DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[Docket No. FWS–R8–ES–2012–0100; 4500030113]

RIN 1018–AZ21

Endangered and Threatened Wildlife and Plants; Endangered Status for the Sierra Nevada Yellow-Legged Frog and the Northern Distinct Population Segment of the Mountain Yellow-Legged Frog, and Threatened Status for the Yosemite Toad

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Proposed rule.

SUMMARY: We, the U.S. Fish and Wildlife Service, propose to list the Sierra Nevada yellow-legged frog and the northern distinct population segment (DPS) (populations that occur north of the Tehachapi Mountains) of the mountain yellow-legged frog as endangered species, and the Yosemite toad as a threatened species under the Endangered Species Act of 1973, as amended (Act). The effect of this regulation would be to add the species to the List of Endangered and Threatened Wildlife under the Act.

DATES: We will accept comments received or postmarked on or before June 24, 2013. Comments submitted electronically using the Federal eRulemaking Portal (see **ADDRESSES** below) must be received by 11:59 p.m. Eastern Time on the closing date. We must receive requests for public hearings, in writing, at the address shown in the **FOR FURTHER INFORMATION CONTACT** section by June 10, 2013.

ADDRESSES: You may submit comments by one of the following methods:

(1) *Electronically:* Go to the Federal eRulemaking Portal: *http://www.regulations.gov.* In the Search box, enter Docket No. FWS–R8–ES–2012–0100, which is the docket number for this rulemaking. Then, in the Search panel on the left side of the screen, under the Document Type heading, click on the Proposed Rules link to locate this document. You may submit a comment by clicking on ''Comment Now!''

(2) *By hard copy:* Submit by U.S. mail or hand-delivery to: Public Comments Processing, Attn: FWS–R8–ES–2012–0100; Division of Policy and Directives Management; U.S. Fish and Wildlife Service; 4401 N. Fairfax Drive, MS 2042–PDM; Arlington, VA 22203.

We request that you send comments only by the methods described above. We will post all comments on *http://www.regulations.gov.* This generally means that we will post any personal information you provide us (see Information Requested below for more information).

FOR FURTHER INFORMATION CONTACT: Jan Knight, Acting Field Supervisor, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, 2800 Cottage Way Room W–2605, Sacramento CA 95825; by telephone 916–414–6600; or by facsimile 916–414–6712. Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

This document consists of: a proposed rule to list the Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog as endangered, and to list the Yosemite toad as threatened.

Executive Summary

Why we need to publish a rule. Under the Act, if a species is determined to be an endangered or threatened species throughout all or a significant portion of its range, we are required to promptly publish a proposal in the **Federal Register** and make a determination on our proposal within one year. Listing a species as an endangered or threatened species can only be completed by issuing a rule.

This rule proposes the listing of the Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog as endangered, and to list the Yosemite toad as threatened.

- We are proposing to list the Sierra Nevada yellow-legged frog as endangered under the Endangered Species Act.
- We are proposing to list the northern DPS of the mountain yellow-legged frog as endangered under the Endangered Species Act.
- We are proposing to list the Yosemite toad as threatened under the Endangered Species Act.

The basis for our action. Under the Act, we can determine that a species is an endangered or threatened species based on any of five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. We reviewed all available scientific and commercial information pertaining to the five threat factors in our evaluation of each species.

We have made the following findings related to these criteria:

Sierra Nevada Yellow-Legged Frog (Rana Sierrae)

The Sierra Nevada yellow-legged frog is presently in danger of extinction throughout its entire range, based on the immediacy, severity, and scope of the threats to its continued existence. These include habitat degradation and fragmentation, predation and disease, climate change, inadequate regulatory protections, and the interaction of these various stressors impacting small remnant populations. There has been a rangewide reduction in abundance and geographic extent of surviving populations of frogs following decades of fish stocking, habitat fragmentation, and most recently a disease epidemic. Surviving populations are smaller and more isolated, and recruitment in disease-infested populations is much reduced relative to historic norms. This combination of population stressors makes persistence of the species precarious throughout the currently occupied range in the Sierra Nevada.

Northern Distinct Population Segment of the Mountain Yellow-Legged Frog (Rana Muscosa)

Populations within the southern DPS of the mountain yellow-legged frog inhabiting the Transverse Ranges of Southern California are currently listed as an endangered species. The northern DPS of the mountain yellow-legged frog is presently in danger of extinction throughout its range within the Sierra Nevada, based on the immediacy, severity, and scope of the threats to its continued existence. These include habitat degradation and fragmentation, predation and disease, climate change, inadequate regulatory protections, and the interaction of these various stressors impacting small remnant populations. There has been a rangewide reduction in abundance and geographic extent of surviving populations of frogs following decades of fish stocking, habitat fragmentation, and most recently a disease epidemic. Surviving populations are smaller and more isolated, and recruitment in disease-infested populations is much reduced relative to historic norms. This combination of population stressors makes persistence of the species precarious throughout the Sierra Nevada range of the mountain yellow-legged frog.

The northern DPS of the mountain yellow-legged frog has different habitat, requires different management, and has different primary constituent elements than the already listed southern DPS . For these reasons, we have proposed a separate DPS for the northern population in this rule. However, if we finalize this rule, the entire range of the mountain yellow-legged frog may be listed as endangered. We request public input on whether we should retain the northern and southern DPS's or combine the two into one listed species in the final rule. Thus, we are giving notice that we may combine the two DPS's into one listed species if we finalize this proposed rule.

Yosemite Toad (Anaxyrus Canorus)

The Yosemite toad is likely to become endangered throughout its range within the foreseeable future, based on the immediacy, severity, and scope of the threats to its continued existence. These include habitat loss associated with degradation of meadow hydrology following stream incision consequent to the cumulative effects of historic land management activities, notably livestock grazing, and also the anticipated hydrologic effects upon habitat from climate change. We also find that the Yosemite toad is likely to become endangered through the direct effects of climate change impacting small remnant populations, likely compounded with the cumulative effect of other threat factors (such as disease).

We will seek peer review. We are seeking comments from knowledgeable individuals with scientific expertise to review our analysis of the best available science and application of that science and to provide any additional scientific information to improve this proposed rule. Because we will consider all comments and information received during the comment period, our final determination may differ from this proposal.

Information Requested

We intend that any final action resulting from this proposed rule will be based on the best scientific and commercial data available and be as accurate and as effective as possible. Therefore, we request comments or information from other concerned governmental agencies, Native American tribes, the scientific community, industry, or any other interested parties concerning this proposed rule. We particularly seek comments concerning:

(1) Biological, commercial trade, or other relevant data concerning any threats (or lack thereof) to these species, and regulations that may be addressing those threats.

(2) Additional information concerning the historical and current status, range, distribution, and population size of these species, including the locations of any additional populations of these species.

(3) Any information on the biological or ecological requirements of these species, and ongoing conservation measures for these species and their habitats.

(4) The factors that are the basis for making a listing determination for a species under section 4(a) of the Act 16 U.S.C. 1531 et seq.), which are:

(a) The present or threatened destruction, modification, or curtailment of its habitat or range;

(b) Overutilization for commercial, recreational, scientific, or educational purposes;

(c) Disease or predation;

(d) The inadequacy of existing regulatory mechanisms; or

(e) Other natural or manmade factors affecting its continued existence.

(5) Land use designations and current or planned activities in the areas occupied by the species, and possible impacts of these activities on these species.

(6) Information on the projected and reasonably likely impacts of climate change on the Sierra Nevada yellow-legged frog, the northern DPS of the mountain yellow-legged frog, and the Yosemite toad.

(7) Input on whether we should retain the northern and southern DPS's of the mountain yellow-legged frog in the final rule or should we combine the two DPS's into one listed entity for the species.

Please include sufficient information with your submission (such as scientific journal articles or other publications) to allow us to verify any scientific or commercial information you include.

Please note that submissions merely stating support for or opposition to the action under consideration without providing supporting information, although noted, will not be considered in making a determination, as section 4(b)(1)(A) of the Act directs that determinations as to whether any species is an endangered or threatened species must be made ''solely on the basis of the best scientific and commercial data available.''

You may submit your comments and materials concerning this proposed rule by one of the methods listed in the **ADDRESSES** section. We request that you send comments only by the methods described in the **ADDRESSES** section.

If you submit information via *http://www.regulations.gov,* your entire submission—including any personal identifying information—will be posted on the Web site. If your submission is made via a hardcopy that includes personal identifying information, you may request at the top of your document that we withhold this information from public review. However, we cannot guarantee that we will be able to do so. We will post all hardcopy submissions on *http://www.regulations.gov.* Please include sufficient information with your comments to allow us to verify any scientific or commercial information you include.

Comments and materials we receive, as well as supporting documentation we used in preparing this proposed rule, will be available for public inspection on *http://www.regulations.gov,* or by appointment, during normal business hours, at the U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**).

Previous Federal Actions

Mountain Yellow-Legged Frog

In February 2000, we received a petition from the Center for Biological Diversity and Pacific Rivers Council to list the Sierra Nevada population of the mountain yellow-legged frog (*Rana muscosa*). The petition stated that this population met the criteria in our DPS Policy and that it should be listed as endangered. On October 12, 2000, we published a 90-day finding on that petition in the **Federal Register** (65 FR 60603), concluding that the petition presented substantial scientific or commercial information to indicate that the listing of the Sierra Nevada population of the mountain yellow-legged frog may be warranted, and we concurrently requested information and data regarding the species. On January 16, 2003, we published a 12-month petition finding in the **Federal Register** that listing was warranted but precluded (68 FR 2283). This finding was in accordance with a court order requiring us to complete a finding by January 10, 2003 (*Center for Biological Diversity* v. *Norton,* No. 01–2106 (N. D. Cal. Dec. 12, 2001)). Upon publication of the finding, we added the Sierra Nevada DPS of the mountain yellow-legged frog to our list of species that are candidates for listing.

The Center for Biological Diversity and Pacific Rivers Council challenged our finding that listing was warranted but precluded, and sought to compel the Service to proceed with listing. On June 21, 2004, the U.S. District Court for the Eastern District of California granted summary judgment in favor of the United States (*Center for Biological Diversity* v. *Norton,* No. 03–01758 (E.D.

Cal. June 21, 2004)). In response to an appeal of the District Court decision, on October 18, 2006, the 9th Circuit Court of Appeals reversed and remanded the lower Court's judgment, concluding that the 12-month finding we published on January 16, 2003, did not meet the requirements of section 4(b)(3)(B) of the Act.

We addressed the 9th Circuit Court's remand by amending our January 16, 2003, warranted-but-precluded finding to include a description of our underlying rationale and an evaluation of the data demonstrating why listing the Sierra Nevada DPS of the mountain yellow-legged frog was precluded from listing. We further described the expeditious progress we had made toward adding qualified species to the Federal Lists of Endangered and Threatened Wildlife and Plants at the time. The revised 12-month finding was published on June 25, 2007 (72 FR 34657), reiterating a warranted-but-precluded finding, and maintaining the Sierra Nevada DPS of the mountain yellow-legged frog as a candidate for listing under the Act. In the intervening time, this entity has been taxonomically split (See Background section in Endangered Status For Sierra Nevada Yellow-legged Frog and the Northern DPS of the Mountain Yellow-legged Frog).

Candidate assessments for the Sierra Nevada DPS of the mountain yellow-legged frog have been prepared annually since the 2007 12-month finding (2008, 73 FR 75176; 2009, 74 FR 57804, corrected 75 FR 8293; 2010, 75 FR 69222; 2011, 76 FR 66370). The taxonomic split was officially recognized in the 2011 Candidate Assessment (76 FR 66370), where we noted that we would include the change in the upcoming proposed rule. Accordingly, in this proposed rule, we address two separate species within the mountain yellow-legged frog "species complex": *Rana muscosa* and *Rana sierrae.*

Yosemite Toad

In April 2000, we received a petition from the Center for Biological Diversity and Pacific Rivers Council to list the Yosemite toad as endangered under the Act, and to designate critical habitat concurrent with listing. On October 12, 2000, the Service published a 90-day finding (65 FR 60607) concluding that the petition presented substantial scientific or commercial information to indicate that the listing of the Yosemite toad may be warranted, and we concurrently requested information and data regarding the species. On December 10, 2002, we published a 12-month finding (67 FR 75834), concluding that the Yosemite toad warranted protection under the Act; however, budgetary constraints precluded the Service from listing the Yosemite toad as endangered or threatened at the time. This finding was in accordance with a court order requiring us to complete a finding by November 30, 2002 (*Center for Biological Diversity* v. *Norton,* No. 01–2106 (N. D. Cal. Dec. 12, 2001)).

Candidate assessments for the Yosemite toad have been prepared annually since the 2002 12-month finding (2004, 69 FR 24876; 2005, 70 FR 24870; 2006, 71 FR 53756; 2007, 72 FR 69034; 2008, 73 FR 75176; 2009, 74 FR 57804; 2010, 75 FR 69222; 2011, 76 FR 66370).

Status for Sierra Nevada Yellow-Legged Frog and the Northern DPS of the Mountain Yellow-Legged Frog

Background

In this section of the proposed rule, it is our intent to discuss only those topics directly relevant to the proposed listing of the Sierra Nevada yellow-legged frog as endangered and the proposed listing of the northern DPS of the mountain yellow-legged frog as endangered.

Taxonomy

Mountain yellow-legged frogs were once thought to be a subspecies of the foothill yellow-legged frog, *Rana boylii* (Camp 1917, pp. 118–123), and were therefore designated as *R. b. sierrae* in the Sierra Nevada and *R. b. muscosa* in southern California. At that time, it was presumed that yellow-legged frog populations from southern California through northern California were a single species. Additional morphological data supported the classification of the two subspecies separate from *R. boylii* as the species *R. muscosa* (Zweifel 1955, pp. 210–240). Macey *et al.* (2001, p. 141) conducted a phylogenetic analysis of mitochondrial deoxyribonucleic acid (DNA) sequences of the mountain yellow-legged frog and concluded that there were two major genetic lineages (and four groups), with populations in the Sierra Nevada falling into three distinct groups, the fourth being the southern California population.

Based on mitochondrial DNA, morphological information, and acoustic studies, Vredenburg *et al.* (2007, p. 371) recently recognized two distinct species of mountain yellow-legged frog in the Sierra Nevada, *Rana muscosa* and *R. sierrae.* This taxonomic distinction was subsequently adopted by the American Society of Ichthyologists and Herpetologists, the Herpetologists' League, and the Society for the Study of Amphibians and Reptiles (Crother *et al.* 2008, p. 11). The Vredenburg study determined that *R. sierrae* occurs in the Sierra Nevada north of the Kern River watershed and over the eastern crest of the Sierra Nevada into Inyo County at its most southern extent, and that *R. muscosa* occurs in the southern portion of the Sierra Nevada within the Kern River watershed to the west of the Sierra Nevada crest (along with those populations inhabiting southern California) (Vredenburg *et al.* 2007, p. 361).

Macey *et al.* (2001, p. 140) suggested that the initial divergence between the Sierra Nevada yellow-legged frog and the mountain yellow-legged frog occurred 2.2 million years before present (mybp). The biogeographic pattern of genetic divergence as detected in the mountain yellow-legged frog complex of the Sierra Nevada has also been observed in four other reptiles and amphibians in this area, suggesting that a common event fragmented their ranges (Macey *et al.* 2001, p. 140).

We identify *Rana sierrae* in this proposed rule as the Sierra Nevada yellow-legged frog, and refer to the Sierra Nevada populations of *R. muscosa* as the northern range of the mountain yellow-legged frog. Together, these species may be termed the "mountain yellow-legged frog complex." Figure 1 shows the newly recognized species split within their historical ranges as determined by Knapp (unpubl. data).

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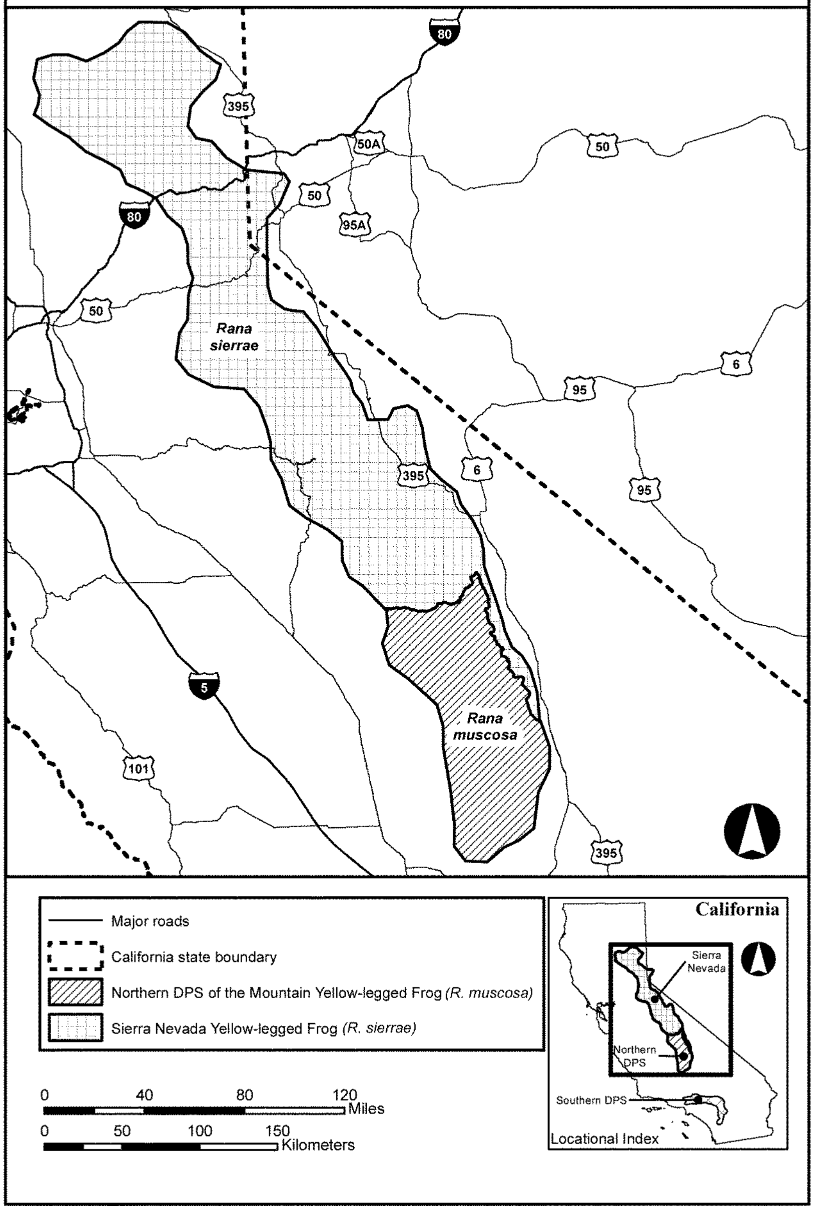
Figure 1
Estimated Historical Range of Sierra Nevada Yellow-legged Frog and Northern DPS of the Mountain Yellow-legged Frog



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For purposes of this proposed rule, we recognize the species designation as presented in Vredenburg *et al.* (2007, p. 371) and adopted by the official societies mentioned above (Crother *et al.* 2008, p. 11). Specifically, Sierra Nevada yellow-legged frogs occupy the western Sierra Nevada north of the Monarch Divide (in Fresno County) and the eastern Sierra Nevada (east of the crest) in Inyo and Mono Counties. The southern DPS of the mountain yellow-legged frog occupies the canyons of the Transverse Ranges in southern California, and is already listed as an endangered species (67 FR 44382, July 2, 2002). The northern portion of the range of mountain yellow-legged frog (extending in the western Sierra Nevada from south of the Monarch Divide in Fresno County through portions of the Kern River drainage) is referred to in this proposed rule as the northern DPS of the mountain yellow-legged frog.

Many studies cited in this document include articles and reports that were published prior to the official species reclassification, where the researchers may reference either one or both species. Where possible and appropriate, information will be referenced specifically (either as Sierra Nevada yellow-legged frog or the northern DPS of the mountain yellow-legged frog) to reflect the split of the species. Where information applies to both species, the two species will be referred to collectively as mountain yellow-legged frogs (or frog complex), consistent with the designation in each particular source document.

Species Description

The body length (snout to vent) of the mountain yellow-legged frog ranges from 40 to 80 millimeters (mm) (1.5 to 3.25 inches (in)) (Jennings and Hayes 1994, p. 74). Females average slightly larger than males, and males have a swollen, darkened thumb base (Wright and Wright 1949, pp. 424–430; Stebbins

1951, pp. 330–335; Zweifel 1955, p. 235; Zweifel 1968, p. 65.1). Dorsal (upper) coloration in adults is variable, exhibiting a mix of brown and yellow, but also can be grey, red, or green-brown, and is usually patterned with dark spots (Jennings and Hayes 1994, p. 74; Stebbins 2003, p. 233). These spots may be large (6 mm (0.25 in)) and few, smaller and more numerous, or a mixture of both (Zweifel 1955, p. 230). Irregular lichen- or moss-like patches (to which the name *muscosa* refers) may also be present on the dorsal surface (Zweifel 1955, pp. 230, 235; Stebbins 2003, p. 233).

The belly and undersurfaces of the hind limbs are yellow or orange, and this pigmentation may extend forward from the abdomen to the forelimbs (Wright and Wright 1949, pp. 424–429; Stebbins 2003, p. 233). Mountain yellow-legged frogs may produce a distinctive mink or garlic-like odor when disturbed (Wright and Wright 1949, p. 432; Stebbins 2003, p. 233). Although these species lack vocal sacs, they can vocalize in or out of water, producing what has been described as a flat clicking sound (Zweifel 1955, p. 234; Ziesmer 1997, pp. 46–47; Stebbins 2003, p. 233). Mountain yellow-legged frogs have smoother skin, generally with heavier spotting and mottling dorsally, darker toe tips (Zweifel 1955, p. 234), and more opaque ventral coloration (Stebbins 2003, pp. 233) than the foothill yellow-legged frog.

The Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog are similar morphologically and behaviorally (hence their shared taxonomic designation until recently). However, these two species can be distinguished from each other physically by the ratio of the lower leg (fibulotibia) length to snout vent length. The northern DPS of the mountain yellow-legged frog has longer limbs (Vredenburg *et al.* 2007, p. 368). Typically, this ratio is greater than or equal to 0.55 in the northern DPS of the mountain yellow-legged frog and less than 0.55 in the Sierra Nevada yellow-legged frog.

Mountain yellow-legged frogs deposit their eggs in globular clumps, which are often somewhat flattened and roughly 2.5 to 5 centimeters (cm) (1 to 2 in) in diameter (Stebbins 2003, p. 444). When eggs are close to hatching, egg mass volume averages 198 cubic cm (78 cubic in) (Pope 1999a, p. 30). 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). Clutch size varies from 15 to 350 eggs per egg mass (Livezey and Wright 1945, p. 703; Vredenburg *et al.* 2005, p. 565). Egg development is temperature dependent. In laboratory breeding experiments, egg hatching time ranged from 18 to 21 days at temperatures of 5 to 13.5 degrees Celsius (°C) (41 to 56 degrees Fahrenheit (°F)) (Zweifel 1955, pp. 262–264). Field observations show similar results (Pope 1999a, p. 31).

The tadpoles of mountain yellow-legged frogs generally are mottled brown on the dorsal side with a faintly yellow venter (underside) (Zweifel 1955, p. 231; Stebbins 2003, p. 460). Total tadpole length reaches 72 mm (2.8 in), the body is flattened, and the tail musculature is wide (about 2.5 cm (1 in) or more) before tapering into a rounded tip (Wright and Wright 1949, p. 431). The mouth has a maximum of eight labial (lip) tooth rows (two to four upper and four lower) (Stebbins 2003, p. 460). Tadpoles may take more than 1 year (Wright and Wright 1949, p. 431), and often require 2 to 4 years, to reach metamorphosis (transformation from tadpoles to frogs) (Cory 1962b, p. 515; Bradford 1983, pp. 1171, 1182; Bradford *et al.* 1993, p. 883; Knapp and Matthews 2000, p. 435), depending on local climate conditions and site-specific variables.

The time required to reach reproductive maturity in mountain yellow-legged frogs is thought to vary between 3 and 4 years post metamorphosis (Zweifel 1955, p. 254). This information, in combination with the extended amount of time as a tadpole before metamorphosis, means that it may take 5 to 8 years for mountain yellow-legged frogs to begin reproducing. Longevity of adults is unknown, but under normal circumstances, adult survivorship from year to year is very high, so mountain yellow-legged frogs are presumed to be long-lived amphibians (Pope 1999a, p. 46).

Habitat and Life History

Mountain yellow-legged frogs currently exist in montane regions of the Sierra Nevada of California. Throughout their range, these species historically inhabited lakes, ponds, marshes, meadows, and streams at elevations ranging from 1,370 to 3,660 meters (m) (4,500 to 12,000 feet (ft)) (California Department of Fish and Game (CDFG) 2011b, pp. A-1–A-5). Mountain yellow-legged frogs are highly aquatic; they are generally not found more than 1 m (3.3 ft) from water (Stebbins 1951, p. 340; Mullally and Cunningham 1956a, p. 191; Bradford *et al.* 1993, p. 886). Adults typically are found sitting on rocks along the shoreline, usually where there is little or no vegetation (Mullally and Cunningham 1956a, p. 191). Although mountain yellow-legged frogs may use a variety of shoreline habitats, both tadpoles and adults are less common at shorelines that drop abruptly to a depth of 60 cm (2 ft) than at open shorelines that gently slope up to shallow waters of only 5 to 8 cm (2 to 3 in) in depth (Mullally and Cunningham 1956a, p. 191; Jennings and Hayes 1994, p. 77).

At lower elevations within their historical range, these species are known to be associated with rocky streambeds and wet meadows surrounded by coniferous forest (Zweifel 1955, p. 237; Zeiner *et al.* 1988, p. 88). Streams utilized by adults vary from streams having high gradients and numerous pools, rapids, and small waterfalls, to streams with low gradients and slow flows, marshy edges, and sod banks (Zweifel 1955, p. 237). Aquatic substrates vary from bedrock to fine sand, rubble (rock fragments), and boulders (Zweifel 1955, p. 237). Mountain yellow-legged frogs appear absent from the smallest creeks, probably because these creeks have insufficient depth for adequate refuge and overwintering habitat (Jennings and Hayes 1994, p. 77). Sierra Nevada yellow-legged frogs do use stream habitats, especially the remnant populations in the northern part of their range.

At higher elevations, these species occupy lakes, ponds, tarns (small steep-banked mountain lake or pool), and streams (Zweifel 1955, p. 237; Mullally and Cunningham 1956a, p. 191). Mountain yellow-legged frogs in the Sierra Nevada are most abundant in high-elevation lakes and slow-moving portions of streams (Zweifel 1955, p. 237; Mullally and Cunningham 1956a, p. 191). The borders of alpine (above the tree line) lakes and mountain meadow streams used by mountain yellow-legged frogs are frequently grassy or muddy. This differs from the sandy or rocky shores inhabited by mountain yellow-legged frogs in lower elevation streams (Zweifel 1955, pp. 237–238).

Adult mountain yellow-legged frogs breed in the shallows of ponds or in inlet streams (Vredenburg *et al.* 2005, p. 565). Adults emerge from overwintering sites immediately following snowmelt, and will even move over ice to reach breeding sites (Pope 1999a, pp. 46–47; Vredenburg *et al.* 2005, p. 565). Mountain yellow-legged frogs deposit their eggs underwater in clusters, which they attach to rocks, gravel, or vegetation, or which they deposit under banks (Wright and Wright 1949, p. 431; Stebbins 1951,

p. 341; Zweifel 1955, p. 243; Pope 1999a, p. 30).

Lake depth is an important attribute defining habitat suitability for mountain yellow-legged frogs. As tadpoles must overwinter multiple years before metamorphosis, successful breeding sites are located in (or connected to) lakes and ponds that do not dry out in the summer, and also are deep enough that they do not completely freeze or become oxygen depleted (anoxic) in winter. Both adults and tadpole mountain yellow-legged frogs overwinter for up to 9 months in the bottoms of lakes that are at least 1.7 m (5.6 ft) deep; however, overwinter survival may be greater in lakes that are at least 2.5 m (8.2 ft) deep (Bradford 1983, p. 1179; Vredenburg *et al.* 2005, p. 565).

Bradford (1983, p. 1173) found that mountain yellow-legged frog die-offs sometimes result from oxygen depletion during winter in lakes less than 4 m (13 ft) in depth. However, tadpoles may survive for months in nearly anoxic conditions when shallow lakes are frozen to the bottom. More recent work reported populations of mountain yellow-legged frogs overwintering in lakes less than 1.5 m (5 ft) deep that were assumed to have frozen to the bottom, and yet healthy frogs emerged the following July (Matthews and Pope 1999, pp. 622–623; Pope 1999a, pp. 42–43). Radio telemetry indicated that the frogs were utilizing rock crevices, holes, and ledges near shore, where water depths ranged from 0.2 m (0.7 ft) to 1.5 m (5 ft) (Matthews and Pope 1999, p. 619). The granite surrounding these overwintering habitats probably insulates mountain yellow-legged frogs from extreme winter temperatures, provided there is an adequate supply of oxygen (Matthews and Pope 1999, p. 622). In lakes and ponds that do not freeze to the bottom in winter, mountain yellow-legged frogs may overwinter in the shelter of bedrock crevices as a behavioral response to the presence of introduced fishes (Vredenburg *et al.* 2005, p. 565).

Mountain yellow-legged frog tadpoles maintain a relatively high body temperature by selecting warmer microhabitats (Bradford 1984, p. 973). During winter, tadpoles remain in warmer water below the thermocline (the transition layer between thermally stratified water). After spring overturn (thaw and thermal mixing of the water), they behaviorally modulate their body temperature by moving to shallow, near shore water when warmer days raise surface water temperatures. During the late afternoon and evening, mountain yellow-legged frogs retreat to offshore waters that are less subject to night cooling (Bradford 1984, p. 974).

