STAFF SUMMARY FOR OCTOBER 11-12, 2017

## 9. CASCADES FROG

**Today's Item** **Information** ☐ **Action** ☒

Determine whether listing Cascades frog *Rana cascadae*) as threatened or endangered under the California Endangered Species Act (CESA) may be warranted pursuant to Section 2074.2 of the Fish and Game Code.

**Summary of Previous/Future Actions**

| | |
|---|---|
| • Received petition | Mar 1, 2017 |
| • FGC transmitted petition to DFW | Mar 6, 2017 |
| • Published notice of receipt of petition | Mar 31, 2017 |
| • Public receipt of petition | Apr 26-27, 2017; Van Nuys |
| • Approved 30-day extension for evaluation | Jun 21-22, 2017; Smith River |
| • Received DFW evaluation of petition | Aug 16, 2017; Sacramento |
| • **Today determine if petitioned action may be warranted** | **Oct 11-12, 2017; Atascadero** |

**Background**

A petition to list Cacades frog as a threatened or endangered species under CESA was submitted by the Center for Biological Diversity on Mar 1, 2017. On Mar 6, 2017, FGC transmitted the petition to DFW for review. A Notice of Receipt of Petition was published in the California Regulatory Notice Register on Mar 31, 2017.

California Fish and Game Code Section 2073.5 requires that DFW evaluate the petition and submit to FGC a written evaluation with a recommendation (Exhibit 3).

Based upon the information contained in the petition and other relevant information, DFW has determined that there is sufficient scientific information available at this time to indicate that the petitioned action may be warranted. DFW recommends that the petition be accepted and considered (Exhibit 2).

**Significant Public Comments (N/A)**

**Recommendation**

***FGC staff:*** Accept DFW's recommendation to accept and consider the petition for further evaluation.

***DFW:*** Accept and consider the petition for further evaluation.

**Exhibits**

1. Petition, dated Mar 1, 2017
2. DFW memo, dated Jul 21, 2017
3. DFW 90-day evaluation, dated Jul 2017

**Motion/Direction**

Moved by __________ and seconded by __________ that the Commission, pursuant to Section 2074.2 of the Fish and Game Code, finds that the petitioned action to list Cascades frog as a threatened or endangered species **may be** warranted based on the information in the record before the Commission, and therefore designates Cascades frog as a candidate for threatened or endangered species status.

**OR**

Moved by __________ and seconded by __________ that the Commission, pursuant to Section 2074.2 of the Fish and Game Code, finds that the petition to designate Cascades frog as a threatened or endangered species and other information in the record before the Commission **does not** provide sufficient information to indicate that the petitioned action may be warranted.

**BEFORE THE FISH AND GAME COMMISSION**

# Petition to List the Cascades Frog (*Rana cascadae*) As Endangered or Threatened Under the California Endangered Species Act

*Photo by Tierra Curry, Center for Biological Diversity*

**Submitted To**: California Fish and Game Commission
1416 Ninth Street
Box 944209
Sacramento, CA 94244-2090
FGC@fgc.ca.gov

**Submitted By**: Center for Biological Diversity

**Date**: March 1, 2017

## EXECUTIVE SUMMARY

The Center for Biological Diversity is petitioning the California Fish and Game Commission to list the Cascades frog (*Rana cascadae*) as an endangered or threatened species under the California Endangered Species Act.

The Cascades frog is a medium sized frog that inhabits lakes, ponds, wet meadows, and streams at moderate to high elevations in the Cascades Range. In California, Cascades frogs historically ranged from the Shasta-Trinity region to the Modoc Plateau, south through the Lassen National Forest to the upper Feather River. Once considered widespread and abundant in the northern mountains of California, Cascades frogs are now extirpated from most of their former range in the state. The Cascades frog currently persists in California in mountainous areas from the Klamath-Trinity region and the Cascades Mountain axis in the vicinity of Mount Shasta, southward to the headwater tributaries of the Feather River, at altitudes from 230 to 2500 meters.

Cascades frog numbers and populations have been declining precipitously in California since about 1970. In the southern Cascades/Lassen area, Cascades frog populations have declined greatly and gone from being abundant historically to very rare. Cascades frogs have disappeared from more than 95 percent of historical localities in the Lassen area, and are still declining in this region. The species appears to be extirpated from Lassen Volcanic National Park. Despite multiple extensive surveys, only 12 remaining sites in the Lassen area support Cascades frogs, all of them with low numbers of frogs. Population viability at these sites is a concern because each of these populations is slowly declining. Half of the remaining Lassen area populations are at risk of extirpation while the others are likely to continue declining. Without active management, some of the remaining populations may disappear within 10 years and the rest will be at risk of extirpation.

In the Klamath Mountains, Cascades frogs are still widespread and relatively abundant; however, there have been some recent extirpations in this region. At most sites recently surveyed in the Klamath Mountains, frog populations have been small, and frog abundance at some previously robust Klamath populations has clearly declined. Populations in the eastern portion of the region in the Castle Crags Wilderness and the Klamath National Forest may be particularly at risk owing to low population numbers and more sites where frogs have recently disappeared.

Major threats to Cascades frogs include nonnative fish that have been introduced to formerly fishless lakes, and pathogens. Introduced trout predate upon and compete with Cascades frogs. Cascades frogs are susceptible to a particularly virulent strain of *Batrachochytrium dendrobatidis*, a fungal pathogen that causes the disease chytridiomycosis in amphibians. Remaining Cascades frog populations in California are also threatened by pesticides, climate change, fire suppression, habitat loss from vegetation management and timber harvest, livestock grazing, impacts from recreational activities, and reduced viability due to small population sizes.

**NOTICE OF PETITION**

Center for Biological Diversity
1212 Broadway, Suite 800
Oakland, CA 94612
Contact: Jeff Miller
Phone: (510) 499-9185
E-mail: jmiller@biologicaldiversity.org

Petitioner Center for Biological Diversity formally requests that the California Fish and Game Commission list the Cascades frog (*Rana cascadae*) as an endangered species under the California Endangered Species Act ("CESA"), Fish and Game Code §§ 2050 et seq. Petitioner alternatively requests that the Commission list the Cascades frog as a threatened species under CESA. This petition sets in motion a specific administrative process as defined by Fish and Game Code §§ 2070-2079, placing mandatory response requirements on the Commission and very specific time constraints upon those responses.

Petitioner Center for Biological Diversity is a national nonprofit organization with more than 1.2 million members and online activists dedicated to the protection of endangered species and wild places, through science, policy, education, citizen activism and environmental law.

**Contents:**

# NATURAL HISTORY AND STATUS OF CASCADES FROG

## NATURAL HISTORY

### Description

The Cascades frog (*Rana cascadae*) is a medium-sized member of the “true frog” family, Ranidae. Cascades frogs are brown, copper, tan, or olive green and spotted on the back with a yellowish to cream underside, dark mottling around the groin, and a cream-colored stripe extending from the jaw to the shoulders. Adult Cascades frogs grow to from 1.75 to 3 inches in length, with females being larger than males (Stebbins 2003; Nafis 2013). Cascades frog tadpoles have oval bodies with dorsal eyes, and grow to about 5 centimeters in length. Tadpoles are dark brown with copper and pinkish speckling, golden coloring on the sides and a finely speckled tail (Nafis 2013). Cascades frog eggs are black above, white below, and spaced out in a gelatinous mass (Nafis 2013).

### Taxonomy

The Cascades frog is a morphologically (Slater 1939; Dunlap 1955) and genetically (Case 1976, 1978; Green 1986a, 1986b) distinct species. Published data on genetic variation within *R. cascadae* (Case 1976, 1978; Monsen and Blouin 2003, 2004) indicate some potentially significant within-species variation. Genetic evidence indicates that California’s populations of Cascades frogs differ significantly from and have been isolated from Oregon and Washington populations for approximately 2 million years (Monsen and Blouin 2003). This physical separation occurs over a known faunal break across Oregon and California’s border that causes a similar biogeographical pattern in numerous taxa (Steinhoff et al. 1983; Brown et al. 1997; Demboski and Cook 2001; Janzen et al. 2002; Monsen and Blouin 2003), including several amphibians (Daugherty et al. 1983; Good 1989; Good and Wake 1992; Howard et al. 1993; Nielson et al. 2001; Monsen and Blouin 2003). California’s Cascade frogs were most likely separated, and never experienced secondary contact, during the last glacial maximum (Monsen and Blouin 2003). This has led to a 3.2 percent difference in mtDNA loci between frog populations in California and Oregon as well as substantial divergence in the nuclear genome (Monsen and Blouin 2003).

There are two disjunct populations of Cascades frogs in California – in the southern Cascades, which comprise about 40 percent of their California range, and in the Klamath Mountains, which comprise about 60 percent (Pope et al. 2014). The exact degree of isolation between these two populations is unknown (Pope et al. 2014).

Cascades frog populations typically occur in a meta-population structure, but genetic studies indicate high degrees of isolation for some local populations in relatively small geographic scales (Monsen and Blouin 2004; Pope et al. 2014). Population exchange likely drops after a distance of just 6.2 miles (10 km) between populations (Pope et al. 2014).

### Range in California

The Cascades frog, as its name suggests, is distributed along the length of the Cascades Range. Cascades frogs historically occupied moderate and high elevation (about 400–2,500 m) lentic habitats throughout the Cascade Range, from northern Washington State within 15 miles of British Columbia to the northern edge of California's Sierra Nevada (Dunlap and Storm 1951; Dunlap 1955; Dumas 1966; Bury 1973a; Hayes and Cliff 1982; Nussbaum et al. 1983; Fellers and Drost 1993; Jennings and Hayes 1994; Blaustein et al. 1995; Stebbins 2003; Pearl and Adams 2005; Pope et al. 2014).

In California, Cascades frogs historically ranged from the Shasta-Trinity region to the Modoc Plateau, south through the Lassen National Forest to the upper Feather River (Jennings and Hayes 1994). Once considered widespread and abundant in the northern mountains of California, Cascades frogs are now extirpated from most of their range in the state (Pearl and Adams 2005). In California, the Cascades frog currently occurs in mountainous areas from the Klamath-Trinity region and the Cascades Mountain axis in the vicinity of Mount Shasta southward to the headwater tributaries of the Feather River, and has a known altitudinal range from 230 to approximately 2500 m (Jennings and Hayes 1994).

### Life History

Cascades frogs are long-living, late-maturing amphibians (Pope et al. 2014). Male frogs reach maturity between 3 and 4 years of age while female frogs mature between 4 and 5 years of age (Pope et al. 2014). Cascades frogs can live from 5 to 10 years (Pope et al. 2014; NatureServe 2015). These frogs are diurnal, active during the day (Stebbins 1985).

Cascades frogs breed shortly after spring snowmelt (Nussbaum et al. 1983; Stebbins 1985; Briggs 1987; Olson 1988; Garwood and Welsh 2007; Nafis 2013). Depending on the location, that could be anytime between March to mid-August (Stebbins 1985). Males appear first and form chorusing groups when melting ice and snow creates open water along the edges of water bodies (Briggs 1987; Garwood and Welsh 2007). Cascades frogs call from above or below water's surface (Stebbins 1985). Males do not defend territories, but male-male interactions may produce a regular spacing pattern in the breeding habitat (Olson 1988). Females are highly cryptic during breeding, swimming primarily underwater to breeding sites and leaving the site as soon as breeding is complete (Olson 1992).

Oviposition occurs between April and July, depending on seasonal conditions and elevation. Eggs are laid in a mass of 300-800 eggs. Egg masses are often laid communally in pond and lake habitats (Garwood et al. 2007; Garwood 2009; Pope and Larson 2010). In the southern Cascades, more than 90 percent of the egg masses found in pond habitats were clumped, whereas more than 80 percent of the egg masses found in meadow pools were singletons (Pope and Larson 2010). A small percentage of egg masses in the southern portion of the southern Cascades have been found in small, low-gradient channels with slow flow (Pope 2008b). Egg masses are usually found at the surface in shallow water with emergent vegetation, but have been found in deep water (2 m) and free-floating in lakes (Garwood et al. 2007, Pope and Larson 2010). They can also be attached to emergent vegetation, wood, boulders, or the shoreline (Pope and Larson 2010).

Length of embryonic development appears highly temperature-dependent as shown by both laboratory and field studies (Sype 1975; Olson 1988; Blouin and Brown 2000), but generally takes about 3 weeks in both the Klamath Mountains and southern Cascades (Garwood and Larson, no date). Consistently cold water conditions (2 to 10 °C), such as found in some springs, may delay hatching by a few days but eggs generally are laid in shallow open-water locations where the sun quickly warms the water surrounding the egg mass to temperatures above 13 °C that are more optimal for development. In the high-elevation habitats in California, larvae usually hatch in early to mid-July and metamorphose into frogs in September. However, some larvae do not successfully complete metamorphosis prior to the onset of winter (Garwood and Welsh 2007). No larvae have been observed to survive the winter (Garwood 2009). In the southern Cascades, larvae usually hatch in June and metamorphose in late August (Pope and Larson 2010).

Tadpoles can tolerate a wide range of water temperatures. They tend to aggregate in the warmest areas of ponds and lakes during the day (Brattstrom 1963; Wollmuth et al. 1987; Pope, no date); this generally consists of wind-protected, gently sloping, shallow near-shore areas (O'Hara 1981; Olson 1992; Welsh et al. 2006) where temperatures can warm to more than 20 °C on a sunny afternoon but drop to near freezing at night. In shallow meadow breeding pools in the southern Cascades, daytime water temperatures have been measured at 38 °C. This seems to be above their temperature tolerance as the tadpoles appeared highly stressed (Pope and Larson, no date).

Tadpoles and metamorphs are known to discriminate between kin and nonkin and preferentially associate with kin in laboratory and field experiments (Blaustein and O'Hara 1982a, 1982b, 1987; Blaustein et al. 1984; O'Hara and Blaustein 1981, 1985). Kin association can influence growth, predator avoidance, and other factors (Hokit and Blaustein 1994, 1995, 1997). Tadpoles are sensitive to visual and physical disturbances of the water and have an explosive escape response when startled (Hews and Blaustein 1985). Tadpoles occasionally become stranded at sites with short hydroperiods and desiccate as the water evaporates (Sype 1975; O'Hara 1981; Garwood 2009; Pope et al. 2011). Tadpoles will develop over 2 to 4 months depending on water temperature (Nafis 2013; Pope et al. 2014). Newly metamorphosed frogs tend to stay near their natal ponds (Garwood 2009).

Adult Cascades frogs display a high degree of site fidelity (Briggs and Storm 1970; Blaustein and Olson 1992; Olson 1992; Garwood 2009). At Deep Creek Basin in the Trinity Alps Wilderness, Garwood (2009) found that adults commonly move among unique breeding, feeding, and overwintering habitats following a consistent annual pattern. At other sites where breeding, feeding, and overwintering habitat occur at the same site, frogs may remain at the same water body throughout the year (Pope 2008a).

Survival rates of adult Cascades frogs in the Trinity Alps Wilderness were found to be between 68 and 93 percent (Pope 2008b; Pope et al. 2014).

Postmetamorphic Cascades frogs are generalist predators, primarily of aquatic and terrestrial insects and spiders (Joseph et al. 2011; Larson 2012). In the Trinity Alps Wilderness, Larson (2012) identified insects from 102 different families in the stomach contents of frogs. Only rarely were larval aquatic insects found in stomach contents, suggesting that most foraging is terrestrial or on the surface of the water (Larson 2012).

