climate change   |
| Indian Creek/Hall Canyon                         | No                  | 2016                 | presumed extant | Factor A: Wildfire<br>Factor C: Nonnative trout downstream; Bd may be present<br>Factor E: Small population size; climate change                       |

\*All occurrences occur on Federal lands managed by the U.S. Forest Service

San Gabriel River (N. Sill, 2011, pers. comm.). Regardless, no areas currently occupied by southern *R. muscosa* are known to be impacted by this threat.

Illegal marijuana plantations adversely impact southern *Rana muscosa* habitat in many ways. Cultivation sites often have terracing which involves ground disturbance, water diversions, and native vegetation removal. Impacts from these activities may include riparian habitat degradation, weed infestations, increased sedimentation, and reduced water quality and quantity (N. Sill, 2011, pers. comm.). There is also the potential for contamination associated with pesticides and fertilizers, which are routinely found at cultivation sites (N. Sill, 2011, pers.

REMOVE SPACE

comm.). Direct injury or mortality to southern *R. muscosa* can also occur through the displacement of egg masses or crushing of individual frogs when growers walk through habitat or through suction of individuals into water diversion pipes. In some cases, the presence of this illegal activity in the forest has impeded the ability to monitor existing populations, and to search for additional populations due to safety concerns. Since listing, illegal marijuana cultivation has occurred at all three mountain ranges where southern *R. muscosa* occurs, in at least five ~~five~~ <sup>SIX</sup> localities: Devil's Canyon, Bear Gulch, Vincent Gulch, East Fork City Creek, and at the reestablishment site at Hall Canyon. ~~TAKOVITZ, A~~

Dumping of trash and toxic materials (soap, motor oil, mercury) that degrades water quality and causes impacts to eggs and developing tadpoles was identified as a threat at listing in the East Fork San Gabriel River, which was considered occupied habitat for southern *Rana muscosa* in the 1990s (Jennings 1995, p. 5; USFWS 2002, p. 44387). Disposal of toxic materials has not been observed in southern *R. muscosa* occupied habitat since listing. However, road construction or repair has resulted in sedimentation of occupied pool-riffle habitat downslope from State Route 2 in the San Gabriel Mountains and Highway 330 in the San Bernardino Mountains.

The streams currently inhabited by southern *Rana muscosa* flow through narrow canyons that provide little opportunity for off-channel refuge during fire and flood events (USFS 2002, p. 22). Wildfire can reduce or eliminate riparian vegetation and refugia; increase water temperature through shade reduction; increase flooding, sedimentation, and debris in waterways, potentially filling pools, affecting water quality, and killing aquatic species; and alter stream channel morphology. In addition, the highly aquatic nature of southern *R. muscosa* makes it particularly susceptible to impacts from alterations in water quality caused by wildfire and from post-fire mudslides. In 2003, a large wildfire and the subsequent scouring and flooding that followed devastated the East Fork City Creek population. Currently, all localities supporting extant populations are at an extreme risk of wildfire (Calfire 2005, p. 1). In some systems, fire is thought to be important in maintaining open aquatic and riparian habitats for amphibians (Russell *et al.* 1999, p. 378). In 2009, the largest wildfire in Los Angeles County history (the Station Fire) burned and population numbers increased dramatically post-Station Fire after being low for many years, until declining again (Table 1). Amphibians may minimize mortality from fire by taking shelter in wet habitats or subterranean burrows, though their moist and permeable skin increases their susceptibility to heat and desiccation (Russell *et al.* 1999, p. 374). Regardless, even a small fire or flood event occurring in occupied southern *R. muscosa* habitat can result in an extirpation due to the few remaining individuals available to support recovery in most populations.