Available evidence suggests that mountain yellow-legged frogs display strong site fidelity and return to the same overwintering and summer habitats from year to year (Pope 1999a, p. 45). In aquatic habitats of high mountain lakes, mountain yellow-legged frog adults typically move only a few hundred meters (few hundred yards) (Matthews and Pope 1999, p. 623; Pope 1999a, p. 45), but single-season distances of up to 3.3 kilometers (km) (2.05 miles (mi)) have been recorded along streams (Wengert 2008, p. 18). Adults tend to move between selected breeding, feeding, and overwintering habitats during the course of the year. Though typically found near water, overland movements by adults of over 66 m (217 ft) have been routinely recorded (Pope 1999a, p. 45); the farthest reported distance of a mountain yellow-legged frog from water is 400 m (1,300 ft) (Vredenburg 2002, p. 4). Along stream habitats, adults have been observed greater than 22 m (71 ft) from the water during the overwintering period (Wengert 2008, p. 20).

Almost no data exist on the dispersal of juvenile mountain yellow-legged frogs away from breeding sites; however, juveniles that may be dispersing to permanent water have been observed in small intermittent streams (Bradford 1991, p. 176). Regionally, mountain yellow-legged frogs are thought to exhibit a metapopulation structure (Bradford *et al.* 1993, p. 886; Drost and Fellers 1996, p. 424). Metapopulations are spatially separated population subunits within migratory distance of one another such that individuals may interbreed among subunits and populations may become reestablished if they are extirpated (Hanski and Simberloff 1997, p. 6).

Historical Range and Distribution

Mountain yellow-legged frogs were historically abundant and ubiquitous across much of the higher elevations within the Sierra Nevada. Grinnell and Storer (1924, p. 664) reported the Sierra Nevada yellow-legged frog to be the most common amphibian surveyed in the Yosemite area. It is difficult to know the precise historical ranges of the Sierra Nevada yellow-legged frog and the mountain yellow-legged frog, because projections must be inferred from museum collections that do not reflect systematic surveys, and survey information predating significant rangewide reduction is very limited. However, projections of historical ranges are available using predictive habitat modeling based on recent research (Knapp, unpubl. data).

The Sierra Nevada yellow-legged frog historically occurred in Nevada on the slopes of Mount Rose in Washoe County and likely in the vicinity of Lake Tahoe in Douglas County (Linsdale 1940, pp. 208–210; Zweifel 1955, p. 231; Jennings 1984, p. 52). The historical range of the Sierra Nevada yellow-legged frog extends in California from north of the Feather River, in Butte and Plumas Counties, to the south at the Monarch Divide, in Fresno County, west of the Sierra Nevada crest. East of the Sierra Nevada crest, the historical range of the Sierra Nevada yellow-legged frog extends from the Glass Mountains of Mono County, through Inyo County, to areas north of Lake Tahoe.

The northern DPS of the mountain yellow-legged frog ranges from the Monarch Divide in Fresno County southward through the headwaters of the Kern River Watershed. The ranges of the two frog species within the mountain yellow-legged complex therefore meet each other roughly along the Monarch Divide to the north, and along the crest of the Sierra Nevada to the east.

Current Range and Distribution

Since the time of the mountain yellow-legged frog observations of Grinnell and Storer (1924, pp. 664–665), a number of researchers have reported disappearances of these species from a large fraction of their historical ranges in the Sierra Nevada (Hayes and Jennings 1986, p. 490; Bradford 1989, p. 775; Bradford *et al.* 1994a, pp. 323–327; Jennings and Hayes 1994, p. 78; Jennings 1995, p. 133; Stebbins and Cohen 1995, pp. 225–226; Drost and Fellers 1996, p. 414; Jennings 1996, pp. 934–935; Knapp and Matthews 2000, p. 428; Vredenburg *et al.* 2005, p. 564).

The current distributions of the Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog are restricted primarily to publicly managed lands at high elevations, including streams, lakes, ponds, and meadow wetlands located within National Forests and National Parks. National Forests with extant (surviving) populations of mountain yellow-legged frogs include the Plumas National Forest, Tahoe National Forest, Humboldt-Toiyabe National Forest, Lake Tahoe Basin Management Unit, Eldorado National Forest, Stanislaus National Forest, Sierra National Forest, Sequoia National Forest, and Inyo National Forest. National Parks with extant populations of mountain yellow-legged frogs include Yosemite National

Park, Kings Canyon National Park, and Sequoia National Park.

The most pronounced declines within the mountain yellow-legged frog complex have occurred north of Lake Tahoe in the northernmost 125-km (78-mi) portion of the range (Sierra Nevada yellow-legged frog) and south of Sequoia and Kings Canyon National Parks in Tulare County, in the southernmost 50-km (31-mi) portion, where only a few populations of the northern DPS of the mountain yellow-legged frog remain (Fellers 1994, p. 5; Jennings and Hayes 1994, pp. 74–78). Mountain yellow-legged frog populations have persisted in greater density in the National Parks of the Sierra Nevada as compared to the surrounding U.S. Forest Service (USFS) lands, and the populations that do occur in the National Parks generally exhibit higher abundances than those on USFS lands (Bradford *et al.* 1994a, p. 323; Knapp and Matthews 2000, p. 430).

Population Estimates and Status

Monitoring efforts and research studies have documented substantial declines of mountain yellow-legged frog populations in the Sierra Nevada. The number of extant populations has declined greatly over the last few decades. Remaining populations are patchily scattered throughout the historical range (Jennings and Hayes 1994, pp. 74–78; Jennings 1995, p. 133; Jennings 1996, p. 936). In the northernmost portion of the range (Butte and Plumas Counties), only a few Sierra Nevada yellow-legged frog populations have been documented since 1970 (Jennings and Hayes 1994, pp. 74–78; CDFG *et al.,* unpubl. data). Declines have also been noted in the central and southern Sierra Nevada (Drost and Fellers 1996, p. 420). In the south (Sierra, Sequoia, and Inyo National Forests; and Sequoia, Kings Canyon, and Yosemite National Parks), modest to relatively large populations (for example, breeding populations of approximately 40 to more than 200 adults) of mountain yellow-legged frogs do remain; however, in recent years some of the largest of these populations have been extirpated (Bradford 1991, p. 176; Bradford *et al.* 1994a, pp. 325–326; Knapp 2002a, p. 10).

Davidson *et al.* (2002, p. 1591) reviewed 255 previously documented mountain yellow-legged frog locations (based on Jennings and Hayes 1994, pp. 74–78) throughout the historical range and concluded that 83 percent of these sites no longer support frog populations. Vredenburg *et al.* (2007, pp. 369–371) compared recent survey records (1995–2004) with museum records from 1899–1994 and reported that 92.5 percent of historical Sierra Nevada yellow-legged frog populations and 92.3 percent of populations of the northern DPS of mountain yellow-legged frog are now extirpated.

CDFG (2011b, pp. 17–20) used historical localities from museum records covering the same time interval (1899–1994), but updated recent locality information with additional survey data (1995–2010) to significantly increase proportional coverage from the Vredenburg *et al.* (2007) study. These more recent surveys failed to detect any extant frog population (within 1 km (0.63 mi), a metric used to capture interbreeding individuals within metapopulations) at 220 of 318 historical Sierra Nevada yellow-legged frog localities and 94 of 109 historical mountain yellow-legged frog localities (in the Sierran portion of their range). This calculates to an estimated loss of 69 percent of Sierra Nevada yellow-legged frog metapopulations and 86 percent of northern DPS of the mountain yellow-legged frog metapopulations from historical occurrences.

In addition to comparisons based on individual localities, CDFG (2011b, pp. 20–25) compared historical and recent population status at the watershed scale. This is a rough index of the geographic extent of the species through their respective ranges. Within the Sierra Nevada, 44 percent of watersheds historically utilized by Sierra Nevada yellow-legged frogs, and 59 percent of watersheds historically utilized by northern DPS mountain yellow-legged frogs, no longer support extant populations. However, as recent survey efforts generally are more thorough than historical ones (they target all aquatic habitats in each surveyed watershed), this watershed-level comparison likely underestimates rangewide declines in total populations because several individual populations may be lost even though a watershed is counted as recently occupied if a single individual (at any life stage) is observed within the entire watershed (CDFG 2011b, p. 20). Furthermore, remaining populations are generally very small. Many watersheds support only a single extant metapopulation, which occupies one to several adjacent water bodies (CDFG 2011b, p. 20).

Rangewide, declines of mountain yellow-legged frog populations were estimated at around one-half of historical populations by the end of the 1980s (Bradford *et al.* 1994a, p. 323). Between 1988 and 1991, Bradford *et al.* (1994a, pp. 323–327) resurveyed sites known historically (1955 through 1979 surveys) to support mountain yellow-legged frogs. They did not detect frogs at 27 historical sites on the Kaweah River, and they detected frogs at 52 percent of historical sites within Sequoia and Kings Canyon National Parks and 12.5 percent of historical sites outside of Sequoia and Kings Canyon National Parks. When both species are combined, this resurvey effort detected mountain yellow-legged frogs at 19.4 percent of historical sites (Bradford *et al.* 1994a, pp. 324–325).

Available information discussed below indicates that the rates of population decline have not abated, and they have likely accelerated during the 1990s into the 2000s. Drost and Fellers (1996, p. 417) repeated Grinnell and Storer's early 20th century surveys, and reported frog presence at 2 of 14 historical sites. The two positive sightings consisted of a single tadpole at one site and a single adult female at another. They identified 17 additional sites with suitable mountain yellow-legged frog habitat, and in those surveys, they detected three additional populations. In 2002, Knapp (2002a, p. 10) resurveyed 302 water bodies known to be occupied by mountain yellow-legged frogs between 1995 and 1997, and 744 sites where frogs were not previously detected. Knapp found frogs at 59 percent of the previously occupied sites, whereas 8 percent of previously unoccupied sites were recolonized. These data suggest an extirpation rate five to six times higher than the colonization rate within this study area. The documented extirpations appeared to occur non-randomly across the landscape, were typically spatially clumped, and involved the disappearance of all or nearly all of the mountain yellow-legged frog populations in a watershed (Knapp 2002a, p. 9). CDFG (2011b, p. 20) assessed data from sites where multiple surveys were completed since 1995 (at least 5 years apart). They found that the Sierra Nevada yellow-legged frog was not detected at 45 percent of sites where they previously had been confirmed, while the mountain yellow-legged frog (rangewide, including southern California) was no longer detectable at 81 percent of historically occupied sites.

The USFS conducts a rangewide, long-term monitoring program for the Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog known as the Sierra Nevada Amphibian Monitoring Program (SNAMPH). This monitoring effort provides unbiased estimates by using an integrated unequal probability design, and it provides numbers for robust statistical comparisons across 5-year monitoring cycles spanning 208 watersheds (Brown *et al.* 2011, pp. 3–4). The results of this assessment indicate that breeding activity for the frogs is limited to 4 percent of watersheds rangewide, and the species have declined in both distribution and abundance from historical records. For the recent historical record (positive surveys during 1990–2002 versus 2006–2009), breeding was found in about half (48 percent) of the survey sites. When compared to data prior to 1990, recent frog occurrence is limited to 3 percent of watersheds for which data exist. Moreover, relative abundances were low; an estimated 9 percent of populations were large (numbering more than 100 frogs or 500 tadpoles); about 90 percent of the watersheds had fewer than 10 adults, while 80 percent had fewer than 10 subadults and 100 tadpoles (Brown *et al.* 2011, p. 24).

To summarize population trends over the available historical record, estimates range from losses between 69 to 93 percent of Sierra Nevada yellow-legged frog populations and 86 to 92 percent of northern DPS of the mountain yellow-legged frog. Rangewide reduction has diminished the number of watersheds that support mountain yellow-legged frogs somewhere between the conservative estimates of 44 percent in the case of Sierra Nevada yellow-legged frogs and at least 59 percent in the case of northern DPS of the mountain yellow-legged frogs, to as high as 97 percent of watersheds for the mountain yellow-legged frog complex across the Sierra Nevada. Remaining populations are much smaller relative to historical norms, and the density of populations per watershed has declined greatly; as a result, many watersheds currently support single metapopulations at low abundances.

Distinct Population Segment (DPS) Analysis

Under the Act, we must consider for listing any species, subspecies, or, for vertebrates, any DPS of these taxa if there is sufficient information to indicate that such action may be warranted. To implement the measures prescribed by the Act, we, along with the National Marine Fisheries Service (National Oceanic and Atmospheric Administration—Fisheries), developed a joint policy that addresses the recognition of DPSes for potential listing actions (61 FR 4722). The policy allows for a more refined application of the Act that better reflects the biological needs of the taxon being considered and avoids the inclusion of entities that do not require the Act's protective measures.

Under our DPS Policy, we use two elements to assess whether a population segment under consideration for listing may be recognized as a DPS: (1) The population segment's discreteness from the remainder of the species to which it belongs and (2) the significance of the population segment to the species to which it belongs. If we determine that a population segment being considered for listing is a DPS, then the level of threat to the population is evaluated based on the five listing factors established by the Act to determine if listing it as either endangered or threatened is warranted.

The newly recognized species, the Sierra Nevada yellow-legged frog (*Rana sierrae*), is confirmed by genetic analysis as distinct from populations of mountain yellow-legged frogs (*R. muscosa*) extant in the southern Sierra Nevada (Vredenburg *et al.* 2007, p. 367). Other distinguishing features have already been mentioned (see ''Taxonomy'' above). We are not conducting a DPS assessment in this proposed rule for the Sierra Nevada yellow-legged frog because we have determined the species is warranted for listing across its entire range. It is our intent to discuss below only those topics directly relevant to the identification and determination of the northern DPS of the mountain yellow-legged frog.

Discreteness

Under our DPS Policy, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following two conditions: (1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or (2) it is delimited by international governmental boundaries within which significant differences in control of exploitation, management of habitat, conservation, status, or regulatory mechanisms exist.

The proposed DPS, the northern DPS of the mountain yellow-legged frog (northern DPS of *Rana muscosa*), satisfies the first condition for discreteness, the marked separation from other populations. The range of these mountain yellow-legged frogs is divided by a natural geographic barrier, the Tehachapi Mountains, which physically isolates populations in the southern Sierra Nevada from those in the mountains of southern California. The distance of the geographic separation is about 225 km (140 mi). Between the two population segments, there remains no connectivity through the presence of contiguous habitat sufficient for the migration, growth, rearing, or reproduction of dispersing frogs. Genetic discreteness is also well-supported in the scientific literature (see ''Taxonomy'' above). Therefore, we find these two population segments are discrete.

Significance

Under our DPS Policy, once we have determined that a population segment is discrete, we consider its biological and ecological significance to the larger taxon to which it belongs. This consideration may include, but is not limited to: (1) Evidence of the persistence of the discrete population segment in an ecological setting that is unusual or unique for the taxon, (2) evidence that loss of the population segment would result in a significant gap in the range of the taxon, (3) evidence that the population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range, or (4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

We have found substantial evidence that three of four significance criteria are met by the northern DPS of the mountain yellow-legged frog in the Sierra Nevada. These include ecological uniqueness, its loss would result in a significant gap in the range of the taxon, and genetic uniqueness (reflecting significant reproductive isolation over time). There are no introduced populations of mountain yellow-legged frogs outside of the species' historical range.

One of the most striking differences between northern DPS mountain yellow-legged frogs and southern California mountain yellow-legged frogs is the ecological settings they occupy. Zweifel (1955, pp. 237–241) observed that the frogs in southern California are typically found in steep gradient streams in the chaparral belt, even though they may range into small meadow streams at higher elevations. In contrast, northern DPS frogs are most abundant in high-elevation lakes and slow-moving portions of streams in the Sierra Nevada. The rugged canyons of the arid mountain ranges of southern California bear little resemblance to the alpine lakes and streams of the Sierra Nevada. The significantly different ecological settings between mountain yellow-legged frogs in southern California and those in the Sierra

Nevada distinguish these populations from each other.

Furthermore, the northern DPS populations of the mountain yellow-legged frog are significant because a catastrophic reduction in abundance of the species as a whole would occur if the populations constituting the northern range of the species were extirpated. The northern DPS mountain yellow-legged frogs comprise the main distribution of the species at the northern limits of the species' range. Loss of the northern DPS would be significant, as it would eliminate the species from a large portion of its range and would reduce the species to 9 small, isolated sites in southern California (USFWS, Jul 2012, pp. 11–12).

Finally, the northern DPS populations of mountain yellow-legged frog are biologically and ecologically significant based on genetic criteria. Vredenburg *et al.* (2007, p. 361) identified that two of three distinct genetic clades (groups of distinct lineage) constitute the northern range of the mountain yellow-legged frog found in the Sierra Nevada, with the remaining single clade represented by the endangered southern California DPS of the mountain yellow-legged frog.

Based on the differences between the ecological settings for the mountain yellow-legged frogs found in southern California (steep gradient streams) and the frogs found in the Sierra Nevada (high-elevation lakes and slow-moving portions of streams), the importance of the northern population found in the Sierra Nevada to the entire range of this species, and the genetic composition of northern clades reflecting isolation over a substantial period of time (more than 1 mybp), mountain yellow-legged frogs found in the Sierra Nevada mountains meet the significance criteria under our Policy Regarding the Recognition of Distinct Vertebrate Population Segments (61 FR 4722).

Summary of Factors Affecting the Species

Section 4 of the Act (16 U.S.C. 1533), and its implementing regulations at 50 CFR part 424, set forth the procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, we may list a species based on any of the following five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. Listing actions may be warranted based on any of the above threat factors, singly or in combination. Each of these factors is discussed below. The following analysis is applicable to both the Sierra Nevada yellow-legged frog (*Rana sierrae*) and the Northern Distinct Population Segment of the mountain yellow-legged frog (*Rana muscosa*).

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Habitat Destruction

A number of hypotheses, including habitat loss, have been proposed for recent global amphibian declines (Bradford *et al.* 1993, p. 883; Corn 1994, p. 62; Alford and Richards 1999, p. 4). However, physical habitat destruction does not appear to be the primary factor associated with the decline of mountain yellow-legged frogs. Mountain yellow-legged frogs occur at high elevations in the Sierra Nevada, which have not had the types or extent of large-scale habitat conversion and physical disturbance that have occurred at lower elevations (Knapp and Matthews 2000, p. 429). Thus, direct habitat destruction or modification associated with intensive human activities has not been implicated in the decline of this species (Davidson *et al.* 2002, p. 1597).

However, other human activities have played a role in the modification of mountain yellow-legged frog habitats and the curtailment of their range. The aggregation of these threats has degraded and fragmented habitats rangewide to a significant extent. These threats include: Recreational activities, fish introductions (see also Factor C below), dams and water diversions, livestock grazing, timber management, road construction and maintenance, and fire management activities. Such activities have degraded habitat in ways that have reduced their capacity to sustain viable populations and have fragmented and isolated mountain yellow-legged frog populations from each other.

Recreation

Recreational activities take place throughout the Sierra Nevada and have significant negative impacts on many plant and animal species and their habitats (U.S. Department of Agriculture (USDA) 2001a, pp. 483–493). High-elevation wilderness areas, where much of the increased recreational activity occurs, are naturally stressed ecosystems because of intense solar exposure; extremes in temperatures, precipitation levels, and wind; short growing seasons; and shallow, nutrient-poor soil. Such habitats are typically not resilient to disturbance (Schoenherr 1992, p. 167; Cole and Landres 1996, p. 170).

Recreational foot traffic in riparian areas tramples the vegetation, compacts the soils, and can physically damage the streambanks (Kondolf *et al.* 1996, pp. 1018–1020). Hiking, horse, bicycle, or off-highway motor vehicle trails compact soils within riparian habitat (Kondolf *et al.* 1996, p. 1019), and can lower the water table and cause increased erosion. The recreational activity of anglers at high mountain lakes can be locally intense in the Sierra Nevada, with most regions reporting a level of use greater than the fragile lakeshore environments can withstand (Bahls 1992, p. 190). However, studies have not been conducted to determine the extent to which recreational activities are directly contributing to the decline of the mountain yellow-legged frog complex, and direct effects from recreation have not been implicated as a major cause of the decline of these species. Nevertheless, recreational activities are the fastest growing use of National Forests. As such, their impacts on the mountain yellow-legged frog complex are likely to continue and to increase (USDA 2001b, p. 213). Currently, recreational activities are considered a threat of low significance to the species' habitat overall.

Habitat Modification Due to Introduction of Trout to Historically Fishless Areas

One habitat feature that is documented to have a significant detrimental impact to mountain yellow-legged frog populations is the presence of trout from current and historical stocking for the maintenance of a sport fishery. To further angling success and opportunity, trout stocking programs in the Sierra Nevada started in the late 19th century (Bahls 1992, p. 185; Pister 2001, p. 280). This anthropogenic activity has community-level effects and constitutes the primary detrimental impact to mountain yellow-legged frog habitat and species viability.

Prior to extensive trout planting programs, almost all streams and lakes in the Sierra Nevada at elevations above 1,800 m (6,000 ft) were fishless. Several native fish species occur naturally in aquatic habitats below this elevation in the Sierra Nevada (Knapp 1996, pp. 12–14; Moyle *et al.* 1996, p. 354; Moyle 2002, p. 25). Natural barriers prevented fish from colonizing the higher elevation headwaters of the Sierra Nevada watershed (Moyle *et al.* 1996, p. 354). The upper reaches of the Kern

River, where native fish such as the Little Kern golden trout (*Oncorhynchus mykiss whitei*) and California golden trout (*O. m. aguabonita*) evolved, represent the only major exception to the 1,800-m (6,000-ft) elevation limit for fishes within the range of the mountain yellow-legged frog in the Sierra Nevada (Moyle 2002, p. 25). Additionally, prior to extensive planting, native Paiute cutthroat (*O. clarki seleneris*) and Lahontan cutthroat (*O. c. henshawi*) also occurred within the range of the mountain yellow-legged frog in the Sierra Nevada, but were limited in their distribution (Moyle 2002, pp. 288–289).

Some of the first practitioners of trout stocking in the Sierra Nevada were the Sierra Club, local sportsmen's clubs, private citizens, and the U.S. military (Knapp 1996, p. 8; Pister 2001, p. 280). As more hatcheries were built, and the management of the trout fishery became better organized, fish planting continued for the purpose of increased angler opportunities and success (Pister 2001, p. 281). After World War II, the method of transporting trout to high-elevation areas changed from packstock to aircraft, which allowed stocking in more remote lakes and in greater numbers. With the advent of aerial stocking, trout planting expanded to new areas, with higher efficiency.

Brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and other trout species assemblages have been planted in most streams and lakes of the Sierra Nevada (Knapp 1996, p. 8; Moyle 2002, p. 25). National Forests in the Sierra Nevada have a higher proportion of lakes with fish occupancy than do National Parks (Knapp 1996, p. 3). This is primarily because the National Park Service (NPS) adopted a policy that greatly reduced fish stocking within their jurisdictional boundaries in the late 1970s. Fish stocking was terminated altogether in Sierra Nevada National Parks in 1991 (Knapp 1996, p. 9). CDFG continues to stock trout in National Forest water bodies, but has recently reduced the number of stocked water bodies to reduce impacts to native amphibians (ICF Jones & Stokes 2010, pp. ES–1–ES–16). Stocking decisions are based on criteria outlined in the Environmental Impact Report for the Hatchery and Stocking Program (ICF Jones & Stokes 2010, Appendix K).

Fish stocking as a practice has been widespread throughout the range of both species of mountain yellow-legged frogs. Knapp and Matthews (2000, p. 428) indicated that 65 percent of the water bodies that were 1 ha (2.5 ac) or larger in National Forests they studied were stocked with fish on a regular basis. Over 90 percent of the total water body surface area in the John Muir Wilderness was occupied by nonnative trout (Knapp and Matthews 2000, p. 434).

Another detrimental feature of fish stocking is that fish often persist in water bodies even after stocking ceases. Lakes larger than 1 ha (2.5 ac) within Sierra Nevada National Parks were estimated to have from 35 to 50 percent nonnative fish occupancy, only a 29 to 44 percent decrease since fish stocking was terminated around 2 decades before the study (Knapp 1996, p. 1). Though data on fish occupancy in streams are lacking throughout the Sierra Nevada, Knapp (1996, p. 11) estimated that 60 percent of the streams in Yosemite National Park were still occupied by introduced trout.

Trout both compete for limited resources and directly prey on mountain yellow-legged frog tadpoles and adults (see Factor C below). The presence of these fish decimates frog populations through competition and predation (see below). The impact of introduced trout was greatest in the past, as it eliminated frogs across a large expanse of their historical range. Fundamentally, this has removed deeper lakes from being mountain yellow-legged frog habitat at a landscape scale, because fish now populate these areas instead of frogs. Moreover, introduced trout continue to limit species viability because remaining populations are now isolated, and functional dispersal barriers make emigration difficult. Finally, the few frogs that do successfully emigrate will move to inhospitable, fish-occupied habitat where they are often outcompeted or preyed upon by trout. These factors make recolonization of extirpated sites unlikely.

The body of scientific research has demonstrated that introduced trout have negatively impacted mountain yellow-legged frogs over much of the Sierra Nevada (Grinnell and Storer 1924, p. 664; Bradford 1989, pp. 775–778; Bradford *et al.* 1993, pp. 882–888; Knapp 1994, p. 3; Drost and Fellers 1996, p. 422; Knapp 1996, pp. 13–15; Knapp and Matthews 2000, p. 428; Knapp *et al.* 2001, p. 401). Fish stocking programs have negative ecological implications because fish eat aquatic flora and fauna, including amphibians and invertebrates (Bahls 1992, p. 191; Erman 1996, p. 992; Matthews *et al.* 2001, pp. 1135–1136; Pilliod and Peterson 2001, p. 329; Schindler *et al.* 2001, p. 309; Moyle 2002, p. 58; Epanchin *et al.* 2010, p. 2406). Finlay and Vredenburg (2007, p. 2187) documented that the same benthic (bottom-dwelling) invertebrate resource base sustains the growth of both frogs and trout, suggesting that competition with trout for prey is an important factor that may contribute to the decline of the mountain yellow-legged frog.

Knapp and Matthews (2000, p. 428) surveyed more than 1,700 water bodies, and concluded that a strong negative correlation exists between introduced trout and mountain yellow-legged frogs (Knapp and Matthews 2000, p. 435). Consistent with this finding are the results of an analysis of the distribution of mountain yellow-legged frog tadpoles, which indicate that the presence and abundance of this life stage are reduced dramatically in fish-stocked lakes (Knapp *et al.* 2001, p. 408). Knapp (2005a, pp. 265–279) also compared the distribution of nonnative trout with the distributions of several amphibian and reptile species in 2,239 lakes and ponds in Yosemite National Park, and found that mountain yellow-legged frogs were five times less likely to be detected in waters where trout were present. Even though stocking within the National Park ceased in 1991, more than 50 percent of water bodies deeper than 4 m (13 ft) and 75 percent deeper than 16 m (52 ft) still contained trout populations in 2000–2002 (Knapp 2005a, p. 270). Both trout and mountain yellow-legged frogs utilize deeper water bodies. Based on the results from Knapp (2005a), the reduced detection of frogs in trout-occupied waters indicates that trout are excluding mountain yellow-legged frogs from some of the best aquatic habitat.

Several aspects of the mountain yellow-legged frog's life history may exacerbate its vulnerability to extirpation by trout (Bradford 1989, pp. 777–778; Bradford *et al.* 1993, pp. 886–888; Knapp 1996, p. 14; Knapp and Matthews 2000, p. 435). Mountain yellow-legged frogs are aquatic and found mainly in lakes. This increases the probability that they will encounter introduced fishes whose distribution has been greatly expanded throughout the Sierra Nevada. The multiple-year tadpole stage of the mountain yellow-legged frog necessitates their use of permanent water bodies deep enough to not freeze solid during multiple winters (unless there is some other refuge from freezing and oxygen depletion, such as submerged crevices). Also, overwintering adults must avoid oxygen depletion when the water is covered by ice (Mullally and Cunningham 1956a, p. 194; Bradford 1983, p. 1179; Knapp and Matthews 2000, pp. 435–436). This functionally restricts tadpoles to the same water bodies most suitable for fishes (Knapp 1996, p. 14), and the consequences of predation and competition thereby isolate mountain yellow-legged frogs to fishless, marginal habitats (Bradford *et al.* 1993, pp. 886–887; Knapp and Matthews 2000, p. 435).

Mountain yellow-legged frogs and trout (native and nonnative) do co-occur at some sites, but these co-occurrences are probably mountain yellow-legged frog population sinks (areas with negative population growth rates in the absence of immigration) (Bradford *et al.* 1998, p. 2489; Knapp and Matthews 2000, p. 436). Mountain yellow-legged frogs have also been extirpated at some fishless bodies of water (Bradford 1991, p. 176; Drost and Fellers 1996, p. 422). A possible explanation is the isolation and fragmentation of remaining populations due to introduced fishes in the streams that once provided mountain yellow-legged frogs with dispersal and recolonization routes; these remote populations are now non-functional as metapopulations (Bradford 1991, p. 176; Bradford *et al.* 1993, p. 887). Based on a survey of 95 basins within Sequoia and Kings Canyon National Parks, Bradford *et al.* (1993, pp. 885–886) estimated that the introduction of fishes into the study area resulted in an approximately 10-fold increase in habitat fragmentation between populations of mountain yellow-legged frogs. Knapp and Matthews (2000, p. 436) believe that this fragmentation has further isolated mountain yellow-legged frogs within the already marginal habitat left unused by fishes.

Fragmentation of mountain yellow-legged frog habitat renders metapopulations more vulnerable to extirpation from random events (such as disease) (Wilcox 1980, pp. 114–115; Bradford *et al.* 1993, p. 887; Hanski and Simberloff 1997, p. 21; Knapp and Matthews 2000, p. 436). Isolated population locations may have higher extinction rates because trout prevent successful recolonization and dispersal to and from these sites (Bradford *et al.* 1993, p. 887; Blaustein *et al.* 1994a, p. 7; Knapp and Matthews 2000, p. 436). Amphibians may be unable to recolonize unoccupied sites following local extinctions because of physiological constraints, the tendency to move only short distances, and high site fidelity (Blaustein *et al.* 1994a, p. 8). Finally, frogs that do attempt recolonization may emigrate into fish-occupied habitat and perish, rendering sites with such metapopulation dynamics less able to sustain frog populations.