In the Klamath Mountains, five prey categories were most important in Cascades frogs diet: Acrididae (grasshoppers), Aranae (spiders), Formicidae (ants), insect larvae, and Tipulidae (crane flies) (Larson 2012).

Joseph et al. (2011) found that the diet of Cascades frogs varied in lakes with fish versus those without; in lakes with fish, the frogs ate more terrestrial insects such as grasshoppers, and in lakes without fish they ate more adult aquatic insects such as caddisflies. Joseph et al. (2011) concluded that introduced trout may influence native amphibians indirectly through competition for food resources. Although their diet primarily consists of invertebrates, Cascades frogs occasionally prey upon larvae and recently metamorphosed Pacific chorus frogs and conspecifics (Pope et al. 2014).

### Habitat Requirements

Cascades frogs inhabit a range of mostly lentic aquatic habitats, including large lakes, ponds, wet meadows, and flowing streams, depending on life stage and season (Jennings and Hayes 1994; Pope et al. 2014). This frog occurs at 230-2500m of elevation – most often at elevations greater than 600m (Nafis 2013). Cascades frogs generally are closely associated with water, but can sometimes move between drainages by crossing over high mountain ridges.

Reproduction occurs in shallow, still-water habitats first to form by snowmelt early in the spring such as shallow alcoves of lakes, ponds, potholes, flooded meadows, and sometimes slow-moving streams. Adults and breeding can also sometimes occur in anthropogenic wetland habitats (Quinn et al. 2001). Eggs are laid in open shallow water or among submerged vegetation. Breeding sites must contain water long enough for egg and tadpole development, which takes about three to four months, depending on water temperature (Pope and Larson 2010; Pope et al. 2014). Tadpoles can tolerate a wide range of temperatures and tend to congregate in warmer areas of their ponds or lakes during the day (Brattstrom 1963; Wollmuth et al. 1987; Pope et al. 2014; Pope, no date); however, observed behaviors in southern Cascades pools with temperatures around 38°C or higher seem to be indicative of high stress levels and a thermal tolerance threshold (Pope et al. 2014; Pope and Larson, no date).

Newly metamorphosed frogs stay near their natal ponds (Garwood 2009). Non-breeding adult frogs occupy a wider array of aquatic habitat, often with open, sunny areas along shorelines which have basking and foraging opportunities (Brown 1977; Fellers and Drost 1993; Bury and Major 1997, 2000; Garwood 2009; Pope et al. 2011; Pope et al. 2014). In the summer months, Cascades frogs may utilize streams more often (Garwood 2009; Pope et al. 2011; Pope et al. 2014). Cascades frogs are less likely to occupy wetland sites that are farther away from lakes, and population sizes are typically smaller at such sites (Cole and North 2014). Cascades frogs maintain site fidelity, where adults will move among unique breeding, feeding and overwintering habitats following a consistent annual pattern (Garwood 2009; Pope et al. 2014).

Overwintering habitat is considered to be almost as restrictive as breeding habitat (Garwood 2009; Pope et al. 2014). Cascades frogs likely hibernate in mud at the bottom of ponds, spring-water saturated ground, and aquatic sites that do not freeze solid in the winter, such as deep ponds and springs, similar to the mountain yellow-legged frog in the Sierra Nevada (Bradford 1983; Briggs 1987; Pope et al. 2014).

### Natural Mortality

Cascades frogs are susceptible to a variety of stochastic environmental events. Breeding occurs soon after thaw, so eggs can be vulnerable to late freezes (Pope and Larson 2010; Pope et al. 2014). In some ephemeral habitats that dry out during the summer, larvae may desiccate before metamorphosis (Pope et al. 2011). Tadpoles can occasionally become stranded and die when all the water evaporates from sites with short hydroperiods (Sype 1975; O'Hara 1981; Garwood 2009; Pope et al. 2011; Pope et al. 2014). Survival of juvenile and adults may also be affected by unusually long winters with heavy snowfall if the frogs do not have enough energy stored to last until the thaw (Pope et al. 2014). Briggs and Storm (1970) estimated a relatively high mortality rate for adults (about 45 percent) in the central Oregon Cascades and suggested that most adult mortality occurred during overwintering.

Natural predators of Cascades frogs include: garter snakes (Garwood and Welsh 2007; Pope et al. 2008); birds such as American dippers (Garwood and Welsh 2007), American robins (Briggs and Storm 1970) and Clark's nutcrackers (Garwood 2006); mammals such as river otters (Pope et al. 2014); other amphibians including rough-skinned newts (Peterson and Blaustein 1991); aquatic insects including diving beetles, giant water bugs, and dragonfly naiads (Peterson and Blaustein 1991; Nauman and Dettlaff 1999; Garwood and Wheeler 2007); and predatory leeches, which are potential predators of eggs and larvae (Stead and Pope 2010).

Predatory leeches such as *Haemopis marmorata* and *Erpobdella puncata* in the Lassen region may also contribute to the decline of Cascades frogs (Stead and Pope 2010). Glossiphoniidae and Erpobdellidae leeches are known to prey on Cascades frog eggs in Oregon (Chivers et al. 2001; Stead and Pope 2010), and *H. marmorata* is known to eat tadpoles (Riggs and Ulner 1983; Stead and Pope 2010). The proliferation of leech species correlates with the dramatic declines seen in Cascades frogs in the Lassen region of California and may be the cause through direct predation, behavioral alterations which reduces fitness, displacement to less optimal habitats, and the spread of disease (Stead and Pope 2010). It is unknown which leech species are native to the Lassen region (Stead and Pope 2010).

## CHANGES IN DISTRIBUTION AND ABUNDANCE

In California, surveys suggest that the Cascades frog is rare to nonexistent in most Californian portions of the historical range (Pearl and Adams 2005). Pope et al. (2014) conducted a comprehensive review on the status of Cascades frogs in California, and found that although the species remains "fairly widespread" in the Klamath Mountains it has become extremely rare in the southern Cascades. See Figure 1 below from Pope et al. (2014) showing the recent and historical distribution of the Cascades frog in California.

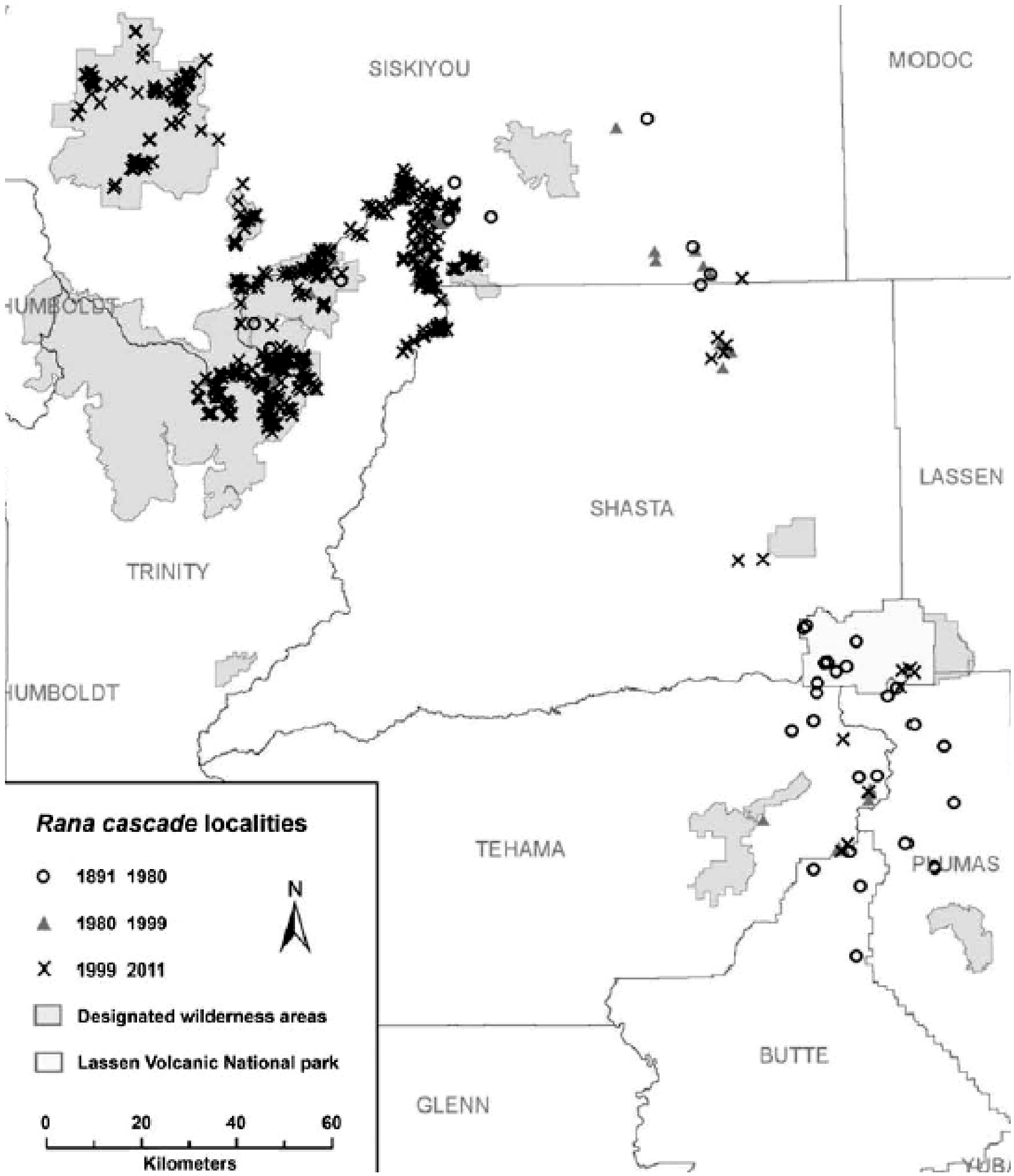


**Figure 1**: Recent and historical distribution of the Cascades frog (*Rana cascadae*) in California. This map contains known localities up to 2011. The sites in Trinity and Siskiyou Counties are in the Klamath Mountains and the sites in Shasta, Tehama, Butte, and Plumas Counties are in the southern Cascade Range. The southernmost grouping of points around Lassen Volcanic National Park is considered the Lassen region (from Pope et al. 2014).

### Southern Cascade Range/Lassen Region

Historic accounts and museum records indicate that the frog was previously abundant in the Mount Lassen area, but have declined greatly and are now very rare (Fellers et al. 2008). For example, Borrel (1924, as cited in Pope et al. 2014) described Cascades frogs as abundant at Lake Helen; and Grinnell et al. (1930) implied that the species was abundant in 1925 at Emerald Lake, recording "one frog for nearly every meter around the lake." There were no surveys for Cascades frogs in the southern Cascades before 1980, but collection data indicate that they were widespread and abundant, especially in and around the Lassen Volcanic National Park and the northwestern and southern portions of Lassen National Forest, encompassing portions of the Pit River and most of the headwater tributaries of Hat, Deer, Mill, Battle, and Butte creeks, and upper North Fork and West Branch Feather River (Pope et al. 2014). Declines in these populations were not noted until the 1970s (Pope et al. 2014).

By the 1990s, surveys of Lassen Volcanic National Park sites that historically had frogs found few or no frogs. A 1991 survey located no Cascades frogs at 16 historic localities, and found that the frog occupied only 2 percent of the suitable sites surveyed (1 of 50 sites) (Fellers and Drost 1993). Jennings and Hayes (1994) estimated that the species had disappeared from about 99 percent of its historical range in the Lassen region. Davidson et al. (2002) reevaluated these data, and found that only 3 percent (1 of 32 sites) of historical Cascades frog sites (defined as pre-1990) was still occupied in the early 1990s. Since 1991, four large-scale surveys have been conducted to evaluate the occurrence of aquatic-breeding amphibians throughout the Lassen region (Fellers 1998; Koo et al. 2004; Welsch and Pope 2004; Stead et al. 2005). These data were analyzed by Fellers et al. (2008) and show that the situation has worsened significantly.

From 1993 to 2007, Fellers et al. (2008) conducted 1,873 amphibian surveys at 856 sites within Lassen Volcanic National Park and Lassen National Forest, California. These surveys encompassed all Cascades frog habitats: ponds, lakes, meadows, and streams on those lands. They found Cascades frogs at only 6 sites during 14 years of surveys, and obtained one report of a single frog at one additional locality. These occupied sites represented less than 1 percent of the historically suitable habitat within the Lassen region. Fellers et al. (2008) found no evidence of reproduction in most of the populations, and reproduction at all but one of the other sites remained lower than the annual reproductive output of one breeding pair for greater than 12 years.

Despite extensive surveys, only 12 remaining sites harboring Cascades frogs have been documented in the Lassen area since 1993, all with low numbers, ranging from 5 individuals at Colby Creek to 150 at Carter Meadow in Lassen National Forest (Pope et al. 2014). Each population was found to be slowly declining over a four year mark-recapture study (2008-2011); researchers concluded that about half are at risk of extirpation while the others are likely to continue declining (Pope et al. 2014). No remaining populations have been found in from Lassen Volcanic National Park since 2008 despite multiple resurveys of the most recent known locations and additional extensive surveys of appropriate meadow habitat (Pope et al. 2014) The species appears to be extirpated from Lassen Volcanic National Park (Pope et al. 2014), but 3 populations have been found to the south on private land and 3 populations to the north near Lassen National Forest (Pope and Larson, no date).

### Klamath Mountains

In the Klamath Mountains, Cascades frogs were known from about 25 localities in and around Shasta-Trinity National Forest in the 1970s, and few populations had been recorded in Klamath National Forest (Pope et al. 2014). Available data provide no evidence for or against the decline of Cascades frogs on the Shasta-Trinity NF through the 1970s (Pope et al. 2014). Up to the mid-1990s, Cascades frogs seemed common in appropriate habitat in the Klamath Mountains (Jennings and Hayes 1994). Davidson et al. (2002) estimated that 77 percent (20 of 26) historical Cascades frog sites (defined as pre-1990) associated with the Shasta-Trinity National Forest were still occupied in the early 1990s. Systematic surveys were carried out in wilderness areas of the Cascades frog range in the Klamath Mountains from 1999-2002. Abundance data as well as occupancy data were collected for all mapped lakes, ponds, and wet meadows in the Trinity Alps Wilderness, Russian Wilderness, Marble Mountains Wilderness, Siskiyou Wilderness, Red Buttes Wilderness, Castle Crags Wilderness, and parts of the Shasta-Trinity and Klamath National Forests outside of wilderness areas (Welsh and Pope 2004; Welsh et al. 2006). Those results are summarized below in Table 1.