Although not described as a threat at listing, fire management activities (particularly former fire suppression policies) likely changed the forest structure and conditions, resulting in increased fuel loads and risk of high intensity wildfire. Appropriate fire management activities may benefit mountain yellow-legged frogs by reducing the potential and/or intensity of wildfire and the subsequent impacts due to flooding. However, fire management activities also have the potential to impact southern *Rana muscosa* habitat during fire-fighting events, including: water drafting from occupied streams; construction of fuel breaks; fire suppression with water applications or fire retardants; and increased human activity in the area. Activities occurring in response to a wildfire may cause minimal or short-term impacts to southern *R. muscosa*, compared to the effects of a large wildfire.

Overall, threats to the habitat of southern *Rana muscosa* remain throughout the range, though impacts occur to varying degrees in each occupied area. Wildfires are the most significant threat rangewide, as they could occur at any time and may impact any population. The USFS actively manages and monitors many impacts associated with recreation, such that the number of impacted localities has been reduced since listing; however, recreation remains a constant concern. Illegal marijuana cultivation has been detected at five occupied sites since listing. Due to the difficulty in monitoring these sites, the extent of this impact is unknown, although exposure to contaminants at cultivation sites is a serious concern. Repeated impacts to southern *R. muscosa* occupied habitat due to roadwork activities have occurred since listing. This has resulted in sedimentation of habitat in two occupied areas. Although threats to the habitat persist on a rangewide scale, many of these threats are controllable. Reduction of impacts has been successful at some locations through management decisions (i.e. closing and/or managing recreational areas, enforcing a moratorium on suction dredge mining, and removing illegal marijuana plantations).

#### **Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes**

Overutilization is not a threat at this time. Since listing, authorized collecting of southern *Rana muscosa* took place during emergency salvages post-wildfire, to save tadpoles from drying habitat, and to preserve genetic representation of the dwindling City Creek population. Due to the uncertainties related to the small sizes of most southern *R. muscosa* populations, future collection of individuals may be necessary to assist captive breeding and augmentation or to prevent loss of individuals that might otherwise perish in the wild (i.e., in drying pools). Long-term recovery of this DPS may require breeding between populations in captivity to increase genetic robustness of bottlenecked or inbred populations. Therefore, additional collection of individuals may be necessary, though such activity will be permitted or authorized such that it does not constitute a threat to recovery.

#### **Factor C: Disease or Predation**

At listing, predation by nonnative trout (rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*)) was thought to be one of the principal causes of the rangewide decline of southern *Rana muscosa* (USFWS 2002, p. 44388). Trout are widespread across the historical range of the DPS and currently occupy habitat immediately downstream of southern *R. muscosa* at all occupied sites and upstream at one site (i.e., Tahquitz Canyon watershed). All remaining extant localities remain isolated in fishless headwaters of tributaries (A. Backlin, 2012, pers.

comm.). Although mentioned as a potential concern in the listing rule, there was no indication that animals were sick with either viral, bacteria, or fungal diseases. Since listing, all populations have tested positive for the amphibian fungal pathogen, *Bd*, which may have also been a reason for the decline of the southern *R. muscosa*. Thus, both disease and predation are widespread concerns of great significance.

Native steelhead trout (*Oncorhynchus mykiss*) historically occupied some of the same watersheds as southern *Rana muscosa* (NMFS 2011, pp. 2-7–2-8). However, it is unclear if the two ever shared the same reaches within waterways. Regardless, research has shown that the interaction between trout and mountain yellow-legged frogs is detrimental to the frogs (Knapp and Matthews 2000, p. 428). The current extensive occupancy of rainbow trout in the historical range of southern *R. muscosa* is the result of continual stocking of hatchery-reared fish from the 1940s to the present.

Once introduced, trout reduce or eliminate mountain yellow-legged frog populations through predation of tadpoles and other lifestages, and then occupy the intervening habitat between populations that persist without trout (Grinnell and Storer 1924, p. 664; Mullally and Cunningham 1956, p. 190; Cory 1962, p. 401, 1963, p. 172; Bradford 1989, pp. 775–777; Bradford and Gordon 1992, p. 65; Bradford *et al.* 1993, pp. 882–888, 1994, p. 326; Drost and Fellers 1996, p. 422; Jennings 1996, p. 940; Knapp 1996, pp. 13-15; Knapp and Matthews 2000, p. 428; Knapp *et al.* 2001, p. 401; Vredenburg 2004, p. 7649). Bradford *et al.* (1993, p. 886) concluded that the presence of trout in intervening waterways sufficiently isolates other frog populations so that recolonization after local extirpations is essentially impossible. This pattern of occupancy has relegated southern *Rana muscosa* to the less preferable, marginal habitat in the headwaters of tributaries.