Although fish stocking has been curtailed within many occupied basins, the impacts to frog populations persist due to the presence of self-sustaining fish populations in some of the best habitat that normally would have sustained mountain yellow-legged frogs. The fragmentation that persists across the range of these frog species renders them more vulnerable to other population stressors, and recovery is slow, if not impossible, without costly and physically difficult direct human intervention (such as physical and chemical trout removal). While most of the impacts occurred historically, the impact upon the biogeographic (population/metapopulation) integrity of the species will be long-lasting. Currently, habitat degradation and fragmentation by fish is considered a highly significant and prevalent threat to persistence and recovery of the species.

Dams and Water Diversions

Numerous reservoirs have been constructed within the ranges of the mountain yellow-legged frog complex. These include Huntington Lake, Florence Lake, Lake Thomas A. Edison, Saddlebag Lake, Convict Lake, Cherry Lake, and other reservoirs associated with Hetch Hetchy, Upper and Lower Blue Lakes, Lake Aloha, Silver Lake, Hell Hole Reservoir, French Meadow Reservoir, Lake Spaulding, Alpine Lake, Loon Lake, Ice House Reservoir, and others. Dams and water diversions have altered aquatic habitats in the Sierra Nevada (Kondolf *et al.* 1996, p. 1014). The combination of these two features has reduced habitat suitability within the range of the species by creating migration barriers and altering local hydrology. This stressor causes considerable habitat fragmentation and direct habitat loss in those areas where water projects were constructed and are operating.

The extent of the impact to mountain yellow-legged frog populations from habitat loss or modification due to these projects has not been quantified. However, the construction of dams has affected populations in the Sierra Nevada by altering the distribution of predators (reservoirs are often stocked with fish species that prey on mountain yellow-legged frogs) and affecting the effective dispersal of migrating frogs. Mountain yellow-legged frogs cannot live in or disperse effectively through the exposed shorelines created by reservoirs, nor can they successfully reproduce in these environments unless there are shallow side channels or disjunct pools free of predatory fishes (Jennings 1996, p. 939). In this fashion, reservoirs represent considerable dispersal barriers that further fragment the range of the mountain yellow-legged frogs.

Dams alter the temperature and sediment load of the rivers they impound (Cole and Landres 1996, p. 175). Dams, water diversions, and their associated structures also alter the natural flow regime with unseasonal and fluctuating releases of water. These features may create habitat conditions unsuitable for native amphibians both upstream and downstream of dams, and they may act as barriers to movement by dispersing juvenile and migrating adult amphibians (Jennings 1996, p. 939). Where dams act as barriers to mountain yellow-legged frog movement, they effectively prevent genetic exchange between populations and the recolonization of vacant sites.

Water diversions may remove water from mountain yellow-legged frog habitat and adversely impact breeding success and adult survivorship. This results in physical reduction in habitat area and potentially lowers water levels to the extent that the entire water column freezes in the winter, thereby removing aquatic habitat altogether. Given the amount of water development within the historical ranges of mountain yellow-legged frogs, these factors likely have contributed to population declines, and ongoing management and habitat fragmentation will continue to pose a risk to the species. The magnitude of such impacts would increase if long droughts become more frequent in the future (see Factor E below) or if increasing diversions and storage facilities are constructed and implemented to meet growing needs for water and power. Currently, dams and water diversions are considered a moderate, prevalent threat to persistence and recovery of the species.

Livestock Use (Grazing)

As discussed below, grazing reduces the suitability of habitat for mountain yellow-legged frogs by reducing its capability to sustain frogs and facilitate dispersal and migration, especially in stream areas. The impact of this stressor to mountain yellow-legged frogs is ongoing, but of relatively low importance as a limiting factor on extant populations. While this stressor may have played a greater role historically, leading in part to rangewide reduction of the species (see below), the geographic extent of livestock grazing activity within current mountain yellow-legged frog habitat does not encompass the entire range of the species.

Grazing of livestock in riparian areas impacts vegetation in multiple ways, including soil compaction, which increases runoff and decreases water availability to plants; vegetation removal, which promotes increased soil temperatures and evaporation rates at the soil surface; and direct physical damage to the vegetation (Kauffman and Krueger 1984, pp. 433–434; Cole and Landres 1996, pp. 171–172; Knapp and Matthews 1996, pp. 816–817). Streamside vegetation protects and stabilizes streambanks by binding soils to resist erosion and trap sediment (Kauffman *et al.* 1983, p. 683; Chaney *et al.* 1990, p. 2). Removal of vegetative cover within mountain yellow-legged frog habitat decreases available habitat, exposes frogs to predation (Knapp 1993b, p.1), and increases the threat of desiccation (Jennings 1996, p. 539).

Aquatic habitat can also be degraded by grazing. Mass erosion from trampling and hoof slide causes streambank collapse and an accelerated rate of soil transport to streams (Meehan and Platts 1978, p. 274). Accelerated rates of erosion lead to elevated instream sediment loads and depositions, and changes in stream-channel morphology (Meehan and Platts 1978, pp. 275–276; Kauffman and Krueger 1984, p. 432). Livestock grazing may lead to diminished perennial streamflows (Armour *et al.* 1994, p. 10). Livestock can increase nutrient-loading in water bodies due to urination and defecation in or near the water, and can cause elevated bacteria levels in areas where cattle are concentrated (Meehan and Platts 1978, p. 276; Stephenson and Street 1978, p. 156; Kauffman and Krueger 1984, p. 432). With increased grazing intensity, these adverse effects to the aquatic ecosystem increase proportionately (Meehan and Platts 1978, p. 275; Clary and Kinney 2000, p. 294).

Observational data indicate that livestock negatively impact mountain yellow-legged frogs by altering riparian habitat and trampling individuals (Knapp 1993a, p. 1; 1993b, p. 1; 1994, p. 3; Jennings 1996, p. 938; Carlson 2002, pers. comm.; Knapp 2002a, p. 29). Livestock tend to concentrate along streams and wet areas where there is water and herbaceous vegetation; grazing impacts are therefore most pronounced in these habitats (Meehan and Platts 1978, p. 274; U.S. Government Accounting Office (GAO) 1988, pp. 10–11; Fleischner 1994, p. 635; Menke *et al.* 1996, p. 17). This concentration of livestock contributes to the destabilization of streambanks, causing undercuts and bank failures (Kauffman *et al.* 1983, p. 684; Marlow and Pogacnik 1985, pp. 282–283; Knapp and Matthews 1996, p. 816; Moyle 2002, p. 55). Grazing activity contributes to the downcutting of streambeds and lowers the water table (Meehan and Platts 1978, pp. 275–276; Kauffman *et al.* 1983, p. 685; Kauffman and Krueger 1984, p. 432; Bohn and Buckhouse 1985, p. 378; GAO 1988, p. 11; Armour *et al.* 1994, pp. 9–11; Moyle 2002, p. 55).

Livestock grazing may impact other wetland systems, including ponds that can serve as mountain yellow-legged frog habitat. Grazing modifies shoreline habitats by removing overhanging banks that provide shelter, and grazing contributes to the siltation of breeding ponds. Pond siltation has been demonstrated to reduce the depth of breeding ponds and to cover underwater crevices, thereby making the ponds less suitable, or unsuitable, as overwintering habitat for tadpoles and adult mountain yellow-legged frogs (Bradford 1983, p. 1179; Pope 1999a, pp. 43–44).

In general, historical livestock grazing within the range of the mountain yellow-legged frog was at a high (although undocumented) level until the establishment of National Parks (beginning in 1890) and National Forests (beginning in 1905) (UC 1996a, p. 114; Menke *et al.* 1996, p. 14). Within the newly established National Parks, grazing by cattle and sheep was replaced by that of packstock, such as horses and burros. Within the National Forests, the amount of livestock grazing was gradually reduced, and the types of animals shifted away from sheep and toward cattle and packstock.

For mountain yellow-legged frogs, livestock grazing activity is likely a minor prevalent threat to currently extant populations, although in certain areas it may exacerbate habitat fragmentation already facilitated by the introduction of trout. There are currently 161 active Rangeland Management Unit Allotments for grazing in USFS-administered lands. Twenty-seven of these allotments have extant mountain yellow-legged frog populations (based on surveys performed after 2005). Currently, other allotments have been closed in certain sensitive areas, and standards have been implemented in remaining allotments to protect aquatic habitats. This threat is likely more one of historical significance. While it may be a factor in certain allotments with active grazing and extant populations, rangewide it is likely not a significant risk factor as many populations persist outside of actively grazed areas.

Packstock Use

Packstock grazing is the only grazing currently permitted in the National Parks of the Sierra Nevada. Use of packstock in the Sierra Nevada has increased since World War II as a result of improved road access and increases in leisure time and disposable income (Menke *et al.* 1996, p. 14). In the Sixty-Lakes Basin of Kings Canyon National Park, packstock use is regulated in wet meadows to protect mountain yellow-legged frog breeding habitat in bogs and lake shores from trampling and associated degradation (Vredenburg 2002, p. 11; Werner 2002, p. 2). Packstock use is also permitted in National Forests within the Sierra Nevada. However, there has been very little monitoring of the impacts of such activity in this region (Menke *et al.* 1996, p. 14), so its contribution to the decline of frog populations is impossible to quantify.

Packstock use is likely a threat of low significance to mountain yellow-legged frogs at the current time, except on a limited, site-specific basis. As California's human population increases, the impact of recreational activities, including packstock use and riding in the Sierra Nevada, are projected to increase (USDA 2001a, pp. 473–474). This activity may pose a risk to some remnant populations of frogs and, in certain circumstances, a hindrance to recovery of populations in heavily used lakes.

Roads and Timber Harvest

Activities that alter the terrestrial environment (such as road construction and timber harvest) may impact amphibian populations in the Sierra Nevada (Jennings 1996, p. 938). These impacts are understandably in proportion to the magnitude of the alteration to the environment, and are more pronounced in areas with less stringent mitigation measures (that is, outside National Parks or wilderness areas). Road construction and timber harvest were likely of greater significance historically, and may have acted to reduce the species' range prior to the more recent detailed studies and systematic monitoring that have quantified and documented these losses.

Timber harvest activities remove vegetation and cause ground disturbance and compaction, making the ground more susceptible to erosion (Helms and Tappeiner 1996, p. 446). This erosion increases siltation downstream that could potentially damage mountain yellow-legged frog breeding habitat. Timber harvest may alter the annual hydrograph (timing and volume of surface flows), possibly lowering the water table, which could dewater riparian habitats used by mountain yellow-legged frogs. The majority of erosion caused by timber harvests is from logging roads (Helms and Tappeiner 1996, p. 447). Prior to the formation of National Parks in 1890 and

National Forests in 1905, timber harvest was widespread and unregulated, but primarily took place at elevations on the western slope of the Sierra Nevada below the range of the mountain yellow-legged frog (University of California (UC) 1996b, pp. 24–25). Between 1900 and 1950, the majority of timber harvest occurred in old-growth forests on private land (UC 1996b, p. 25). Between 1950 and the early 1990s, there were increases in timber harvest on National Forests, and the majority of timber harvest-associated impacts on mountain yellow-legged frogs may therefore have taken place during this period.

Roads, including those associated with timber harvests, can contribute to habitat fragmentation and limit amphibian movement, thus having a negative effect on amphibian species richness (Lehtinen *et al.* 1999, pp. 8–9; deMaynadier and Hunter 2000, p. 56). This effect could fragment mountain yellow-legged frog habitat if the road bisected habitat consisting of water bodies in close proximity.

Currently, most of the mountain yellow-legged frog populations occur in National Parks or designated wilderness areas where timber is not harvested (Bradford *et al.* 1994a, p. 323; Drost and Fellers 1996, p. 421; Knapp and Matthews 2000, p. 430). Other mountain yellow-legged frog populations outside of these areas are located above the timberline, so timber harvest activity is not expected to affect the majority of extant mountain yellow-legged frog populations. There remain some mountain yellow-legged frog populations in areas where timber harvests occur or may occur in the future. Roads also exist within the range of the mountain yellow-legged frog, and more may be constructed. However, neither of these factors has been implicated as an important contributor to the decline of this species (Jennings 1996, pp. 921–941). It is likely a minor prevalent threat to mountain yellow-legged frogs factored across the range of the species.

Fire and Fire Management Activities

Mountain yellow-legged frogs are generally found at high elevations in wilderness areas and National Parks where vegetation is sparse and fire suppression activities are infrequently implemented. Where such activities may occur, potential impacts to the species resulting from fire management activities include: Habitat degradation through water drafting (taking of water) from occupied ponds and lakes, erosion and siltation of habitat from construction of fuel breaks, and contamination by fire retardants from chemical fire suppression.

In some areas within the current range of the mountain yellow-legged frog, long-term fire suppression has changed the forest structure and created conditions that increase fire severity and intensity (McKelvey *et al.* 1996, pp. 1934–1935). Excessive erosion and siltation of habitats following wildfire is a concern in shallow, lower elevation areas below forested stands. However, prescribed fire has been used by land managers to achieve various silvicultural objectives, including fuel load reduction. In some systems, fire is thought to be important in maintaining open aquatic and riparian habitats for amphibians (Russell ASLO 1999, p. 378), although severe and intense wildfires may reduce amphibian survival, as the moist and permeable skin of amphibians increases their susceptibility to heat and desiccation (Russell *et al.* 1999, p. 374). Amphibians may avoid direct mortality from fire by retreating to wet habitats or sheltering in subterranean burrows.

It is not known what impacts fire and fire management activities have had on historical populations of mountain yellow-legged frogs. Neither the direct nor indirect effects of prescribed fire or wildfire on the mountain yellow-legged frog have been studied. Where fire has occurred in southern California, the character of the habitat has been significantly altered, leading to erosive scouring and flooding after surface vegetation is denuded (North 2012, pers. comm.). When a large fire does occur in occupied habitat, mountain yellow-legged frogs are susceptible to direct mortality (leading to significantly reduced population sizes) and indirect effects (habitat alteration and reduced breeding habitat). It is suspected that at least one population in the southern DPS was nearly extirpated by fire on the East Fork City Creek (San Bernadino Mountains) in 2003 (North 2012, pers. comm.). It is possible that fire has caused localized extirpations in the past. However, because the species generally occupies high-elevation habitat, fire is likely not a significant risk to this species over much of its current range.

In summary, based on the best available scientific and commercial information, we consider the threats of modification and curtailment of the species' habitat and range to be significant, ongoing threats to the Sierra Nevada yellow-legged frog and northern DPS of the mountain yellow-legged frog. Threats from recreational foot traffic, camping, and timber harvest and related activities are not quantified, but they are not thought to be major drivers of frog population dynamics. Threats of low prevalence (important limiting factors in some areas, but not across a large part of the mountain yellow-legged frog complex's range) include grazing and fire management activities. Dams and water diversions likely present a moderate prevalent threat. Habitat fragmentation and degradation (loss of habitat through competitive exclusion) by stocked and persistent introduced trout across the majority of the species' range are a threat of high prevalence. This threat is a significant limiting factor to persistence and recovery of the species rangewide.

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

There is no known commercial market for mountain yellow-legged frogs, nor are there documented recreational or educational uses for these species. Mountain yellow-legged frogs do not appear to be particularly popular among amphibian and reptile collectors; however, Federal listing could raise the value of the animals within wildlife trade markets and increase the threat of unauthorized collection above current levels (McCloud 2002, pers. comm.).

Scientific collection for museum specimens has resulted in the death of numerous individuals (Zweifel 1955, p. 207; Jennings and Hayes 1994, pp. 74–78). However, this occurred at times when the populations were at greater abundances and geographic distribution and in numbers that likely had little influence on the overall population from which individuals were sampled. Scientific research may cause stress to mountain yellow-legged frogs through disturbance, including disruption of the species' behavior, handling of individual frogs, and injuries associated with marking and tracking individuals. However, this is a relatively minor nuisance and not likely a negative impact to the survival and reproduction of individuals or the viability of the population.

Based on the best available scientific and commercial information, we do not consider the overutilization for commercial, recreational, scientific, or educational purposes to be a threat to the mountain yellow-legged frog complex now or in the future.

Factor C. Disease or Predation

Predation

Researchers have observed predation of mountain yellow-legged frogs by the mountain garter snake (*Thamnophis* *elegans elegans*), Brewer's blackbird (*Euphagus cyanocephalus*), Clark's nutcracker (*Nucifraga columbiana*), coyote (*Canis latrans*), and black bear (*Ursus americanus*) (Mullally and Cunningham 1956a, p. 193; Bradford 1991, pp. 176–177; Jennings *et al.* 1992, p. 505; Feldman and Wilkinson 2000, p. 102; Vredenburg *et al.* 2005, p. 565). However, none of these has been implicated as a driver of population dynamics, so it is presumed that such predation occurrences are incidental and do not significantly impact frog populations (except perhaps in circumstances where so few individuals remain that the loss of low numbers of individuals would be of significant concern).

The most prominent predator of mountain yellow-legged frogs is introduced trout, whose significance is well-established because it has been repeatedly observed that nonnative fishes and frogs rarely coexist, and it is known that introduced trout can and do prey on all frog life stages (Grinnell and Storer 1924, p. 664; Mullally and Cunningham 1956a, p. 190; Cory 1962a, p. 401; 1963, p. 172; Bradford 1989, pp. 775–778; Bradford and Gordon 1992, p. 65; Bradford *et al.* 1993, pp. 882–888; 1994a, p. 326; Drost and Fellers 1996, p. 422; Jennings 1996, p. 940; Knapp 1996, p. 14; Knapp and Matthews 2000, p. 428; Knapp *et al.* 2001, p. 401; Vredenburg 2004, p. 7649). It is estimated that 63 percent of lakes larger than 1 ha (2.5 ac) in the Sierra Nevada contain one or more nonnative trout species, and greater than 60 percent of streams contain nonnative trout (Knapp, 1996, pp. 1–44), in some areas comprising greater than 90 percent of total water body surface area (Knapp and Matthews 2000, p. 434).

The multiple-year tadpole stage of the mountain yellow-legged frog requires submersion in the aquatic habitat year-round until metamorphosis. Moreover, all life stages are highly aquatic, increasing the frog's susceptibility to predation by trout (where they co-occur) throughout its lifespan. Overwinter mortality due to predation is especially significant because, when water bodies ice over in winter, tadpoles are forced from shallow margins of lakes and ponds into deeper unfrozen water where they are more vulnerable to predation; fish encounters in such areas increase, while refuge is less available.

The predation of mountain yellow-legged frogs by fishes observed in the early 20th century by Grinnell and Storer and the documented declines of the 1970s (Bradford 1991, pp. 174–177; Bradford *et al.* 1994a, pp. 323–327; Stebbins and Cohen 1995, pp. 226–227) were not the beginning of the mountain yellow-legged frog's decline, but rather the end of a long decline that started soon after fish introductions to the Sierra Nevada began in the mid-1800s (Knapp and Matthews 2000, p. 436). Metapopulation theory (Hanski 1997, pp. 85–86) predicts this type of time lag from habitat modification to population extinction (Knapp and Matthews 2000, p. 436). In 2004, Vredenburg (2004, p. 7647) concluded that introduced trout are effective predators on mountain yellow-legged frog tadpoles and suggested that the introduction of trout is the most likely reason for the decline of the mountain yellow-legged frog complex. This threat is a significant, prevalent risk to mountain yellow-legged frogs rangewide, and it will persist into the future.

Disease

Over roughly the last 2 decades, pathogens have been associated with amphibian population declines, mass die-offs, and even extinctions worldwide (Bradford 1991, pp. 174–177; Blaustein *et al.* 1994b, pp. 251–254; Alford and Richards 1999, pp. 506; Muths *et al.* 2003, p. 357; Weldon *et al.* 2004, p. 2100; Rachowicz *et al.* 2005, p. 1446; Fisher *et al.* 2009, p. 292). One pathogen strongly associated with dramatic declines on all five continents is the chytrid fungus, *Batrachochytrium dendrobatidis* (Bd) (Rachowicz *et al.* 2005, p. 1442). This chytrid fungus has now been reported in amphibian species worldwide (Fellers *et al.* 2001, p. 945; Rachowicz *et al.* 2005, p. 1442). Early doubt that this particular pathogen was responsible for worldwide die-offs has largely been overcome by the weight of evidence documenting the appearance, spread, and detrimental effects to affected populations (Vredenburg *et al.* 2010a, p. 9689). The correlation of notable amphibian declines with reports of outbreaks of fatal chytridiomycosis (the disease caused by Bd) in montane areas has led to a general association between high altitude, cooler climates, and population extirpations associated with Bd (Fisher *et al.* 2009, p. 298).

Bd affects the mouth parts and epidermal (skin) tissue of tadpoles and metamorphosed frogs (Fellers *et al.* 2001, pp. 950–951). The fungus can reproduce asexually, and can generally withstand adverse conditions such as freezing or drought (Briggs *et al.* 2002, p. 38). It also may reproduce sexually, leading to thick-walled sporangia that would be capable of long-term survival (for distant transport and persistence in sites even after all susceptible host animal populations are extirpated) (Morgan *et al.* 2007, p. 13849). Adult frogs can acquire this fungus from tadpoles, and it can also be transmitted between tadpoles (Rachowicz and Vredenburg 2004, p. 80).

In California, chytridiomycosis has been detected in many amphibian species, including mountain yellow-legged frogs (Briggs *et al.* 2002, p. 38; Knapp 2002b, p. 1). The earliest documented case in the mountain yellow-legged frog complex was in 1998, at Yosemite National Park (Fellers *et al.* 2001, p. 945). It is unclear how Bd was originally transmitted to the frogs (Briggs *et al.* 2002, p. 39). Visual examination of 43 tadpole specimens collected between 1955 and 1976 revealed no evidence of Bd infection; however 14 of 36 specimens preserved between 1993 and 1999 did have abnormalities attributable to Bd (Fellers *et al.* 2001, p. 947). Since at least 1976, Bd has affected adult Yosemite toads (Green and Kagarise Sherman 2001, p. 92), whose range overlaps with the mountain yellow-legged frogs. Therefore, it is possible that this pathogen has affected all three amphibian species covered in this proposed rule since at least the mid-1970s. Mountain yellow-legged frogs may be especially vulnerable to Bd infections because all life stages share the same aquatic habitat nearly year round, facilitating the transmission of this fungus among individuals at different life stages (Fellers *et al.* 2001, p. 951).

During the epidemic phase of chytrid infection into unexposed populations, rapid die-offs are observed within short order for adult and subadult lifestages (Vredenburg *et al.* 2010a, p. 9691), while tadpoles are less affected at first (Vredenburg *et al.* 2010a, p. 9689). In mountain yellow-legged frogs, Bd causes overwinter mortality and mortality during metamorphosis (Briggs *et al.* 2002, p. 39; Rachowicz 2005, pp. 2–3); metamorphs are the most sensitive life stage to Bd infection (Kilpatrick *et al.* 2009, p. 113; Vredenburg *et al.* 2010b, p. 3). Field and laboratory experiments indicate that Bd infection is generally lethal to mountain yellow-legged frogs, and is likely responsible for recent declines (Knapp 2005b; Rachowicz 2005, pers. comm.). Rachowicz *et al.* (2006, p. 1671) monitored several infected and uninfected populations in Sequoia and Kings Canyon National Parks over multiple years, documenting dramatic declines and extirpations in only the infected populations. Rapid die-offs of mountain yellow-legged frogs from chytridiomycosis have been observed in more than 50 water bodies in the southern Sierra Nevada (Briggs *et al.*

2005, p. 3151). Studies of the microscopic structure of tissue and other evidence suggests Bd caused many of the recent extinctions in the Sierra National Forest's John Muir Wilderness Area and in Kings Canyon National Park, where 41 percent of the populations went extinct between 1995 and 2002 (Knapp 2002a, p. 10).

In several areas where detailed studies of the effects of Bd on the mountain yellow-legged frog are ongoing, substantial declines have been observed following the course of the disease infection and spread. Survey results from 2000 in Yosemite and Sequoia-Kings Canyon National Parks indicate that 24 percent of the mountain yellow-legged frog populations showed signs of Bd infection (Briggs *et al.* 2002, p. 40). In both 2003 and 2004, 19 percent of assayed populations in Sequoia and Kings Canyon National Parks were infected with Bd (Rachowicz 2005, pp. 2–3). By 2005, 91 percent of assayed populations in Yosemite National Park showed evidence of Bd infection (Knapp 2005b, pp. 1–2). Currently, it is believed that all populations in Yosemite Park are infected with Bd (Briggs *et al.* 2010, p. 9695).

The effects of Bd on host populations of the mountain yellow-legged frog are variable, ranging from extinction, to persistence with a high level of infection, to persistence with a low level of infection (Briggs *et al.* 2002, pp. 40–41). In populations where Bd infection first occurs, the most common outcome is epidemic spread of the disease and population extirpation (Briggs *et al.* 2010, p. 9699). Die-offs are characterized by rapid onset of high level Bd infections, followed by death due to chytridiomycosis. Adults in persistent populations frequently recover and are subsequently re-infected by Bd at low levels (Briggs *et al.* 2010, pp. 9695–9696). However, it is apparent that even at sites exhibiting population persistence with Bd, high mortality of metamorphosing frogs persists, and this phenomenon may explain the lower abundances observed in such populations (Briggs *et al.* 2010, p. 9699).

Vredenburg *et al.* (2010a, pp. 2–4) studied frog populations before, during, and after the infection and spread of Bd in three study basins constituting 13, 33, and 42 frog populations, then comprising the most intact metapopulations remaining for these species throughout their range. The spread of Bd averaged 688 m/year (yr) (2,257 ft/yr), reaching all areas of the smaller basin in 1 year, and taking 3 to 5 years to completely infect the larger basins, progressing like a wave across the landscape. The researchers documented die-offs following the spread of Bd, with decreased population growth rates evident within the first year of infection. Basinwide, metapopulations crashed from 1,680 to 22 individuals (northern DPS of the mountain yellow-legged frog) in Milestone Basin, with 9 of 13 populations extirpated; from 2,193 to 47 individuals (northern DPS of the mountain yellow-legged frog) in Sixty Lakes Basin, with 27 of 33 populations extirpated; and from 5,588 to 436 individuals (Sierra Nevada yellow-legged frog) in Barrett Lakes Basin, with 33 of 42 populations extirpated. It is clear from the evidence that Bd can and does decimate newly infected frog populations. Moreover, this rangewide population threat is acting upon a landscape already impacted by habitat modification and degradation by introduced fishes (see Factor A discussion, above). As a result, remnant populations in fishless lakes are now impacted by Bd.

Vredenburg *et al.* (2010a, p. 3) projected that at current extinction rates, and given the disease dynamics of Bd (infected tadpoles succumb to chytridiomycosis at metamorphosis), most if not all extant populations within the recently infected basins they studied will go extinct within the next 3 years. Available data (CDFG, unpubl. data; Knapp 2005b; Rachowicz 2005, pers. comm.; Rachowicz *et al.* 2006, p. 1671) indicate that Bd is now widespread throughout the Sierra Nevada, and, although it has not infected all populations at this time, it is effectively a serious and substantial threat rangewide to the mountain yellow-legged frog complex.

Other diseases have also been reported as adversely affecting amphibian species, and these may be present within the range of the mountain yellow-legged frog. Bradford (1991, p. 174–177) reported an outbreak of red-leg disease in Kings Canyon National Park, and suggested this was a result of overcrowding within a mountain yellow-legged frog population. Red-leg disease is caused by the bacterial pathogen *Aeromonas hydrophila,* along with other pathogens. Though red-leg disease is opportunistic and successfully attacks immune-suppressed individuals, this pathogen appears to be highly contagious, affecting the epidermis and digestive tract of otherwise healthy amphibians (Shotts 1984, pp. 51–52; Carey 1993, p. 358; Carey and Bryant 1995, pp. 14–15). Although it has been observed in at least one instance correlated to frog population decline, red-leg disease is likely not a significant contributor to observed frog population declines rangewide, based on the available literature.

Saprolegnia is a globally distributed fungus that commonly attacks all life stages of fishes (especially hatchery-reared fishes), and has recently been documented to attack and kill egg masses of western toads (*Bufo boreas*) (Blaustein *et al.* 1994b, p. 252). This pathogen may be introduced through fish stocking, or it may already be established in the aquatic ecosystem. Fishes and migrating or dispersing amphibians may be a vector for this fungus (Blaustein *et al.* 1994b, p. 253; Kiesecker *et al.* 2001, p. 1068). *Saprolegnia* has been reported in the southern DPS of the mountain yellow-legged frog (North 2012, pers. comm.); however, its prevalence within the Sierran range of the mountain yellow-legged frog complex and associated influence on population dynamics (if any) are unknown.

Other pathogens of concern for amphibian species include ranaviruses (Family Iridoviridae). Mao *et al.* (1999, pp. 49–50) isolated identical iridoviruses from co-occurring populations of the threespine stickleback (*Gasterosteus aculeatus*) and the red-legged frog (*Rana aurora*), indicating that infection by a given virus is not limited to a single species, and that iridoviruses can infect animals of different taxonomic classes. This suggests that virus-hosting trout introduced into mountain yellow-legged frog habitat may be a vector for amphibian viruses. Recreationists also may contribute to the spread of pathogens between water bodies and populations via clothing and fishing equipment. However, definitive mechanisms for disease transmission to the mountain yellow-legged frog remain unknown. No viruses were detected in the mountain yellow-legged frogs that Fellers *et al.* (2001, p. 950) analyzed for Bd. In Kings Canyon National Park, Knapp (2002a, p. 20) found mountain yellow-legged frogs showing symptoms preliminarily attributed to a ranavirus. To date, ranaviruses remain a concern for the mountain yellow-legged frog complex, but there is insufficient evidence to indicate they are negatively affecting populations.