**Table 1**: Summary of Cascades Frogs Population Data in Klamath Mountains, California (Data from Welsh and Pope 2004, cited in Pope et al. 2014, p. 15).

| Wilderness Area | Occupied (%) | n (sites) = | Reproducing (%) | n (sites) = |
|---|---|---|---|---|
| Trinity Alps | 58.7 | 223/380 | 30.5 | 116/380 |
| Russian | 31 | 17/54 | 5.5 | 3/54 |
| Marble Mountains | 32 | 80/250 | 11 | 28/250 |
| Castle Crags | 19 | 3/16 | - | - |
| Shasta-Trinity | 100 | 15/15 | - | - |

Of 380 water bodies surveyed in the Trinity Alps Wilderness by Welsh and Pope (2004), 58.7 percent (n = 223) were found to support at least one individual of any life stage of Cascades frogs. Evidence of reproduction (egg masses or larvae) was recorded at 30.5 percent (n = 116) of the sites. Approximately 250 water bodies were searched in the Marble Mountains and 54 water bodies were searched in the Russian Wilderness. Cascades frogs were recorded from 32 percent of the water bodies in the Marble Mountains (n = 80) and at 31 percent of water bodies in the Russian Wilderness (n = 17). However, evidence of reproduction (egg masses or tadpoles) was found at even fewer sites: only 11 percent of sites in the Marble Mountains (n = 28) and at only 5.5 percent of sites in the Russian Wilderness (n = 3). Cascades frogs were also detected at 3 of 16 water bodies in Castle Crags Wilderness, three sites on the Klamath National Forest outside of a wilderness area and 15 sites on the Shasta-Trinity National Forest outside of a wilderness area (Welsh and Pope 2004). No Cascades frogs were found in the Siskiyou or Red Buttes wilderness areas (Welsh and Pope 2004).

In 2008, 112 sites in the Klamath Mountains where Cascades frogs were previously found were re-surveyed, and 79 percent were found to still support frog populations (Piovia-Scott et al. 2011; Pope et al. 2014). No major declines were noted, but the abundances of some previously robust populations seemed low (Pope et al. 2014). At the majority of sites surveyed since 1999, abundances of Cascades frogs have appeared low (Welsh et al. 2006). Of 695 water bodies searched from 1999 to 2001 in the Trinity Alps, Marble Mountains, and Russian Wildernesses, the maximum number of adults seen at a water body was 32 and the mean number of adults encountered at sites with Cascades frogs was only 4 (Welsh and Pope 2004). Since then, 8 frog populations in the Trinity Alps Wilderness were studied for 9 years using mark-recapture techniques (Garwood, no date; Pope 2008a). While adult numbers were less than 25 in five of these populations, three populations appeared fairly robust. Two headwater lakes were estimated to support more than 500 adult frogs in 2010 (Pope and Piovia-Scott, 2010). Only one other site in the Trinity Alps is thought to have comparable numbers (Pope et al. 2014).

Overall, Cascades frogs have not seen the dramatic declines in the Klamath Mountains that has been noted in the southern Cascades, but small populations and some extirpations are cause for concern (Pope et al. 2014).

### Population Trends

In the southern Cascades/Lassen area, Cascades frog populations have declined greatly and gone from being abundant historically to very rare. The species appears to be extirpated from Lassen Volcanic National Park. Despite multiple extensive surveys, only 12 remaining sites in the Lassen area support Cascades frogs, all of them with low numbers of frogs. Population viability at these sites is a concern because each of these populations is slowly declining. Half of the remaining Lassen area populations are at risk of extirpation while the others are likely to continue declining. Pope et al. (2014) concluded that without active management, some of the remaining populations may disappear within 10 years and the rest will be at risk of extirpation.

In the Klamath Mountains, Cascades frogs are still widespread and fairly abundant. However, there have been some recent extirpations. At most sites recently surveyed in the Klamath Mountains, frog populations have been small and frog abundance at some previously robust populations has clearly declined. Populations in the eastern portion of the region in the Castle Crags Wilderness and the Klamath National Forest may be particularly at risk owing to low population numbers and more sites where frogs have recently disappeared.

### Documented Range Contraction

Severe range contractions have been documented in the southern end of the Cascades frog's range (Fellers and Drost 1993; Jennings and Hayes 1994a). Jennings and Hayes (1994a) and Fellers and Drost (1993) estimate that Cascades frogs are extirpated from about 99 percent of their southernmost population clusters in Mount Lassen and surrounding areas, and 50 percent of their total historical distribution in California. Since that time, further range contractions have occurred (Fellers et al. 2008). The historic range of the Cascades frog might have once included much lower altitudes (Leonard et al. 1993).

## THREAT FACTORS

### Airborne Contaminants

Agrochemicals are a threat to Cascades frog survival, and pollution from pesticides and other agrochemicals has likely contributed to Cascades frog population declines seen in some regions (Davidson et al. 2002; Davidson 2004; Fellers et al. 2004). In California, the transport of agrochemical pollution from the Central Valley to the Sierra Nevada and southern Cascades has been well documented (Aston and Seiber 1997; Datta et al. 1998; McConnell et al. 1998; Lenoir et al. 1999; Davidson et al. 2002; Davidson 2004; Hageman et al. 2006; Bradford et al. 2010; Pope et al. 2014). An annual average of 168 million pounds of pesticides was used between 1998 and 2014 in agricultural areas in

California (primarily in the Central Valley) (CDPR 2017). Where Cascades frogs had mostly disappeared in the Lassen region, about four times as much agricultural land use can be found upwind compared to where frog populations are still present (Pope et al. 2014). However, no significant pattern was found in pesticide concentrations compared between Cascades frog populations in the Klamath Mountains and Southern Cascades (Davidson et al. 2012; Pope et al. 2014). Regardless, Chlorpyrifos, Dacthal, and Endosulfans, banned organochlorines, and polycyclic aromatic hydrocarbons (PCBs) were found in frog tissues collected within the range of the Cascades frog (Davidson et al. 2012; Pope et al. 2014).

Paulk and Wagner (2004) found that glyphosate and malathion significantly affect Cascades frog larval mortality and development at levels below EPA-recommended maximum levels for surface water. In addition to impaired growth and development, deformities, and behavioral alterations that have been documented in amphibians as a result to pesticide exposure, these chemicals may be interacting with other environmental stressors to exacerbate the impacts of disease and invasive species (Davidson et al. 2007; Blaustein et al. 2011; Pope et al. 2014). Pesticides could be weakening frogs' immune systems and facilitating chytrid outbreaks (Bradford et al. 2011; Bruhl et al. 2011).

Fertilizers such as urea likely pose a threat; in laboratory studies, juvenile Cascades frogs were unable to sense and avoid toxic levels (Hatch et al. 2001). Nitrites can affect behavior and metamorphosis of frog larvae (Marco and Blaustein 1999).

The risk factor to Cascades frogs in California from airborne contaminants is thought to be low, but complex interactions may exist between contaminants and other stressors that have not been thoroughly examined (Pope et al. 2014). Such indirect effects would likely be strongest in low- to mid-elevation habitats downwind of agricultural areas (Pope et al. 2014).

### Climate Change

Climate change is a major threat to Cascades frogs. Higher average temperatures, varying precipitation patterns, and alterations in disturbance regimes such as fire are already affecting many wildlife species across North America, including Cascades frogs (Root et al. 2003; Parmesan 2006; Chen et al. 2011; Case et al. 2015). As ectothermic animals, all aspects of amphibians' life history are strongly influenced by the external environment, particularly temperature and moisture.

Most climate change research that analyzes the impacts on wildlife species have focused on physiological sensitivities, projected range shifts, and changes in phenology (Parmesan and Yohe 2003; Chen et al. 2011; Pinsky et al. 2013; Case et al. 2015), but Case et al. (2015) argue that more emphasis should be placed on ecosystem responses to climate change, thus better understanding how species dependent on those ecosystems may be impacted. Case et al. (2015) determined that out of the four taxonomic groups and 195 species they studied in the Pacific Northwest, amphibians and reptiles were on average the most sensitive to climate change, largely due to the fact that 90 percent of the 20 amphibians and reptiles studied were identified as having at least one highly sensitive habitat upon which they depended. Among studied amphibians was the Cascades frog, which had a sensitivity score of 77 (out of a potential range of 14-100, with a higher number indicating a higher sensitivity) and an average confidence in that score of 4 out of 5 (Case et al. 2015). For context, the overall average sensitivity score for reptiles and amphibians was 76 (Case et al. 2015). Similar to the other studied amphibians of the Pacific Northwest, Cascades frogs depend on seasonal wetlands which are sensitive to climate-driven changes in hydrology (Case et al. 2015).

Numerous studies have documented climate-associated shifts in amphibian phenology, range, and pathogen-host interactions (Corn 2005; Blaustein et al. 2010; Li et al. 2013), with emerging evidence for climate change-related population declines (Lowe 2012; Rohr and Palmer 2013). Li et al. (2013) reported the results of 14 long-term studies of the effects of climate change on amphibian timing of breeding in the temperate zone of the U.S. and Europe. This meta-analysis indicated that more than half of studied populations (28 of 44 populations of 31 species) showed earlier breeding dates, while 13 showed no change, and 3 populations showed later breeding dates, where spring-breeding species tended to breed earlier and autumn-breeding species tended to breed later. Several studies indicate that shifts in timing of breeding can have fitness and population-level consequences. For example, amphibians that emerge earlier in the spring can be vulnerable to winter freeze events or desiccation if they arrive at breeding sites prior to spring rains (Li et al. 2013).

Climate-associated shifts in amphibian ranges can be particularly problematic for restricted range and high-elevation species that have specific habitat requirements and limited options for movement (Li et al. 2013). As greenhouse gas emissions continue to grow, studies project high turnover of amphibian species as habitats become climatically unsuitable. For example, Lawler et al. (2014) projected 50 percent or greater climate-induced turnover of amphibian species in many regions of the U.S. by the later part of the century.

Cascades frogs thrive in montane wetland habitats, where habitat diversity and life histories of wetland species are adapted to and sorted by coarse hydrologic gradients (Ryan et al. 2014; Lee et al. 2015). Because these habitats are naturally variable, they are extremely vulnerable to climate change (Ryan et al. 2014; Lee et al. 2015). Specifically, “hydrologically intermediate ponds” - which hold water in most years but may occasionally dry up during droughts – provide the best habitat for Cascades frogs and will become less available to them as the distribution and composition of montane wetlands in the Pacific Northwest are significantly altered by climate change (Ryan et al. 2014; Lawler et al. 2014; Lee et al. 2015).

Most of the factors that determine the condition of montane wetlands – snowpack volume, runoff, direct precipitation, and evapotranspiration – are projected to change in the western U.S. over the next century (Hamlet et al. 2005; IPCC 2007; Ryan et al. 2014). Snowpack has become a particular concern in recent years, and it is estimated to have declined by more than 50 percent over the last half century (Hamlet et al. 2005; Mote et al. 2005; Ryan et al. 2014). Climate projections indicate a significant reduction in the range of snow-dominated landscapes in most of the western U.S., with the exception of regions with much higher elevations such as the Rockies (Klos et al. 2014). Additionally, snowmelt runoff and peak water availability is occurring earlier in the spring, and soil moisture is receding (Hamlet et al. 2007; Ryan et al. 2014). As temperatures continue to increase in all seasons and summer precipitation decreases, mountain snowpack will continue to decrease while evapotranspiration and soil-moisture stress increases in late summer months (Lee et al. 2015). Projections of climate impacts on wetlands in the Pacific Northwest show that many ephemeral wetlands will likely disappear, and more than half of the intermediate montane wetlands will become ephemeral wetlands by the 2080s (Lee et al. 2015).

In the Cascades Range, wetland drawdown is occurring earlier and faster, water availability is greatly reduced, complete drying is occurring more often, and summers have longer dry periods (Ryan et al. 2014). These changes, and the changes likely to happen in the future explained above, will reduce habitat availability and recruitment, and cause declines or extinctions in some regions for wetland-reliant amphibians and their invertebrate prey (Walls et al. 2013; Ryan et al. 2014; Lee et al. 2015). In addition to the direct loss of breeding grounds through wetland drying, Cascades frogs may experience a decrease in larval densities, a change in size at metamorphosis, and reduced recruitment success through an increase in water temperatures and changes in timing of water availability, especially since Cascades frog tadpoles metamorphose within a single summer (Smith 1987; Semlitsch et al. 1988; Walls et al. 2013; Lawler et al. 2014; Lee et al. 2015). Cole and North (2014) found that the number of pools and the distance to the nearest lake are among the most important environmental factors that determine the presence of Cascades frogs.

Climate change has also been implicated in stimulating the emergence of infectious amphibian diseases at the local and global scale. Increases in climate variability and extreme weather events resulting from climate change appear to provide an advantage to pathogens such as chytridio-mycosis (chytrid fungus), which is driving amphibian declines worldwide (Li et al. 2013; Raffel et al. 2013). Raffel et al. (2013) found a causal link between increased temperature variability and chytrid-induced mortality in frogs, which in the context of other studies linking chytrid outbreaks to temperature shifts, provides compelling evidence for a climate-change role in amphibian mortality from chytrid fungus (Li et al. 2013). Several recent studies indicate a role of climate change in amphibian population declines, in combination with other stressors (Lowe 2012; Rohr and Palmer 2013).

For all these reasons, climate change threatens the survival of Cascades frogs, which were found to be at the highest risk of climate-induced declines among three common northwest amphibians (Lawler et al. 2014). Scientists are especially concerned about the adaptability of this species in the face of climate impacts because the loss of high elevation, intermediate wetlands will force the frogs to move to larger, deeper lakes that likely have introduced predators, a factor known to decrease the abundance and survival rates of the Cascades frog (Ryan et al. 2014). Climate impacts are likely to also interact with other threats such as disease and pollution (Lee et al. 2015).

The current drought in parts of the Pacific Northwest provides an analog for what is predicted under climate change projections. Already, scientists have observed near complete reproductive failure at monitored Cascades frog sites due to ponds drying early, and many of these ponds are ones that do not usually dry at all. Even dead adults have been observed (Dr. Maureen Ryan, personal communication).

The risk factor to Cascades frogs in California from climate change is potentially high, particularly for populations that breed in ephemeral waters (Pope et al. 2014). More frequent weather extremes could increase in the probability of Cascades frog extirpations (Pope et al. 2014). This risk is greatest in the southern Cascades where the species is already rare and, therefore, highly susceptible to environmental stochasticity (Pope et al. 2014).

### Disease

*Batrachochytrium dendrobatidis* (Bd) is a fungal pathogen that causes the disease chytridiomycosis in amphibians. The rate of infection and mortality it has caused in amphibians worldwide has been described as 'the most spectacular loss of vertebrate biodiversity due to disease in recorded history' (Skerratt et al. 2007; Piovia-Scott et al. 2015). Adult amphibians infected with chytrid exhibit symptoms such as lethargy and reluctance to flee, skin abnormalities, loss of righting reflex, and extended back legs (Fellers et al. 2001). In tadpoles infected with chytrid fungus, jaw sheaths and tooth rows are abnormally formed or lack pigment, and this type of deformity likely inhibits tadpole foraging ability (Fellers et al. 2001). The effect of Bd on individual species, however, is considerably variable and often dependent on other environmental factors, including temperature, other environmental stressors such as predation pressures, pesticide exposure, and UV-B radiation (Pope et al. 2014; Piovia-Scott et al. 2015). Also, the virulence of different Bd strains may vary (Berger et al. 2005; Retallick and Miera 2007; Fisher et al. 2009; Farrer et al. 2011; Gahl et al. 2012; Piovia-Scott et al. 2015).

Cascades frogs are susceptible to Bd (Garcia et al. 2006; Piovia-Scott et al. 2015), and Bd occurs throughout the species' range (Adams et al. 2010; Piovia-Scott et al. 2011; Piovia-Scott et al. 2015). Bd exposure experiments resulted in significant mortality rates for Cascades frog metamorphs (Garcia et al. 2006), however declines in Cascades frogs in nature due to Bd are not universal (Piovia-Scott et al. 2011; Pope et al. 2011; Pope et al. 2014). The reasons why some populations infected with Bd dramatically suffer while others remain stable are not well known (Pope et al. 2014).