CDFW has ceased trout stocking in all localities currently occupied by southern *Rana muscosa*. Trout-induced declines of mountain yellow-legged frogs may be reversed in some locations with an intensive and focused effort to restore fishless conditions (Knapp and Matthews 1998, p. 207; 2000, p. 437; Knapp *et al.* 2001, p. 418; Knapp *et al.* 2007, p. 17). At Little Rock Creek, CDFW led a trout removal effort between two trout barriers immediately downstream of the southern *R. muscosa* population until trout were eradicated. From 2005 through 2015, the number of southern *R. muscosa* found within the trout removal reach increased. Tadpoles were first detected in the area in 2008 (USGS 2008a, p. 10), and approximately eight adults occupied the trout removal area in 2010 (USGS 2011a, p.8). Little Rock Creek is now the largest southern *R. muscosa* population and the entire length of the occupied area supports all lifestages. From 2009 to 2013, trout removal also occurred between the Dark Canyon and Fuller Mill Creek populations. The area between these populations is now free of trout (J. Bennett, 2013, pers. comm.). In 2014, trout removal efforts were also initiated in the Tahquitz Canyon area (J. Bennett, 2014, pers. comm.).

In southern California, trout removal efforts in the immediate future should focus on areas adjacent to existing populations in order to aid survivorship of individuals that will naturally disperse downstream and thus facilitate the expansion of these populations. Trout removal near existing populations can also provide opportunities for augmentation of small populations using either individuals bred in captivity or individuals translocated from other populations, as necessary.

Although positive identification of *Bd* on southern *Rana muscosa* did not occur until 2007 (USGS 2007a, p. 1; USGS 2007b, p. 1), all populations have now tested positive with results dating back to 2001 (A. Backlin, 2012, pers. comm.). The offspring of these individuals may be succumbing to chytridiomycosis, as evidenced by low numbers of juveniles in all populations. The most probable cause for this observation is infection from *Bd*, which is known to have the greatest impact on juveniles (Lamirande and Nichols 2002, p. 11). Additional information regarding infection rates and intensities for other age classes is needed. This may be the most significant stressor to southern *R. muscosa* because it affects all extant populations, is likely hindering recruitment, and could have a significant impact on animals released from captive biosecure conditions that have not previously been exposed to *Bd*.

Although much remains unknown regarding the interaction between *Bd* and southern *Rana muscosa*, recent research on northern *R. muscosa* indicates that a strategy termed “bioaugmentation” may be an effective management tool to control chytridiomycosis in captive and wild populations (Harris *et al.* 2009, p. 1). This experiment showed that adding an antifungal bacterial species, *Janthinobacterium lividum*, to the skin of northern *R. muscosa* (at higher densities than it naturally occurs) prevented morbidity and mortality associated with *Bd*. This research demonstrated that “cutaneous microbes are a part of the innate immune system of amphibians, that this microbial community on the frog skin is a determinant of disease outcome, and that altering the microbial interactions on frog skin can prevent a lethal disease outcome” (Harris *et al.* 2009, p. 1). Thus far, bioaugmentation has been focused on prevention of *Bd* infections, rather than treatment of animals infected with *Bd*. Given that the research was performed on *R. muscosa*, it could be a useful tool for preventing infection on captive animals released into the wild, or potentially as a treatment to increase survivorship in wild populations.