It is unknown whether amphibian pathogens in the high Sierra Nevada have always coexisted with amphibian populations or if the presence of such pathogens is a recent phenomenon. However, it has been suggested that the susceptibility of amphibians to pathogens may have recently increased in response to anthropogenic environmental disruption (Carey 1993, pp. 355–360; Blaustein *et al.* 1994b, p. 253; Carey *et al.* 1999, p. 7). This hypothesis suggests that environmental changes may be indirectly responsible for certain amphibian die-offs due to immune system suppression of tadpoles or post-metamorphic amphibians (Carey 1993, p. 358; Blaustein *et al.* 1994b, p. 253; Carey *et al.* 1999, p. 7–8). Pathogens such as *Aeromonas hydrophila,* which are present in fresh water and in healthy organisms, may become more of a threat, potentially causing localized amphibian population die-offs when the immune systems of individuals within the host population are suppressed (Carey 1993, p. 358; Carey and Bryant 1995, p. 14).

The contribution of Bd as an environmental stressor and limiting factor on mountain yellow-legged frog population dynamics is currently extremely high, and it poses a significant future threat to remnant uninfected populations in the southern Sierra Nevada. Its effects are most dramatic following the epidemic stage as it spreads across newly infected habitats; massive die-off events follow the spread of the fungus, and it is likely that survival through metamorphosis is substantially reduced even years after the initial epidemic (Rachowicz *et al.* 2006, pp. 1679–1680). The relative impact from other diseases and the interaction of other stressors and disease on the immune systems of mountain yellow-legged frogs remains poorly documented to date.

In summary, based on the best available scientific and commercial information, we consider the threats of predation and disease to be significant, ongoing threats to the Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog. These threats include amphibian pathogens (most specifically, the chytrid fungus) and predation by introduced fishes, two primary driving forces leading to population declines in the mountain yellow-legged frog complex. These are highly prevalent threats, and they are predominant limiting factors hindering population viability and precluding recovery across the ranges of the mountain yellow-legged frog complex.

Factor D. The Inadequacy of Existing Regulatory Mechanisms

In determining whether the inadequacy of regulatory mechanisms constitutes a threat to the mountain yellow-legged frog complex, we analyzed the existing Federal and State laws and regulations that may address the threats to these species or contain relevant protective measures. Regulatory mechanisms are typically nondiscretionary and enforceable, and may preclude the need for listing if such mechanisms are judged to adequately address the threat(s) to the species such that listing is not warranted. Conversely, threats on the landscape are not addressed where existing regulatory mechanisms are not adequate (or when existing mechanisms are not adequately implemented or enforced).

Federal

Wilderness Act

The Wilderness Act of 1964 (16 U.S.C. 1131 *et seq.*) established a National Wilderness Preservation System made up of federally owned areas designated by Congress as ''wilderness'' for the purpose of preserving and protecting designated areas in their natural condition. Within these areas, the Wilderness Act states, with limited exception to administer the area as wilderness, the following: (1) New or temporary roads cannot be built; (2) there can be no use of motor vehicles, motorized equipment, or motorboats; (3) there can be no landing of aircrafts; (4) there can be no form of mechanical transport; and (5) no structure or installation may be built. A large number of mountain yellow-legged frog locations occur within wilderness areas managed by the USFS and NPS and, therefore, are afforded protection from direct loss or degradation of habitat by some human activities (such as, development, commercial timber harvest, road construction, some fire management actions). Livestock grazing and fish stocking are both permitted within designated wilderness areas.

National Forest Management Act of 1976

Under the National Forest Management Act of 1976, as amended (NFMA) (16 U.S.C. 1600 *et seq.*), the USFS is tasked to manage National Forest lands based on multiple-use, sustained-yield principles, and implement land and resource management plans (LRMP) on each National Forest to provide for a diversity of plant and animal communities. The purpose of an LRMP is to guide and set standards for all natural resource management activities for the life of the plan (10 to 15 years). NFMA requires the USFS to incorporate standards and guidelines into LRMPs. The 1982 planning regulations for implementing NFMA (47 FR 43026; September 30, 1982), under which all existing forest plans in the Sierra Nevada were prepared until recently, guided management of National Forests and required that fish and wildlife habitat on National Forest system lands be managed to maintain viable populations of existing native and desired nonnative vertebrate species in the planning area. A viable population is defined as a population of a species that continues to persist over the long term with sufficient distribution to be resilient and adaptable to stressors and likely future environments. In order to insure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area.

On April 9, 2012, the USFS published a final rule (77 FR 21162) amending 36 CFR 219 to adopt new National Forest System land management regulations to guide the development, amendment, and revision of LRMPs for all Forest System lands. These revised regulations, which became effective on May 9, 2012, replace the 1982 planning rule. The 2012 planning rule requires that the USFS maintain viable populations of species of conservation concern at the discretion of regional foresters. This rule could thereby result in removal of the limited protections that are currently in place for mountain yellow-legged frogs under the Sierra Nevada Forest Plan Amendment (SNFPA), as described below.

Sierra Nevada Forest Plan Amendment

In 2001, a record of decision was signed by the USFS for the Sierra Nevada Forest Plan Amendment (SNFPA), based on the final environmental impact statement for the SNFPA effort and prepared under the 1982 NFMA planning regulations. The Record of Decision amends the USFS Pacific Southwest Regional Guide, the Intermountain Regional Guide, and the LRMPs for National Forests in the Sierra Nevada and Modoc Plateau. This document affects land management on all National Forests throughout the range of the mountain yellow-legged frog complex. The SNFPA addresses and gives management direction on issues pertaining to old forest ecosystems; aquatic, riparian, and meadow ecosystems; fire and fuels; noxious weeds; and lower west-side hardwood ecosystems of the Sierra Nevada. In January 2004, the USFS amended the SNFPA, based on the final supplemental environmental impact statement, following a review of fire and fuels treatments, compatibility with the National Fire Plan, compatibility with the Herger-Feinstein Quincy Library

Group Forest Recovery Pilot Project, and effects of the SNFPA on grazing, recreation, and local communities (USDA 2004, pp. 26–30).

Relevant to the mountain yellow-legged frog complex, the Record of Decision for SNFPA aims to protect and restore aquatic, riparian, and meadow ecosystems, and to provide for the viability of associated native species through implementation of an aquatic management strategy. The aquatic management strategy is a general framework with broad policy direction. Implementation of this strategy is intended to take place at the landscape and project levels. There are nine goals associated with the aquatic management strategy:

(1) The maintenance and restoration of water quality to comply with the Clean Water Act (CWA) and the Safe Drinking Water Act;

(2) The maintenance and restoration of habitat to support viable populations of native and desired nonnative riparian-dependent species, and to reduce negative impacts of nonnative species on native populations;

(3) The maintenance and restoration of species diversity in riparian areas, wetlands, and meadows to provide desired habitats and ecological functions;

(4) The maintenance and restoration of the distribution and function of biotic communities and biological diversity in special aquatic habitats (such as springs, seeps, vernal pools, fens, bogs, and marshes);

(5) The maintenance and restoration of spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction;

(6) The maintenance and restoration of hydrologic connectivity between floodplains, channels, and water tables to distribute flood flows and to sustain diverse habitats;

(7) The maintenance and restoration of watershed conditions as measured by favorable infiltration characteristics of soils and diverse vegetation cover to absorb and filter precipitation, and to sustain favorable conditions of streamflows;

(8) The maintenance and restoration of instream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats, and to keep sediment regimes within the natural range of variability; and

(9) The maintenance and restoration of the physical structure and condition of streambanks and shorelines to minimize erosion and sustain desired habitat diversity.

If these goals of the aquatic management strategy are pursued and met, threats to the mountain yellow-legged frog complex resulting from habitat alterations could be reduced. However, the aquatic management strategy is a generalized approach that does not contain specific implementation timeframes or objectives, and it does not provide direct protections for the mountain yellow-legged frog. Additionally, as described above, the April 9, 2012, final rule (77 FR 21162) that amended 36 CFR 219 to adopt new National Forest System land management planning regulations could result in removal of the limited protections that are currently in place for mountain yellow-legged frogs under the SNFPA.

Federal Power Act

The Federal Power Act of 1920, as amended (FPA) (16 U.S.C. 791 *et seq.*) was enacted to regulate non-federal hydroelectric projects to support the development of rivers for energy generation and other beneficial uses. The FPA provides for cooperation between the Federal Energy Regulatory Commission (Commission) and other Federal agencies in licensing and relicensing power projects. The FPA mandates that each license includes conditions to protect, mitigate, and enhance fish and wildlife and their habitat affected by the project. However, the FPA also requires that the Commission give equal consideration to competing priorities, such as power and development, energy conservation, protection of recreational opportunities, and preservation of other aspects of environmental quality. Further, the FPA does not mandate protections of habitat or enhancements for fish and wildlife species, but provides a mechanism for resource agency recommendations that are incorporated into a license at the discretion of the Commission. Additionally, the FPA provides for the issuance of a license for the duration of up to 50 years, and the FPA contains no provision for modification of the project for the benefit of species, such as mountain yellow-legged frogs, before a current license expires.

Numerous mountain yellow-legged frog populations occur within developed and managed aquatic systems (such as reservoirs and water diversions) operated for the purpose of power generation and regulated by the FPA.

State

California Endangered Species Act

The California Endangered Species Act (CESA) (California Fish and Game Code, section 2080 *et seq.*) prohibits the unauthorized take of State-listed endangered or threatened species. CESA requires State agencies to consult with CDFG on activities that may affect a State-listed species, and mitigate for any adverse impacts to the species or its habitat. Pursuant to CESA, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The State may authorize permits for scientific, educational, or management purposes, and allow take that is incidental to otherwise lawful activities.

Recently, the California Fish and Game Commission approved the listing of the Sierra Nevada yellow-legged frog as a threatened species and the mountain yellow-legged frog (Statewide) as an endangered species under CESA (CDFG 2012, pp. 1–10). However, CDFG has not yet officially listed these species under CESA, and therefore both species remain candidate species under State law.

As a candidate species under CESA, the mountain yellow-legged frog complex receives the same protections as a listed species, with specified exceptions. However, CESA is not expected to provide adequate protection for the mountain yellow-legged frog complex given that the CDFG has currently approved take authorization for the Statewide stocking program under CESA for fish hatchery and stocking activities consistent with the joint Environmental Impact Statement/ Environmental Impact Report (ICF Jones & Stokes 2010, App. K), wildland fire response and related vegetation management, water storage and conveyance activities, and forest practices and timber harvest (CDFG 2011a, pp. 2–3).

In 2001, CDFG revised fish stocking practices and implemented an informal policy on fish stocking in the range of the Sierra Nevada yellow-legged frog and northern DPS of the mountain yellow-legged frog. This policy directs that: (1) Fish will not be stocked in lakes with known populations of mountain yellow-legged frogs, nor in lakes that have not yet been surveyed for mountain yellow-legged frog presence; (2) waters will be stocked only with a fisheries management justification; and (3) the number of stocked lakes will be reduced over time. In 2001, the number of lakes stocked with fish within the range of the mountain yellow-legged frog in the Sierra Nevada was reduced by 75 percent (Milliron 2002, pp. 6–7; Pert *et al.* 2002, pers. comm.). Water bodies within the same basin and 2 km (1.25 mi) from a known mountain yellow-legged frog population will not be stocked with fish unless stocking is justified through a management plan that considers all the aquatic resources in the basin, or unless there is heavy angler use and no opportunity to improve the mountain yellow-legged frog habitat (Milliron 2002a, p. 5). The Hatchery and Stocking Program Environmental Impact Report/Environmental Impact Statement, finalized in 2010 (ICF Jones & Stokes 2010, Appendix K), outlines a decision approach to mitigate fish stocking effects on Sierra amphibians that prohibits fish stocking in lakes with confirmed presence of frogs using recognized survey protocols.

CDFG is in the process of developing management plans for basins within the range of the Sierra Nevada yellow-legged frog and the northern DPS of mountain yellow-legged frog (CDFG 2001, p. 1; Lockhart 2011, pers. comm.). The objectives of the basin plans specific to the mountain yellow-legged frog include management in a manner that maintains or restores native biodiversity and habitat quality, supports viable populations of native species, and provides for recreational opportunities that consider historical use patterns (CDFG 2001, p. 3). Under this approach, some lakes are managed primarily for the mountain yellow-legged frogs and other amphibian resources, with few or no angling opportunities, while lakes with high demand for recreational angling are managed primarily for angling purposes (CDFG 2001, p. 3).

Existing Federal and State laws and regulatory mechanisms currently offer some level of protection for the mountain yellow-legged frog complex.

Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

The mountain yellow-legged frog is sensitive to environmental change or degradation because it has an aquatic and terrestrial life history and highly permeable skin that increases exposure of individuals to substances in the water, air, and terrestrial substrates (Blaustein and Wake 1990, p. 203; Bradford and Gordon 1992. p. 9; Blaustein and Wake 1995, p. 52; Stebbins and Cohen 1995, pp. 227–228). Several natural or anthropogenically influenced factors, including contaminants, acid precipitation, ambient ultraviolet radiation, and climate change, have been implicated as contributing to amphibian declines (Corn 1994, pp. 62–63; Alford and Richards 1999, pp. 2–7). These factors have been studied to varying degrees specific to the mountain yellow-legged frog and are discussed below. There are also documented incidences of direct mortality of, or the potential for direct disturbance to, individuals from some activities already discussed; in severe instances, these actions may have population-level consequences.

Contaminants

Environmental contaminants have been suggested, and in some cases documented, to negatively affect amphibians by causing direct mortality (Hall and Henry 1992, pp. 66–67; Berrill *et al.* 1994, p. 663; 1995, pp. 1016–1018; Carey and Bryant 1995, p. 16; Relyea and Mills 2001, p. 2493); immune system suppression, which makes amphibians more vulnerable to disease (Carey 1993, pp. 358–360; Carey and Bryant 1995, p. 15; Carey *et al.* 1999, p. 9; Daszak *et al.* 1999, p. 741; Taylor *et al.* 1999, p. 540); disruption of breeding behavior and physiology (Berrill *et al.* 1994, p. 663; Carey and Bryant 1995, p. 16; Hayes *et al.* 2002, p. 5479); disruption of growth or development (Hall and Henry 1992, p. 66; Berrill *et al.* 1993, p. 537; 1994, p. 663; Berrill *et al.* 1995, pp. 1016–1018; Carey and Bryant 1995, p. 8; Berrill *et al.* 1998, pp. 1741–1744; Sparling *et al.* 2001, p. 1595; Brunelli *et al.* 2009, p. 135); and disruption of predator avoidance behavior (Hall and Henry 1992, p. 66; Berrill *et al.* 1993, p. 537; 1994, p. 663; Berrill *et al.* 1995, p. 1017; Carey and Bryant 1995, pp. 8–9; Berrill *et al.* 1998, p. 1744; Relyea and Mills 2001, p. 2493; Sparling *et al.* 2001, p. 1595).

Wind-borne pesticides that are deposited in the Sierra Nevada from upwind agricultural sources have been suggested as a cause of sublethal effects to amphibians (Cory *et al.* 1971, p. 3; Davidson *et al.* 2001, pp. 474–475; Sparling *et al.* 2001, p. 1591; Davidson 2004, p. 1892; Fellers *et al.* 2004, p. 2176). In 1998, more than 97 million kilograms (215 million pounds) of pesticides were reportedly used in California (California Department of Pesticide Regulation (CDPR) 1998, p. ix). Originating from the agriculture in California's Central Valley, and mainly from the San Joaquin Valley, where upwind agricultural activity is greatest, pesticides are passively transported eastward to the high Sierra Nevada where they have been detected in precipitation (rain and snow), air, dry deposition, surface water, plants, fish, and amphibians (including Pacific tree frogs (*Pseudacris regilla*) and mountain yellow-legged frogs) (Cory *et al.* 1970, p. 204; Zabik and Seiber 1993, p. 80; Aston and Seiber 1997, p. 1488; Datta *et al.* 1998, p. 829; McConnell *et al.* 1998, pp. 1910–1911; LeNoir *et al.* 1999, p. 2721; Sparling *et al.* 2001, p. 1591; Angermann *et al.* 2002, p. 2213; Fellers *et al.* 2004, pp. 2173–2174).

Spatial analysis of mountain yellow-legged frog population trends in the Sierra Nevada showed a strong positive association between population decline and areas with greater amounts of upwind agriculture (Davidson *et al.* 2002, pp. 1597–1598). Analysis of upwind pesticide use determined that pesticides may play a role in the decline of the mountain yellow-legged frog in pristine regions of the Sierra Nevada (Davidson and Knapp 2007, pp. 593–594). Although pesticide detections decrease with altitudinal gain, they have been detected at elevations in excess of 3,200 m (10,500 ft) (Zabik and Seiber 1993, p. 88; McConnell *et al.* 1998, p. 1908; LeNoir *et al.* 1999, p. 2721; Angermann *et al.* 2002, pp. 2210–2211).

Snow core samples from the Sierra Nevada contain a variety of contaminants from industrial and automotive sources, including excess hydrogen ions that are indicative of acidic precipitation, nitrogen and sulfur compounds (ammonium, nitrate, sulfite, and sulfate), and heavy metals (lead, iron, manganese, copper, and cadmium) (Laird *et al.* 1986, p. 275).

The pattern of recent frog extirpations in the southern Sierra Nevada corresponds with the pattern of highest concentration of air pollutants from automotive exhaust, and it has been suggested that this may be due to increases in nitrification (or other changes) caused by those pollutants (Jennings 1996, p. 940). Shinn *et al.* (2008, p. 186) suggested that mountain amphibians may be more sensitive to nitrite toxicity based on acute toxicity observed at low concentrations (less than 0.5 milligrams/liter in Iberian water frogs (*Pelophylax perezi*)). Macias and Blaustein (2007, p. 55) observed a synergistic effect (when the net effect of two things acting together exceeds the sum of both alone) in the common toad (*Bufo bufo*) where nitrite in combination with ultraviolet radiation (UV–B; 280 to 320 nanometers (11–12.6 microinches)) was up to seven times more lethal than mortality from either stressor alone (the synergy was four times the summed effect from both treatments alone in the Iberian water frog).

The correlative evidence between areas of pesticide (and other) contamination in the Sierra Nevada and areas of amphibian decline support hypotheses that contaminants may present a risk to the mountain yellow-legged frog and could have contributed to the species' decline (Jennings 1996, p. 940; Sparling *et al.* 2001, p. 1591; Davidson *et al.* 2002. p. 1599; Davidson and Knapp 2007, p. 587). However, studies confirming exposure in remote locations to ecotoxicologically relevant concentrations of contaminants are not available to support this hypothesis.

To the contrary, efforts to date have found fairly low concentrations of many of the primary suspect constituents commonly indicating agricultural and industrial pollution (organochlorines, organophosphates/carbamates, polycyclic hydrocarbons). Bradford *et al.* (2010, p. 1064) observed a rapid decline in concentrations of endosulfan, chlorpyrifos, and DDE (among others) going out to 42 km (26 mi) linear distance from the valley floor in air, water, and tadpole tissues. These researchers also found relatively minute variation in concentrations among high-elevation study sites relative to the differences observed between the San Joaquin Valley and the nearest high-elevation sites. Essentially, sites beyond 42 km (26 mi) exhibited very low concentrations of measured compounds, which did not appreciably decrease with distance (Bradford *et al.* 2010, p. 1064). These observations make the contaminant decline hypotheses less tenable, and so windborne organic contaminants are currently considered minor contributors (if at all) to observed frog declines.

Acidic deposition has been suggested to contribute to amphibian declines in the western United States (Blaustein and Wake 1990, p. 204; Carey 1993, p. 357; Alford and Richards 1999, pp. 4–5). Acid precipitation has also been postulated as a cause of amphibian declines at high elevations in the Sierra Nevada (Bradford *et al.* 1994b, p. 156) because waters there are low in acid neutralizing capacity and, therefore, are susceptible to changes in water chemistry caused by acid deposition (Byron *et al.* 1991, p. 271). Extreme pH in surface waters of the Sierra Nevada is estimated at 5.0, with most high-elevation lakes having a pH of greater than 6 (Bradford *et al.* 1992, p. 374). Near Lake Tahoe, at an elevation of approximately 2,100 m (6,900 ft), precipitation acidity has increased significantly (Byron *et al.* 1991, p. 272). In surface waters of the Sierra Nevada, acidity increases and acid neutralizing capacity decreases during snow melt and summer storms, though rarely does pH drop below 5.4 (Nikolaidis *et al.* 1991, p. 339; Bradford and Gordon 1992, p. 73; Bradford *et al.* 1998, p. 2489). The mountain yellow-legged frog breeds shortly after snow melt; therefore, its most sensitive early life stages are exposed to acidification (Bradford and Gordon 1992, p. 9). Bradford *et al.* (1998, p. 2482) found that mountain yellow-legged frog tadpoles were sensitive to naturally acidic conditions, and that their distribution was significantly related to lake acidity (they were not found in lakes with a pH lower than 6).

Laboratory studies have documented sublethal effects (reduced growth) on mountain yellow-legged frog embryos at pH 5.25 (Bradford *et al.* 1992, p. 369). Survivorship of mountain yellow-legged frog embryos and tadpoles was negatively affected as acidity increased (at approximately pH 4.5 or lower); embryos were more sensitive to increased acidity than tadpoles (Bradford and Gordon 1992, p. 3; Bradford *et al.* 1992, pp. 374–375). Potential indirect effects via impacts to the larger pond community were suggested by the observation that mountain yellow-legged frogs, common microcrustaceans, and caddisfly larvae were rare or absent at lakes with lower pH, and community richness declined with decreasing pH (Bradford *et al.* 1998, p. 2478).

However, other studies do not support this hypothesis of acid deposition as a contributing factor to amphibian population declines in this area (Bradford and Gordon 1992, pp. 74–77; Bradford *et al.* 1992, p. 375; Corn and Vertucci 1992, p. 366; Bradford *et al.* 1994a, p. 326; 1994b, p. 160; Corn 1994, p. 61). The hypothesis of acidic deposition as a cause of mountain yellow-legged frog declines has been rejected by field experiments that failed to show differences in water chemistry parameters between occupied and unoccupied mountain yellow-legged frog sites (Bradford *et al.* 1994b, p. 160). Though acidity may have an influence on mountain yellow-legged frog abundance or distribution, it is unlikely to have contributed significantly to the species' decline, given the rarity of lakes acidified either by natural or anthropogenic sources (Bradford *et al.* 1998, pp. 2488–2489).

Collectively, contaminant risks to mountain yellow-legged frogs are likely a minor risk factor across the range of the species that does not represent a threat to the species at a population level. Frogs are sensitive to contaminants, although exposure to contaminants from upwind sources has not been substantiated. Localized exposure to upgradient or directly applied compounds is of theoretical concern. However, the overlap of extant populations and such land uses, and contribution of these management activities to aquatic pollution, is undocumented.

Ultraviolet Radiation

Melanic pigment on the upper surfaces of amphibian eggs and tadpoles protects these sensitive life stages against UV–B damage, an important protection for normal development of amphibians exposed to sunlight, especially at high elevations in clear and shallow waters (Perotti and Diéguez 2006, p. 2064). Blaustein *et al.* (1994c, p. 1793) observed decreased hatching success in several species of amphibian embryos (the mountain yellow-legged frog was not tested) exposed to increased UV–B radiation, and proposed that this may be a cause of amphibian declines.

Ambient UV–B radiation has increased at north temperate latitudes over the past 2 decades (Adams *et al.* 2001, p. 521). If UV–B is contributing to amphibian population declines, the declines would likely be greater at higher elevations and more southerly latitudes where the thinner atmosphere allows greater penetration (Davidson *et al.* 2001, p. 474; Davidson *et al.* 2002, p. 1589). In California, where there is a north-to-south gradient of increasing UV–B exposure, amphibian declines would also likely be more prevalent at southerly latitudes (Davidson *et al.* 2001, p. 474; Davidson *et al.* 2002, p. 1589). In a spatial test of the hypothesis that UV–B has contributed to the decline of the mountain yellow-legged frog in the Sierra Nevada, Davidson *et al.* (2002, p. 1598) concluded that patterns of this species' decline are inconsistent with the predictions of where UV–B-related population declines would occur. Greater numbers of extant populations of this species were present at higher elevations than at lower elevations, and population decline was greater in the northern portion of the species' range than it was in the southern portion.

Adams *et al.* (2005, p. 497) also found no evidence that the distribution of mountain yellow-legged frogs in lakes in Sequoia and Kings Canyon National Parks was determined by UV–B. Pahkala *et al.* (2003, p. 197) even observed enhanced tadpole growth rates in two of three amphibian species exposed to moderate amounts of UV–B. Vredenburg *et al.* (2010b, p. 509) studied the effects of field level exposures of UV–B on hatching success in mountain the yellow-legged frog, Yosemite toad, and Pacific tree frog and found only a small increase in time to hatching in one of three lakes for the mountain yellow-legged frog. The authors suggested that amphibians occupying habitats with high UV–B exposure may have evolved mechanisms for coping with or avoiding the damaging UV rays. This is plausible, given that such a field level experiment was testing a persistent population, one that would logically be a survivor from past exposure (made up of tolerant individuals), and this level of experimental bias is inherent to experiments with such designs.

The UV–B hypothesis is controversial and has been the topic of much scientific debate. Support is undermined by lack of evidence linking experimental results to observed changes in abundance and distribution in the wild, and also the inability of proponents to document increased exposure in amphibian populations (Corn 2005, p. 60). In weighing the available evidence, UV–B does not appear to be a contributing factor to mountain yellow-legged frog population declines in the Sierra Nevada.

Climate Change

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms ''climate'' and ''climate change'' are defined by the Intergovernmental Panel on Climate Change (IPCC). The term ''climate'' refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a, p. 78). The term ''climate change'' thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007a, p. 78).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see IPCC 2007a, p. 30 and Solomon *et al.* 2007, pp. 35–54, 82–85). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is ''very likely'' (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007a, pp. 5–6 and figures SPM.3 and SPM.4; Solomon *et al.* 2007, pp. 21–35). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (for example, Meehl *et al.* 2007, entire; Ganguly *et al.* 2009, pp. 11555, 15558; Prinn *et al.* 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007a, pp. 44–45; Meehl *et al.* 2007, pp. 760–764, 797–811; Ganguly *et al.* 2009, pp. 15555–15558; Prinn *et al.* 2011, pp. 527, 529). (See IPCC 2007b, p. 8, for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation. Also see IPCC 2011 (entire) for a summary of observations and projections of extreme climate events.)

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (for example, habitat fragmentation) (IPCC 2007a, pp. 8–14, 18–19). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007a, p. 89; see also Glick *et al.* 2011, pp. 19–22). There is no single method for conducting such analyses that applies to all situations (Glick *et al.* 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Global climate projections are informative and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (for example, IPCC 2007a, pp. 8–12). Therefore, we use downscaled projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to the spatial scales used for analyses of a given species (see Glick *et al.* 2011, pp. 58–61, for a discussion of downscaling). With regard to our analysis for the Sierra Nevada of California (and western United States), downscaled projections are available.

Variability exists in outputs from different climate models, and uncertainty regarding future GHG emissions is also a factor in modeling (PRBO 2011, p. 3). A general pattern that holds for many predictive models indicates northern areas of the United States will become wetter, and southern areas (particularly the Southwest) will become drier. These models also predict that extreme events, such as heavier storms, heat waves, and regional droughts, may become more frequent (Glick *et al.* 2011, p. 7). Moreover, it is generally expected that the duration and intensity of droughts will increase in the future (Glick *et al.* 2011, p. 45; PRBO 2011, p. 21).

The last century has included some of the most variable climate reversals documented, at both the annual and near-decadal scales, including a high frequency of El Niño (associated with more severe winters) and La Niña (associated with milder winters) events (reflecting drought periods of 5 to 8 years alternating with wet periods) (USDA 2001b, p. 33). Scientists have confirmed a longer duration climate cycle termed the Pacific Decadal Oscillation (PDO), which operates on cycles between 2 to 3 decades, and generally is characterized by warm and dry (PDO positive) followed by cool and wet cycles (PDO negative) (Mantua *et al.* 1997, pp. 1069–1079; Zhang *et al.* 1997, pp. 1004–1018). Snowpack is seen to follow this pattern—heavier in the PDO negative phase in California, and lighter in the positive phase (Mantua *et al.* 1997, p. 14; Cayan *et al.* 1998, p. 3148; McCabe and Dettinger 2002, p. 24).

Mantua *et al.* (1997, pp. 15–19) observed a relationship in population trends in Pacific salmon that mirror the PDO. The last turn of this cycle was in 1977, towards a warm and dry phase for the western United States. If this interdecadal trend holds, indications are that we are currently trending back into a cooler and wetter phase in California. Given the impacts to climate (snowpack, and therefore, hydrology in the alpine system), and the extended duration of these cycles relative to generation time for these species, it is logical to presume that amphibian population trends (other things being equal) would also tend to track these cycles. Drost and Fellers (1996, p. 423) indicated that drought probably has an exacerbating or compounding effect in mountain yellow-legged frog complex population declines.

For the Sierra Nevada ecoregion, climate models predict that mean annual temperatures will increase by 1.8 to 2.4 °C (3.2 to 4.3 °F) by 2070, including warmer winters with earlier spring snowmelt and higher summer temperatures. However, it is expected that temperature and climate variability will vary based on topographic diversity (for example, wind intensity will determine east versus west slope variability) (PRBO 2011, p. 18). Mean annual rainfall is projected to decrease from 9.2–33.9 cm (3.6–13.3 in) by 2070; however, projections have high uncertainty and one study predicts the opposite effect (PRBO 2011, p. 18). Given the varied outputs from differing modeling assumptions, and the influence of complex topography on microclimate patterns, it is difficult to draw general conclusions about the effects of climate change on precipitation patterns in the Sierra Nevada (PRBO, 2011, p. 18). Snowpack is, by all projections, going to decrease dramatically (following the temperature rise and more precipitation falling as rain). Higher winter streamflows, earlier runoff, and reduced spring and summer streamflows are projected, with increasing severity in the southern Sierra Nevada (PRBO 2011, pp. 20–22).