The decline of Cascades frog populations in parts of California is thought to be due to a particularly virulent strain of Bd (Fellers et al. 2008; Pope et al. 2014; Piovia-Scott et al. 2015). At Section Line Lake in the Klamath Mountains, where Cascades frogs were found to be infected with this viral strain, juvenile frog abundance decreased by more than 99 percent between 2009 and 2012. Whereas hundreds of juvenile frogs were observed at Section Line Lake in 2010, juvenile frog numbers dwindled to only 2 seen in 2012 (Piovia-Scott et al. 2015). Adult frogs began to decline at Section Line Lake three years following the collapse of juvenile abundance (Piovia-Scott et al. 2015). For this population, there was no evidence for other causes of decline such as predation or desiccation, and the high overwintering mortality is consistent with other declines associated with Bd infection (Piovia-Scott et al. 2015).

Regardless of the variation of susceptibility to Bd observed in Cascades frogs, the significant decline in Cascades frog populations in the southern portion of their range due to Bd and the prevalence of the disease throughout the species' range is cause for concern (Pope et al. 2014), especially given the finding that larger populations of Cascades frogs likely increase their resistance to the disease (Knapp et al. 2011; Pope et al. 2014). Efforts to increase Cascades frog population sizes, by removing predatory trout, for example, are crucial to ensuring their survival in light of the spread of Bd (Pope et al. 2014).

Chytrid was detected at 64 percent of sites surveyed in the Klamath Mountains of California and Cascades frogs were often infected (Piovia-Scott et al. 2011). While Cascades frogs have experienced increased mortality from exposure to the fungus in laboratory experiments (Garcia et al. 2006; Piovia-Scott et al. 2011), the current impact on wild frogs is unclear as many infected frogs appear asymptomatic (Gaulke et al. 2011) and many extant populations appear to be coexisting with the pathogen (Piovia-Scott et al. 2011).

Other infectious diseases present challenges to Cascades frog survival as well. *Saprolegnia ferax*, a species of water mold that commonly infects fish, can spread to amphibians, and has caused die-offs of Cascades frogs in Oregon (Blaustein et al. 1994; Kiesecker and Blaustein 1997; Pope et al. 2014). Romansic et al. (2007) found that juvenile Cascades frogs exposed to *Saprolegnia* had significantly greater rates of mortality than unexposed controls. Prevalence of *Saprolegnia* has increased due to movement of hatchery-raised fish (Blaustein et al. 1994; Bucciarelli et al. 2014), and because *Saprolegnia* strains have also been found to vary in virulence, introduced fish may transmit a strain more virulent to amphibians (Bucciarelli et al. 2014). The spread of *S. ferax* is especially concerning when combined with UV-B radiation (Kiesecker and Blaustein 1995; Pope et al. 2014), which is becoming more of an issue for Cascades frogs as climate change reduces the depth of wetlands and increases their exposure to the sun. Increased mortality has been documented in toad embryos from *Saprolegnia* infection during El Nino/Southern Oscillation events which decreased winter precipitation and snowpack, thus increasing exposure to UV-B radiation (Kiesecker et al. 2001; Bucciarelli et al. 2014).

Antifungal drugs such as itraconazaole and terbinafine hydrochloride have been used to treat Bd diseased frogs with some success (Berger et al. 2010; Bowerman et al. 2010). Among the most promising treatments is application of anti-Bd bacteria such as *Janthinobacterium lividum* to the skin of frogs to help protect them from the disease (Harris et al. 2009). Hardy et al. (2015) found some success with treatment of Bd in wild-caught Cascades frogs from the Cascades Mountains with the antifungal drug itraconazole. Bd prevalence was low at the time of treatment and did not differ between treated frogs and controls immediately following treatment, but following release, Bd prevalence gradually increased in controls but not in treated frogs, with noticeable differences 3 weeks after treatment and strong differences 5 weeks after treatment (Hardy et al. 2015). Recaptures of frogs from this population the next year suggested that over-winter survival was higher for treated frogs. The itraconazole treatment did appear to reduce frog growth rates: treated frogs weighed 22 percent less than control frogs 3 weeks after treatment and were 9 percent shorter than control frogs 5 weeks after treatment (Hardy et al. 2015). Hardy et al. (2015) concluded that itraconazole treatment can be effective against Bd infection in wild amphibians, and that the beneficial effects on survivorship may outweigh the detrimental effects on growth. Though these results are encouraging, attempting to treat entire wild populations would be highly resource intensive.

The risk factor to Cascades frogs in California from disease is high, since *Chytridiomycosis* is present in Cascades frog populations across the range in California (Pope et al. 2014). Although extant populations appear to be coexisting with the pathogen in the short term, it appears that Bd is significantly reducing juvenile frog survival in many populations (Pope et al. 2014). Reduced recruitment resulting from the disease increases extinction risk for the Cascades frog (Pope et al. 2014).

### Fire Suppression

Fire-suppression activities in California may negatively affect Cascades frogs. The effects of fire suppression activities on amphibians have not been well studied, so most evidence is anecdotal (Pilliod et al. 2003). Fire-suppression impacts have the potential to be strong in the southern Cascades. Pope et al. (2014) concluded that the risk of negative impacts to Cascades frogs from fire-suppression activities is potentially high for Lassen National Forest populations, primarily because so few populations and animals remain. However, in the Klamath Mountains the Cascades frog primarily occurs within subalpine aquatic habitats with long fire return intervals and in wilderness areas where fire suppression activities are less than in areas where they are closer to the wildland-urban interface. Fire suppression activities do occur regularly in the frog's lower elevation forested habitats outside of wilderness areas, and potential direct impacts include water drafting from ponds and streams, application of fire retardant, and construction of fuel breaks. These activities could also produce changes in aquatic and riparian habitats via sedimentation changes, alteration in down woody debris, and reduction (producing both positive and negative effects) in amounts of vegetation associated with the habitat.

Only anecdotal evidence is available specific to Cascades frogs for any of these activities. In June 2008, northern California was struck by a severe dry lightning storm that started more than 2,700 fires. With dry conditions and heavy fuel loads, several strikes turned into major fires, including those in the Marble Mountains Wilderness, Trinity Alps Wilderness, and Lassen National Forest. In the Marble Mountains and Trinity Alps, no known Cascades frog populations were harmed because fire suppression activities occurred in lower elevations and wilderness edges, and the fires only patchily burned inside the areas where the majority of the frog populations are found. On the Lassen National Forest, fires got close to two southern populations of Cascades frogs and a fire line was placed on the ridge above one meadow population. In the following 3 years, no noticeable damage occurred to the frog population or its habitat from the fire suppression activities that occurred in the area. Fire crews and other fire personnel attempt to minimize impacts to aquatic and semiaquatic species and their habitats, but inadvertent impacts can occur. During the severe 1987–1991 drought in California, fire suppression personnel in the Sierra Nevada were forced to take water from locations where aquatic amphibians and reptiles had often concentrated.

The construction of fire lines or firebreaks by firefighters using hand tools or machinery such as bulldozers may be extensive and result in habitat changes similar to those associated with road and road construction. Fire line or firebreak restoration features, such as water bars and revegetation, may mitigate erosion rates and roadlike effects (Pilliod et al. 2003). Sedimentation may be the most detrimental roadlike effect of firelining on amphibians, as unpaved roads are responsible for greater increases in sediment mobility and erosion than either logging or fire per se (Rieman and Clayton 1997). Mechanized equipment is not a permitted activity in wilderness areas for fire suppression.

Application of retardant has become an important wildlife issue (Pilliod et al. 2003). In large wildfires, large amounts of ammonia-based fire retardants and surfactant-based fire-suppressant foams are dropped from air tankers and sprayed from fire engines to slow or stop the spread of fire. Some fire-suppressant cocktails are toxic or hazardous to aquatic organisms (Buhl and Hamilton 2000, Gaikowski et al. 1996, MacDonald et al. 1996). Concerns regarding the effects of aerial application of fire retardant on aquatic systems and threatened, endangered, or candidate species were addressed in the Forest Service Chief's Record of Decision (USDA 2011). This directs tanker pilots to avoid aerial application of retardant or foam within 91 m of waterways. A "waterway" is considered to be any body of water including lakes, rivers, streams, and ponds irrespective of whether they contain aquatic life. This is considered binding direction, subject to qualifications and exceptions only as noted in the Decision Notice. However, accidental contamination of aquatic habitats can and has occurred, especially from aerial applications (Minshall and Brock 1991). For example, during fire-suppression activities, a direct "hit" of fire-retardant was dropped adjacent to the Buck's Lake Wilderness in a small mountain yellow-legged frog breeding pond. No studies occurred to determine the effects, but there was a noticeable decline in the tadpoles within this pond (Hopkins, pers. comm. 2007, as cited in Pope et al. 2014).

Successful forest fire suppression over the past century has resulted in dense forests with very high fuel loads. The Forest Service initiated a program of active management to reduce fuel loading in an effort to reduce the intensity and extent of wildfires. Catastrophic fire can produce some of the most intensive and extensive changes in watershed condition of any disturbance (Kattelmann 1996). In addition, dense forests reduce snowpack on forested slopes and take up water for transpiration, resulting in reduced water yields downslope (Kattelmann 1996). These indirect large-scale effects of fire suppression can affect Cascades frog habitats by decreasing water input, altering peak flows, and increasing sediment yield.

The risk factor to Cascades frogs in California from fire suppression is unlikely to be high where frog habitat occurs in wilderness and high-elevation areas with sparse vegetation, where fire-suppression activities are rarely conducted and mechanized equipment is not used (Pope et al. 2014). However, the risk is potentially high for Lassen National Forest frog populations primarily because so few populations and animals remain (Pope et al. 2014).

### Habitat Loss and Alteration

Activities such as vegetation and fuels management, water development and diversion, and mining, as well as impacts from roads, have the potential to degrade or destroy suitable habitat within the California range of the Cascades frog. Most of these factors pose relatively low or moderate risk for Cascades frogs (Pope et al. 2014).

Vegetation management on national forest lands outside of wilderness areas, such as timber harvest, fuels management, salvage logging, and prescribed fire, pose a risk to Cascades frogs (Pope et al. 2014). Changes in vegetation, shade, and woody debris can alter breeding, active-season, refuge, and overwintering habitat quality for Cascades frogs; and changes in vegetation can also influence soil stability, erosion, and sediment loading to aquatic habitats (Pope et al. 2014). The effects of controlled burns for fuel reduction on Cascades frogs are poorly understood (Pilliod et al. 2003). Cascades frogs are thought to be losing suitable habitat in Lassen Volcanic National Park in part due to fire suppression and drought, which has increased the natural invasion of shrubs and trees into open meadows, so that former open frog breeding sites are now clogged with vegetation (Fellers and Drost 1993). Some of the Cascades frog range is on granitic soils, so improperly implemented prescribed burning could be risky because erosion rates of burned areas on such soils can be 66 times as great as in undisturbed watersheds, and can elevate annual sediment yields for 10 years or more (Megahan et al. 1995). Prescribed fire could benefit Cascades frogs if it reduced the risk of future high-intensity wildfire or reduced encroachment of woody vegetation into meadows that provide aquatic habitat for frogs.

Water developments, such as dams and diversions, can radically change aquatic habitats and are a prominent component of the landscape in the Sierra Nevada Forest Planning Area (Harris et al. 1987, Moyle and Randall 1998) and Klamath Mountains. Dams can raise the levels of existing lakes or ponds or flood meadow habitat, eliminating or in some cases creating Cascades frog habitat. Diversions may alter the hydrology and water retention at a site potentially affecting frog breeding. Although most major water development and diversions occur at lower elevations (Moyle and Randall 1998), some water developments for hydroelectric power generation and water storage also exist in higher elevation areas that overlap with the Cascades frog range (Pope et al. 2014). Major water projects within the southern Cascades that overlap with the Cascades frog's range are limited in the Pit River system and North Fork Feather River (e.g., Lake Almanor, Butt Valley Reservoir). Smaller water projects are located within the West Branch Feather River watershed (e.g., Snag Lake and Philbrook Lake). Major water projects within the Klamath Mountains include Shasta Dam on the upper Sacramento River and Trinity Dam on the and upper Trinity River. About 15 small lakes and meadow systems in the known historical range of the Cascades frog in California have some form of hydrological development. The majority of these consist of small dam structures to raise the water level of an existing water body (e.g., Gumboot Lake). Although existing dams and water diversions are not a widespread risk for Cascades frogs, local impacts from dams and diversions can be significant and permanent (Pope et al. 2014).

Suction-dredge gold mining of streams and rivers increases suspended sediment, rearranges stream substrate, changes stream geomorphology, and can directly trap or kill aquatic organisms including Cascades frogs (CDFG 2011). Since 2009, all California instream suction dredge mining has been suspended with the passage of SB 670. The legacy effects of historic hydraulic mining include alteration of stream geomorphology and release of pollutants such as acid, cadmium, mercury, and asbestos in waterways (Larson 1996). Although hydraulic mining has long been banned, legacy effects on water quality may still be apparent in portions of the mid-elevation Pit and Feather River systems within the range of Cascades frogs (Pope et al. 2014).

Although most populations of Cascades frogs are not likely to be affected by roads directly, indirect effects to their habitats and dispersal ability may be significant (Pope et al. 2014). Roads can alter soil density, temperature, soil water content, light, dust, surface-waterflow, pattern of runoff, and sedimentation (Trombulak and Frissell 2000). Roads may also serve as barriers to frog movement. Six major highways (Interstate 5 and Highways 32, 36, 44, 89, and 299) partly or completely fragment portions of the Cascades frog range in California. Roughly 62 percent of the Cascades frog range occurs on national forest lands that contain a total of 115 km of paved roads, 258 km of gravel roads, 1,714 km of dirt roads, and 300 km of trails (USDA 2001b). Road crossings of water courses may block in-channel migrations and dispersal events because culverts are too steep, become blocked by debris, or become disconnected from the streambed. Barriers or partial barriers as a result of fragmentation may have a strong effect on populations of Cascades frog if they operate as metapopulations (Bradford 1991). Barriers, such as roads, could prevent recolonization of locations where extirpations have occurred. Risks to Cascades frogs from roads associated with population isolation and habitat alteration are expected to be moderate on private lands and on the Lassen and Klamath national forests, and low in Lassen Volcanic National Park and wilderness areas in the Klamath Mountains (Pope et al. 2014).

### Introduced Fish

Cascades frogs are threatened by introduction of fish into historically fishless habitats (Knapp and Matthews 2000; Knapp 2005; Welsh et al. 2006). Cascades frogs have suffered population declines as a result of non-native fish stocking due to high levels of predation and competition (Knapp et al. 2003; Welsh et al. 2006; Morgan et al. 2007; Piovia-Scott et al. 2011; Hartman et al. 2013; Cole and North 2014; Pope et al. 2014). Because most montane species are unable to adapt to the presence of nonnative fish (Knapp et al. 2001; Ryan et al. 2014), fish introduction often leads to a direct loss of range in amphibian species, and this is true of the Cascades frog.