While *Bd* poses a significant risk to the small and isolated populations, persistent individuals may be able to replenish these populations with time if enough survive to reproductive maturity. Additional information is needed regarding the effects of *Bd* on southern *Rana muscosa*, particularly with consideration of the reestablishment, augmentation, and translocation efforts occurring, and the potential for bioaugmentation. Nonnative trout principally reduce the egg mass and tadpole lifestages, while *Bd* may be preventing recruitment of juveniles. Both threats are rangewide concerns.

#### **Factor D: Inadequacy of Existing Regulatory Mechanisms**

In the listing rule, regulatory mechanisms thought to have some potential to protect southern *Rana muscosa* included: (1) the California Environmental Quality Act (CEQA); (2) section 1603 of the California Department of Fish and Wildlife Code (California Lake and Streambed Alteration Program); (3) the National Environmental Policy Act (NEPA); (4) section 404 of the Federal Clean Water Act; (5) local land use processes and ordinances; and, (6) the Federal Endangered Species Act in those cases where southern *R. muscosa* occurs in habitat occupied by a listed wildlife species (USFWS 2002, p. 44388). The listing rule provides an analysis of the level of protection that was anticipated from those regulatory mechanisms.

Since listing, the State of California has listed *Rana muscosa* as endangered under the California Endangered Species Act (CESA), critical habitat has been designated under the Act, and one habitat conservation plan (HCP), the Western Riverside County Multiple Species Habitat

Conservation Plan (Western Riverside County MSHCP; see Conservation Efforts – Habitat Conservation Plans below for a description of this HCP), for which southern *R. muscosa* is a covered species, was permitted and is currently being implemented. Several State and Federal mechanisms provide a conservation benefit to southern *R. muscosa*. At this time, the Act is the primary Federal law that provides protection for southern *R. muscosa* since its listing as endangered in 2002, while CESA is the primary State law providing protection to the species since 2013. Critical habitat was designated throughout the range of southern *R. muscosa* in 2006, including unoccupied areas essential for the conservation of the species. Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Act. Therefore, in absence of the Act, other laws and regulations have limited ability to protect the species. Inadequacies in provisions or implementation of regulatory mechanisms are not currently considered a threat to the species.

**Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence**

Small population size was the only **Factor E** threat thought to be impacting southern *Rana muscosa* at listing. This threat continues to be of critical importance. New threats identified since listing that may be impacting southern *R. muscosa* include climate change and contaminants. There is a possibility that UV-B radiation, pesticides, and acid precipitation have also contributed to the decline of the DPS; however, there is very little information regarding these threats, therefore they are not described below.

At listing, southern *Rana muscosa* was thought to have a high extinction risk because of the small size and isolation of the remaining seven populations (USFWS 2002, p. 44389). Two additional populations have been discovered in the San Jacinto Mountains since listing and frogs have been reestablished at Hall Canyon. The risk of extinction to the DPS remains high because all 10 populations are small and highly isolated, and the additional populations do not appreciably increase the representative abundance or distribution of the listed entity. Small populations are vulnerable to extirpation (local extinction) from environmental, demographic, and genetic stochasticity (random, natural occurrences), and unforeseen (natural or unnatural) catastrophes (Shaffer 1981, p. 131).

Environmental stochasticity refers to annual variation in birth and death rates in response to weather, disease, competition, predation, or other factors external to the population (Shaffer 1981, p. 131). Small populations may be less able to respond to natural environmental changes (Kéry *et al.* 2000, p. 28), such as predation or prolonged drought. Periods of prolonged drought are likely to have a significant effect on southern *Rana muscosa* because drought conditions occur on a landscape scale and all life stages are dependent on habitat supporting a perennial water source.

Demographic stochasticity is random variability in survival or reproduction among individuals within a population (Shaffer 1981, p. 131), and could increase the risk of extirpation of the remaining populations. This risk has declined since listing in the Little Rock Creek population and to a lesser extent in the Big Rock Creek population due to increases in numbers.