Snow-dominated elevations from 2,000–2,800 m (6,560–9,190 ft) will be the most sensitive to temperature increases, and a warming of 5 °C (9 °F) is projected to shift center timing (the measure when half a stream's annual flow has passed a given point in time) to more than 45 days earlier in the year as compared to the 1961–1990 baseline (PRBO 2011, p. 23). Lakes, ponds, and other standing waters fed by snowmelt or streams may dry out or be more ephemeral during the non-winter months (PRBO 2011, p. 24). This pattern could influence ground water transport, and springs may be similarly depleted, leading to lower lake levels.

Vulnerability of species to climate change is a function of three factors: Sensitivity of a species or its habitat to climate change, exposure of individuals to such physical changes in the environment, and their capacity to adapt to those changes (Glick *et al.* 2011, pp. 19–22). Critical sensitivity elements broadly applicable across organizational levels (from species through habitats to ecosystems) are associated with physical variables, such as hydrology (timing, magnitude, and volume of waterflows), fire regime (frequency, extent, and severity of fires), and wind (Glick *et al.* 2011, pp. 39–40). Species-level sensitivities generally include physiological factors, such as changes in temperature, moisture, or pH as they influence individuals; these also include dependence on sensitive habitats, ecological linkages to other species, and changes in phenology (timing of key life-history events) (Glick *et al.* 2011, pp. 40–41).

Exposure to environmental stressors renders species vulnerable to climate change impacts, either through direct mechanisms (for example, physical temperature extremes or changes in solar radiation), or indirectly through impacts upon habitat (hydrology; fire regime; or abundance and distribution of prey, competitors, or predator species). A species' capacity to adapt to climate change is increased by behavioral plasticity (the ability to modify behavior to mitigate the impacts of the stressor), dispersal ability (the ability to relocate to meet shifting conditions), and evolutionary potential (for example, shorter-lived species with multiple generations have more capacity to adapt through evolution) (Glick *et al.* 2011, pp. 48–49).

The International Union for Conservation of Nature describes five categories of life-history traits that render species more vulnerable to climate change (Foden *et al.* 2008 in Glick *et al.* 2011, p. 33): (1) Specialized habitat or microhabitat requirements, (2) narrow environmental tolerances or thresholds that are likely to be exceeded under climate change, (3) dependence on specific triggers or cues that are likely to be disrupted (for example, rainfall or temperature cues for breeding, migration, or hibernation), (4) dependence on interactions between species that are likely to be disrupted, and (5) inability or poor ability to disperse quickly or to colonize more suitable range. We apply these criteria in this proposed rule to assess the vulnerability of mountain yellow-legged frogs to climate change.

The mountain yellow-legged frog is not necessarily a habitat specialist, although it does depend on fishless high mountain lakes with particular properties necessary to sustain a multi-year life cycle. As a species that inhabits areas with relative climate extremes, some conditions may directly push mountain yellow-legged frogs past physiological or ecological tolerance thresholds, and therefore enhance risk from the effects of climate change. For example, the increased severity of some winter storms may freeze lakes to greater depths than is historically typical. Severe winters (typical of El Niño Southern Oscillation years and PDO negative decades) would force longer hibernation times and could stress mountain yellow-legged frogs by reducing the time available for them to feed and breed. The deeper lakes that once supported frog populations (but now harbor introduced trout) are no longer available as refuge for frogs in a drier climate with possible severe cold winters. It is important to note that these episodic stressors may be infrequent, but they are important to long-lived species with small populations.

In summer, reduced snowpack and enhanced evapotranspiration following higher temperatures may dry out ponds that otherwise would have sustained rearing tadpoles (Lacan *et al.* 2008, p. 220), and may also reduce fecundity (egg production) (Lacan *et al.* 2008, p. 222). Lacan *et al.* (2008, p. 211) observed most frog breeding in the smaller, fishless lakes of Kings Canyon National Park, lakes that are shallow and prone to summer drying. Thus, climate change will likely reduce available breeding habitat for mountain yellow-legged frogs and lead to greater frequency of stranding and death of tadpoles (Corn 2005, p. 64; Lacan *et al.* 2008, p. 222).

Earlier snowmelt is expected to cue breeding earlier in the year. The advance of this primary signal for breeding phenology in montane and boreal habitats (Corn 2005, p. 61) 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 (or eggs) to killing frosts in more variable conditions of early spring (Corn 2005, p. 60).

It is unclear if there are dependencies upon other species with which mountain yellow-legged frogs interact that may be affected either positively or negatively by climate change. Climate change may alter invertebrate communities (PRBO 2011 p. 24). In one study, an experimental increase in stream temperature was shown to decrease density and biomass of invertebrates (Hogg and Williams 1996, p. 401). Thus, climate change might have a negative impact on the mountain yellow-legged frog prey base.

Indirect effects from climate change may lead to greater risk to mountain yellow-legged frog population persistence. For example, fire intensity and magnitude are projected to increase (PRBO 2011, pp. 24–25), and therefore the contribution and influence of this stressor upon frog habitat and populations will increase. Climate change may alter lake productivity through changes in water chemistry, the extent and timing of mixing, and nutrient inputs from increased fires, all of which may influence community dynamics and composition (Melack *et al.* 1997, p. 971; Parker *et al.* 2008, p. 12927). These changes may not all be negative; for example, water chemistry and nutrient inputs, along with warmer summer temperatures, could increase net primary productivity in high mountain lakes to enhance frog food sources.

Changes in temperature may also affect virulence of pathogens (Carey 1993, p. 359), which could make mountain yellow-legged frogs more susceptible to disease. Climate change could also affect the distribution of pathogens and their vectors, exposing mountain yellow-legged frogs (potentially with weakened immune systems as a result of other environmental stressors) to new pathogens (Blaustein *et al.* 2001, p. 1808). Climate change (warming) has been hypothesized as a driver for the range shift of Bd (Pounds *et al.* 2006, p. 161; Bosch *et al.* 2007, p. 253). However, other work has indicated that survival and transmission of Bd is more likely facilitated by cooler and wetter conditions (Corn 2005, p. 63). Fisher *et al.* (2009, p. 299) present a review of information available to date, and evaluate the competing hypotheses regarding Bd dynamics and present some cases that suggest a changing climate can change the host-pathogen dynamic to a more virulent state.

The key risk factor for climate change impacts on mountain yellow-legged frogs is likely the combined effect of reduced water levels in high mountain lakes and ponds and the relative inability of individuals to disperse and colonize across longer distances in order to occupy more favorable habitat conditions (if they exist). Although such adaptive range shifts have been observed in some plant and animal species, they have not been reported in amphibians. The changes observed in amphibians to date have been more associated with changes in timing of breeding (phenology) (Corn 2005, p. 60). This reduced adaptive capacity for mountain yellow-legged frogs is a function of high site fidelity and the extensive habitat fragmentation due to the introduction of fishes in many of the more productive and persistent high mountain lake habitats and streams that constitute critical dispersal corridors throughout much of the frog's range (see Factor C discussion above).

An increase in the frequency, intensity, and duration of droughts caused by climate change may have compounding effects on populations of mountain yellow-legged frogs already in decline. In situations where other stressors have resulted in the isolation of mountain yellow-legged frogs in marginal habitats factors (such as introduced fish), localized mountain yellow-legged frog population crashes or extirpations resulting from drought may exacerbate their isolation and preclude natural recolonization (Bradford *et al.* 1993, p. 887; Drost and Fellers 1996, p. 424; Lacan *et al.* 2008, p. 222). Climate change represents a substantial future threat to the persistence of mountain yellow-legged frog populations.

Direct and Indirect Mortality

Other risk factors include direct and indirect mortality as an unintentional consequence of activities within mountain yellow-legged frog habitat. Recreation may threaten all life stages of the mountain yellow-legged frog through trampling by humans, packstock, or vehicles, including off-highway vehicles; harassment by pets; and habitat degradation associated with these various land uses (Cole and Landres 1996, p. 170; USDA 2001b, pp. 213–214). Fire management activities probably lead to some direct mortality and have the potential to disrupt behavior. Fire retardant chemicals contain nitrogen compounds and surfactants (chemical additive used to facilitate application). Laboratory tests have shown that surfactants or ammonia byproducts can cause mortality in fishes and aquatic invertebrates (Hamilton *et al.* 1996, pp. 132–144); similar effects are possible in amphibians. Calfee and Little (2003, pp. 1529–1530) report that southern leopard frogs (*Rana sphenocephala*) and boreal toads (*Bufo boreas*) are more tolerant than rainbow trout (*Oncorhynchus mykiss*) to fire retardant chemicals; however the acute toxicity of some compounds is enhanced by ultraviolet light, which may harm amphibians at environmentally relevant concentrations. Therefore, if fire retardant chemicals are dropped in or near mountain yellow-legged frog habitat, they could have negative effects on individuals. The prevalence of this impact is undetermined, but this threat may be sporadically significant. Roads create the potential for direct mortality of amphibians by vehicle strikes (deMaynadier and Hunter 2000, p. 56) and the possible introduction of contaminants into new areas; however, most extant populations are not located near roads. Collectively, direct mortality risks to mountain yellow-legged frogs are likely of sporadic significance. They may be important incidentally on a site-specific basis, but are likely of low prevalence across the range of the species.

Small Population Size

Remaining populations for both the Sierra Nevada yellow-legged frog and the mountain yellow-legged frog are small in many localities (CDFG, unpubl. data). Brown *et al.* (2011, p. 24) reported that about 90 percent of watersheds have fewer than 10 adults and 80 percent have fewer than 10 subadults and 100 tadpoles. Remnant populations in the far northern extent of the range for the Sierra Nevada yellow-legged frog (from Lake Tahoe north) and the southern extent of the Sierran populations of the mountain yellow-legged frog (south of Kings Canyon National Park) currently also exhibit very low abundances (CDFG, unpubl. data).

Compared to large populations, small populations are more vulnerable to extirpation 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 a prolonged drought or even a significant natural predation event. Periods of prolonged drought are more likely to have a significant effect on mountain yellow-legged frogs because drought conditions occur on a landscape scale and all life stages are dependent on habitat with 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. Genetic stochasticity results from changes in gene frequencies due to the founder effect (loss of genetic variation that occurs when a new population is established by a small number of individuals) (Reiger 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) (Reiger 1968, p. 371); or inbreeding depression (loss of fitness or vigor due to mating among relatives) (Soulé 1980, 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).

Allee effects (Dennis 1989, pp. 481–538) occur when a population loses its positive stock-recruitment relationship (when population is in decline). In a declining population, an extinction threshold or ''Allee threshold'' (Berec *et al.* 2006, pp. 185–191) may be crossed, where adults in the population either cease to breed or the population becomes so compromised that breeding does not contribute to population growth. Allee effects typically fall into three broad categories (Courchamp *et al.* 1999, pp. 405–410): Lack of facilitation (including low mate detection and loss of breeding cues), demographic stochasticity, and loss of heterozygosity (a measure of genetic variability). Environmental stochasticity amplifies Allee effects (Dennis 1989, pp. 481–538; Dennis 2002, pp, 389–401). The Allee effects of demographic stochasticity and loss of heterozygosity are likely as mountain yellow-legged frog populations continue to diminish. Lack of facilitation is a possible threat, though less probable as frogs can vocalize to advertise presence.

The extinction risk of a species represented by few small populations is magnified when those populations are isolated from one another. This is especially true for species whose populations normally 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. Additionally, fewer populations increase the risk of extinction.

The combination of low numbers with the other extant stressors of disease, fish persistence, and potential for climate extremes could have adverse consequences for the mountain yellow-legged frog complex as populations approach the Allee threshold. Small population size is currently a significant threat to most populations of mountain yellow-legged frogs across the range of the species.

Cumulative Impacts of Extant Threats

Stressors may act additively or synergistically. An additive effect would mean that an accumulation of otherwise low threat factors acting in combination may collectively result in individual losses that are meaningful at the population level. A synergistic effect is one where the interaction of one or more stressors together leads to effects greater than the sum of those individual factors combined. Further, the cumulative effect of multiple added stressors can erode population viability over successive generations and act as a chronic strain on the viability of a species, resulting in a progressive loss of populations over time. Such interactive effects from compounded stressors thereby act synergistically to curtail the viability of frog metapopulations and increase the risks of extinction.

It is difficult to predict the precise impact of the cumulative threat represented by the relatively novel Bd epidemic across a landscape already fragmented by fish stocking. The singular threat of the Bd epidemic wave in the uninfected populations of the mountain yellow-legged frog complex in the southern Sierra Nevada could extirpate those populations as the lethal pathogen spreads. A compounding effect of disease-caused extirpation is that recolonization may never occur because streams connecting extirpated sites to extant populations now contain introduced fishes, which act as barriers to frog movement within metapopulations. This isolates the remaining populations of mountain yellow-legged frogs from one another (Bradford 1991, p. 176; Bradford *et al.* 1993, p. 887). It is logical to presume that the small, fragmented populations left in the recent wake of Bd spread through the majority of the range of the Sierra Nevada yellow-legged frog may experience further extirpations as surviving adults eventually die, and recruitment into the breeding pool from the Bd-positive subadult class is significantly reduced. These may be exacerbated by the present and growing threat of climate change, although this effect may take years to materialize.

In summary, based on the best available scientific and commercial information, we consider other natural and manmade factors to be substantial ongoing threats to the Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog. These include high, prevalent risk associated with climate change and small population sizes, and the associated risk from the additive or synergistic effects of these two stressors interacting with other acknowledged threats, including habitat fragmentation and degradation (see Factor A), disease (see Factor C), or other threats currently present but with low relative contribution in isolation.

Proposed Determination for the Sierra Nevada Yellow-legged Frog

We have carefully assessed the best scientific information available regarding the past, present, and future threats to the Sierra Nevada yellow-legged frog.

There has been a rangewide decline in the geographic extent of populations, and losses of populations have continued in recent decades. There are now fewer, increasingly isolated populations maintaining viable recruitment (entry of post-metamorphic frogs into the breeding population). Coupled with the observation that remnant populations are also numerically smaller (in some cases consisting of few individuals), this reduction in occupancy and population density across the landscape suggests significant losses in metapopulation viability and high attendant risk to the overall population. The impacts of the declines on population resilience are two-fold: (1) The geographic extent and number of populations are reduced across the landscape, resulting in fewer and more isolated populations (the species is less able to withstand population stressors and unfavorable conditions exist for genetic exchange or dispersal to unoccupied areas (habitat fragmentation)); and (2) species abundance (in any given population) is reduced, making local extirpations much more likely (decreased population viability). Knapp *et al.* (2007b, pp. 1–2) estimated a 10 percent decline per year in the number of remaining mountain yellow-legged frog populations, and argued for the listing of the species as endangered based on this observed rate of population loss.

The best available science indicates the cause of the decline of the Sierra Nevada yellow-legged frog is the introduction of fishes to its habitat (Factor A, C) to support recreational angling. Water bodies throughout this range have been intensively stocked with introduced fish (principally trout). It is a threat of significant influence, and although it more directly impacted populations historically, it remains prevalent today because fish persist in many high-elevation habitats even where stocking has ceased. Competitive exclusion and predation by fish have reduced frog populations in stocked habitats, and left remnant populations isolated. It is important to recognize that throughout the vast majority of its range, Sierra Nevada yellow-legged frogs did not co-evolve with any species of fish, as they predominantly occur in water bodies above natural fish barriers. Further, the introduction of fish has generally restricted remaining Sierra Nevada yellow-legged frog populations to more marginal habitats, thereby increasing the likelihood of localized extinctions. Recolonization in these situations is difficult for a highly aquatic species with high site fidelity and unfavorable dispersal conditions. Climate change is likely to exacerbate these other threats and further threaten population resilience.

Historical grazing activities may have modified the habitat of the Sierra Nevada yellow-legged frog throughout much of its range (Factor A). Grazing pressure has been significantly reduced from historical levels, although grazing may continue to contribute to some localized degradation and loss of suitable habitat. The effects of recreation, dams and water diversions, roads, timber harvests, and fire management activities on the Sierra Nevada yellow-legged frog are not well-studied, and although they may negatively affect frog populations and their habitat, these effects have not been implicated as primary factors in the decline of this species. However, these activities may be factors of secondary importance in the decline of the Sierra Nevada yellow-legged frog and the modification of its habitat. Although these threat factors are of relatively lower current magnitude and imminence, part of their lesser studied, more uncertain contribution to population dynamics may be a function of timing. Historical losses may already be realized in areas where impacts are greater, and these would not be documented in studies that have mostly been conducted over the last 2 to 3 decades amongst surviving populations. During this same time interval, management practices by Federal agencies with jurisdiction within the current range of the Sierra Nevada yellow-legged frog have generally improved.

Sierra Nevada yellow-legged frogs are vulnerable to multiple pathogens, whose effects range from low levels of infection within persistent populations to disease-induced extirpation of entire populations. The Bd epidemic has caused localized extirpations of Sierra Nevada yellow-legged frog populations and associated significant declines in numbers of individuals. Though Bd was only recently discovered to affect the Sierra Nevada yellow-legged frog, it appears to infect populations at much higher rates than other diseases. The imminence of this risk to currently uninfected habitats is immediate, and the potential effects severe. The already-realized effects to the survival of sensitive amphibian life stages in Bd-positive areas are well-documented. Although some populations survive the initial Bd wave, survival rates of metamorphs and population viability are markedly reduced relative to historical (pre-Bd) norms.

The main and interactive effects of these various risk factors have acted to reduce Sierra Nevada yellow-legged frog populations to a small fraction of its historical range and reduce population abundances significantly throughout most of its range. Remaining areas in the southern Sierra Nevada that have yet to be impacted by Bd are at immediate and severe risk.

Given the life history of this species, dispersal, recolonization, and genetic exchange are largely precluded by the fragmentation of habitat common throughout its current range as a result of fish introductions. Frogs that may disperse are susceptible to hostile conditions in many circumstances. In essence, Sierra Nevada yellow-legged frogs have been marginalized by historical fish introductions and, likely, other land management activities. Populations have recently been decimated by Bd, and the accumulation of other stressors (such as anticipated reduction of required aquatic breeding habitats with climate change and more extreme weather) upon a fragmented landscape make adaptation and recovery a highly improbable scenario without active intervention. The cumulative risk from these stressors to the persistence of the Sierra Nevada yellow-legged frog throughout its range is significant.

The Act defines an endangered species as any species that is ''in danger of extinction throughout all or a significant portion of its range'' and a threatened species as any species ''that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future.'' We find that the Sierra Nevada yellow-legged frog is presently in danger of extinction throughout its entire range, based on the immediacy, severity, and scope of the threats described above. Specifically, these include habitat degradation and fragmentation under Factor A, predation and disease under Factor C, and climate change and the interaction of these various stressors cumulatively impacting small remnant populations under Factor E. There has been a rangewide reduction in abundance and geographic extent of surviving populations of the Sierra Nevada yellow-legged frog following decades of fish stocking, habitat fragmentation, and, most recently, a disease epidemic. Surviving populations are smaller and more isolated, and recruitment in Bd-positive populations is much reduced relative to historical norms. This combination of population stressors makes species persistence precarious throughout the currently occupied range in the Sierra Nevada.

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the species, and have determined that the Sierra Nevada yellow-legged frog meets the definition of endangered under the Act, rather than threatened. This is because significant threats are occurring now and will occur in the future, at a high magnitude and across the species' entire range, making the species in danger of extinction at the present time. The rate of population decline remains high in the wake of chytrid epidemics, and core areas are at high, imminent risk. Population declines are expected to continue as maturing tadpoles succumb to Bd infection, and fragmented populations at very low abundances will face significant obstacles to recovery.

Under the Act and our implementing regulations, a species may warrant listing if it is endangered or threatened throughout all or a significant portion of its range. The Sierra Nevada yellow-legged frog proposed for listing in this rule is restricted in its range, and the threats occur throughout the remaining occupied habitat. Therefore, we assessed the status of this species throughout its entire range. The threats to the survival of the species occur throughout the species' range and are not restricted to any particular significant portion of that range. Accordingly, our assessment and proposed determination applies to the species throughout its entire range.

Proposed Determination for the Northern DPS of the Mountain Yellow-legged Frog

We have carefully assessed the best scientific information available regarding the past, present, and future threats to the northern DPS of the mountain yellow-legged frog.

There has been a rangewide decline in the geographic extent of populations, and losses of populations have continued in recent decades. There are now fewer, increasingly isolated populations maintaining viable recruitment (entry of post-metamorphic frogs into the breeding population). Coupled with the observation that remnant populations are also numerically smaller (in some cases consisting of few individuals), this reduction in occupancy and population density across the landscape suggests significant losses in metapopulation viability and high attendant risk to the overall population. The impacts of the declines on population resilience are two-fold: (1) The geographic extent and number of populations are reduced across the landscape, resulting in fewer and more isolated populations (the species is less able to withstand population stressors and unfavorable conditions exist for genetic exchange or dispersal to unoccupied areas (habitat fragmentation)); and (2) species abundance (in any given population) is reduced, making local extirpations much more likely (decreased population viability). Knapp *et al.* (2007b, pp. 1–2) estimated a 10 percent decline per year in the number of remaining mountain yellow-legged frog populations, and argued for the listing of the species as endangered based on this observed rate of population loss.

The best available science indicates the cause of the decline of the northern DPS of the mountain yellow-legged frog is the introduction of fishes to its habitat (Factor A, C) to support recreational angling. Water bodies throughout this range have been intensively stocked with introduced fish (principally trout). It is a threat of significant influence, and although it more directly impacted populations historically, it remains prevalent today because fish persist in many high-elevation habitats even where stocking has ceased. Competitive exclusion and predation by fish have reduced frog populations in stocked habitats, and left remnant populations isolated. It is important to recognize that throughout the vast majority of their range, mountain yellow-legged frogs did not co-evolve with any species of fish, as they predominantly occur in water bodies above natural fish barriers. Further, the introduction of fish has generally restricted remaining mountain yellow-legged frog populations to more marginal habitats, thereby increasing the likelihood of localized extinctions. Recolonization in these situations is difficult for a highly aquatic species with high site fidelity and unfavorable dispersal conditions. Climate change is likely to exacerbate these other threats and further threaten population resilience.

Historical grazing activities may have modified the habitat of the mountain yellow-legged frog throughout much of its range (Factor A). Grazing pressure has been significantly reduced from historical levels, although grazing may continue to contribute to some localized degradation and loss of suitable habitat. The effects of recreation, dams and water diversions, roads, timber harvests, and fire management activities on the mountain yellow-legged frog are not well-studied, and although they may negatively affect frog populations and their habitat, these effects have not been implicated as primary factors in the decline of this species. However, these activities may be factors of secondary importance in the decline of the mountain yellow-legged frog and the modification of its habitat. Although these threat factors are of relatively lower current magnitude and imminence, part of their lesser studied, more uncertain contribution to population dynamics may be a function of timing. Historical losses may already be realized in areas where impacts are greater, and these would not be documented in studies that have mostly been conducted over the last 2 to 3 decades amongst surviving populations. During this same time interval, management practices by Federal agencies with jurisdiction within the current range of the mountain yellow-legged frog have generally improved.

Mountain yellow-legged frogs are vulnerable to multiple pathogens, whose effects range from low levels of infection within persistent populations to disease-induced extirpation of entire populations. The Bd epidemic has caused localized extirpations of mountain yellow-legged frog populations and associated significant declines in numbers of individuals. Though Bd was only recently discovered to affect the mountain yellow-legged frog, it appears to infect populations at much higher rates than other diseases. The imminence of this risk to currently uninfected habitats is immediate, and the potential effects severe. The already-realized effects to the survival of sensitive amphibian life stages in Bd-positive areas are well-documented. Although some populations survive the initial Bd wave, survival rates of metamorphs and population viability are markedly reduced relative to historical (pre-Bd) norms.

The main and interactive effects of these various risk factors have acted to reduce the northern DPS of the mountain yellow-legged frog populations to a small fraction of its historical range and reduce population abundances significantly throughout most of its range. Remaining areas in the southern Sierra Nevada that have yet to be impacted by Bd are at immediate and severe risk.

Given the life history of this species, dispersal, recolonization, and genetic exchange are largely precluded by the fragmentation of habitat common throughout its current range as a result of fish introductions. Frogs that may disperse are susceptible to hostile conditions in many circumstances. In essence, mountain yellow-legged frogs have been marginalized by historical fish introductions and, likely, other land management activities. Populations have recently been decimated by Bd, and the accumulation of other stressors (such as anticipated reduction of required aquatic breeding habitats with climate change and more extreme weather) upon a fragmented landscape make adaptation and recovery a highly improbable scenario without active intervention. The cumulative risk from these stressors to the persistence of the mountain yellow-legged frog throughout its range is significant.

The Act defines an endangered species as any species that is ‘‘in danger of extinction throughout all or a significant portion of its range’’ and a threatened species as any species ‘‘that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future.’’ We find that the northern DPS of the mountain yellow-legged frog is presently in danger of extinction throughout its entire range, based on the immediacy, severity, and scope of the threats described above. Specifically, these include habitat degradation and fragmentation under Factor A, predation and disease under Factor C, and climate change and the interaction of these various stressors cumulatively impacting small remnant populations under Factor E. There has been a rangewide reduction in abundance and geographic extent of surviving populations of the northern DPS of the mountain yellow-legged frog following decades of fish stocking, habitat fragmentation, and, most recently, a disease epidemic. Surviving populations are smaller and more isolated, and recruitment in Bd-positive populations is much reduced relative to historical norms. This combination of population stressors makes species persistence precarious throughout the currently occupied range in the Sierra Nevada.

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the species, and have determined that the northern DPS of the mountain yellow-legged frog, already endangered in the southern part of its range, meets the definition of endangered under the Act, rather than threatened. This is because significant threats are occurring now and will occur in the future, at a high magnitude and across the species' entire range, making the species in danger of extinction at the present time. The rate of population decline remains high in the wake of chytrid epidemics, and core areas are at high, imminent risk. The recent rates of decline for these populations are even higher than declines in the Sierra Nevada yellow-legged frog, and as Bd infects remaining core areas, population viability will be significantly reduced, and extirpations or significant population declines are expected. Population declines are further expected to continue as maturing tadpoles succumb to Bd infection, and fragmented populations at very low abundances will face significant obstacles to recovery. Therefore, on the basis of the best available scientific and commercial information, and the threats posed to these species under the listing factors above, we propose listing the northern DPS of the mountain yellow-legged frog as endangered in accordance with sections 3(6) and 4(a)(1) of the Act.

Under the Act and our implementing regulations, a species may warrant listing if it is endangered or threatened throughout all or a significant portion of its range. The northern DPS of the mountain yellow-legged frog proposed for listing in this rule is restricted in its range, and the threats occur throughout the remaining occupied habitat. Therefore, we assessed the status of this DPS throughout its entire range in the Sierra Nevada of California. The threats to the survival of this DPS occur throughout its range in the southern Sierra Nevada and are not restricted to any particular significant portion of that range. Accordingly, our assessment and proposed determination applies to the DPS throughout its entire range.

Status for Yosemite Toad

Background

In this section of the proposed rule, it is our intent to discuss only those topics directly relevant to the listing of the Yosemite toad (*Anaxyrus canorus*) as threatened.

Taxonomy

The Yosemite toad (*Anaxyrus canorus;* formerly *Bufo canorus*) was originally described by Camp (1916, pp. 59–62), and given the common name Yosemite Park toad. The word ''canorus'' means ''tuneful'' in Latin, referring to the male's sustained melodious trill, which attracts mates during the early spring breeding season. Later, Grinnell and Storer (1924, pp. 657–660) referred to this species as the Yosemite toad when the species' range was found to extend beyond the boundaries of Yosemite National Park.

When he described the species, Camp noted similarities in appearance of the Yosemite toad and the western toad (Camp 1916, pp. 59–62). Based on general appearance, structure, and distribution, it appeared that the western toad and the Yosemite toad were closely related (Myers 1942, p. 10; Stebbins 1951, pp. 245–248; Mullally 1956b, pp. 133–135; Savage 1958, pp. 251–253). The close relationship between the western toad and the Yosemite toad is also supported by studies of bone structure (Tihen 1962, pp. 1–50) and by the survivorship of hybrid toads produced by artificially crossing the two species (Blair 1959, pp. 427–453; 1963, pp. 1–16; 1964, pp. 181–192).

Camp (1916, pp. 59–62), using characteristics of the skull, concluded that *Bufo boreas, B. canorus,* and *B. nestor* (extinct) were more closely related to one another than to other North American toads (Family Bufonidae), and that these species comprised the most primitive group of *Bufo* in North America. Blair (1972, pp. 93–95) grouped *B. borea*s, *B. canorus,* black toads (*B. exsul*), and Amargosa toads (*B. nelsoni*) together taxonomically as the ''boreas group.'' Subsequently, Frost *et al.* (2006, p. 297) divided the paraphyletic genus ''Bufo'' into three separate genera, assigning the North American toads to the genus *Anaxyrus.* This taxonomic distinction has been recently adopted by the American Society of Ichthyologists and Herpetologists, the Herpetologists' League, and the Society for the Study of Amphibians and Reptiles (Crother *et al.* 2008. p. 3).

Feder (1977, pp. 43–55) found Yosemite toads to be the most genetically distinct member of the boreas group based on samples from a limited geographic range. However, Yosemite toads hybridize with western toads in the northern part of their range (Karlstrom 1962, p. 84; Morton and Sokolski 1978, pp. 52–55). A genetic analysis of a segment of mitochondrial DNA from Yosemite toads was performed by Shaffer *et al.* (2000, pp. 245–257) using 372 toads from Yosemite and Kings Canyon National Parks. These data showed significant genetic differences in Yosemite toads between the two National Parks. They observed that genetic divergence among regionally proximate populations of Yosemite toads was high, implying low rates of genetic exchange. Their data also suggest that black toads are a nested subgroup within Yosemite toads, rather than a separate species, and that a group of western toad populations in the Oregon Cascades appears more closely related to Yosemite toads than their current classification would indicate. However, sufficient molecular evidence to change the taxonomic classification of these three species is not yet available.