Nonnative trout and other salmonids occupy 95 percent of large mountain lakes and 60 percent of smaller ponds and lakes in the western U.S. that were formerly fishless (Bahls 1992; Ryan et al. 2014). The widespread introductions of these species have had severe consequences on ecosystem functions and native species assemblages (Bradford 1989; Knapp and Matthews 2000; Knapp et al. 2001; Schindler et al. 2001; Knapp 2005; Welsh et al. 2006; Ryan et al. 2014; Pope et al. 2014). The impacts that introduced trout have on amphibians are particularly severe (Pilliod and Peterson 2001; Vredenburg 2004; Hartel et al. 2007; Hartman et al. 2013). The stocking of predatory fishes has contributed to the endangered status of two other high elevation Ranid frogs in California, the mountain yellow-legged frog (*Rana muscosa*) and Sierra Nevada yellow-legged frog (*Rana sierrae*) (Ryan et al. 2014)

Introduced fishes alter amphibian assemblages through multiple mechanisms. Introduced fish and native species compete for resources such as invertebrate prey (Finlay and Vredenburg 2007; ICF Jones and Stokes 2010; Bucciarelli et al. 2014). Adult Cascades frogs that co-occurred with introduced trout were found to have smaller proportions of aquatic invertebrate prey in their stomachs than frogs that live in areas without trout (Joseph et al. 2011; Bucciarelli et al. 2014). Introduced fish may also prey directly upon native amphibians, driving population declines (Simons 1998; Finlay and Vredenburg 2007; ICF Jones and Stokes 2010; Bucciarelli et al. 2014). Where trout were present Cascades frog tadpoles were most often found in shallow, vegetated areas that serve as a refuge from the fish (Hartman et al. 2013). In some cases, the presence of nonnative fish has also allowed for the increase in prevalence of other predators. For example, in the Klamath Mountains, the Pacific coast aquatic garter snake was able to expand its range as a result of more prey availability (introduced fish) thus facilitating opportunities to also prey upon Cascades frogs, exacerbating their declines (ICF Jones and Stokes 2010).

In the Klamath-Siskiyou region of northwestern California, Welsh et al. (2006) found that Cascades frog distribution negatively correlates with fish distribution, and that larvae occurred 3.7 times more frequently in lakes without trout. Garwood and Welsch (2007) found summer Cascades frog densities to be 6.3 times higher in a stream lacking trout than at a similar stream with high densities of brook trout. Pope (2008a) found that within three years of fish removals from three lakes, Cascades frog densities increased by a factor of 13.6. In addition, the survival of young adult frogs increased from 59 to 94 percent, and realized population growth and recruitment rates at the fish-removal lakes were more than twice as high as the rates for fish-free reference lakes and lakes that contained fish (Pope 2008a).

In a species assemblage study of the Klamath Mountains, nonnative trout had an exclusively negative correlation with Cascades frog occupancy (Cole and North 2014). This study determined that nonnative trout presence was one of the most important factors in determining Cascades frog distribution (Cole and North 2014). At higher elevations where trout were absent, assemblages were dominated by Cascades frogs (Cole and North 2014). In the context of climate change, the frog's inability to co-exist with nonnative fish, which now occupy the majority of large ponds, lakes, and streams within the species range, is especially troubling. As higher elevation, intermediate wetlands dry up due to a lack of snowpack in the western U.S., Cascades frogs will be forced to move to areas likely occupied by fish. The shallow refuges that protect tadpoles from fish will likely also dry up, forcing the species into deeper waters with predators that it has no defenses from (Ryan et al. 2014; Pope et al. 2014).

The declines of Cascades frog populations as well as two other native amphibians in California led to a successful lawsuit that ruled that the California Department of Fish and Wildlife must consider the impacts of fish stocking on the environment and native ecosystems (Knapp and Matthews 2000; Vredenburg 2004; Welsh et al. 2006; Hartman et al. 2013). The resulting Environmental Impact Statement (ICF Jones and Stokes 2010) concluded that the impacts of nonnative trout on Cascades frogs were "potentially significant." There are 175 trout stocking locations within the range of the Cascades frog in California (ICF Jones and Stokes 2010). Although new stocking has since ceased in areas known to support Cascades frogs (ICF Jones and Stokes 2010; Pope et al. 2014), many populations of stocked fish are likely self-sustaining (Pope et al. 2014). The majority of large and deep lakes in the Klamath Mountains and southern Cascades support nonnative populations of brook trout (*Salvelinus fontinalis*) or rainbow trout (*Oncorhynchus mykiss*) (Welsh et al. 2006; Pope et al. 2014).

Fish removal and the restoration and protection of wetlands that do not already contain fish are likely the most important actions needed to recover and protect Cascades frogs throughout their range (Cole and North 2014), especially when faced with other, less manageable, threats such as climate change and disease (Ryan et al. 2014). Previous fish removals have resulted in the rapid recolonization of native amphibians and invertebrates (Drake and Naiman 2000; Knapp et al. 2005; Ryan et al. 2014), including the Cascades frog (Pope 2008a; Pope et al. 2014). Survival, recruitment, and population densities of Cascades frog all rapidly increased when fish were removed from lakes in the Klamath Mountains (Pope et al. 2014).

The risk factor to Cascades frogs in California from introduced fish and other predators is high and widespread, since introduced fish are found over most of the California range of the species and are known to affect presence and densities of Cascades frogs (Pope et al. 2014). Fish introductions across most of its California range coupled with evidence of a fish effect in the Klamath Mountains strongly implicates fish as a contributor to frog declines in the southern Cascades (Pope et al. 2014). Risks associated with the interactive effects of fish and other stressors, such as climate change and disease, may also be high (Pope et al. 2014).

### Livestock Grazing

Livestock grazing has been considered the most widespread influence on native ecosystems of western North America (Fleischner 1994; Kattlemann 1996). Seasonal grazing of sheep and cattle across the mountains of California has occurred since the early 1800s and continues today, except in national parks (Fleischner 1994; Menke et al. 1996). Researchers have found widespread negative impacts from livestock grazing, including loss of native species, changes in species composition, alteration of hydrology including lowered water tables, soil deterioration, degradation of fish and aquatic insect habitat, and changes in ecosystem structure and function (Kauffman and Krueger 1984; Fleischner 1994; Belsky et al. 1999; Flenniken et al. 2001). The negative impacts of livestock grazing on high elevation wetland ecosystems and Ranid frog habitat include reducing vegetative cover, creating excess nitrogen pollution, increasing siltation of breeding ponds, and altering the local hydrology through erosion (Jennings 1988, 1996; Jennings and Hayes 1994). Where historical grazing has resulted in channel incision and lowered water tables, Cascades frogs may be affected by less available breeding habitat and shorter hydroperiods (Pope et al. 2011), but these long-term effects are difficult to quantify. Short-term direct impacts such as trampling and local water quality degradation are also a concern, especially in the southern Cascades where populations are small (Pope et al. 2014).

Although livestock distribution and numbers on public lands have been reduced dramatically compared to historical numbers, livestock grazing currently still occurs throughout much of the range of the Cascades frog. One recently discovered occupied Cascades frog site in Childs Meadow includes a portion of the Lassen National Forest that is currently grazed, but exclusion fencing is planned for around the breeding pool (Foote, pers. comm. 2012, as cited in Pope et al. 2014). Meadow sites occupied by Cascades frogs on private lands both north and south of Lassen Volcanic National Park in the southern Cascades are still grazed by livestock. Much of the Cascades frog range in the Klamath Mountains is still grazed, although portions of the wilderness areas are inaccessible by cattle or are not permitted for grazing.

Minimal data exists on the impacts of livestock grazing on Cascades frogs. A research team in the Sierra Nevada recently assessed the short-term impacts of grazing on Yosemite toads (*Anaxyrus canorus*) through a 5-year exclosure experiment over nine meadows (Allen-Diaz et al. 2010; Lind et al. 2011; Roche et al. 2012). The researchers did not detect differences between grazed and ungrazed meadows in survival or abundance of Yosemite toads and saw no improvement in toad breeding habitat quality after cattle were removed from meadows (Lind et al. 2011; Roche et al. 2012). However, these studies had major limitations and the U.S. Fish and Wildlife Service commented extensively on why conclusions about grazing impacts should not be drawn based on the results (USFWS 2014, pages 24290-24291). Also, although Yosemite toads breed in aquatic habitats within meadows similar to those of Cascades frogs, they differ in that after breeding and metamorphosis, toads leave aquatic habitats and move into nearby upland habitats (Liang 2010), so conclusions about lack of impacts to toads may not be assumed for Cascades frogs.

The risk factor to Cascades frogs in California from livestock grazing is thought to be low, because livestock use has not been permitted for more than 10 years in most breeding habitats on public lands in the Lassen region where sensitive frog populations occur, livestock numbers have been reduced on other public lands across the range, and recent studies have not found significant evidence of direct effects on meadow-associated amphibian population numbers (Pope et al. 2014). However, livestock grazing is still fairly widespread throughout the California range of the Cascades frog, and even minimal effects such as trampling of a couple of adult frogs could be harmful to population persistence of some small populations in the southern Cascades (Pope et al. 2014). Legacy effects from grazing to riparian and wet meadow habitats are likely extensive, especially in the southern Cascades and eastern Klamath Mountains, and some montane meadows in northern California have become too degraded and desiccated to support appropriate habitats for Cascades frogs (Pope et al. 2014).

**Recreational Activities**

The geographic range of the Cascades frog in California occurs primarily on public lands with about 5 percent on national park land and 62 percent on national forest lands (USDA 2001). About half of the range on national forest lands occurs within designated wilderness areas where recreational use is limited to non-motorized and dispersed activities such as hiking, backpacking, fishing, and camping. Outside the wilderness areas and national parks, recreational activities can include motorized activities such as off-highway vehicle use that have the potential for greater impact. About 33 percent of the historical range of the Cascades frog in California lies on private lands with restricted public recreation (owned by timber companies), but some private lands with camps and lodges support heavy recreational use.

To date, no studies have specifically examined the impacts of recreational activities on Cascades frogs. However, some information exists on the effects of selected recreational activities on the aquatic habitats also used by Cascades frogs. The mid to high mountain lakes, streams, ponds, and wet meadows inhabited by Cascades frogs receive a disproportionate amount of recreational use through trail networks, campsites, angling opportunities, and swimming. Establishment of trails and camps has been shown to disturb vegetation and soil structure, resulting in changes in habitat structure and microclimate (Garton et al. 1977; Boyle and Samson 1985; Knight and Cole 1991). Anglers often create shoreline trails for access to fishing spots even at remote wilderness lakes. These activities that occur near high-elevation meadows, ponds, lakes and streams can result in increases in pool sediments, modification of pool mudflats, erosion, bank trampling, and vegetation disturbance (Bronmark and Hansson 2002). Generally, studies have found that recreation impacts can happen rapidly even with light use, whereas recovery occurs only after lengthy periods of no use (Cole and Marion 1988).

Studies examining the effects of recreational packstock (usually horses and mules used to assist travel into the backcountry) grazing on alpine meadow habitat have found significant changes in meadow structure resulting from horse and mule grazing (Olson-Rutz et al. 1996a, 1996b; Moore et al. 2000; Cole et al. 2004). These changes in meadow condition may affect breeding habitat of Cascades frogs. Cascades frogs typically breed in small potholes in meadows or fens, and shallow areas of ponds and lakes. These shallows are especially prone to damage by trampling of hikers, packstock, or off-highway vehicles. Recreational activities may also result in direct mortality to Cascades frogs through trampling (see Bartelt 1998).

Recreational activities that reduce habitat quality or frequently disturb normal basking and feeding behaviors of Cascades frogs can increase the glucocorticoid stress hormones in the frogs. Long-term physiological effects of glucocorticoid exposure include the suppression of growth, reproduction, and immune system components (Moore and Jessop 2003). Stress hormones in amphibians are also elevated by exposure to *Bd* and cause increases in metabolic rates which are energetically costly (Peterson 2012; Wack et al. 2012). The interactive effects of *Bd* and environmental stress on amphibians are currently being studied and initial results suggest that stressed Australian green treefrogs (*Litoria caerulea*) experience lower energy stores and lower survival when exposed to *Bd* compared to unstressed frogs (Peterson 2012).

The risk factor to Cascades frogs in California from recreational activities is assumed to be low to moderate, since recreational use through most of the range of the Cascades frog is light and dispersed (Pope et al. 2014). However in high-use areas, such as lakes outside of wilderness areas with road access, recreational activities likely have measurable impacts to frogs and their habitats (Pope et al. 2014). Recreational impacts also act synergistically with other stressors to increase stress, which reduces the health and resilience of Cascades frogs (Pope et al. 2014).

**Small Population Sizes**

Montane habitats tend to promote strong genetic isolation among frog populations (Monsen and Blouin 2004), and small population sizes of already declining populations, such as in the Lassen area of California, reduces the species' long-term viability (Fellers et al. 2008). Cascades frogs are particularly vulnerable, and they exhibit extreme genetic isolation in relatively small geographic scales compared to other anurans, with reduced gene flow at distances starting at just 10 km (Monsen and Blouin 2004). This species spends over half the year in hibernation and given the limited amount of time that they are active, combined with their ephemeral habitat, it is not surprising long distance gene flow is rare in this species (Monson and Blouin 2004). These population dynamics make Cascades frogs vulnerable to not only genetic isolation (ODFW 2016) but also to chance events where local extirpations have a low likelihood of recolonization (Pope et al. 2014). For example, the recolonization of one historic Cascades frog site in Oregon was reported to have taken 12 years despite the presence of a population within 2 km (Blaustein et al. 1994; Pope et al. 2014). Adult frogs rarely move more than a couple miles (Monsen and Bouin 2004), and isolated sites are less likely to support Cascades frogs for the long term (Pope et al. 2014). Therefore, population recovery and habitat connectivity are important factors in ensuring the long term viability of Cascades frogs. Young and Clarke (2000) observed that the small size of, and lack of connectivity between, the current populations of the Cascades frog in the Lassen area greatly reduces their long-term viability, potentially leading to a genetic bottleneck.

## INADEQUACY OF EXISTING REGULATORY MECHANISMS

There are no existing regulatory mechanisms that provide adequate protection for the Cascades frog in California.

### Federal Regulatory Mechanisms

The Cascades frog is not currently protected under the federal Endangered Species Act (ESA). The Center for Biological Diversity petitioned for federal ESA listing for the Cascades frog in 2012 (CBD 2012). In 2015 the U.S. Fish and Wildlife Service found that the petition presented substantial information indicating that the petitioned action may be warranted, and initiated a status review of the species (USFWS 2015). However, according to the USFWS Listing Workplan, the agency will not make a 12-month finding on the petition until 2022 at the earliest (USFWS 2016). Other federal regulatory mechanisms that could potentially provide some form of protection for the Cascades frog include occurrence on federally protected land, or consideration under the National Environmental Policy Act. There are no federal Habitat Conservation Plans in California that cover the Cascades frog (USFWS 2017).

#### Occurrence in National Forests and National Parks

Populations of Cascades frogs in California occur in National Parks, National Forests and other federal lands, where their habitat is mostly protected from development. However, this does not necessarily protect Cascades frogs from harmful management activities or ensure their long-term survival. Adams et al. (2013) noted that amphibian declines are occurring on federally protected lands where management policies are designed to protect natural resources, with some of the greatest rates of declines occurring on National Park Service lands. Even on federal lands that are protected for ecological values, foothill yellow-legged frogs are not protected from threats such as drifting pesticides or impacts from nonnative predators. For example, although nonnative fish stocking has been halted in California where Cascades frogs occur (ICF Jones and Stokes 2010), there do not appear to be any current efforts to remove invasive fish that have already established self-sustaining populations within Cascades frog habitat on federal lands.