Genetic stochasticity results from changes in gene frequencies due to founder effect (loss of genetic variation that occurs when a new population is established by a small number of individuals) (Rieger *et al.* 1968, p. 163); random fixation (the complete loss of one of two alleles in a population, the other allele reaching a frequency of 100 percent) (Rieger *et al.* 1968, p. 371); or, inbreeding depression (loss of fitness or vigor due to mating among relatives) (Soulé 1987, p. 96). Additionally, small populations generally have an increased chance of genetic drift (random changes in gene frequencies from generation to generation that can lead to a loss of variation) and inbreeding (Ellstrand and Elam 1993, p. 225). Evidence of inbreeding within southern *Rana muscosa* populations is not strong but has been detected in three populations (East Fork City Creek, Little Rock Creek, and Dark Canyon) (Schoville *et al.* 2011, p. 2037). However, every southern *R. muscosa* population has low levels of genetic variation (a measure of the genetic differences within populations or species) (Schoville *et al.* 2011, p. 1). Such low diversity could impair the ability to adapt to changes in the environment, such as the introduction of a novel disease, or contribute to a more pronounced inbreeding depression over time (Shaffer 1981, p. 133; Noss and Cooperrider 1994, p. 6; Primack 1998, p. 305). In every population there is some evidence of recent genetic bottlenecks (an event in which a population's size is radically reduced causing gene frequencies to change by random chance and ultimately reducing genetic variation) (Schoville *et al.* 2011, p. 5). It is currently unknown whether the effects of reduced genetic variability in each population will affect fitness (Schoville *et al.* 2011, p. 7).

The extinction risk of a species represented by few small populations is magnified when those populations are also isolated from one another. This is especially true for species whose populations function in a metapopulation structure, whereby dispersal or migration of individuals to new or formerly occupied areas is necessary. Connectivity between these populations is essential to increase the number of reproductively active individuals in a population; mitigate the genetic, demographic, and environmental effects of small population size; and recolonize extirpated areas. Genetic data indicate that there is no migration occurring between the small, highly isolated southern *Rana muscosa* populations (Schoville *et al.* 2011, p. 6) and functional self-sustaining metapopulations no longer exist. However, since analysis of this data the trout removal effort in Dark Canyon and Fuller Mill Creek allows for these occurrences to more easily exchange individuals. Southern *R. muscosa* would likely recover from stochastic events under historical circumstances where more and larger populations exist in closer proximity to one another. Currently, however, metapopulation dynamics are severely inhibited, possibly preventing the natural recovery of populations through recolonization. Therefore, southern *R. muscosa* is likely to be significantly affected by small population size.

Changes in climate that occur faster than the ability of endangered species to adapt could cause local extinctions (U.S. Environmental Protection Agency (USEPA) 1989, p. 145). In the southwestern California ecoregion, climate models predict that mean annual temperatures will increase from 1.7 to 2.2°C (3.1 – 4.0°F) by 2070 (PRBO 2011, p. 41). High temperature events are expected to become more common in southern California and species with narrow temperature tolerance levels may experience thermal stress (PRBO 2011, p. 42). Increases in extremely high temperature events may cause direct mortality or halt or diminish reproduction (PRBO 2011, p. 42). Regional models suggest a decrease in mean annual rainfall of 51 to 184 mm (2 to 7.2 in) (a reduction by 10 to 37 percent) by 2070 (PRBO 2011, p. 41). Snyder *et al.* (2004, p. 594) has projected that snowpack will decrease by 90 percent in the South Coast

hydrologic region of California, therefore snow-fed rivers and streams are expected to have less water.

Climate change could impact mountain yellow-legged frogs in several ways, because southern *Rana muscosa* spend the first 2 years of their life as tadpoles and are dependent on perennial stream flow. In the summer, reduced snowpack and enhanced evapo-transpiration following high temperature events may dry out pools, which otherwise would have sustained tadpoles (Lacan *et al.* 2008, p. 220) and may also reduce fecundity (egg production) (Lacan *et al.* 2008, p. 222). Predicted increases in mean annual temperatures, high temperature events, and potentially decreased precipitation could also diminish the volume and timing of water availability to support all lifestages. Furthermore, earlier snowmelt could cue emergence from hibernation and breeding earlier in the year, on average, advancing this primary signal for breeding phenology in montane and boreal habitats (Corn 2005, p. 61). This may have both positive and negative effects. Additional time for growth and development may render larger individuals more fit to overwinter; however, earlier breeding may also expose young tadpoles to killing frosts in more variable conditions of early spring (Corn 2005, p. 60). Conversely, severe winters would force longer hibernation times and could stress individuals by reducing the time available for them to feed and breed.