Stephens (2001, pp. 1–62) examined mitochondrial DNA from 8 Yosemite toads (selected to represent the range of variability found in the Shaffer *et al.* (2000, pp. 245–257) study) and 173 western toads. This study indicated that *Bufo* in the Sierra Nevada occurs in northern and southern evolutionary groups, each of which includes both Yosemite toads and western toads (that is, toads of both species are more closely related to each other within an evolutionary group than they are to members of their own species in the other evolutionary group). Goebel *et al.* (2008, p. 223) also concluded that the Yosemite toad is paraphyletic, split between a northwest and southwest haplotype group.

Further genetic analysis of Yosemite toads is needed to fully understand the evolutionary history and appropriate taxonomic status of the Yosemite toad (Stephens 2001, pp. 1–62). Current information indicates that the range is segregated between northern and southern evolutionary groups. This information also indicates that genetic introgression (movement of genes into the native gene pool to create hybrid populations) is occurring from a closely related counterpart (likely over an extended period), possibly associated with range expansion and overlap with the western toad following reproductive isolation that occurred during the Pleistocene glaciation (Feder 1977, p. 43). It therefore appears that natural hybridization has occurred where

Yosemite toad and western toad ranges overlap. We have assessed the available information, and have determined that the Yosemite toad is a valid species, following its current classification by the American Society of Ichthyologists and Herpetologists, the Herpetologists' League, and the Society for the Study of Amphibians and Reptiles (Crother *et al.* 2008, p. 3).

Species Description

The Yosemite toad is moderately sized, with a snout-urostyle length (measured from the tip of the snout to the posterior edge of the urostyle, a bony structure at the posterior end of the spinal column) of 30–71 mm (1.2–2.8 in) with rounded to slightly oval paratoid glands (a pair of glands, one on each side of the head, that produce toxins) (Karlstrom 1962, pp. 21–23). The paratoid glands are less than the width of a gland apart (Stebbins 1985, pp. 71–72). A thin mid-dorsal stripe (on the middle of the back) is present in juveniles of both sexes. The stripe disappears or is reduced with age; this process takes place more quickly in males (Jennings and Hayes 1994, pp. 50–53). The iris of the eye is dark brown with gold iridophores (reflective pigment cells) (Jennings and Hayes 1994, pp. 50–53).

Male Yosemite toads are smaller than female Yosemite toads, with less conspicuous warts (Stebbins 1951, p. 246). Differences in coloration between males and females are more pronounced in the Yosemite toad than in any other North American frog or toad (Stebbins 1951, p. 246). Females have black spots or blotches edged with white or cream set against a grey, tan, or brown background color (Jennings and Hayes 1994, pp. 50–53). Males have a nearly uniform dorsal coloration of yellow-green to olive drab to darker greenish brown (Jennings and Hayes 1994, pp. 50–53). Karlstrom (1962, pp. 80–81) suggested that differences in coloration between the sexes evolved because they provide the Yosemite toad with protective coloration (camouflage). The uniform coloration of the adult males matches and blends with the silt and grasses that they frequent during the breeding season, whereas the young and females with disruptive coloration tend to use a wider range of habitats with broken backgrounds; thus, coloration may help conceal individual toads from predators.

Habitat and Life History

Yosemite toads are found in wet meadow habitats and lake shores surrounded by lodgepole (*Pinus contorta*) or whitebark (*P. albicaulis)* pines (Camp 1916, pp. 59–62). They are most often found in areas with thick meadow vegetation or patches of low willows (*Salix* spp.) (Mullally 1953, pp. 182–183). Liang (2010, p. 81) observed Yosemite toads most frequently associated with (in order of preference): wet meadows, alpine-dwarf scrub, red fir (*Abies magnifica*), water, lodgepole pine, and subalpine conifer habitats.

Yosemite toads were found as often at large as at small sites (Liang 2010, p. 19), suggesting that this species is capable of successfully utilizing small habitat patches. Liang also found that population persistence was greater at higher elevations, with an affinity for relatively flat sites with a southwesterly aspect (Liang 2010, p. 20). These areas receive higher solar radiation and are capable of sustaining hydric (wet), seasonally ponded, and mesic (moist) breeding and rearing habitat. The Yosemite toad is more common in areas with less variation in mean annual temperature, or more temperate sites with less climate variation (Liang 2010, pp. 21–22).

Adults are thought to be long-lived, and this factor allows for persistence in variable conditions and more marginal habitats where only periodic good years allow high reproductive success (USFS *et al.* 2009, p. 27). Females have been documented to reach 15 years of age, and males as many as 12 years (Kagarise Sherman and Morton 1993, p. 195); however the average longevity of the Yosemite toad in the wild is not known. Jennings and Hayes (1994, p. 52) indicated that females begin breeding at ages four to six, while males begin breeding at ages three to five.

Adults tend to breed at a single site and appear to have high site-fidelity (Liang 2010, p. 99), although individuals will move between breeding areas (Liang 2010, p. 52). Breeding habitat includes the edges of wet meadows and slow-flowing streams (Jennings and Hayes 1994, pp. 50–53). Tadpoles have also been observed in shallow ponds and shallow areas of lakes (Mullally 1953, pp. 182–183).

Males exit burrows first, and spend more time in breeding pools than females, who do not breed every year (Kagarise Sherman and Morton, 1993, p. 196). It is suggested that higher lipid storage in females, which enhances overwinter survival, also precludes the energetic expense of breeding every year (Morton 1981, p. 237). The Yosemite toad is a prolific breeder, laying many eggs immediately at snowmelt. This is accomplished in a short period of time, coinciding with water levels in meadow habitats and ephemeral pools they use for breeding. Female toads lay approximately 700–2,000 eggs in two strings (one from each ovary) (USFS *et al.* 2009, p. 21). Females may split their egg clutches within the same pool, or even between different pools, and may lay eggs communally with other toads (USFS *et al.* 2009, p.22).

Eggs hatch within 3–15 days, depending on ambient water temperatures (Kagarise Sherman 1980, pp. 46–47; Jennings and Hayes 1994, p. 52). Tadpoles typically metamorphose around 40–50 days after fertilization, and are not known to overwinter (Jennings and Hayes 1994. p. 52). Tadpoles are black in color, tend to congregate together (Brattstrom 1962, pp. 38–46) in warm shallow waters during the day (Cunningham 1963, pp. 60–61), and then retreat to deeper waters at night (Mullaly 1953, p. 182). Rearing through metamorphosis takes approximately 5–7 weeks after eggs are laid (USFS *et al.* 2009, p. 25).

Reproductive success is dependent on the persistence of tadpole rearing sites and conditions for breeding, egg deposition, hatching, and rearing to metamorphosis (USFS *et al.* 2009, p. 23). Given their association with shallow, ephemeral habitats, Yosemite toads are susceptible to droughts and weather extremes. Abiotic factors leading to mortality (such as freezing or desiccation) appear to be more significant during the early life stages of toads, while biotic factors (such as predation) are probably more prominent factors during later life stages (USFS *et al.* 2009, p. 30). However, since adult toads lead a much more inconspicuous lifestyle, direct observation of adult mortality is difficult and it is usually not possible to determine causes of adult mortality.

Adult Yosemite toads are most often observed near water, but only occasionally in water (Mullally and Cunningham 1956b, pp. 57–67). Moist upland areas such as seeps and springheads are important summer non-breeding habitats for adult toads (Martin 2002, pp. 1–3). The majority of their life is spent in the upland habitats proximate to their breeding meadows. They use rodent burrows for overwintering and probably for temporary refuge during the summer (Jennings and Hayes 1994, pp. 50–53), and they spend most of their time in burrows (Liang 2010, p. 95). They also use spaces under surface objects, including logs and rocks, for temporary refuge (Stebbins 1951, pp. 245–248; Karlstrom 1962, pp. 9–10). Males and females also likely inhabit different areas and habitats when not breeding, and females tend to move farther from breeding ponds than males (USFS *et al.* 2009, p. 28).

Yosemite toads can move farther than 1 km (0.63 mi) from their breeding meadows (average movement is 275 m (902 ft)), and they utilize terrestrial environments extensively (Liang 2010, p. 85). The average distance traveled by females is twice as far as males, and home ranges for females are 1.5 times greater than those for males (Liang 2010, p. 94). Movement into the upland terrestrial environment following breeding does not follow a predictable path, and toads tend to traverse longer distances at night, perhaps to minimize evaporative water loss (Liang 2010, p. 98). Martin (2008, p. 123) radio-tracked adult toads during the active season and found that on average toads traveled a total linear distance of of 494 m (1,620 ft) within the season, with minimum travel distance of 78 m (256 ft) and maximum of 1.76 km (1.09 mi).

Historical Range and Distribution

The historical range of the Yosemite toad in the Sierra Nevada extended from the Blue Lakes region north of Ebbetts Pass (Alpine County) to just south of Kaiser Pass in the Evolution Lake/Darwin Canyon area (Fresno County) (Jennings and Hayes 1994, pp. 50–53). Yosemite toad habitat historically spanned elevations from 1,460 to 3,630 m (4,790 to 11,910 ft) (Stebbins 1985, pp. 72; Stephens 2001, p. 12).

Current Range and Distribution

The current range of the Yosemite toad, at least in terms of overall geographic extent, remains largely similar to the historical range defined above (USFS *et al.* 2009, p. 41). However, within that range, toad habitats have been degraded and may be decreasing in area as a result of conifer encroachment and livestock grazing (see Factor A below). The vast majority of the Yosemite toad's range is within Federal land. Figure 2, Estimated Range of Yosemite Toad, displays a range map for the species.

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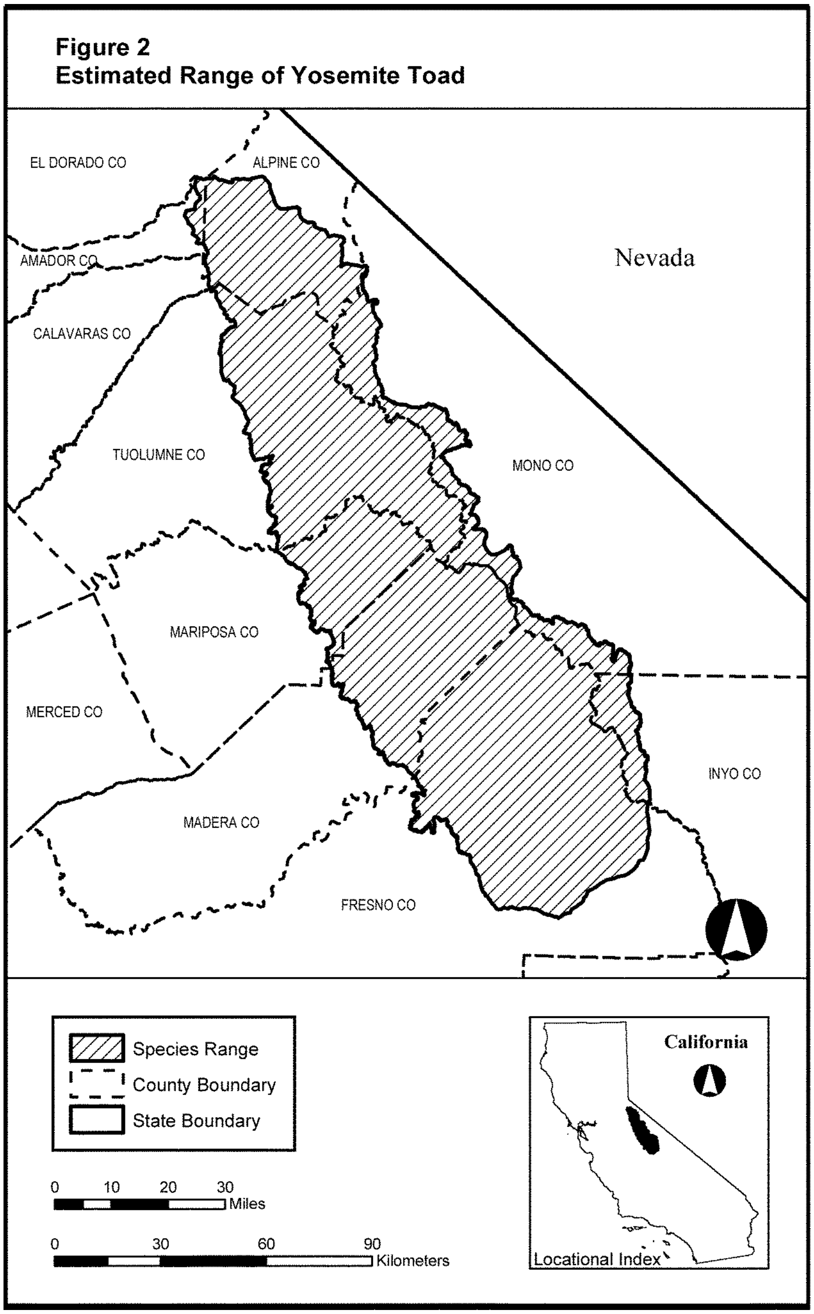

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Population Estimates and Status

Baseline data on the number and size of historical Yosemite toad populations are limited, and historic records are largely based on accounts from field notes, or pieced together through museum collections. Systematic survey information across the range of the species largely follows the designation of the Yosemite toad as a candidate species under the Act. From these recent inventories, Yosemite toads have been found at 469 localities collectively on six National Forests (more sites than previously known), indicating that the species is still widespread throughout its range (USFS *et al.* 2009, p. 40). These inventories were conducted to determine toad presence or absence (they were not censuses), and the referenced figure does not explicitly compare historic sites to recent surveys. Moreover, single-visit surveys of toads are unreliable as indices of abundance because timing is so critical to the presence of detectable life stages (USFS *et al.* 2009, p. 41; Liang 2010, p. 10). Given these considerations, conclusions about population trends, abundance, or extirpation rates are not possible relative to this specific dataset.

One pair of studies allows us to compare current distribution with historic distributions and indicates that large reductions have occurred. In 1915 and 1919, Grinnell and Storer (1924, pp. 657–660) surveyed for vertebrates at 40 sites along a 143-km (89-mi) west-to-east transect across the Sierra Nevada, through Yosemite National Park, and found Yosemite toads at 13 of those sites. Drost and Fellers (1996, pp. 414–425) conducted more thorough surveys, specifically for amphibians, at 38 of the Grinnell and Storer sites plus additional nearby sites in 1992. Drost and Fellers found that Yosemite toads were absent from 6 of 13 sites where they had been found in the original Grinnell and Storer survey. Moreover, at the sites where they were present, Yosemite toads occurred in very low numbers relative to general abundance reported in the historical record (Grinnell and Storer 1924, pp. 657–660). Specifically, by the early 1990s, the species was either undetectable or had declined in numbers at 9 of 13 (69 percent) of the Grinnell and Storer (1924, pp. 657–660) sites.

Another study comparing historic and current occurrences also found a large decline in Yosemite toad distribution. In 1990, David Martin surveyed 75 sites throughout the range of the Yosemite toad for which there were historical records of the species' presence. This study found that 47 percent of historically occupied sites showed no evidence of any life stage of the species (Stebbins and Cohen 1995, pp. 213–215). This result suggests a rangewide decline to about one half of historical sites, based on occupancy alone.

A third study comparing historic and recent surveys indicates declines in Yosemite toad distribution. Jennings and Hayes (1994, pp. 50–53) reviewed the current status of Yosemite toads using museum records of historic and recent sightings, published data, and unpublished data and field notes from biologists working with the species. They estimated a loss of over 50 percent of former Yosemite toad locations throughout the range of the species (based on 144 specific sites).

The only long-term, site-specific population study for Yosemite toads documented a dramatic decline over 2 decades of monitoring. Kagarise Sherman and Morton (1993, pp. 186–198) studied Yosemite toads at Tioga Pass Meadow (Mono County, California) from 1971 through 1991 (with the most intensive monitoring through 1982). They documented a decline in the average number of males entering the breeding pools from 258 to 28 during the mid-1970s through 1982. During the same time period, the number of females varied between 45 and 100, but there was no apparent trend in number observed. During the 1980s, it appeared that both males and females continued to decline, and breeding activity became sporadic. By 1991, they found only one male and two egg masses. The researchers also found similar population declines in local nonbreeding habitat.

Kagarise Sherman and Morton (1993, pp. 186–198) also conducted occasional surveys of six other populations in the eastern Sierra Nevada. Five of these populations showed long-term declines that were evident beginning between 1978 through 1981, while the sixth population held relatively steady until the final survey in 1990, at which time it dropped. In 1991, E.L. Karlstrom revisited the site where he had studied a breeding population of Yosemite toads from 1954 to 1958 (just south of Tioga Pass Meadow within Yosemite National Park), and found no evidence of toads or signs of breeding (Kagarise Sherman and Morton 1993, pp. 190).

The most reliable information about Yosemite toad population status and trends is the USFS SNAMPH. This study is designed to provide statistical comparisons across 5-year monitoring cycles with at 134 watersheds (Brown *et al.* 2011, pp. 3–4). This approach allows researchers to assess trends for the entire range of the toad, rather than make year-to-year comparisons at limited survey sites (C. Brown 2012, pers. comm.). The results of this assessment indicate the species has declined from historical levels, with Yosemite toads occurring in only 12 percent of watersheds where they existed prior to 1990. This study also found that breeding currently occurs in an estimated 22 percent of watersheds within their current estimated range. Additionally, the study found that breeding was occurring in 81 percent of the watersheds that were occupied from 1990–2001, suggesting that the number of locations where breeding occurs has continued to decline (Brown *et al.* 2011, p. 4).

Moreover, overall abundances in the intensively monitored watersheds were very low (fewer than 20 males per meadow per year) relative to other historically reported abundances of the species (Brown *et al.* 2011, p. 4). Brown *et al.* (2011, p. 35) suggest that populations are now very small across the range of the species. They found only 18 percent of occupied survey watersheds rangewide had ''large'' populations during their monitoring over the past decade (more than 1,000 tadpoles or 100 of any other lifestage detected at the time of survey). The researchers interpret this data, in combination with documented local population declines from other studies (see above), to support the hypothesis that population declines have occurred rangewide (Brown *et al.* 2012, p. 11).

Summary of Factors Affecting the Species

Section 4 of the Act (16 U.S.C. 1533), and its implementing regulations at 50 CFR part 424, set forth the procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, we may list a species based on any of the following five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. Listing actions may be warranted based on any of the above threat factors, singly or in combination. Each of these factors is discussed below.

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

The habitat comprising the current range of the Yosemite toad is generally characterized by low levels of physical disturbance (there is little to no current development pressure). However, these areas are also generally more sensitive to perturbation and take longer to recover from disturbances due to reduced growing seasons and harsher environmental conditions. Past management and development activity has played a role in the degradation of certain habitat features within the Sierra Nevada. Anthropogenic activities within these habitats include grazing, timber harvest, fuels management, recreation, and water development. Collectively, these factors continue to degrade habitat conditions for the toad, although the contribution of this factor to population dynamics has probably lessened over time, perhaps because toad populations disappear from impacted areas first, but also through improved management practices implemented in recent decades.

Meadow Habitat Loss and Degradation

Some of the threat factors associated with grazing activities for the mountain yellow-legged frogs (see their Summary of Factors Affecting the Species section, above) also apply to Yosemite toads. However, there are differences based on the Yosemite toad's affinity for meadow and pool habitats versus the lakes and streams frequented by mountain yellow-legged frogs. Meadow habitat quality in the Western United States, and specifically the Sierra Nevada, has been degraded by various stressors over the last century (Stillwater Sciences 2008, pp. 1–53; Halpern *et al.* 2010, pp. 717–732; Vale 1987, pp. 1–18; Ratliff 1985, pp. *i*–48). These various stressors have contributed to erosion and stream incision, leading to meadow dewatering and encroachment by invasive vegetation (Menke et al. 1996, pp. 25–28; Linquist 2000, p. 2). The legacy of these impacts remains extant to this day in the ecosystems of the high Sierra Nevada (Vankat and Major 1978, pp. 386–397).

Given the reliance of the Yosemite toad on these meadow and pool habitats for breeding, rearing, and adult survival, it is logical to conclude that the various stressors have had an indirect effect on the viability of Yosemite toad populations via degradation of their habitat. Loss of connectivity of habitats leads to further isolation and population fragmentation. Due to constraints of their physiology, low mobility, and higher site fidelity, many amphibian populations may be unable to recolonize after local extirpations (Blaustein *et al.* 1994a, p. 60).

Since the existence of meadows is largely dependent on their hydrologic setting, most meadow degradation is due fundamentally to hydrologic alterations (Stillwater Sciences 2008, p. 13). There are many drivers of hydrologic alterations in meadow ecosystems. Historic water development and ongoing management has physically changed the underlying hydrologic landscape. Diversion and irrigation ditches formed a vast network that altered local and regional stream hydrology. Timber harvest and associated road construction further affected erosion and sediment delivery patterns in rivers and meadow streams. Changes in the pre-settlement fire regime, fire suppression, and an increase in the frequency of large wildfires due to excessive fuel buildup, introduced additional disturbance pressure to the meadows of the Sierra Nevada (Stillwater Sciences 2008, p. 13). Many meadows now have downcut stream courses, compacted soils, altered plant community compositions, and diminished wildlife and aquatic habitats (SNEP 1996, pp. 120–121). Meadow dewatering by these changes within the watershed has facilitated these shifts in the vegetative community. Finally, climate variability has also played a role in the conifer encroachment.

Land uses causing channel erosion threaten Sierra Nevada meadows. These threats include erosive activities within the watershed upslope of the meadow, along with impacts from land use directly in the meadows themselves. Compaction of meadow soils by roads and/or intensive trampling (for example, overgrazing) can reduce infiltration, accelerate surface run-off, and thereby lead to channel incision (Menke et al. 1996, pp. 25–28). Mining, overgrazing, timber harvesting, and railroad and road construction and maintenance have contributed to watershed degradation, resulting in accelerated erosion, sedimentation in streams and reservoirs, meadow dewatering, and degraded terrestrial and aquatic habitats (Linquist 2000, p. 2). Deep incision has been documented in several meadows in the Sierra Nevada. One example is Halstead Meadow in Sequoia National Park, where headcutting exceeds 10 feet in many areas and is resulting in widening channels, erosion in additional meadows, and a lowered water table (Cooper 2006, p. 1).

The hydrologic effects of stream incision on the groundwater system may significantly impact groundwater storage, affecting late summer soil moisture and facilitating vegetation change (Bergmann 2004, pp. 24–31). For example, in the Last Chance Watershed in the northern Sierra Nevada, logging, overgrazing, and road/railroad construction have caused stream incision, resulting in dewatering of riparian meadow sediments and a succession from native wet meadow vegetation to sagebrush and dryland grasses (Loehide and Gorelick 2007, p. 2). A woody shrub (*Artemisia rothrockii*) is invading meadows as channel incision causes shallow-water-dependent herbs to die back, allowing shrub seedlings to establish in disturbed areas during wet years (Darrouzet-Nardi *et al.* 2006, p. 31).

Mountain meadows in the western United States and Sierra Nevada have also been progressively colonized by trees (Thompson 2007, p. 3; Vale 1987, p. 6), with an apparent pattern of encroachment during two distinct periods in the late 1800s and mid 1900s (Halpern *et al.* 2010, p. 717). This trend has been attributed to a number of factors, including climate, changes in fire regime, and cessation of sheep grazing (Halpern *et al.* 2010, pp. 717–718; Vale 1987, pp. 10–13), but analyses are limited to correlational comparisons and research results are mixed, so the fundamental contribution of each potential driver remains uncertain. We discuss the contribution of these factors to habitat loss and degradation for the Yosemite toad below.

Livestock Use (Grazing) Effects to Meadow Habitat

Grazing of livestock in Sierra Nevada meadows and riparian areas (rivers, streams, and adjacent upland areas that directly affect them) began in the mid-1700s with the European settlement of California (Menke *et al.* 1996, p. 7). Following the gold rush of the mid-1800s, grazing increased to a level exceeding the carrying capacity of the available range, causing significant impacts to meadow and riparian ecosystems (Meehan and Platts 1978, p. 275; Menke *et al.* 1996, p. 7). By the turn of the 20th century, high Sierra Nevada meadows were converted to summer rangelands for grazing cattle, sheep, horses, goats, and pigs, although the alpine areas were mainly grazed by sheep (Beesley 1996, pp. 7–8; Menke *et al.* 1996, p. 14). Stocking rates of both cattle and sheep in Sierra meadows in the late 19th and early 20th centuries were very heavy (Kosco and Bartolome 1981, pp. 248–250), and grazing severely degraded many meadows (Ratliff 1985, pp. 26–31; Menke *et al.* 1996, p. 14). Grazing impacts occurred rangewide, as cattle and sheep were driven virtually everywhere in the Sierra Nevada where forage was available (Kinney 1996, pp. 37–42; Menke *et al.* 1996, p. 14).

Grazing within the National Forests has continued into modern times, with reduction in activity (motivated by resource concerns, conflicts with other uses, and deteriorating range conditions) beginning in the 1920s. A brief wartime increase in the 1940s followed, before activity continued to be scaled back beginning in the 1950s through the early 1970s. However, despite these reductions, grazing still exceeded sustainable capacity in many areas (Menke *et al.* 1996, p. 9; UC 1996a, p. 115). Currently, approximately 33 percent of the estimated range of the Yosemite toad is within active USFS grazing allotments (USFS 2008, geospatial data). While stocking rates have been reduced or eliminated in most areas, many meadows remain disturbed from the historical period of heavy grazing, with legacy effects including eroded channels, non-vegetated patches from heavy trampling and grazing, altered plant composition, and reduced plant production (Vankat and Major 1978, pp. 386–397; Ratliff 1985, pp. ii–iii).

Livestock grazing in the Sierra Nevada has been widespread for so long that, in most places, no ungrazed areas are available to illustrate the natural condition of the habitat (Kattelmann and Embury 1996, pp. 16–18). Dull (1999, p. 899) conducted stratigraphic pollen analysis (identification of pollen in sedimentary layers) in mountain meadows of the Kern Plateau, and found significant vegetation changes attributable to sheep and cattle grazing by 1900 (though fire regime change was also implicated; see below). This degradation is widespread across the Sierra Nevada. Cooper 2006 (p. 1) reports that 50 to 80 percent of grazed meadows now dominated by dry meadow plants were formerly wet meadows (Cooper 2006, p. 1).

Overgrazing has been associated with accelerated erosion and gullying of meadows (Kattelmann 1996, p. 13), which leads to siltation and more rapid succession of meadows. Grazing can cause erosion by disturbing the ground, damaging and reducing vegetative cover, and destroying peat layers in meadows, which lowers the groundwater table and summer flows (Armour *et al.* 1994, pp. 9–12; Martin 2002, pp. 1–3; Kauffman and Krueger 1984, pp. 431–434). Downcut channels, no longer connected to the historic, wide floodplains of the meadow, instead are confined within narrow, incised channels. Downstream, formerly perennial (year-round) streams often become intermittent or dry due to loss of water storage capacity in the meadow aquifers that formerly sustained them (Lindquist *et al.* 1997, pp. 7–8). Many examples exist like the one at Cottonwood Creek (in the Feather River watershed) where overgrazing of meadow vegetation and soil erosion of streambanks led to meadow channel incision (Linquist 2000, pp. 1–7; Odion *et al.* 1988, pp. 277–292, Schoenherr 1992, pp. 167–227).

Heavy grazing can alter vegetative species composition and contribute to lodgepole pine (*Pinus contorta*) invasion (Ratliff 1985, pp. 33–36). Lowering of the water table facilitates encroachment of conifers into meadows. Gully formation and lowering of water tables, changes in the composition of herbaceous vegetation, increases in the density of forested stands, and the expansion of trees into areas that formerly were treeless have been documented in California Wilderness areas and National Parks (Cole and Landres 1996, p. 171). This invasion has been attributed to sheep grazing, though the phenomenon has been observed on both ungrazed meadows and on meadows grazed continually since about 1900 (Ratliff 1985, p. 35), suggesting an interaction with other drivers (see ‘‘Fire Management Regime Effects to Meadow Habitats’’ and ‘‘Climate Effects to Meadow Habitat’’ below).

Due to the long history (Menke *et al.* 1996, Ch. 22 pp. 1–52) of livestock and packstock grazing in the Sierra Nevada and the lack of historical Yosemite toad population size estimates, it is impossible to establish a reliable quantitative estimate for the historical significance and contribution of grazing on Yosemite toad populations. However, because of the documented negative effects of livestock on Yosemite toad habitat, and the documented direct mortality caused by livestock, the decline of some populations of Yosemite toad has been attributed to the effects of livestock grazing (Jennings and Hayes 1994, pp. 50–53; Jennings 1996, pp. 921–944). Because Yosemite toad breeding habitat is in shallow waters at high elevation, the habitat is believed to be more vulnerable to changes in hydrology caused by grazing (Knapp 2002c, p. 1; Martin 2002, pp. 1–3; USFS *et al.* 2009, p. 62).

The influence of grazing on toad populations in recent history is uncertain, despite more available data on land use and Yosemite toad occurrence. In 2005, the USFS began a long-term study to assess the effects of grazing on Yosemite toads (Allen Diaz *et al.* 2010, pp. 1–45). The researchers assessed: (1) Whether livestock grazing under SNFPA Riparian Standards and Guidelines has a measurable effect on Yosemite toad populations and (2) effects of livestock grazing intensity on key habitat components that affect survival and recruitment of Yosemite toad populations. SNFPA standards and guidelines limit livestock utilization of grass and grass-like plants to a maximum of 40 percent (or a minimum 4-inch stubble height) (USDA 2004, p. 56). This study did not detect an effect from grazing activity on young-of-year toad density or breeding pool occupancy, water quality, or cover (when grazing under SNFPA Riparian Standards and Guidelines) (Allen Diaz *et al.* 2010, p. 1).

However, the design of these studies did not include direct measurements of toad survival (for example, mark-recapture analysis of population trends), and the design was limited in numbers of years and treatment replicates. It is plausible that for longer-lived species with irregular female breeding activity over the time course of this particular study, statistical power was not sufficient to discern a treatment effect. Further, there may be a time lag between effect and discernible impacts, and significant confounding variability in known drivers such as interannual variation in climate.