Within the range of the Cascades frog in California, management of National Forest lands fall under the direction of different land and resource management plans developed for the Lassen National Forest, Shasta-Trinity National Forest, and Klamath National Forest. Although management direction for aquatic areas differs slightly among the forests, all three forest plans include direction specific for management and protection of aquatic and riparian-dependent species, including habitat for the Cascades frog (Pope et al. 2014). In areas of national forest lands that are designated “multiple-use” management areas (e.g., most non-wilderness areas), riparian and aquatic ecosystems are supposed to receive special consideration through the designation of riparian management zones. Riparian management zones are land area allocations designated around all water bodies and fluvial systems to ensure riparian-dependent resources receive primary emphasis and serve to help maintain the integrity of aquatic ecosystems. In general, only activities that contribute to the maintenance or restoration of riparian-driven objectives and goals are permitted. However, these plans do not preclude timber harvest, road building, cattle grazing and other activities that have the potential to degrade Cascades frog habitat.

The Forest Service adopted the Sierra Nevada Forest Plan Amendment in 2001 after more than a decade of scientific study, to direct the management of 11.5 million acres of California's national forest lands in the Sierra. The Sierra Nevada Forest Plan Amendment represented a shift in Forest Service management to ecosystem management principles. The Sierra Nevada Plan's primary emphasis is on terrestrial species, but it also contains an Aquatic Conservation Strategy focused on reducing some threats to amphibians, including the Cascades frog. Some of these measures include changes to livestock grazing and exotic fish stocking practices. Yet at the same time, the plan contains proposed management activities (such as fire and fuels management) that may increase risk of habitat degradation for Cascades frogs. In addition, the Sierra Nevada Forest Plan Amendment has been under attack since its adoption, with ongoing efforts by legislators and industry to increase the amount of logging allowed, limit protections for forests, water quality and wildlife, and to weaken forest monitoring requirements by reducing the management indicator species lists that are tracked across Sierra Nevada national forests.

The Sierra Nevada Forest Plan Amendment also committed the Forest Service to complete a conservation assessment for the Cascades frog in cooperation with other federal agencies, state agencies, universities, and research scientists (USDA 2001a). The conservation assessment (Pope et al. 2014) was published in 2014. It is important to note that Conservation Assessments provide only management recommendations, not mandated habitat protections. The conservation assessment is envisioned to be the first of a three-phase process that also includes a conservation strategy and a conservation agreement. However, this process is moving far too slowly to provide prompt protection for Cascades frogs. The Conservation Assessment alone took more than a decade to produce.

The Pacific Southwest Region (Region 5) of the Forest Service includes the Cascades frog on its Sensitive Species List (USDA 1998). Forest Service policy is that "sensitive species" must receive special management emphasis to ensure their viability and to preclude trends toward endangerment that would result in the need for federal listing. Sensitive species cannot be affected without an analysis of significance of adverse effects on the populations, their habitat, and on the viability of the species in the area covered by the forest land and resource management plan. However, this designation as a "sensitive species" translates into little protection for individual frogs, frog populations or frog habitat. The designation merely requires that the impacts to the species be considered, but does not prevent agency actions, such as logging, road building, fire suppression, recreational activities, or cattle grazing, that could harm the species or its habitat. All Forest Service planned, funded, executed, or permitted programs and activities are reviewed under NEPA for possible effects on sensitive species, through a Biological Assessment and Evaluation. Yet the Forest Service can conclude in a Biological Evaluation that even though individual frogs or frog populations will be harmed or destroyed by an action, it can still carry out this action.

The one National Park within the California range of the Cascades frog, Lassen Volcanic National Park, has guiding principles, management goals and a management plan that are beneficial for protecting aquatic ecosystems and maintaining park ecosystems and native wildlife (NPS, 1999, 2006). The Resource Management Plan for Lassen Volcanic National Park (NPS 1999) recognizes that Cascades frog populations have declined in the park and provides management guidance relevant to Cascades frog conservation:

1. Maintain, rehabilitate, and perpetuate water and aquatic systems to preserve their inherent natural integrity.
2. Populations of endangered, threatened, and other species of concern are protected from population decline and are monitored sufficiently to detect significant changes in population trends.
3. The health of Lassen region ecosystems, of which park lands are only a part, will be preserved as a result of cooperative work among federal, state, and private entities.
4. Exotic animal species that have the potential to substantially disrupt native animal populations or plant communities are eliminated or controlled.
5. Extirpated animal species are, to the extent feasible, restored in accordance with NPS policy.

However, the Cascades frog is now extirpated from Lassen Volcanic National Park.

Fish stocking began in Lassen Volcanic National Park prior to the establishment of the park in 1916; a gradual phase-out was initiated in 1968; and fish stocking was discontinued at all sites within the park by 1992 (Stead et al. 2005). Because of the long history of stocking, it is unclear which park lakes and streams naturally contained fish, and what species of fish are native to each system. As of 2004, 16 percent (9 of 57) of the park's lakes still supported introduced trout fish (Stead et al. 2005).

#### National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) (42 U.S.C.4321-4370a) requires federal agencies to consider the environmental impacts of their actions. The NEPA process requires these agencies to describe a proposed action, consider alternatives, identify and disclose potential environmental impacts of each alternative, and involve the public in the decision-making process. Most actions taken by the federal agencies such as the U.S. Forest Service and National Park Service that could affect the Cascades frog are subject to the NEPA process. NEPA does not, however, prohibit these agencies from choosing alternatives that will negatively affect individual frogs, populations of Cascades frogs, or potential Cascades frog habitat. De facto evidence of NEPA's inability to protect the Cascades frog is that the species has declined precipitously in spite of the existence of NEPA for more than 45 years.

### State Regulatory Mechanisms

The state of California lists the Cascades frog as a "Species of Special Concern" (CDFW 2017a). However this status is an administrative designation which merely reflects the fact that the species is suffering population declines, but it does not afford any substantive or legal protection. There are no state Natural Community Conservation Plans in California that cover the Cascades frog (CDFW 2017b). Other state regulatory mechanisms that could potentially provide some form of protection for the Cascades frog include a state aquatic biodiversity strategy, and consideration under the California Environmental Quality Act.

#### Aquatic Biodiversity Strategy

The California Department of Fish and Wildlife has initiated a conservation strategy for maintaining aquatic biodiversity in high-elevation wilderness ecosystems. This strategy is aimed to protect and enhance native amphibian species while attempting to optimize recreational trout fishing opportunities (Garwood and Welch 2007). Starting in 1999, the

Department began implementing this conservation strategy in the Sierra Nevada Mountains through watershed-based management plans, but these plans are focused on mountain (and Sierra) yellow-legged frogs, not Cascades frogs (Garwood and Welsch 2007). Garwood and Welsch (2007) concluded that important differences between the ecology of Cascades frogs and mountain yellow-frogs make these watershed plans inadequate to fully protect Cascades frogs.

California Environmental Quality Act

The environmental review process under the California Environmental Quality Act ("CEQA", California Public Resources Code §§ 21000-21177) requires state agencies, local governments and special districts to evaluate and disclose impacts from "projects" in the state. CEQA declares that it is the policy of the state to prevent "the elimination of fish or wildlife species due to man's activities, ensure that fish and wildlife populations do not drop below self-perpetuating levels, and preserve for future generations representations of all plant and animal communities" (California Public Resources Code, section 21001(c)). The CEQA process is triggered when discretionary activities of state agencies may have a significant effect on the environment. When the CEQA process is triggered, it requires full disclosure of the potential environmental impacts of proposed projects. The operative document for major projects is usually the Environmental Impact Report.

Under CEQA, Species of Special Concern must be considered during the environmental review process, with an analysis of the project impacts on the species, only if they meet the criteria of sensitivity under Section 15380 of the CEQA Guidelines. However, project impacts to Cascades frogs would not need to be analyzed if project proponents are able to claim insignificant impacts to non-listed species, if the project does not have population-level or regional effects or impacts a small proportion of the species' range.

Theoretically, besides ensuring environmental protection through procedural and informational means, CEQA also has substantive mandates for environmental protection. The most important of these is the provision requiring public agencies to deny approval of a project with significant adverse effects when feasible alternatives or feasible mitigation measures can substantially lessen such effects. In practice, however, this substantive mandate is rarely implemented, particularly with regard to instream projects, water diversions, mining permits, grazing permits and projects causing pollution and sedimentation that have the potential to impact habitat for Cascades frogs. If significant impacts remain after all mitigation measures and alternatives deemed feasible by a lead agency have been adopted, a lead agency is allowed under CEQA to approve a project despite environmental impacts if it finds that social or economic factors outweigh the environmental costs. It is important to note that CEQA is not, nor was it ever intended to be, a habitat protection mechanism.

*Summary*: There are no existing federal or state regulatory mechanisms that adequately protect Cascades frog populations or habitat. Without state listing, significant conservation efforts for the Cascades frog, reintroduction of the species at unoccupied historic sites, and implementation of frog habitat enhancement methods are unlikely to occur.

## RECOMMENDED MANAGEMENT AND RECOVERY ACTIONS

*Invasive Fish Removal*: Begin trout removal in former and current high montane habitats for Cascades frogs in the Klamath Mountains and Lassen area, to increase the amount of fishless habitat available. Continue current state policy to not stock fish in waters supporting Cascades frogs.

*Investigate Treatments for Disease*: Experimentally research effectiveness of techniques to reduce mortality of juvenile frogs caused by Bd, such as bioaugmentation of anti-Bd skin microbes or the use of antifungal drugs. Determine the feasibility of treating wild populations.

*Modify Fuel Management and Livestock Grazing*: Determine the effects of vegetation and fuels management and livestock grazing on Cascades frogs and their habitat in Shasta-Trinity, Klamath and Lassen National Forests. Modify vegetation management practices and grazing leases to protect and restore frog habitat.

*Habitat Restoration*: Determine the effectiveness of restoration and habitat enhancement measures, such as modifying breeding pools, removing livestock from breeding habitats, thinning riparian vegetation in occupied streams to improve basking habitat, or thinning lodgepole pines adjacent to breeding pools in meadow habitats in the southern Cascades. Test methods and monitor Cascades frog populations pre- and post-treatments. Prioritize sites for targeted restoration actions and monitor their effects on frog populations.

*Restrict Pesticide Use*: Determine where and which pesticide uses should be restricted to prevent exposure and harm to Cascades frogs.

*Reduce Recreational Impacts*: In Shasta-Trinity, Klamath and Lassen National Forests, and Lassen Volcanic National Park, encourage diffuse recreation and limit camping at lakes inhabited by Cascades frogs, to reduce potential impacts of recreational activities on frogs.

*Consider a Captive Breeding Program*: Begin a captive breeding program for eventual reintroduction of Cascades frogs if local populations are extirpated.

*Reintroduction*: Explore reintroduction of Cascades frogs into appropriate habitat within the historical range of the species. Investigate the feasibility and options for translocation or reintroduction of captive raised frogs to historically occupied habitats, particularly in Lassen Volcanic National Park.

*Monitoring*: Institute a long-term, rangewide program to monitor remaining Cascades frog populations in California.

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**State of California**
**Department of Fish and Wildlife**

# Memorandum

**Date:** July 21, 2017

**To:** Ms. Valerie Termini
Executive Director
California Fish and Game Commission

**From:** Charlton H. Bonham
Director

**Subject: Evaluation of the Petition to List Cascades Frog (*Rana cascadae*) as Endangered or Threatened under the California Endangered Species Act**

The California Department of Fish and Wildlife (Department) has completed its evaluation of the Petition to list Cascades Frog as an endangered or threatened species (Petition) under the California Endangered Species Act, Fish and Game Code section 2050 et seq. The California Fish and Game Commission (Commission) received the Petition from the Center for Biological Diversity on March 1, 2017. Pursuant to Fish and Game Code section 2073, the Commission referred the Petition to the Department on March 6, 2017. On June 6, 2017, in accordance with Fish and Game Code section 2073.5, subdivision (b), the Department requested a 30-day extension to further analyze the Petition and complete its evaluation report. The Commission approved the request at its June 21st meeting, extending the due date to July 5, 2017.

The Department completed the attached Petition evaluation report pursuant to Fish and Game Code section 2073.5. (See also Cal. Code Regs., tit. 14, § 670.1, subd. (d)(1).). The Department's evaluation report delineates the categories of information required in a petition, evaluates the sufficiency of the available scientific information regarding each of the Petition components, and incorporates additional relevant information that the Department possessed or received during the review period. Based upon the information contained in the petition and other relevant information in the Department's possession, the Department has determined that there is sufficient scientific information available at this time to indicate that the petitioned action may be warranted. The Department recommends that the Petition be accepted and considered.

If you have any questions or need additional information, please contact Ms. Kari Lewis, Acting Wildlife Branch Chief, at (916) 445-3789 or by email at Kari.Lewis@wildlife.ca.gov or Mr. Kevin Shaffer, Fisheries Branch Chief, at (916) 327-8841 or by email at Kevin.Shaffer@wildlife.ca.gov.

Attachment

ec: **California Department of Fish and Wildlife**

Stafford Lehr, Deputy Director
Wildlife and Fisheries Division
Stafford.Lehr@wildlife.ca.gov

Wendy Bogdan, General Counsel
Office of the General Counsel
Wendy.Bogdan@wildlife.ca.gov

Mary Loum, Attorney
Office of the General Counsel
Mary.Loum@wildlife.ca.gov

Kari Lewis, Acting Chief
Wildlife Branch
Kari.Lewis@wildlife.ca.gov

Kevin Shaffer, Chief
Fisheries Branch
Kevin.Shaffer@wildlife.ca.gov

**State of California**
**Natural Resources Agency**
**Department of Fish and Wildlife**

**REPORT TO THE FISH AND GAME COMMISSION**

# EVALUATION OF THE PETITION FROM THE CENTER FOR BIOLOGICAL DIVERSITY TO LIST THE CASCADES FROG (*RANA CASCADAE*) AS ENDANGERED OR THREATENED UNDER THE CALIFORNIA ENDANGERED SPECIES ACT


Photo by Justin Garwood

**Prepared by**
**California Department of Fish and Wildlife**

**July 2017**

**Table of Contents**

## I. Executive Summary

The Center for Biological Diversity (CBD) submitted a petition (Petition) to the Fish and Game Commission (Commission) to list the Cascades Frog (*Rana cascadae*) as endangered or threatened pursuant to the California Endangered Species Act (CESA), Fish and Game Code Section 2050 et seq.

The Commission referred the Petition to the Department of Fish and Wildlife (Department) in accordance with Fish and Game Code Section 2073. (Cal. Reg. Notice Register 2017, No. 13-Z, p. 479.) Pursuant to Fish and Game Code Section 2073.5 and Section 670.1 of Title 14 of the California Code of Regulations, the Department has prepared this evaluation report for the Petition (Petition Evaluation). The Petition Evaluation is an evaluation of the scientific information discussed and cited in the Petition in relation to other relevant and available scientific information possessed by the Department during the evaluation period. The Department's recommendation as to whether to make Cascades Frog a candidate for listing under CESA is based on an assessment of whether the scientific information in the Petition is sufficient under the criteria prescribed by CESA to consider listing Cascades Frog as endangered or threatened.