Contaminants are a potential threat to southern *Rana muscosa*. It appears there has been some exposure to nitrogenous pollutants in the San Gabriel and San Bernardino Mountains (Fenn and Bytnerowicz 1993, p. 277; Fenn *et al.* 2005, p. 269), although the impacts on southern *R. muscosa* have not been measured. It is hypothesized that such pollutants contributed to the decline of the DPS, and may continue to limit dispersal potential. Water quality testing at extant localities has not identified contaminants; however, only basic variables are tested (pH, conductivity, dissolved oxygen). Pesticides, herbicides, and nitrogen-based fertilizers may have been used directly adjacent to streams where illegal marijuana cultivation sites are planted (Devil's Canyon, Bear Gulch, Vincent Gulch, and City Creek). Any waterways where these contaminants are used in the future should be tested to evaluate the effects on southern *R. muscosa*. Impacts may also result from the use of fire retardants to suppress wildfires, which contain nitrogen compounds and surfactants.

Due to the threats associated with small populations, potential impacts from global climate change, and contamination, **Factor E** threats continue to threaten southern *R. muscosa*.

## CONSERVATION EFFORTS

Extensive collaboration with numerous Federal, State, and private agencies has supported recovery related activities for southern *Rana muscosa*. Such activities include: 1) monitoring extant populations; 2) surveying suitable habitat for additional populations; 3) research of ecological requirements and biological characteristics; 4) salvage operations for at-risk populations or tadpoles from drying pools; 5) captive propagation programs at the San Diego, Los Angeles, and Fresno zoos; 6) habitat assessments for reestablishment and potential trout removal; 7) trout barrier construction; 8) trout removal operations; 9) monitoring of released individuals; 10) genetics research; 11) testing for infectious disease (*Bd* and viruses); 12) closures to public access and fencing to reduce recreational pressures at extant populations; and, 13) other recovery-related activities. Partners supporting various recovery-related activities include USGS, USFS (Angeles and San Bernardino National Forests), CDFW (Regions 5 and 6), California Department of Parks and Recreation (CDPR), University of California James Reserve, ICR, LAZ, HDZ, Fresno Zoo, Caltrans, Riverside County, and the Service. The coordinated effort of these partners to provide greater information specific to the DPS has been important for making informed decisions regarding threat abatement and recovery options on a rangewide scale. Many of the activities listed above are ongoing and contribute to our knowledge of the southern *Rana muscosa* population to help conserve this imperiled species (Table 3).

### *Habitat Conservation Plans*

One HCP was completed since listing that addresses non-Federal projects that may result in incidental take of southern *Rana muscosa*. The Western Riverside County Multiple Species Habitat Conservation Plan (Western Riverside County MSHCP) was permitted on June 22, 2004, and is a regional, multi-jurisdictional habitat conservation plan encompassing about 1.26 million ac (510,000 ha) in western Riverside County. This plan covers two southern *R. muscosa* populations occurring in the San Jacinto Mountains (Dark Canyon and Fuller Mill Creek) and the reestablishment area at Hall Canyon. The Western Riverside County MSHCP addresses 146 listed and unlisted "covered species," including southern *R. muscosa*, and was designed to establish a multi-species conservation program that minimizes and mitigates the effects of expected habitat loss and associated incidental take of covered species. The Western Riverside County MSHCP will establish approximately 153,000 ac (61,917 ha) of new conservation lands to complement the approximately 347,000 ac (140,426 ha) of pre-existing natural and open space areas to form the overall Western Riverside County MSHCP Conservation Area over the 75-year permit period (USFWS 2004, p. 2).