Additionally, the experimental design in the Allen Diaz study tested the hypothesis that forest management guidelines (at 40 percent use threshold) were impacting toad populations, and this limited some analyses and experimental design to sites with lower treatment intensities. Researchers reported annual utilization by cattle ranging from 10–48 percent, while individual meadow use ranged from 0–76 percent (the SNFPA allowable use is capped at 40 percent) (Allen Diaz *et al.* 2010, p. 5). As a result of the study design, the Allen Diaz study does not provide sufficient information on the impacts of grazing on Yosemite toads above the prescribed management guidelines. It is also not clear to what extent brief episodes of intense use (such as in cattle gathering areas) have as negative impacts on toads, or over what percentage of the grazed meadow landscape such heavier usage may occur.

The researchers observed significant variation in young-of-year occupancy in pools between meadows and years, and within meadows over years (Allen Diaz *et al.* 2010, p. 7). This variability would likely mask treatment effects, unless the grazing variable was a dominant factor driving site occupancy, and the magnitude of the effect was quite severe. Further, Lind *et al.* (2011, pp. 12–14) report statistically significant negative (inverse) relationships for tadpole density and grazing intensity (tadpole densities decreased when percent use exceeded between 30 and 40 percent). This result supports the hypothesis that grazing at intensities approaching and above the 40 percent threshold can negatively affect Yosemite toad populations.

Allen Diaz *et al.* (2010, p. 2) found that toad occupancy is strongly driven by meadow wetness (hydrology) and suggested attention should focus on contemporary factors directly impacting meadow wetness, such as climate, fire regime changes, and conifer encroachment (see Factor A above). Lind *et al.* (2011, pp. 12–14) noted a positive relationship between meadow dryness and livestock use (cattle prefer drier meadows), and also found that the proportion of Yosemite toad-occupied pools and tadpole and young-of-year densities declined in drier sites (toads prefer wetter meadows). The researchers suggest that this provides for some segregation of toad and livestock use in meadow habitats, so that at least direct mortality threats may be mitigated by behavioral isolation.

The available grazing studies focus on breeding habitat (wet meadows) and do not consider impacts to upland habitats. The USFS grazing guidelines for protection of meadow habitats of the Yosemite toad include fencing breeding meadows, but they do not necessarily protect upland habitat. Grazing removes vegetative cover, and surveys have shown reductions in the number of Yosemite toads in an area after the herbaceous cover was grazed (Martin 2008, p. 298). Grazing can also degrade or destroy moist upland areas used as nonbreeding habitat by Yosemite toads (Martin 2008, pp. 159), especially when nearby meadow and riparian areas have been fenced to exclude livestock. Livestock may also collapse rodent burrows used by Yosemite toads as cover and hibernation sites (Martin 2008, p. 159) or disturb toads and disrupt their behavior. Martin (2008, pp. 305–306) observed that grazing significantly reduced vegetation height, and since these areas are not protected by current grazing guidelines, deduced that cattle grazing is having a negative effect on terrestrial life stage survivorship in Yosemite toads. This problem was exacerbated as fenced areas effectively shifted grazing activity to upland areas actively used by terrestrial life stages of the Yosemite toad (Martin 2008, p. 306). Based on the limitations of the study as described above, we find the initial results from Allen Diaz *et al.* (2010, pp. 1–45) to be inconclusive to discern the impacts of grazing on Yosemite toad populations rangewide.

Although we lack definitive data to assess the link between Yosemite toad population dynamics and habitat degradation by livestock grazing activity (see Factor E below), in light of the documented impacts to meadow habitats (including effects on local hydrology) from grazing activity in general, we consider this threat prevalent with moderate impacts to the Yosemite toad and a potential limiting factor in population recovery rangewide. In addition, given the potential for negative impacts from heavy use, and the vulnerability of toad habitat should grazing management practices change with new management plans, we expect this threat to continue into the future.

Roads and Timber Harvest Effects to Meadow Habitat

Road construction and use, along with timber harvest activity, may impact Yosemite toad habitat via fragmentation, ground disturbance, and soil compaction or erosion (Helms and Tappeiner 1996, pp. 439–476). These activities, similar to overgrazing, may lead to increased rates of siltation and succession of wet meadows, contributing to the loss of breeding habitats for the Yosemite toad.

Prior to the formation of National Parks and National Forests, timber harvest was widespread and unregulated in the Sierra Nevada; however, most cutting occurred below the current elevation range of the Yosemite toad (University of California at Davis (UCD) UC 1996b, pp. 17–45). Between 1900 and 1950, most timber harvest occurred in old growth forests on private land (UC 1996b, pp. 17–45). The majority of roads in National Forests of the Sierra Nevada were built between 1950 and 1990, to support major increases in timber harvest on National Forests and also at higher elevations (USDA 2001a, p. 445).

It is plausible to hypothesize that the majority of timber harvest, road development, and associated management impacts (see ''Fire Management Regime Effects to Meadow Habitats'' below) to Yosemite toads would have taken place during this expansion period in the latter half of the 20th century. However, the magnitude (and perhaps even whether it is positive or negative) of this effect would likely be a function of site-specific parameters, and the level of intensity of each particular land use. In contrast to overharvest, it is also possible that moderate harvest activity adjacent to meadow habitats could benefit meadows and upland habitat by discouraging encroachment and opening the forest canopy (Liang *et al.* 2010, p. 16). Despite this possibility, there is no evidence that the current level of timber harvest occurring within watersheds currently inhabited by the Yosemite toad is adversely affecting habitat. Therefore the best available scientific and commercial information does not indicate whether ongoing road construction and maintenance or timber harvest are significant threats to the Yosemite toad.

Fire Management Regime Effects to Meadow Habitats

Fire management refers to activities over the past century to combat forest fires. Historically, it is known that American Indians regularly burned the mountains (Parsons and Botti 1996, p. 29), and in the latter 19th century, the active use of fire to eliminate tree canopy in favor of forage plants continued by sheepherders (Kilgore and Taylor 1979, p. 139). Beginning in the 20th century, land management in the Sierra Nevada shifted to focus on fire suppression as a guiding policy (UC 2007, p. 10).

Long-term fire suppression has influenced forest structure and altered ecosystem dynamics in the Sierra Nevada. In general, the time between fires is now much longer than it was historically, and live and dead fuels are more abundant and continuous (USDA 2001a, p. 35). It is not clear how this has precisely affected Yosemite toad populations; however Liang *et al.* (2010, p. 16) observed that toads were less likely to occur in areas where the fire regime was significantly altered from historical conditions, and suggested that the toads are affected by some unknown or unmeasured factors related to fire management.

Evidence indicates that fire plays a significant role in the evolution and maintenance of meadows of the Sierra Nevada. Under natural conditions, conifers are excluded from meadows by fire and saturated soils. Small fires thin and/or destroy encroaching conifers, while large fires are believed to determine the meadow-forest boundary (Vankat and Major 1978, p. 394; Parsons and DeBenedetti 1979, pp. 29–31). Fire is thought to be important in maintaining open aquatic and riparian habitats for amphibians in some systems (Russel *et al.* 1999, pp. 374–384), and fire suppression may have thereby contributed to conifer encroachment on meadows (Chang 1996, pp. 1071–1099; NPS 2002, p. 1).

While no definitive studies have confirmed a link between fire management and rangewide population decline of the Yosemite toad, circumstantial evidence to date suggests that historic fire suppression has been a factor underlying meadow encroachment that has reduced the suitability of these areas to sustain the life history of the Yosemite toad. Given this link and based on the best available information, we find it likely that habitat modification due to reduced fire frequency is an extant threat to Yosemite toad habitat, acting with moderate prevalence.

Recreation Effects to Meadow Habitat

Recreational activities take place throughout the Sierra Nevada, and they can have significant negative impacts on wildlife and their habitats (USDA 2001a, pp. 221, 453–500). Recreation can cause considerable impact to western U.S. Wilderness Areas and National Parks even with light use, with recovery only occurring after considerable periods of non-use (USFS *et al.* 2009, p. 66). Heavy foot traffic in riparian areas tramples vegetation, compacts soils, and can physically damage streambanks. Trails (foot, horse, bicycle, or off-highway motor vehicle) compact the soil, displace vegetation, and increase erosion, thereby potentially lowering the water table (Kondolph *et al.* 1996, pp. 1009–1026).

Packstock use has similar effects to those discussed for livestock grazing, although this risk factor is potentially more problematic as this land use typically takes place in more remote and higher elevation areas occupied by Yosemite toads, and packstock tend to graze in many of the same locations that the toads prefer (USFS *et al.* 2009, p. 65). Currently, there are very few studies on the effects of packstock grazing on amphibians, especially in the Sierra Nevada. It is not clear how well studies on livestock grazing can be extrapolated to packstock, and even then, shorter-term experiments may not show effects if landscapes have already been pushed beyond a threshold of effect (Brooks 2012, pers. comm.). However, current guidelines in the National Parks limit trips to 20–25 animals, regulated under conditional use permits (Brooks 2012, pers. comm.). In general, National Parks and commercial users are reducing their usage, so packstock impacts, if they occur, are declining within the National Parks (Berlow 2012, pers. comm.).

The effects of recreational activities on the Yosemite toad are not quantified, but they may have impacts in certain areas and under certain conditions. For example, where foot traffic or vehicle activity adjacent to occupied meadows is more prevalent, erosion and channel incision could result. The cumulative impact to the species from localized threats associated with recreational impacts is not possible to quantify, but we do know that recreation is the fastest growing use of National Forests (USDA 2001a, pp. 453–500). The relative sensitivity of high-elevation sites to recreational use makes them vulnerable to disturbance, and the significance of this impact is expected to increase into the future as recreational use continues to increase. Nevertheless, collectively at this time, we consider recreational activities to be a low prevalence threat across the range of the Yosemite toad.

Dams and Water Diversions Effects to Meadow Habitat

Diversion and irrigation ditches form a vast network that altered local and regional stream hydrology in the Sierra Nevada (SNEP 1996, p. 120). Several artificial lakes are located in or above Yosemite toad habitat, most notably Edison, Florence, Huntington, Courtright, and Wishon Reservoirs. By altering the timing and magnitude of water flows, these reservoirs have caused changes in hydrology that may have altered Yosemite toad habitat. Changes in water flows have increased water levels upstream of the reservoirs, which may have reduced the suitability of shallow water habitats necessary for egg laying and allowed fish competitors into those habitats. Moreover, water level declines caused by drawdown of reservoirs can lead to the mortality of eggs and tadpoles by stranding and desiccation.

The artificial lakes (reservoirs) mentioned above were probably created within, and inundated, Yosemite toad habitat, and most native Sierra Nevada amphibians cannot live in or move through reservoirs (Jennings 1996, pp. 921–944). Therefore, reservoirs represent both a loss of habitat and a barrier to dispersal and gene flow. These factors have likely contributed to the decline of the Yosemite toad and continue to pose a risk to the species. Impacts due to increasing effects from climate change, or new water supply development in response to such effects, may exacerbate this risk in the future. The contribution of reservoir construction and operation to population losses was likely of high historical significance in these developed areas, but less so in the current extent of the Yosemite toad's (remnant) range. Therefore, currently, we consider this threat to be of low prevalence to the Yosemite toad across its range.

Climate Effects to Meadow Habitat

Different studies indicate that multiple drivers are behind the phenomenon of conifer encroachment on meadows. The first factor affecting the rate of conifer encroachment on meadow habitats, fire suppression, was discussed above. Climate variability is another factor affecting the rate of conifer encroachment on meadow habitats. A study by Franklin *et al.* (1971, p. 215) concluded that fire had little influence on meadow maintenance of their study area, while another study concluded that climate change is a more likely explanation for encroachment of trees into the adjacent meadow at their site, rather than fire suppression or changes in grazing intensity (Dyer and Moffett, 1999, pp. 444).

Climatic variability is strongly correlated with encroachment of dry subalpine meadows (Jakubos and Romme 1993, p. 382). In the Sierra Nevada, most lodgepole pine seedlings become established during years of low snowpack when soil meadow moisture is reduced (Wood 1975, p. 129). The length of the snow-free period may be the most critical variable in tree invasion of subalpine meadows (Franklin *et al.* 1971, pp. 222), with the establishment of a good seed crop, followed by an early snowmelt, resulting in significant tree establishment. It is apparent that periods of low snowpack and early melt may in fact be necessary for seedling establishment (Ratliff, 1985, p. 35). Millar *et al.* (2004, p. 181) reported that increased temperature, coupled with reduced moisture availability in relation to large-scale temporal shifts in climate, facilitated the invasion of 10 subapline meadows studied in the Sierra Nevada.

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms ''climate'' and ''climate change'' are defined by the Intergovernmental Panel on Climate Change (IPCC). ''Climate'' refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term ''climate change'' thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (for example, habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

For the Sierra Nevada ecoregion, climate models predict that mean annual temperatures will increase by 1.8 to 2.4 °C (3.2 to 4.3 °F) by 2070, including warmer winters with earlier spring snowmelt and higher summer temperatures (PRBO 2011, p. 18). Additionally, mean annual rainfall is projected to decrease from the current average by some 9.2–33.9 cm (3.6–13.3 in) by 2070 (PRBO 2011, p. 18). However, projections have high uncertainty and one study predicts the opposite effect (PRBO 2011, p. 18). Snowpack is, by all projections, going to decrease dramatically (following the temperature rise and increase in precipitation falling as rain) (PRBO 2011, p. 19). Higher winter streamflows, earlier runoff, and reduced spring and summer streamflows are projected, with increasing severity in the southern Sierra Nevada (PRBO 2011, pp. 20–22).

Snow-dominated elevations from 2,000–2,800 m (6,560–9,190 ft) will be the most sensitive to temperature increases (PRBO 2011, p. 23). Meadows fed by snowmelt may dry out or be more ephemeral during the non-winter months (PRBO 2011, p. 24). This pattern could influence ground water transport, and springs may be similarly depleted, leading to lower water levels in available breeding habitat and decreased area of suitable habitat for rearing tadpoles of Yosemite toads.

Historically, drought has contributed to the decline of the Yosemite toad (Kagarise Sherman and Morton 1993, p. 186; Jennings and Hayes 1994, pp. 50–53). Climate change itself may also have contributed to that decline if greenhouse gas emissions have contributed to the intensity of droughts and severity of occasional extreme cold winters during the last several decades. Extended and more severe droughts pose an ongoing, rangewide risk to the species. Less water, specifically less water as snow, means less and lower quality habitat for Yosemite toads. However, it is difficult to discern the effects of climate change on Yosemite toad populations without focused, long-term study.

Davidson *et al.* (2002, p. 1598) analyzed geographic decline patterns in Yosemite toad. They compared known areas of extirpation against a hypothesized model for climate change that would predict greater numbers of extirpations at lower altitudes, and in more southern latitudes. The researchers did not observe a pattern in the available historic data to support the climate change hypothesis as a driver of historic population losses, although they acknowledge that climate change may be a contributor in more complex or subtle ways. Additionally, this study was limited by small sample size, and it is possible that climate change effects on the Yosemite toad (a long-lived species) may not become evident for many years (USFS *et al.* 2009, p. 48). Finally, Davidson *et al.* (2002, p. 1598) did find an increase in occupancy with elevation (greater densities of populations at altitude), and it is suggested that this observation is consistent with a pattern that would fit a response to climate change (USFS *et al.* 2009, p. 48). However, this observation would also be consistent if the features of these particular habitats (such as at higher elevation) were more suited to the special ecological requirements of the toad, or if other stressors acting on populations at lower elevations were responsible for the declines. We therefore find these results inconclusive.

The breeding ecology and life history of the Yosemite toad are that of a habitat specialist, as it utilizes pool and meadow habitats during the onset of snowmelt and carefully times its reproduction to fit available conditions within ephemeral breeding sites. The most striking documented declines in Yosemite toad populations in the historical record are correlated with extreme climate episodes (drought) (Kagarise Sherman and Morton 1993, pp. 186–198). Given these observations, it is likely that climate change (see also discussion in mountain yellow-legged frog's Summary of Factors Affecting the Species, under Factor E) poses a significant risk to the Yosemite toad now and in the future. It is quite possible that these impacts are occurring currently, and have occurred over the last few decades. However, it is difficult in short time intervals to discern the degree of effect from climate change within the variability of natural climate cycles.

In summary, based on the best available scientific and commercial information, we consider the threats of destruction, modification, and curtailment of the species' habitat and range to be significant ongoing threats to the Yosemite toad. The legacy effects of past land uses have altered meadow communities through the mechanism of stream incision by permanently reducing habitat quantity and quality unless active and costly restoration is implemented. Climate change is a current threat of high magnitude. Threats considered of moderate magnitude include livestock grazing and fire management regime. Threats considered currently low magnitude include roads and timber harvest, dams and water diversions, and recreational land uses.

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

We do not have any scientific or commercial information to indicate that overutilization for commercial, recreational, or scientific purposes poses a threat to the Yosemite toad. There is no known commercial market for Yosemite toads, and there is also no documented recreational or educational use for Yosemite toads.

Scientific research may cause some stress to Yosemite toads through disturbance and disruption of behavior, handling, and injuries associated with marking individuals. This activity has resulted in the known death of a few individuals through accidental trampling (Green and Kagarise Sherman 2001, pp. 92–103), irradiation from radioactive tags (Karlstrom 1957, pp. 187–195), and collection for museum specimens (Jennings and Hayes 1994, pp. 50–53). However, there is currently relatively little research effort on this species, and scientists as a general rule take actions to mitigate harm to their study species. Therefore, scientific research is not a threat to the Yosemite toad. It is anticipated that further research into the genetics and life history of the Yosemite toad and broader methodological censuses will provide a net conservation benefit to this under-studied species.

Based on the best available scientific and commercial information, we do not consider the overutilization for commercial, recreational, scientific, or educational purposes to be a threat to the Yosemite toad.

Factor C. Disease or Predation

Predation

Prior to the trout stocking of high Sierra Nevada lakes, which began over a century ago, fish were entirely absent from most of this region (Bradford 1989, pp. 775–778). Observations regarding the effects of introduced fishes on the Yosemite toad are mixed. However, re-surveys of historical Yosemite toad sites have shown that the species has disappeared from several lakes where they formerly bred, and these areas are now occupied by fish (Stebbins and Cohen 1995, pp. 213–215; Martin 2002, p. 1).

Drost and Fellers (1994, pp. 414–425) suggested that Yosemite toads are less vulnerable to fish predation than frogs because they breed primarily in ephemeral waters that do not support fish. Further, Jennings and Hayes (1994, pp. 50–53) stated that the palatability of Yosemite toad tadpoles to fish predators is unknown, but often assumed to be low based on the unpalatability of western toads (Drost and Fellers 1994, pp. 414–425; Kiesecker *et al.* 1996, pp. 1237–1245), to which Yosemite toads are closely related. Grasso (2005, p. 1) observed brook trout swimming near, but the trout ignored Yosemite toad tadpoles, suggesting that tadpoles are unpalatable. The study also found that subadult Yosemite toads were not consumed by brook trout (Grasso 2005, p. 1), although the sublethal effects of trout ''sampling'' (mouthing and ejecting tadpoles) and the palatability of subadults to other trout species are unknown. Martin (2002, p. 1) observed brook trout preying on Yosemite toad tadpoles, and also saw them ''pick at'' Yosemite toad eggs (which later became infected with fungus). In addition, metamorph western toads have been observed in golden trout stomach contents (Knapp 2002c, p. 1). Nevertheless, Grasso *et al.* (2010, p. 457) concluded that early life stages of the Yosemite toad likely possess chemical defenses that provide sufficient protection from native trout predation.

The observed predation of Yosemite toad tadpoles by trout (Martin 1992, p.1) indicates that introduced fishes may pose a predation risk to the species in some situations, which may be accentuated during drought years. At a site where Yosemite toads normally breed in small meadow ponds, they have been observed to successfully switch breeding activities to stream habitat containing fish during years of low water (Strand 2002, p. 1). Thus, drought conditions may increase the toads' exposure to predatory fish, and place them in habitats where they compete with fish for invertebrate prey. Additionally, although the number of lake breeding sites used by Yosemite toads is small relative to the number of ephemeral sites, lake sites may be especially important because they are more likely to be habitable during years with low water (Knapp 2002c, p. 1).

Overall, the data and available literature suggest that direct mortality from fish predation is likely not an important factor driving Yosemite toad population dynamics. This does not discount other indirect impacts, such as the possibility that fish may be effective disease vectors (see below). Yosemite toad use of more ephemeral breeding habitats (which are less habitable to fish species as they cannot tolerate drying or freezing) minimizes the interaction of fish and toad tadpoles. Further, where fish and toads co-occur, it is possible that food depletion (outcompetition) by fish negatively affects Yosemite toads (USFS *et al.* 2009, p. 58).

Other predators may also have an effect on Yosemite toad populations. Kagarise Sherman and Morton (1993, p. 194) reported evidence of toad predation by common ravens (*Corvus corax*) and concluded this was the responsible factor in the elimination of toads from one site. These researchers also confirmed, as reported in other studies, predation on Yosemite toad by Clark's nutcrackers (*Nucifraga columbiana*). The significance of avian predation may increase if the abundance of common ravens within the current range of the Yosemite toad increases as it has in nearby regions (Camp *et al.* 1993, p. 138; Boarman *et al.* 1995, p. 1; Kelly *et al.* 2002, p. 202). However, the degree to which avian predation may be affecting Yosemite toad populations has not been quantified.

Disease

Although not all vectors have been confirmed in the Sierra Nevada, introduced fishes, humans, pets, livestock, packstock, vehicles, and wild animals may all act to facilitate disease transmission between amphibian populations. Infection of both fish and amphibians by a common disease has been documented with viral (Mao *et al.* 1999, pp. 45–52) and fungal pathogens in the western United States (Blaustein *et al.* 1994b, pp. 251–254). Mass die-offs of amphibians in the western United States and around the world have been attributed to Bd fungal infections of metamorphs and adults (Carey *et al.* 1999, pp. 1–14), *Saprolegnia* fungal infections of eggs (Blaustein *et al.* 1994b, pp. 251–254), ranavirus infections, and bacterial infections (Carey *et al.* 1999, pp. 1–14).

Various diseases are confirmed to be lethal to Yosemite toads (Green and Kagarise Sherman 2001, pp. 92–103), and recent research has elucidated the potential role of Bd infection as a threat to Yosemite toad populations (Dodge and Vredenburg 2012, p.1). These various diseases and infections, in concert with other factors, have likely contributed to the decline of the Yosemite toad (Kagarise Sherman and Morton 1993, pp. 193–194), and may continue to pose a risk to the species (Dodge and Vredenburg 2012, p. 1).

Die-offs in Yosemite toad populations have been documented in the literature, and an interaction with diseases in these events has been confirmed. However, no single cause has been validated by field studies. Tissue samples from dead or dying adult Yosemite toads and healthy tadpoles were collected during a die-off at Tioga Pass Meadow and Saddlebag Lake and analyzed for disease (Green and Kagarise Sherman 2001, pp. 92–103). Six infections were found in the adults, including infection with Bd, bacillary bacterial septicemia (red-leg disease), *Dermosporidium* (a fungus), myxozoa spp. (parasitic cnidarians), *Rhabdias* spp. (parasitic roundworms), and several species of trematode (parasitic flatworms). Despite positive detections, no single infectious disease was found in more than 25 percent of individuals, and some dead toads showed no signs of infection to explain their death. Further, no evidence of infection was found in tadpoles. A meta-analysis of red-leg disease also revealed that the disease is a secondary infection that may be associated with a suite of different pathogens, and so actual causes of decline in these instances were ambiguous (Kagarise Sherman and Morton 1993, p. 194). The authors concluded that the die-off was caused by suppression of the immune system caused by an undiagnosed viral infection or chemical contamination that made the toads susceptible to the variety of diagnosed infections.

Saprolegnia ferax, a species of water mold that commonly infects fish in hatcheries, caused a massive lethal infection of eggs of western toads at a site in Oregon (Blaustein *et al.* 1994b, pp. 252). It is unclear whether this event was caused by the introduction of the fungal pathogen via fish stocking, or if the fungus was already present and the eggs' ability to resist infection was inhibited by some unknown environmental factor (Blaustein *et al.* 1994b, pp. 253). Subsequent laboratory experiments have shown that the fungus could be passed from hatchery fish to western toads (Kiesecker *et al.* 2001, pp. 1064–1070). Fungal growth on Yosemite toad eggs has been observed in the field, but the fungus was not identified and it was unclear whether the fungus was the source of the egg mortality (Kagarise Sherman 1980, p. 46). Field studies conducted in Yosemite National Park found that an undetermined species of water mold infected only the egg masses that contained dead embryos of Yosemite toads (Sadinski 2004, pp. 33–34). The researchers also observed that the water mold became established on egg masses only after embryo death, and subsequently spread, causing the mortality of additional embryos of Yosemite toads.

Sadinski (2004, p. 35) discovered that mortality of Yosemite toad embryos may be attributed to an unidentified species of a free-living flatworm (*Turbellaria* spp.). In Yosemite National Park, these worms were observed to penetrate Yosemite toad egg masses and feed directly on the embryos. In some locations, *Turbellaria* spp. reached such large densities that they consumed all the embryos within a Yosemite toad egg mass. Predation also facilitated the colonization and spread of water mold on egg masses, leading to further embryo mortality. Further studies would be needed to determine which species of *Turbellaria* feeds on Yosemite toad eggs, and the extent of this impact on Yosemite toad populations.

Until recently, the contribution of Bd infection to Yosemite toad population declines was relatively unknown. Although the toad is hypothetically susceptible due to co-occurrence with the mountain yellow-legged frog, it is suspected that the spread and growth of Bd in the warmer pool habitats, occupied for a much shorter time relative to the frog, renders individuals less prone to epidemic outbreaks (USFS *et al.* 2009, p. 50). Fellers *et al.* (2011, p. 391) documented the occurrence of Bd infection in Yosemite National Park toads over at least a couple of decades, and they note population persistence in spite of the continued presence of the pathogen. In a survey of 196 museum specimens, Dodge and Vredenburg (2012, p. 1) report the first presence of Bd infection in Yosemite toads beginning in 1961, with the pathogen becoming highly prevalent during the recorded declines of the late 1970s, before it peaked in the 1990s at 85 percent positive incidence. In live specimen sampling, Dodge and Vredenburg (2012, p. 1) collected 1,266 swabs of Yosemite toads between 2006 and 2011, and found Bd infection intensities at 17–26 percent (with juvenile toads most affected). The results from these studies support the hypothesis that Bd infection and chytridiomycosis have played an important role in Yosemite toad population dynamics over the period of their recent recorded decline.

Carey (1993, pp. 355–361) developed a model to explain the disappearance of boreal toads (*Bufo boreas boreas*) in the Rocky Mountains, suggesting immune system suppression from extreme winter stress (''winter stress syndrome'') could have contributed to the decline in that species. This model may also fit Yosemite toad die-offs observed by Kagarise Sherman and Morton (1993, pp. 186–198), given the close relationship between the two toads, and their occupation of similar habitats. However, an analysis of immune system suppression and the potential role of winter stress relative to Yosemite toad population trends is not available at this time. Yet, the decline pattern observed in the Carey study is mirrored by the pattern in the Yosemite toad (heavy mortality exhibited in males first) (Knapp 2012, pers. comm.). This observation, in concert with the recent results from museum swabs (Dodge and Vredenburg 2012, p. 1), provides a correlative link to the timing of the recorded Yosemite toad declines and Bd infection intensities.

Although disease as a threat factor to the Yosemite toad is relatively less documented, there is evidence for Bd infection related to historical die-offs in Yosemite toads. Much of the historic research documenting Yosemite toad declines predated our awareness of Bd as a major amphibian pathogen. Additionally, the life history of the Yosemite toad, as a rapid breeder during early snowmelt, limits the opportunities to observe population crashes in the context of varied environmental stressors. Currently available evidence indicates that Bd was likely a significant factor contributing to the recent historical declines observed in Yosemite toad populations (Dodge and Vredenburg 2012, p. 1). Although infection intensities are currently lower than some peak historic measurements, this threat remains a potential factor to date that may continue to reduce survival through metamorphosis, and therefore recruitment to the breeding population (Knapp 2012, pers. comm.). Additionally, the interaction of disease and other stressors, such as climate extremes, is not well understood in the Yosemite toad. Research does suggest that the combination of these threats represents a factor in the historical decline of the species (Kagarise Sherman and Morton 1993, p. 186).

In summary, based on the best available scientific and commercial information, we consider disease to be a threat to the Yosemite toad that has a moderate, ongoing effect on populations of the species rangewide. The threat most specifically includes the amphibian pathogen, Bd. Based on the best available scientific and commercial information, we are uncertain about the impacts of avian predation on Yosemite toads at this time, and therefore do not consider it to be a listing factor. Although definitive empirical data quantifying the contribution of disease to Yosemite toad population declines are not currently available, the concurrence of population declines with the prevalence and spread of Bd across the Sierra Nevada support the assertion that disease has played a role in the observed trend. Further, Bd infection, even at lower intensities, may interact with climate extremes and continue to depress recruitment of yearling and subadult Yosemite toads to breeding Yosemite toad populations. We suspect this threat was historically significant, that it is currently having a moderate influence on toad populations, and we expect it to be a future concern.

Factor D. The Inadequacy of Existing Regulatory Mechanisms

In determining whether the inadequacy of regulatory mechanisms constitutes a threat to the Yosemite toad, we analyzed the existing Federal and State laws and regulations that may address the threats to the species or contain relevant protective measures. Regulatory mechanisms are typically nondiscretionary and enforceable, and may preclude the need for listing if such mechanisms are judged to adequately address the threat(s) to the species such that listing is not warranted. Conversely, threats on the landscape are not addressed by existing regulatory mechanisms where the existing mechanisms are not adequate (or not adequately implemented or enforced).