After reviewing the Petition and other relevant information, the Department makes the following findings:

- Population Trend. The Petition contains sufficient information to indicate that the overall trend in California populations of Cascades Frogs is declining, with the most precipitous declines occurring in the southern portion of the species' range.
- Range. The Petition contains a sufficient description of the Cascades Frog's range in California, including evidence suggesting range contractions in the Lassen and Mount Shasta regions.
- Distribution. The Petition contains a sufficient description of the historical and recent distribution of Cascades Frogs' populations in California, which indicate declines across the species' range, with the most extensive losses occurring in the southern portion.
- Abundance. The Petition contains a sufficient description of what was known about historical and recent abundance of Cascades Frogs' populations, which indicate declines across the species' range, with the most extensive reductions in population size occurring in the southern portion.
- Life History. The Petition contains a sufficient description of the life history of Cascades Frogs based on the scientific information available for the species, which indicates some aspects may render it particularly vulnerable to natural and anthropogenic impacts.
- Kind of Habitat Necessary for Survival. The Petition contains a sufficient description of the types and conditions of habitats required for Cascades Frog survival, including the fact that it is a highly aquatic species with specialized needs.

- Factors Affecting the Ability to Survive and Reproduce. The Petition contains sufficient information to suggest that Cascades Frogs are adversely affected by historical habitat damage and a number of on-going and future threats such as habitat loss, climate change, disease, and introduced fish, that act together in threatening the species' continued survival.

- Degree and Immediacy of Threat. The Petition contains sufficient information to indicate impacts from some of the primary threats to the long-term survival of Cascades Frogs will continue or potentially worsen in the future.

- Impacts of Existing Management. The Petition contains sufficient information to suggest that existing regulatory mechanisms and management efforts do not adequately protect Cascades Frogs from impacts that threaten their long-term survival.

- Suggestions for Future Management. The Petition contains sufficient scientific information on additional management actions that may aid in maintaining and increasing self-sustaining populations of Cascades Frogs in California.

- Availability and Sources of Information. The Petition contains a 17-page bibliography of literature cited, the majority of which were provided to the Department.

- A Detailed Distribution Map. The Petition contains a sufficiently detailed map of the historical and contemporary distribution of Cascades Frogs in California.

In completing its Petition Evaluation, the Department has determined the Petition provides sufficient scientific information to indicate that the petitioned action may be warranted. Therefore, the Department recommends the Commission accept the Petition for further consideration under CESA.

## II. Introduction

### A. Candidacy Evaluation

CESA sets forth a two-step process for listing a species as threatened or endangered. First, the Commission determines whether to designate a species as a candidate for listing by determining whether the petition provides "sufficient information to indicate that the petitioned action may be warranted." (Fish & G. Code, § 2074.2, subd. (e)(2).) If the petition is accepted for consideration, the second step requires the Department to produce within 12 months of the Commission's acceptance of the petition a peer reviewed report based upon the best scientific information available that indicates whether the petitioned action is warranted. (Fish & G. Code, § 2074.6.) The Commission, based on that report and other information in the administrative record, then determines whether or not the petitioned action to list the species as threatened or endangered is warranted. (Fish & G. Code, § 2075.5.)

A petition to list a species under CESA must include “information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and other factors the petitioner deems relevant.” (Fish & G. Code, § 2072.3; see also Cal. Code Regs., tit. 14, § 670.1, subd. (d)(1).) The range of a species for the Department’s petition evaluation and recommendation is the species’ California range. (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal. App. 4th 1535, 1551.)

Within 10 days of receipt of a petition, the Commission must refer the petition to the Department for evaluation. (Fish & G. Code, § 2073.) The Commission must also publish notice of receipt of the petition in the California Regulatory Notice Register. (Fish & G. Code, § 2073.3.) Within 90 days of receipt of the petition, the Department must evaluate the petition on its face and in relation to other relevant information and submit to the Commission a written evaluation report with one of the following recommendations:

- Based upon the information contained in the petition, there is not sufficient information to indicate that the petitioned action may be warranted, and the petition should be rejected; or

- Based upon the information contained in the petition, there is sufficient information to indicate that the petitioned action may be warranted, and the petition should be accepted and considered.

(Fish & G. Code, § 2073.5, subds. (a)(1), (a)(2).) The Department’s candidacy recommendation to the Commission is based on an evaluation of whether or not the petition provides sufficient scientific information relevant to the petition components set forth in Fish and Game Code Section 2072.3 and the California Code of Regulations, Title 14, Section 670.1, subdivision (d)(1).

In *Center for Biological Diversity v. California Fish and Game Commission* (2008) 166 Cal.App.4th 597, the California Court of Appeals addressed the parameters of the Commission’s determination of whether a petitioned action should be accepted for consideration pursuant to Fish and Game Code Section 2074.2, subdivision (e), resulting in the species being listed as a candidate species. The court began its discussion by describing the standard for accepting a petition for consideration previously set forth in *Natural Resources Defense Council v. California Fish and Game Commission* (1994) 28 Cal.App.4th 1104:

> As we explained in *Natural Resources Defense Council* [citation], “the term ‘sufficient information’ in section 2074.2 means that amount of information, when considered with the Department’s written report and the comments received, that would lead a reasonable person to conclude the petitioned action may be warranted.” The phrase “may be warranted” “is appropriately characterized as a ‘substantial possibility that listing could occur.’” [Citation.] “Substantial possibility,”

> in turn, means something more than the one-sided "reasonable possibility" test for an environmental impact report but does not require that listing be more likely than not. [Citation.]

(*Center for Biological Diversity*, *supra*, 166 Cal.App.4th at pp. 609-10.) The court acknowledged that "the Commission is the finder of fact in the first instance in evaluating the information in the record." (*Id.* at p. 611.) However, the court clarified:

> [T]he standard, at this threshold in the listing process, requires only that a substantial possibility of listing could be found by an objective, reasonable person. The Commission is not free to choose between conflicting inferences on subordinate issues and thereafter rely upon those choices in assessing how a reasonable person would view the listing decision. Its decision turns not on rationally based doubt about listing, but on the absence of any substantial possibility that the species could be listed after the requisite review of the status of the species by the Department under [Fish and Game Code] section 2074.6.

(*Ibid*.)

### B. Petition History

On March 1, 2017, CBD submitted the Petition to the Commission to list Cascades Frog as endangered or threatened under CESA. On March 6, 2017, the Commission referred the Petition to the Department for evaluation. The Department requested of the Commission, and was granted, a 30-day extension to the 90-day Petition evaluation period. This Petition Evaluation report was submitted to the Commission on July 25, 2017.

The Department evaluated the scientific information presented in the Petition as well as other relevant information the Department possessed at the time of review. The Department did not receive any information from the public during the Petition Evaluation period pursuant to Fish and Game Code Section 2073.4. Pursuant to Fish and Game Code Section 2072.3 and Section 670.1, subdivision (d)(1), of Title 14 of the California Code of Regulations, the Department evaluated whether the Petition includes sufficient scientific information regarding each of the following petition components to indicate that the petitioned action may be warranted:

- Population trend;
- Range;
- Distribution;
- Abundance;
- Life history;
- Kind of habitat necessary for survival;

- Factors affecting ability to survive and reproduce;
- Degree and immediacy of threat;
- Impacts of existing management;
- Suggestions for future management;
- Availability and sources of information; and
- A detailed distribution map.

C. Overview of Cascades Frog Ecology

The Cascades Frog (*Rana cascadae*) is a medium-sized member of the “true frog” family Ranidae. Females are larger than males and can grow to over 8 cm (3.1 in) in length (Garwood and Welsh 2007). The species’ typical dorsal (top) coloration is brown, tan, or drab-green with well-defined inky black spots, a cream-colored jaw stripe, and strong dorsolateral folds (Thomson et al. 2016). Their sides are mottled and fade into a cream or buff ventral (bottom) coloration, usually with yellowish (sometimes reddish) areas posteriorly and on the undersides of their legs (Slater 1939, Thomson et al. 2016). California populations are genetically distinct from populations in Oregon and Washington (Monsen and Blouin 2003).

Within California, Cascades Frogs range from the Klamath-Trinity region, along the Cascades Range axis in the vicinity of Mt. Shasta, southward to the headwater tributaries of the Feather River (Jennings and Hayes 1994). The historical elevation range of Cascades Frogs in California was from approximately 230 to 2500 m (750 to 8200 ft), although extant populations appear to be restricted to sites above 1220 m (4000 ft) (Garwood and Welsh 2007). There are two disjunct populations recognized in California: the Southern Cascades, which comprises about 40% of their California range, and Klamath Mountains, which comprises about 60% (Pope et al. 2014); however, they do not appear to form distinct genetic units (Chang and Shaffer 2010).

Cascades Frogs inhabit a variety of mostly lentic (still water) habitats such as large lakes, ponds, wet meadows, and streams (Jennings and Hayes 1994, Pope et al. 2014). Adult Cascades Frogs demonstrate a high degree of site fidelity (Olson 1992), and at a site in the Trinity Alps, they were often observed moving from different breeding, feeding, and overwintering habitats in a consistent pattern year after year (Garwood 2009). They are diurnal (active during the day) and are typically found close to water, often in open, sunny areas along shorelines that provide basking and foraging opportunities, but they can move between basins by crossing over mountain ridges (Brown 1997, Garwood 2009, Pope et al. 2014, Welsh et al. 2006).

Breeding occurs shortly after snowmelt as surface water becomes available, and eggs are typically deposited in shallow lake alcoves, ponds, potholes, flooded meadows, and sometimes slow-moving streams and anthropogenic (human-made) wetland habitats (Garwood et al. 2007, Pope 2008b, Pope and Larson 2010, Quinn et al. 2001). Cascades Frogs are explosive breeders, with all egg laying taking place at a site over a period of 3 to 14 days (Briggs 1987, Garwood 2009, Nussbaum et al. 1983, Olson 1988, Sype 1975). For breeding to be successful, sites cannot freeze over after eggs are deposited and must possess water long enough to support egg and larval development, which can take three to four months depending on temperature (Pope and Larson 2010, Pope et al. 2014, Pope et al. 2011). Larvae (tadpoles) can tolerate a wide range of temperatures and tend to aggregate in warmer areas (Pope n.d., Wollmuth et al. 1987); however, some shallow sites may exceed their critical thermal threshold (Pope et al. 2014, Pope and Larson n.d.). Larvae that do not metamorphose prior to winter probably do not survive (Garwood 2009). Adults and juveniles likely hibernate in mud at the bottom of ponds, spring-fed saturated ground, and deep ponds and springs (Briggs 1987, Pope et al. 2014) and require sites that do not freeze solid to survive. Annual adult survival is generally relatively high, although substantial mortality can occur during prolonged winters with heavy snow if individuals do not possess the energy reserves to last the duration of the season (Briggs and Storm 1970, Pope 2008b, Pope et al. 2014).

Juvenile and adult Cascades Frogs are generalist predators, primarily consuming aquatic and terrestrial invertebrates (Joseph et al. 2011, Larson 2012) but occasionally preying on larvae or recently metamorphosed Pacific treefrogs or conspecifics (i.e., cannibalism) (Pope et al. 2014). The most common Cascades Frog prey items in one study included grasshoppers, spiders, ants, crane flies, and insect larvae (Larson 2012). Aquatic invertebrates are consumed less at sites with non-native fish, which may compete for the same prey (Joseph et al. 2011). Non-native fish may also prey on Cascades Frogs, at least their young life stages. Welsh et al (2006) reported that Cascades Frog larvae were 3.7 times (CL: 1.8-5.6) less likely to be found in lakes with fish than those without, and Pope (2008a) reported an increase in survival of young frogs from 59% to 94% and an increase in frog density by a factor of 13.6 due to increased recruitment within 3 years of removing non-native fish from 3 lakes.

Natural predators on Cascades Frogs include: gartersnakes, American dippers, American robins, Clark's nutcrackers, river otters, rough-skinned newts, diving beetles, giant water bugs, dragonfly naiads, and predatory leeches (Briggs and Storm 1970, Garwood 2006, Garwood and Welsh 2007, Garwood and Wheeler 2007, Nauman and Dettlaff 1999, Peterson and Blaustein 1991, Pope et al. 2008, Stead and Pope 2010).

## III. Sufficiency of Scientific Information to Indicate the Petitioned Action May Be Warranted

The order in which the petition components are evaluated below more closely reflects the order that they were provided in the Petition. This differs from their sequence in Fish and Game Code section 2072.3 and Section 670.1, subdivision (d)(1), of Title 14 of the California Code of Regulations, as well as in the Executive Summary and Introduction of this Petition Evaluation.

## A. Range

### 1. Scientific Information in the Petition

The Petition provides the following information on the Cascades Frog's range on pages 4 and 5. However, for purposes of this Petition Evaluation, "range" is limited to the species' California range. (*Cal. Forestry Assn. v. Cal. Fish and Game Com., supra,* 156 Cal. App. 4th at p. 1551.)

The Cascades Frog's range extends along the length the Cascade Range, from approximately 24 km (15 mi) south of the border with British Columbia in northern Washington, to the northern edge of the Sierra Nevada in California (Pearl and Adams 2005). Within California, the species' range extends from the Klamath-Trinity region, along the Cascades' axis in the vicinity of Mt. Shasta, southward to the headwater tributaries of the Feather River at elevations from approximately 230 to 2500 m (750 to 8200 ft) (Jennings and Hayes 1994). There are two disjunct populations: the Southern Cascades, which comprise about 40% of their California range, and Klamath Mountains, which comprise about 60% (Pope et al. 2014).

### 2. Other Relevant Scientific Information

Figure 1 shows the presumed range of Cascades Frogs in California (Thomson et al. 2016). The range of the Southern Cascades population encompasses parts of Butte, Lassen, Plumas, Shasta, and Tehama counties. The range of the Klamath Mountains population encompasses parts of Shasta, Siskiyou, and Trinity counties. The total area of the Cascades Frog range in California (gray area in Figure 1) is 321,346 ha (794,062 ac) in the Southern Cascades and 715,730 ha (1,768,600 ac) in the Klamath Mountains, but the species is patchily distributed within these areas.

In addition, there is a recent sighting of a Cascades Frog on private land approximately 500 m (1640 ft) outside of the range boundary depicted in Figure 1 (CDFW 2017a). While this distance represents a minimal extension, it suggests that, where suitable habitat exists in close proximity to the existing recognized range, the species may be present. For example, there are a few clusters of suitable habitat that have not been sufficiently surveyed that, if occupied, could slightly expand the species' range in the vicinity of the Shasta-Trinity and Lassen national forests (J. Garwood pers. comm.).

### 3. Sufficiency of the Petition with regard to Range

The Department concludes the Petition contains a sufficient description of the Cascades Frog's range in California, including evidence suggesting range contractions in the Lassen and Mount Shasta regions.