The Western Riverside County MSHCP is intended to reduce the threats to southern *Rana muscosa* and its habitat as the plan is implemented by placing large blocks of habitat into preservation throughout the Conservation Area. The Western Riverside County MSHCP identifies six conservation objectives that will be implemented to contribute to the long-term conservation of southern *R. muscosa* (Dudek and Associates, Inc. 2003, pp. F-19–20). As outlined in the Western Riverside County MSHCP, the goal is to conserve 136 ha (335 ac) of primary breeding habitat above 370 m (1,214 ft) (riparian scrub woodland and forest) within the San Jacinto Mountains for southern *R. muscosa* (Dudek and Associates, Inc. 2003, p. A-48).

**Table 3. Recovery activities funded and carried out for southern *Rana muscosa*.**

| Year      | Activity   | Lead Partner*                               | Reporting                            | Progress  |
|-----------|--|---|--------------------------------------|-----------|
| 1994-2017 | Monitoring of all wild populations, PIT-tagging to determine movement patterns, surveys for additional extant populations and habitat assessments for new reestablishment areas, salvages from drying pools, disease testing | USGS<br><i>DEMOGRAPHY<br/>POP ESTIMATES</i> | USGS 1994-2017                       | Ongoing   |
| 2001      | Acquisition of 60 ac (24 ha) of habitat in the headwaters of Fuller Mill Creek   | USFS  | USFWS 2002                           | Completed |
| 2001-2017 | Recreational monitoring at Fuller Mill Creek and Dark Canyon   | USFS  | Annual reports                       | Ongoing   |
| 2002      | Study: Mountain Yellow-legged Frog Conservation Assessment and Strategy for the Angeles and San Bernardino National Forests  | USFS  | USFS 2002                            | Completed |
| 2002-2012 | Trout removal at Little Rock Creek   | CDFW  | Meeting notes and email confirmation | Completed |
| 2003      | Study: Natural history and recovery analysis for southern California populations of <i>Rana muscosa</i>  | USGS  | USGS 2003                            | Completed |
| 2003      | Trout barrier constructed at Little Rock Creek   | USFS  | Email confirmation                   | Completed |
| 2003-2017 | Maintenance of captive populations   | ICR, LAZ, HDZ, Fresno Zoo                   | Email confirmation                   | Ongoing   |
| 2006      | Campground fencing at Dark Canyon  | USFS  | Email confirmation                   | Completed |
| 2006-2017 | Anti-fungal treatment of <i>Bd</i> -positive captive individuals   | ICR, LAZ, Fresno Zoo                        | Email confirmation                   | Completed |

|              |  |                              |                                      |           |
|--------------|--|------------------------------|--------------------------------------|-----------|
| 2008         | Trout barrier constructed at Big Rock Creek  | USFS                         | Email confirmation                   | Completed |
| 2009-2011    | Study: Genetics evaluation of captive and wild populations   | USGS and private researchers | Schoville <i>et al.</i> 2011         | Completed |
| 2009-2011    | Trout removal at Fuller Mill Creek and Dark Canyon   | CDFW                         | Meeting notes and email confirmation | Completed |
| 2010-2017    | Release of captive-raised egg masses and tadpoles at Hall Canyon, Fuller Mill Creek, and City Creek DC   | USGS, LAZ, ICR               | Email confirmation                   | Completed |
| 2010-2017    | Monitoring of captive individuals released at Hall Canyon, Fuller Mill Creek, and City Creek DC  | USGS, ICR                    | Email confirmation                   | Ongoing   |
| 2010-current | Study: Microhabitat use, monitoring of reintroduced individuals, feeding preferences of reintroduced individuals, hibernation preferences of captive individuals and use of hormones to stimulate captive breeding | ICR                          | Master's Thesis: Santana 2012        | Ongoing   |
| 2013         | Translocation from Devil's Canyon to Dorr Canyon   | USGS                         | Meeting notes and email confirmation | Completed |
| 2014         | Trout removal at Tahquitz Canyon   | CDFW                         | Meeting notes and email confirmation | Ongoing   |
| 2014-2017    | Trout removal at Big Rock Creek  | USFS                         | Meeting notes and email confirmation | Ongoing   |