We discussed the applicable State and Federal laws and regulations, including the Wilderness Act, NFMA above (see Factor D discussion for mountain yellow-legged frog complex). In general, the same administrative policies and statutes are in effect for the Yosemite toad. This section additionally addresses regulatory mechanisms with a specific emphasis on the Yosemite toad.

Taylor Grazing Act of 1934

In response to overgrazing of available rangelands by livestock from the 1800s to the 1930s, Congress passed the Taylor Grazing Act in 1934 (43 U.S.C. 315 *et seq.*). This action was an effort to stop the damage to the remaining public lands as a result of overgrazing and soil depletion, to provide coordination for grazing on public lands, and to attempt to stabilize the livestock industry (Meehan and Platts 1978, p. 275; *Public Lands Council et al.* v. *Babbitt Secretary of the Interior et al.* (167 F. 3d 1287)). Although passage of the Taylor Grazing Act resulted in reduced grazing in some areas, it did not reduce grazing severity, and localized use remained high, precluding regeneration of many meadow areas (Beesley 1996, p. 14; Menke *et al.* 1996, p. 14; *Public Lands Council et al.* v. *Babbitt Secretary of the Interior et al.* (167 F. 3d 1287)).

Existing Federal and State laws and regulatory mechanisms currently offer some level of protection for the Yosemite toad. Specifically, these include the Wilderness Act, the NFMA, the SNFPA, and the FPA (see Factor D discussion for mountain yellow-legged frog complex). Based on the best available scientific and commercial information, we do not consider the inadequacy of existing regulatory mechanisms to be a threat to the Yosemite toad.

Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

The Yosemite toad is sensitive to environmental change or degradation due to its life history, biology, and existence in ephemeral habitats characterized by climate extremes and low productivity. It is also sensitive to anthropogenically influenced factors. For example, contaminants, acid precipitation, ambient ultraviolet radiation, and climate change have been implicated as contributing to amphibian declines (Corn 1994, pp. 62–63; Alford and Richards 1999, pp. 2–7). These factors are discussed in the context of the mountain yellow-legged frog above (see Factor E discussion for mountain yellow-legged frog complex), and are largely applicable to the Yosemite toad. The following discussion will focus on potential threat factors specifically studied in the Yosemite toad, or areas where the prevalence of the threat may differ based on the unique life history, population status, demographics, or biological factors specific to Yosemite toad populations.

Contaminants

The Yosemite toad is likely exposed to a variety of pesticides and other chemicals throughout its range. This includes those imported via aerial drift and precipitation (see ''Contaminants'' discussion for mountain yellow-legged frog complex). But, given their life history that includes significant time in upland habitats, there are also locally applied pesticides that may have more of an impact on the terrestrial life stages of Yosemite toads. In order of their application rate, the most commonly used locally applied pesticides for forest resource management are: glyphosate, triclopyr, clopyralid, hexazinone, aminopyralid, chlorsulfuron, imazapyr, and aluminum phosphide (applied to rodent burrows) (USFS *et al.* 2009, p. 63).

Large amounts of ammonia-based fire retardants and surfactant-based fire-suppressant foams, including ammonium phosphate, ammonium sulfate, and sodium ferrocyanide, are applied to areas managed by the USFS (National Forests and Wilderness Areas) that may be inhabited by Yosemite toads when wildfires occur within their range (USFS *et al.* 2009, p. 54). Fire retardant chemicals contain nitrogen compounds and surfactants. Applied surfactants and dyes include: R–11, Hasten, Syltac, highlight blue, bas-oil red, and colorfast purple (USFS *et al.* 2009, p. 63). Laboratory tests of these chemicals have shown that they cause mortality in fish and aquatic invertebrates (Hamilton *et al.* 1996, pp. 132–144); similar effects are possible in amphibians. Calfee and Little (2003, pp. 1529–1530) report that southern leopard frogs (*Rana sphenocephala*) and boreal toads (*Bufo boreas*) are more tolerant than rainbow trout (*Oncorhynchus mykiss*) to fire retardant chemicals. However, the acute toxicity of some compounds is enhanced by ultraviolet light, which may harm amphibians at environmentally relevant concentrations. Therefore, if fire retardant chemicals are dropped in or near Yosemite toad habitat, they may have negative effects on individual toads. Yosemite toad populations span wilderness areas and sparsely vegetated, high-elevation habitats. As fire is infrequent in these areas, fire retardant chemicals are likely not a threat through much of the species' range (USFS *et al.* 2009, p. 55).

The risk to Yosemite toad from locally applied pesticides, surfactants, and dyes is not known. However, most of the use of these chemicals also largely occurs below the current elevational range of the toad, so this risk factor is likewise limited in scale.

The effect of contamination from other environmental pollutants is not well-studied. Preliminary research indicates that Yosemite toad tadpoles in grazed areas take longer to metamorphose and produce smaller metamorphs than those in areas being rested from grazing, potentially due to high bacterial and nutrient levels in the grazed areas (Martin 2002, pp. 1–3; Martin 2008, p. 157). Finally, water quality may be affected by the introduction of chemicals and wastes from camp use (USFS *et al.* 2009, p. 68), which would logically have greater influence on the more aquatic life stages. However, given the early season breeding for this species, the coincidence of recreational use wastes and tadpoles is likely relatively minor.

Acid precipitation has been hypothesized as a cause of amphibian declines (including toads) in the Sierra Nevada because waters there are extremely low in acid-neutralizing capacity, and therefore susceptible to changes in water chemistry due to acidic deposition (Bradford *et al.* 1994b, pp. 155–161). In addition to raising the acidity of water bodies, acid deposition may also cause increases in dissolved aluminum (from soils), which may be toxic to amphibians (Bradford *et al.* 1992, 271–275). In laboratory experiments (Bradford *et al.* 1992, pp. 369–377; Bradford and Gordon 1992, pp. 75–76), high acidity and high aluminum concentrations did not have significant effects on survival of Yosemite toad embryos or newly hatched tadpoles. However, at pH 5.0 and at high aluminum concentrations, Yosemite toad embryos hatched earlier and the tadpoles showed a reduction in body size.

In a complementary field study of 235 amphibian breeding sites, Bradford *et al.* (1994, pp. 155–161) concluded that acid precipitation is an unlikely cause of decline in Yosemite toad populations. However, researchers suggest this risk factor should still be considered in conservation efforts because of the possibility of sublethal effects, of its interaction with other factors, and of the potential for more severe acid deposition in the future (Bradford *et al.* 1992, p. 375; USFS *et al.* 2009, p. 44). Overall, we consider acid deposition a low risk to the species at this time, and likely not a significant threat into the future (see discussion under Factor E for mountain yellow-legged frogs above).

In summary, a number of studies have investigated the potential threats of a number of contaminants, such as pesticides, fire retardants, and acid precipitation. Based on the best available commercial and scientific information, we do not believe that contaminants pose a significant threat to populations of the Yosemite toad.

Ultraviolet Radiation

Ambient UV–B radiation has increased at north temperate latitudes in the past 2 decades (Adams *et al.* 2001, pp. 519–525). Ambient levels of UV–B were demonstrated to cause significant decreases in survival of western toad eggs in field experiments (Blaustein 1994, pp. 32–39). In a laboratory experiment (Kats *et al.* 2000, pp. 921–931), western toad metamorphs exposed to levels of UV–B below those found in ambient sunlight showed a lower alarm response to chemical cues of injured toads than metamorphs that were completely shielded from UV–B. This indicates that ambient levels of UV–B may cause sublethal effects on toad behavior that could increase their vulnerability to predation. In a field experiment (Kiesecker and Blaustein 1995, pp. 11049–11052), the combined effects of exposure to ambient levels of UV–B radiation and exposure to a pathogenic fungus (*Saprolegnia*) were shown to cause significantly higher mortality of western toad embryos than either factor alone.

Sadinski *et al.* (1997, pp. 1–8) observed a high percentage of embryo mortality in Yosemite toads at six breeding sites in Yosemite National Park, but in a subsequent field experiment this mortality did not appear to be related to UV–B (Sadinski 2004, p. 37). In spatial analyses of extant and extinct populations, higher elevation was positively correlated with extant Yosemite toad populations. This is counter to what would be expected if UV–B were the primary cause of decline (Davidson 2002, p. 15), as sites at higher elevations would be expected to receive more solar radiation due to the thinner atmosphere. UV–B at high elevations in the Sierra Nevada has increased less than 5 percent in the past several decades (Jennings 1996, pp. 921–944). These data further indicate that UV–B has likely not contributed significantly to the decline of Yosemite toads. Based on the best available commercial and scientific information, this threat factor is currently considered a low risk to the species.

Climate Change Effects on Individuals

As discussed above in Factor A, climate change can result in detrimental impacts to Yosemite toad habitat. Climate variability could also negatively impact populations through alteration of the frequency, duration, and magnitude of either droughts or severe winters (USFS *et al.* 2009, p. 47). Yosemite toads breed and their tadpoles develop in shallow meadow and ephemeral habitats, where mortality from desiccation and freezing can be very high, often causing complete loss of an annual cohort (USFS *et al.* 2009, p. 10). Kagarise Sherman and Morton (1993, pp. 192–193) documented in a long-term population study that Yosemite toad hatching success and survival were subject to a balance between the snowpack water contribution to breeding pools and the periodicity and character of breeding season storms and post-breeding climate (whether it is cold or warm). When it is too cold, eggs and tadpoles are lost to freezing. This poses a risk as earlier snowmelt is expected to cue breeding earlier in the year, exposing young tadpoles (or eggs) to killing frosts in more variable conditions of early spring (Corn 2005, p. 60). When it is too warm, tadpoles are lost to pool desiccation. Alterations in the annual and seasonal hydrologic cycles that influence water volume and persistence in Yosemite toad breeding areas can thereby impact breeding success. The threat of climate change on individuals is significant, and is of high prevalence now and into the future.

Other Sources of Direct and Indirect Mortality

Direct and indirect mortality of Yosemite toads has occurred as a result of livestock grazing. Recently metamorphosed (juvenile) toads congregate in large numbers in mesic meadow habitats, and are at highest risk for trampling because their presence coincides with grazing activity (USFS *et al.* 2009, p. 61). Cattle have been observed to trample Yosemite toad eggs, and new metamorphs and subadult toads can fall into deep hoof prints and die (Martin 2008, p. 158). Martin (2008, p. 158) also witnessed some 60 subadult and metamorph toad deaths during the movement of 25 cattle across a stream channel bordered by willows within a meadow complex. Adult Yosemite toads trampled to death by cattle have also been observed (Martin 2002, pp. 1–3). This risk factor is likely of sporadic significance, and is of greatest concern where active grazing allotments coincide with breeding meadows. However, it is difficult to determine the degree of this impact without quantitative data.

Trampling and collapse of rodent burrows by recreationists, pets, and vehicles could lead to direct mortality of terrestrial life stages of the Yosemite toad. Recreational activity may also disturb toads and disrupt their behavior (Karlstrom 1962, pp. 3–34). Recreational anglers may be a source of introduced pathogens and parasites, and they have been observed using toads and tadpoles as bait (USFS *et al.* 2009, p. 66). However, Kagarise Sherman and Morton (1993, p. 196) did not find a relationship between the distance from the nearest road and the declines in their study populations, suggesting that human activity was not the cause of decline in that situation. Recreational activity may be of conservation concern, and this may increase with greater activity in mountain meadows. However, current available information does not indicate that recreational activity is a significant stressor for Yosemite toads.

Fire management practices over the last century have created the potential for severe fires in the Sierra Nevada. Wildfires do pose a potential direct mortality threat to Yosemite toads, although amphibians in general are thought to retreat to moist or subterranean refuges and thereby suffer low mortality during natural fires (Russel *et al.* 1999, pp. 374–384). However, data on the direct and indirect effects of fire on Yosemite toads are lacking.

USFS *et al.* (2009, p. 74) suggested that the negative effects of roads that have been documented in other amphibians, in concert with the substantial road network across a portion of the Yosemite toad's range, indicate this risk factor may be potentially significant to the species. Roads may facilitate direct mortality of amphibians through vehicle strikes (DeMaynadier and Hunter 2000, pp. 56–65). Levels of timber harvest and road construction have declined substantially since implementation of the California Spotted Owl Sierran Province Interim Guidelines in 1993, and some existing roads have been decommissioned or are scheduled to be decommissioned (USDA 2001a, p. 445). Therefore, the risks posed by new roads and timber harvests have declined, but those already existing still may pose risks to the species and its habitat. Collectively, direct mortality from land uses within the Yosemite toad range may have a population-level impact. However, we are aware of no studies that have quantified or estimated the prevalence of this particular threat to be able to assess its impact to frog populations. At the current time, direct and indirect mortality from roads are not considered to be a significant factor affecting the Yosemite toad.

Small Population Size

Although it is believed that the range of the Yosemite toad has not significantly contracted, the majority of populations across this area have been extirpated, and this loss has been significant relative to the historical condition (reflecting multitudes of populations within many watersheds across their geographic range) (see ''Population Estimates and Status'' above). Further, the populations that remain are small, numbering less than 20 males in most cases (Brown *et al.* 2011, p. 4). This situation renders these remnant populations susceptible to risks inherent to small populations (see Factor E discussion, ''Small Population Size,'' for mountain yellow-legged frogs, above) including inbreeding depression and genetic drift, along with a higher probability of extirpation from unpredictable events such as severe storms or extended droughts.

Traill *et al.* (2009, p. 32) argued for a benchmark viable population size of 5,000 adult individuals (and 500 to prevent inbreeding) for a broad range of taxa, although this type of blanket figure has been disputed as an approach to conservation (Flather *et al.* 2011, pp. 307–308). Another estimate, specific to amphibians, is that populations of at least 100 individuals are less susceptible to demographic stochasticity (Schad 2007, p. 10). Amphibian species with highly fluctuating population size, high frequencies of local extinctions, and living in changeable environments may be especially susceptible to curtailment of dispersal and restriction of habitat (Green 2003, p. 331). These conditions are all likely applicable to the Yosemite toad.

Therefore, based on the best available commercial and scientific information, we conclude that small population size is a prevalent and significant threat to the species viability of the Yosemite toad across its range, especially in concert with other extant stressors (such as climate change).

Cumulative Impacts of Extant Threats

Interactive effects or cumulative impacts from multiple additive stressors acting upon Yosemite toad populations over time are evident by the documented declines in populations and abundance across the range of the species. Although no single causative factor linked to population declines in Yosemite toads has been confirmed in the literature (excepting perhaps extreme climate conditions such as droughts) (Kagarise Sherman and Morton 1993, p. 186; Jennings and Hayes 1994, pp. 50–53), there has been a decline in population abundance and numbers of extant populations inhabiting the landscape (Brown *et al.* 2012, pp. 115–131; Kagarise Sherman and Morton 1993, pp. 186–198). This pattern of decline suggests a factor or combination of factors common throughout the range of the toad. The available literature (Kagarise Sherman and Morton 1993, pp. 186–198; Jennings and Hayes 1994, pp. 50–53; USFS *et al.* 2009, pp. 1–133; Martin 2008, pp. *i*–393) supports the contention that a combination of factors has interacted and is responsible for the decline observed in Yosemite toad populations over the past few decades.

Disease has been documented in Yosemite toad populations, and recent data documenting historic trends in Bd infection intensity are compelling (Dodge and Vredenburg 2012, p. 1), but disease has not been definitively tied to the observed rangewide decline. There is considerable evidence that various stressors, mediated via impacts to meadow hydrology following upslope land management practices over the last century, have detrimentally affected the quantity and quality of breeding meadows. Many of these stressors, such as grazing, have likely been more significant in the past than under current management standards. However, legacy effects remain and meadows tend not to recover without active intervention once excessive stream incision in their watershed is set in motion (Vankat and Major 1978, pp. 386–397). Certain stressors may be of concern, such as increasing recreational impacts and avian predation upon terrestrial life stages of toads, although we do not have sufficient data to document the magnitude of these particular stressors.

Given the evidence supporting the role of climate in reducing populations and potentially leading to the extirpation of many of the populations studied through the 1970s and into the early 1990s (Kagarise Sherman and Morton 1993, pp. 186–198), it is likely that this factor is either a primary driver, or at least a significant contributing factor in the declines that have been observed. Climate models predict increasing drought intensity and changes to the hydroperiod based on reduced snowpack, along with greater climate variability in the future (PRBO 2011, pp. 18–25). It is likely that these changes will exacerbate stress to the habitat specialist Yosemite toad through a pronounced impact on its ephemeral aquatic habitat, and also through an increase in the frequency of freezing and drying events that kill exposed Yosemite toad eggs and tadpoles. These changes and the resultant impacts will effectively reduce breeding success of remnant populations already at low abundance and still in decline. If an interaction such as winter stress and disease (Carey 1993, pp. 355–362) is the underlying mechanism for Yosemite toad declines, then the enhanced influence of climate change as a stressor may tip the balance further towards higher incidence and increased disease virulence, which would also lead to greater population declines and extirpations.

Proposed Determination

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the Yosemite toad. The Yosemite toad is the most narrowly distributed, Sierra Nevada endemic, pond-breeding amphibian (Shaffer *et al.* 2000, p. 246). Although it apparently still persists throughout a large portion of its historical range, it has been reduced to an estimated 12 percent of historical watersheds. In addition, remnant populations are predominantly small.

Yosemite toad populations are subject to threats from habitat degradation associated with land uses that negatively influence meadow hydrology, fostering meadow dewatering, and conifer and other invasive plant encroachment. These activities include grazing, the fire management regime of the past century, historic timber management activities, and associated road construction. The impacts from these threats are cumulatively of moderate magnitude, and their legacy impacts on meadow habitats act as a constraint upon extant populations now and are expected to hinder persistence and recovery into the future. Disease are threats of conservation concern that have likely also had an effect on populations leading to historical population decline, and these threats are operating currently and will continue to do so into the future, likely with impacts of moderate magnitude effects on Yosemite toad populations.

The direct, interactive, and cumulative effects of these various risk factors have acted to reduce the geographic extent and abundance of this species throughout its habitat in the Sierra Nevada. The combined effect of these stressors acting upon small remnant populations of Yosemite toads is of significant conservation concern. The Yosemite toad has a life history and ecology that make it sensitive to drought and anticipated weather extremes associated with climate change. Climate change is expected to become increasingly significant to the Yosemite toad and its habitat in the future throughout its range. Therefore, climate change represents a threat that has a high magnitude of impact as an indirect stressor via habitat loss and degradation, and as a direct stressor via enhanced risk of climate extremes to all life stages of toads.

The Act defines an endangered species as any species that is ''in danger of extinction throughout all or a significant portion of its range'' and a threatened species as any species ''that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future.'' We find that the Yosemite toad is likely to become endangered throughout all or a significant portion of its range within the foreseeable future, based on the immediacy, severity, and scope of the threats described above. These include habitat loss associated with degradation of meadow hydrology following stream incision consequent to the cumulative effects of historic land management activities, notably livestock grazing, and also the anticipated hydrologic effects upon habitat from climate change under listing Factor A. Additionally, we find that disease under listing Factor C was likely a contributor to the recent historic decline of the Yosemite toad, and may remain an important factor limiting recruitment in remnant populations. We also find that the Yosemite toad is likely to become endangered through the direct effects of climate change impacting small remnant populations under Factor E, likely compounded with the cumulative effect of other threat factors (such as disease).

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the species, and have determined that the Yosemite toad meets the definition of threatened under the Act, rather than endangered. This is because the impacts from the threats are occurring now at moderate magnitude, but are likely to become of high magnitude in the foreseeable future across the species' entire range, making the species likely to become in danger of extinction. While population decline has been widespread, the rate of decline is not so severe to indicate extinction is imminent, but this rate could increase as stressors such as climate change impact small remnant populations. Further, the geographic extent of the species remains rather widespread throughout its historic range, conferring some measure of ecological and geographic redundancy. Therefore, on the basis of the best available scientific and commercial information, we propose listing the Yosemite toad as threatened in accordance with sections 3(20) and 4(a)(1) of the Act.

The term ''threatened species'' means any species (or subspecies or, for vertebrates, distinct population segments) that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The Act does not define the term ''foreseeable future'' but it likely describes the extent to which the Service could reasonably rely on predictions about the future in making determinations about the future conservation status of the species. In considering the foreseeable future as it relates to the status of the Yosemite Toad, we considered the historical data to identify any relevant existing trends that might allow for reliable prediction of the future (in the form of extrapolating the trends). We also considered how current stressors are affecting the species and whether we could reliably predict any future trends in those stressors that might affect the species recognizing that our ability to make reliable predictions for the future is limited by the quantity and quality of available data. Thus the foreseeable future includes the species response to these stressors and any trends.

Under the Act and our implementing regulations, a species may warrant listing if it is endangered or threatened throughout all or a significant portion of its range. The Yosemite toad proposed for listing in this rule is highly restricted in its range and the threats occur throughout its range. Therefore, we assessed the status of the species throughout its entire range. The threats to the survival of the species occur throughout the species' range and are not restricted to any particular significant portion of that range. Accordingly, our assessment and proposed determination applies to the species throughout its entire range.

Available Conservation Measures

Conservation measures provided to species listed as endangered or threatened under the Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness and conservation by Federal, State, tribal, and local agencies, private organizations, and individuals. The Act encourages cooperation with the States and requires that recovery actions be carried out for all listed species. The protection required by Federal agencies and the prohibitions against certain activities are discussed, in part, above.

The primary purpose of the Act is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate goal of such conservation efforts is the recovery of these listed species, so that they no longer need the protective measures of the Act. Subsection 4(f) of the Act requires the Service to develop and implement recovery plans for the conservation of endangered and threatened species. The recovery planning process involves the identification of actions that are necessary to halt or reverse the species' decline by addressing the threats to its survival and recovery. The goal of this process is to restore listed species to a point where they are secure, self-sustaining, and functioning components of their ecosystems.

Recovery planning includes the development of a recovery outline shortly after a species is listed, preparation of a draft and final recovery plan, and revisions to the plan as significant new information becomes available. The recovery outline guides the immediate implementation of urgent recovery actions and describes the process to be used to develop a recovery plan. The recovery plan identifies site-specific management actions that will achieve recovery of the species, measurable criteria that determine when a species may be downlisted or delisted, and methods for monitoring recovery progress. Recovery plans also establish a framework for agencies to coordinate their recovery efforts and provide estimates of the cost of implementing recovery tasks. Recovery teams (comprised of species experts, Federal and State agencies, nongovernmental organizations, and stakeholders) are often established to develop recovery plans. When completed, the recovery outline, draft recovery plan, and final recovery plan will be available on our Web site (*http://www.fws.gov/endangered*), or from our Sacramento Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**).

Implementation of recovery actions generally requires the participation of a broad range of partners, including other Federal agencies, States, tribal, nongovernmental organizations, businesses, and private landowners. Examples of recovery actions include habitat restoration (for example, restoration of native vegetation), research, captive propagation and reintroduction, and outreach and education. The recovery of many listed species cannot be accomplished solely on Federal lands because their range may occur primarily or solely on non-Federal lands. To achieve recovery of these species requires cooperative conservation efforts on private, State, and tribal lands.

If these species are listed, funding for recovery actions will be available from a variety of sources, including Federal budgets, State programs, and cost-share grants for non-Federal landowners, the academic community, and nongovernmental organizations. In addition, pursuant to section 6 of the Act, the State of California would be eligible for Federal funds to implement management actions that promote the protection and recovery of the Sierra Nevada yellow-legged frog, the northern DPS of the mountain yellow-legged frog, and the Yosemite toad. Information on our grant programs that are available to aid species recovery can be found at: *http://www.fws.gov/grants.*

Although the Sierra Nevada mountain yellow-legged frog, the northern DPS of the mountain yellow-legged frog, and the Yosemite toad are only proposed for listing under the Act at this time, please let us know if you are interested in participating in recovery efforts for this species. Additionally, we invite you to submit any new information on these species whenever it becomes available and any information you may have for recovery planning purposes (see **FOR FURTHER INFORMATION CONTACT**).

The Act and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. The prohibitions of section 9(a)(2) of the Act, codified at 50 CFR 17.21 for endangered wildlife, in part, make it illegal for any person subject to the jurisdiction of the United States to take (includes harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or to attempt any of these), import, export, ship in interstate commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. Under the Lacey Act (18 U.S.C. 42–43; 16 U.S.C. 3371–3378), it is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions apply to agents of the Service and State conservation agencies.

We may issue permits to carry out otherwise prohibited activities involving endangered and threatened wildlife species under certain circumstances. Regulations governing permits are codified at 50 CFR 17.22 for endangered species, and at 17.32 for threatened species. With regard to endangered wildlife, a permit must be issued for the following purposes: for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities.

It is our policy, as published in the **Federal Register** on July 1, 1994 (59 FR 34272), to identify to the maximum extent practicable at the time a species is listed, those activities that would or would not constitute a violation of section 9 of the Act. The intent of this policy is to increase public awareness of the effect of a proposed listing on proposed and ongoing activities within the range of species proposed for listing. The following activities could potentially result in a violation of section 9 of the Act; this list is not comprehensive:

(1) Unauthorized collecting, handling, possessing, selling, delivering, carrying, or transporting of the species, including import or export across State lines and international boundaries, except for properly documented antique specimens of these taxa at least 100 years old, as defined by section 10(h)(1) of the Act;

(2) Introduction of species that compete with or prey upon the Sierra Nevada yellow-legged frog, the northern DPS of the mountain yellow-legged frog, or the Yosemite toad;

(3) The unauthorized release of biological control agents that attack any life stage of these species;

(4) Unauthorized modification of the mountain meadow habitats or associated upland areas important for the breeding, rearing, and survival of these species; and

(5) Unauthorized discharge of chemicals or fill material into any waters in which the Sierra Nevada yellow-legged frog, the northern DPS of the mountain yellow-legged frog, or the Yosemite toad are known to occur.

Questions regarding whether specific activities would constitute a violation of section 9 of the Act should be directed to the Sacramento Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**). Requests for copies of the regulations concerning listed animals and general inquiries regarding prohibitions and permits may be addressed to the U.S. Fish and Wildlife Service, Endangered Species Permits, 2800 Cottage Way, Suite W–2606, Sacramento, CA 95825–1846 (telephone 916–414–6464; facsimile 916–414–6486).

Peer Review

In accordance with our joint policy on peer review published in the **Federal Register** on July 1, 1994 (59 FR 34270), we will seek the expert opinions of at least three appropriate and independent specialists regarding this proposed rule. The purpose of such review is to ensure that our proposed actions are based on scientifically sound data, assumptions, and analyses. We have invited these peer reviewers to comment, during the public comment period, on the specific assumptions and conclusions in this proposed listing.

We will consider all comments and information we receive during the comment period on this proposed rule during preparation of a final determination. Accordingly, the final decision may differ from this proposal.

Public Hearings

Section 4(b)(5) of the Act provides for one or more public hearings on this proposal, if requested. Requests must be received within 45 days after the date of publication of this proposed rule in the **Federal Register**. Such requests must be sent to the address shown in the **FOR FURTHER INFORMATION CONTACT**. We will schedule public hearings on this proposal, if any are requested, and announce the dates, times, and places of those hearings, as well as how to obtain reasonable accommodations, in the **Federal Register** and local newspapers at least 15 days before the hearing.

Required Determinations

Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.)

This rule does not contain any new collections of information that require approval by OMB under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 *et seq.*). This rule will not impose recordkeeping or reporting requirements on State or local governments, individuals, businesses, or organizations. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

National Environmental Policy Act (42 U.S.C. 4321 et seq.)

We have determined that environmental assessments and environmental impact statements, as defined under the authority of the National Environmental Policy Act (NEPA; 42 U.S.C. 4321 *et seq.*), need not be prepared in connection with listing a species as endangered or threatened under the Endangered Species Act. We published a notice outlining our reasons for this determination in the **Federal Register** on October 25, 1983 (48 FR 49244).

Clarity of the Rule

We are required by Executive Orders 12866 and 12988 and by the Presidential Memorandum of June 1, 1998, to write all rules in plain language. This means that each rule we publish must:

(1) Be logically organized;

(2) Use the active voice to address readers directly;

(3) Use clear language rather than jargon;

(4) Be divided into short sections and sentences; and

(5) Use lists and tables wherever possible.

If you feel that we have not met these requirements, send us comments by one of the methods listed in the **ADDRESSES** section. To better help us revise the rule, your comments should be as specific as possible. For example, you should tell us the numbers of the sections or paragraphs that are unclearly written, which sections or sentences are too long, the sections where you feel lists or tables would be useful, etc.

References Cited

A complete list of references cited in this rulemaking is available on the Internet at *http://www.regulations.gov* and upon request from the Sacramento Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**).

Authors

The primary authors of this package are the staff members of the Sacramento Fish and Wildlife Office.

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, Transportation.

Proposed Regulation Promulgation

Accordingly, we propose to amend part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as set forth below:

PART 17—[AMENDED]

■ 1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361–1407; 1531–1544; and 4201–4245, unless otherwise noted.

■ 2. Amend § 17.11(h) by adding entries for ‘‘Frog, mountain yellow-legged (northern California DPS)’’, ‘‘Frog, Sierra Nevada yellow-legged’’, and ‘‘Toad, Yosemite’’ to the List of Endangered and Threatened Wildlife in alphabetical order under AMPHIBIANS to read as follows:

§ 17.11 Endangered and threatened wildlife.

* * * * *

(h) * * *

Species		Historical range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
*	*	*	*	*	*		*
AMPHIBIANS							
*	*	*	*	*	*		*
Frog, mountain yellow-legged (northern California DPS).	*Rana muscosa*	U.S.A. (CA)	Entire	E	....	NA	NA
*	*	*	*	*	*		*
Frog, Sierra Nevada yellow-legged.	*Rana sierrae*	U.S.A. (CA, NV)	Entire	E	....	NA	NA
*	*	*	*	*	*		*
Toad, Yosemite	*Anaxyrus canorus* ...	U.S.A. (CA)	Entire	T	....	NA	NA
*	*	*	*	*	*		*

Dated: March 15, 2013.

Rowan Gould,

Director, U.S. Fish and Wildlife Service.

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