\*Partners include: United States Fish and Wildlife Service (USFWS), United States Forest Service (USFS), United States Geological Survey (USGS), California Department of Fish and Wildlife (CDFW), California Department of Parks and Recreation (CDPR), San Diego Zoo Institute for Conservation Research (ICR), Los Angeles Zoo (LAZ), Fresno Zoo, and University of California (UC), Riverside County. HDZ

The Western Riverside County MSHCP permittees are required to implement management and monitoring activities. For southern *R. muscosa*, the Western Riverside County MSHCP specifically identifies conservation objectives to: (1) conduct surveys as part of the project review process and conserve southern *R. muscosa* localities as a result of survey efforts, (2) maintain, or if feasible, restore ecological processes (with a particular emphasis on removing nonnative predatory fish and bullfrogs) within occupied habitat and suitable new areas, and (3) maintain successful reproduction as measured by observing the presence/absence of tadpoles, egg masses, or juvenile frogs once a year for the first 5 years after permit issuance and not less frequently than every 8 years (Dudek and Associates, Inc. 2003, pp. F-19–20).

## SUMMARY

Southern *Rana muscosa*, which historically was widely distributed in at least 166 known populations across four mountain ranges in southern California, are currently considered to be extant in 10 small populations distributed disproportionately across three mountain ranges. Most populations are isolated in the headwaters of streams or tributaries due to the extensive distribution of predatory nonnative trout in historical habitat; thus, it exists in a highly fragmented environment. Such isolation and fragmentation followed by the prevention of successful recolonization increases the potential for extirpation of the remaining populations.

Each population is small and highly susceptible to stochastic events, especially wildfire, which devastated the East Fork City Creek population. Measures have been taken to reduce the impact of certain threats, including recreation, trout, and stochastic extinction. However, these threats and other threats to the habitat remain, including illegal activities (marijuana cultivation and suction dredge mining), and legal activities (recreational activities, fire management activities, and roadwork construction). Wildfire and climate change both have a high likelihood of affecting southern *Rana muscosa* and its habitat; however, the timing and options available to reduce these threats are either limited or unclear. Disease is also a concern rangewide. Providing sufficient representation, resiliency, and redundancy across the historical range through the reestablishment of additional populations may be the best way to address these threats.

The small population sizes and loss of potential metapopulation dynamics are a great impetus for threat abatement. Populations have proved to be sensitive to both the presence of threats, as well as their amelioration. Two populations have responded positively to restoration efforts (through nonnative trout removal and recreational closures). Increasing such efforts should be prioritized to prevent extirpation of small populations, expand the area available to all existing populations, and reconnect subpopulations to ultimately recreate local metapopulation dynamics. Southern *Rana muscosa* faces a high degree of threat with a high potential for recovery, therefore proactive efforts are needed to aid in the continued survival and recovery of this critically endangered species.

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Bennett, Jesse <jesse\_bennett@fws.gov>

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## MYLF Recovery Plan comments

1 message

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**Backlin, Adam** <abacklin@usgs.gov> Mon, Oct 1, 2018 at 1:37 PM  
To: "Bennett, Jesse" <Jesse\_Bennett@fws.gov>  
Cc: "Bridges, Bradd" <bradd\_bridges@fws.gov>, Elizabeth Gallegos <egallegos@usgs.gov>, "Dr. Robert Fisher" <rfisher@usgs.gov>

Jesse,

Attached are Liz and my comments on the draft Species Biological Report.

Two general comments are that this report is not consistent with the site name Big Rock Creek. It is sometimes referred to South Fork Big Rock Creek and others as Big Rock Creek. Also "Devil's" doesn't have an apostrophe, and should be Devils Canyon.

Let me know if you have any questions.

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