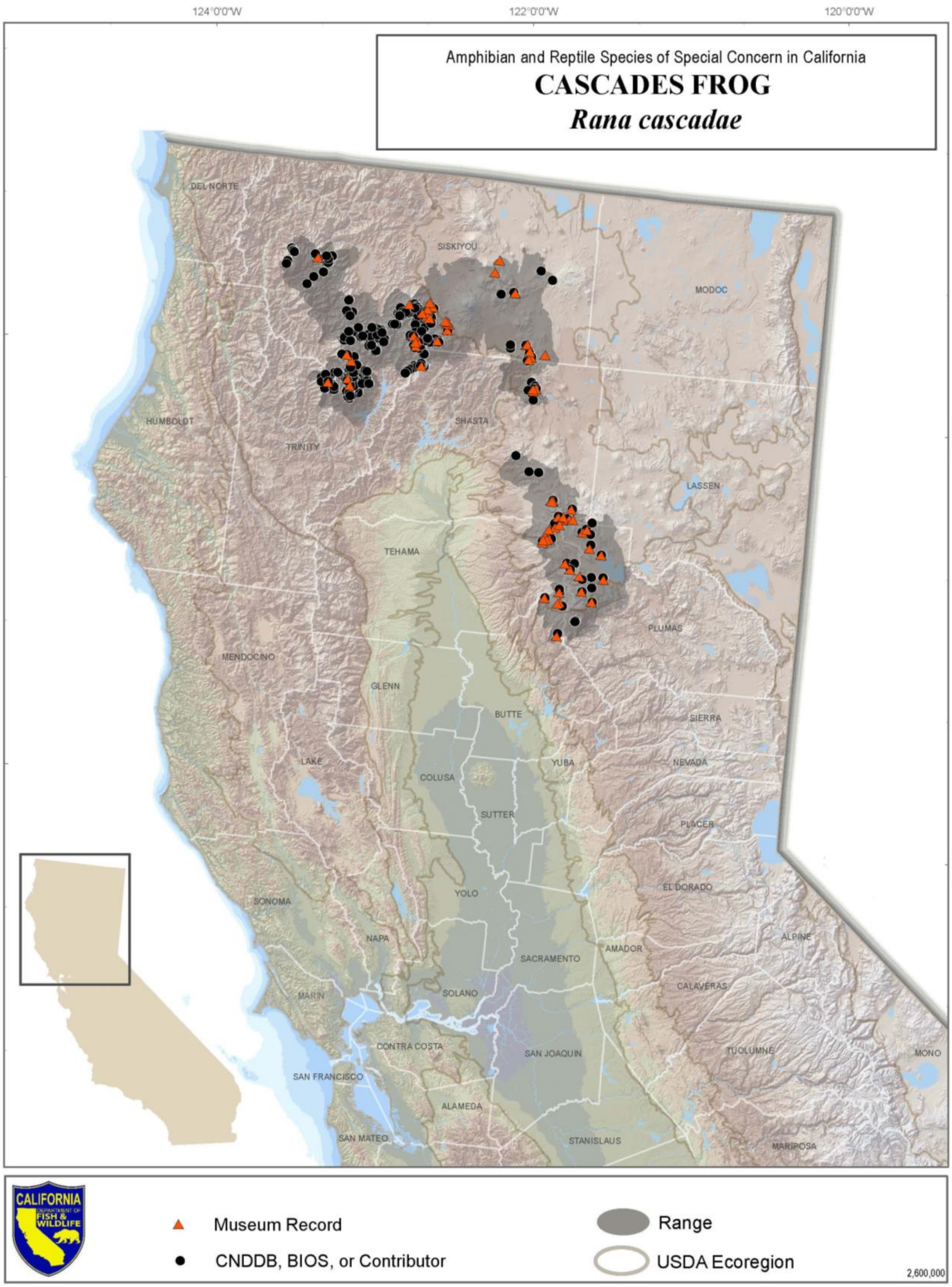


Figure 1. Cascades Frog range in California (Thomson et al. 2016)

B. Life History

1. Scientific Information in the Petition

The Petition contains the following information on the Cascades Frog's life history on pages 4 to 8, including species description, taxonomy, life cycle, diet, movements, and sources of mortality.

Cascades Frogs are brown, copper, tan, or olive colored with a spotted back and yellowish to cream underside, dark mottling around the groin, and a cream-colored stripe extending from the jaw to the shoulders. Adults grow to 4.4-7.6 cm (1.75-3 in) in length, and females are larger than males (Stebbins 2003). Cascades Frog larvae are dark brown with copper and pinkish speckling, golden coloring on the sides, and a finely speckled tail (Nafis 2013). Their bodies are oval, their eyes are dorsally located (as opposed to on the sides of their head), and they grow to approximately 5 cm (2 in) in length. Cascades Frog eggs are black above, white below, and widely spaced within a gelatinous mass containing 300-800 eggs (Nafis 2013).

The Cascades Frog is a medium-sized member of the family Ranidae, the "true frogs." It is morphologically (Dunlap 1955, Slater 1939) and genetically (Case 1978; Green 1986a, 1986b) distinct from other Ranids. Populations in California have been isolated from Oregon and Washington populations for approximately 2 million years and differ significantly genetically (Monsen and Blouin 2003). The extent of genetic differentiation between the Southern Cascades and Klamath Mountains populations in California is unknown (Pope et al. 2014). The species typically exhibits a metapopulation structure, but high degrees of genetic isolation have been observed in some local populations over relatively small distances (Monsen and Blouin 2004, Pope et al. 2014). Gene flow likely drops over a distance of 10 km (6.2 mi) between populations (Pope et al. 2014).

Cascades Frogs are relatively long-lived, and late-maturing (Pope et al. 2014). Males attain sexual maturity between 3 and 4 years of age, while females mature between 4 and 5 years of age, and lifespan is typically 5 to 10 years (Ibid.). Cascades Frogs are active during the day (Stebbins 1985).

Cascades Frog reproduction is triggered by spring snowmelt, which can occur from March to mid-August (Stebbins 1985) depending on location, seasonal conditions, and elevation. Males enter the breeding sites first after ice and snow thaw, opening up surface water along the shoreline, and form chorusing groups (Briggs 1987, Garwood and Welsh 2007). Calling occurs above and below the surface (Stebbins 1985). It appears that males do not defend territories, but their interactions may result in regular spacing across breeding habitat (Olson 1988). Females are rarely seen during breeding; they primarily swim underwater to oviposition sites and leave after breeding is complete (Olson 1992).

Egg masses are typically laid communally in pond and lake habitats but singly in meadow pools (Garwood et al. 2007, Pope and Larson 2010), and a small portion have been found in small low-gradient streams with slow flows (Pope 2008b). They are usually deposited near the surface in shallow water attached to emergent vegetation, wood, boulders, or the shoreline, but they have also been found 2 m (6.6 ft) deep and free-floating (Garwood et al. 2007, Pope and Larson

2010). Because breeding occurs soon after open water habitat becomes available, egg masses may be vulnerable to late freezes (Pope and Larson 2010, Pope et al. 2011).

The duration of embryonic development (i.e., time to hatching) is temperature-dependent but typically takes around three weeks in California (Blouin and Brown 2000, Garwood and Larson n.d., Sype 1975). In spring-fed sites with consistently cold water (2 to 10 ºC [35 to 50 ºF]), hatching may be delayed slightly, but since egg masses are usually laid in shallow open water, sun exposure rapidly increases temperatures to above 13 ºC (55 ºF), which are better for development. Larvae are able to tolerate a wide range of water temperatures and tend to aggregate in the warmest areas of ponds and lakes during the day (Pope n.d., Wollmuth et al. 1987). These areas are typically near shore, gently sloping, and protected from the wind (O'Hara 1981, Olson 1992) where temperatures can reach over 20 ºC (68 ºF) during the day and drop to near freezing at night. Larvae have also been observed in shallow pools as warm as 38 ºC (100 ºF), but they appeared highly stressed (Pope and Larson n.d.).

Larval development is also temperature-dependent and can take from 2 to 4 months to metamorphosis (Pope et al. 2014). At sites with short hydroperiods, larvae can become stranded and desiccate prior to metamorphosis (Garwood 2009, O'Hara 1981, Pope et al. 2011, Sype 1975). Larvae that fail to metamorphose prior to the onset of winter do not apparently survive overwintering (Garwood 2009). Larvae and metamorphs (individuals transitioning from larvae to frog) preferentially associate with kin over non-kin (Blaustein and O'Hara 1982a, 1982b, 1987; Blaustein et al. 1984; O'Hara and Blaustein 1981, 1985). This kind of kin association can affect growth, predator avoidance, and other factors (Hokit and Blaustein 1994, 1995, 1997). Garwood (2009) found that newly metamorphosed frogs tended to remain near their natal ponds.

Adult Cascades Frogs demonstrate a high degree of site fidelity (Olson 1992), and at a site in the Trinity Alps, they were often observed moving from different breeding, feeding, and overwintering habitats in a consistent pattern year after year (Garwood 2009). In other areas that can support all habitat needs, they may remain at the waterbody year-round (Pope 2008a).

Adult Cascades Frog survival varies by location. Survival rates in the Trinity Alps were estimated between 68 and 93% (Pope 2008b, Pope et al. 2014), but Briggs and Storm (1970) reported survival at around 55% from a site in central Oregon. In the latter study, it appeared most of the mortality occurred over winter. This can occur during unusually long winters with heavy snowfall if individuals do not possess sufficient energy stores to survive the protracted season (Pope et al. 2014).

Juvenile and adult Cascades Frogs are generalist predators, primarily consuming aquatic and terrestrial invertebrates (Joseph et al. 2011, Larson 2012) but occasionally preying on larvae or recently metamorphosed Pacific Treefrogs (*Pseudacris regilla*) or conspecifics (Pope et al. 2014). The extent to which aquatic prey are consumed appears to be influenced by the presence of fish; in fishless lakes, more aquatic invertebrates were eaten, whereas in lakes with fish, more terrestrial species were eaten (Joseph et al. 2011). Larson (2012) recorded invertebrates from 102 families in Cascades Frog stomach contents with 5 groups among the most important diet components: grasshoppers (Acridiadae), spiders (Aranae), ants (Formicidae), crane flies (Tupilidae), and insect larvae.

Natural predators of Cascades Frog include: gartersnakes (*Thamnophis* spp.) (Garwood and Welsh 2007, Pope et al. 2008); birds such as American dippers (*Cinclus mexicanus*) (Garwood and Welsh 2007), American robins (*Turdus migratorius*) (Briggs and Storm 1970), and Clark's nutcrackers (*Nucifraga columbiana*) (Garwood 2006); mammals such as river otters (*Lontra canadensis*) (Pope et al. 2014); other amphibians such as Rough-skinned Newts (*Taricha granulosa*) (Peterson and Blaustein 1991); aquatic insects such as diving beetles (Dytiscidae), giant water bugs (Belostomatidae), and dragonfly naiads (Odonata) (Garwood and Wheeler 2007, Nauman and Dettlaff 1999); and predatory leeches (Hirudinida) (Stead and Pope 2010). Predatory leeches have been implicated as a potential contributor to dramatic declines in Cascades Frogs in the Lassen region (Ibid.).

2. Other Relevant Scientific Information

Cascades Frogs have prominent dorsolateral folds, and their dorsal black spots are often described as "inky" with sharply defined edges (Stebbins 2003, Thomson et al. 2016). Jennings and Hayes (1994) note that numerous specimens from eastern Siskiyou and Shasta counties were previously misidentified as Oregon Spotted Frogs (*Rana pretiosa*). The last verified Oregon Spotted Frog in California was from a 1918 museum collection; the species is considered likely extirpated in the state (USFWS 2014, 2016a), so future misidentifications are not likely to occur.

Preliminary data indicate Southern Cascades and Klamath Mountains populations of Cascades Frogs are not separate genetic units (Chang and Shaffer 2010). Instead, populations from southeastern Siskiyou County and Shasta counties appear to form one group, while the rest form another (Ibid.). This suggests that populations from southern portion of the range (Plumas and Tehama counties) are more closely related to those in Trinity Alps than they are to those in Shasta County (i.e., their nearest neighbor), although the authors noted that the southern-most populations may also form a separate group (Ibid.). They cautioned that these results are preliminary and may change with a larger dataset (Ibid.).

In addition, a second genetic study at the University of Wisconsin-Madison is currently exploring if any broad- and fine-scale patterns of Cascades Frog genetic structure occurs throughout isolated populations of California and its entire range (Bennett Hardy pers. comm.). This study is using more advanced sequencing techniques and single nucleotide polymorphism datasets. The Department was involved with providing tissues to this study from the Klamath Mountains region in 2016.

Cascades Frogs are considered explosive breeders (Sype 1975). The typical oviposition period for a particular site lasts between 3 to 14 days (Briggs 1987, Garwood 2009, Olson 1988), and mature females are thought to produce a maximum of one clutch of eggs per year (Sype 1975). This life history strategy makes the species particularly vulnerable to late freezes, which can eliminate an entire cohort.

The species does not appear to possess a bet-hedging strategy where some individuals breed early and some later when conditions may be more favorable.

Cascades Frog dispersal appears to be limited, which has implications for gene flow among extant populations and recolonization of extirpated populations. Garwood (2009) measured Cascades Frog dispersal in the Klamath Mountains and found significant differences in patch connectivity within a basin relative to between basins. Garwood (2009) found on average 51% of juvenile Cascades Frogs dispersed from their natal patches within an individual basin, and only 1% dispersed over mountain passes to colonize adjacent basins. The study indicated habitats occurring in close proximity, but in separate adjacent basins, should be recognized as essential for gene flow given the low dispersal rates between basins.

3. Sufficiency of the Petition with regard to Life History

The Department concludes the Petition contains a sufficient description of the life history of Cascades Frogs based on the scientific information available for the species, which indicates some aspects may render it particularly vulnerable to natural and anthropogenic impacts.

## C. <u>Kind of Habitat Necessary for Survival</u>

1. Scientific Information in the Petition

The Petition contains the following information on Cascades Frog habitat use and requirements on page 7.

Cascades Frogs inhabit a variety of mostly lentic habitats such as large lakes, ponds, wet meadows, and streams at mid- to high-elevations (Jennings and Hayes 1994, Pope et al. 2014). They are typically found close to water, often in open, sunny areas along shorelines that provide basking and foraging opportunities, but can occasionally move between basins by crossing over mountain ridges (Brown 1997, Garwood 2009, Pope et al. 2014, Welsh et al. 2006). Cascades Frogs are less likely to occupy wetlands that are farther away from lakes, and their abundance is often lower at these sites as well (Cole and North 2014).

Breeding occurs in areas that are first to become available after snowmelt such as shallow lake alcoves, ponds, potholes, flooded meadows, and sometimes slow-moving streams and anthropogenic (human-made) wetland habitats. For breeding to be successful, sites must possess water long enough to support egg and larval development, which can take three to four months depending on temperature (Pope and Larson 2010, Pope et al. 2014). As previously mentioned, while larvae can tolerate a wide range of temperatures and will select for warmer areas, some shallow sites may exceed their critical thermal threshold (Pope and Larson n.d., Pope et al. 2014).

Cascades Frogs require overwintering sites that do not freeze solid. They likely hibernate in mud at the bottom of ponds, spring-fed saturated ground, and deep ponds and springs (Briggs 1987, Pope et al. 2014).

2. Other Relevant Scientific Information

The effect of non-native fish presence on Cascades Frogs is discussed in more detail below in Section F-1, but it is worth briefly noting here as it relates to habitat quality and its ability to sustain healthy populations of Cascades Frogs. Welsh et al. (2006) found that Cascades Frog larvae were 3.7 times more likely to be found in fishless lakes than lakes with fish. Garwood and Welsh (2007) reported Cascades Frog densities were 6.3 times greater in a fishless meadow than one with trout. Pope (2008a) observed an increase in survival of young frogs from 59% to 94% and an increase in frog density by a factor of 13.6 due to increased recruitment within 3 years of removing non-native fish from 3 lakes.

3. Sufficiency of the Petition with regard to Kind of Habitat Necessary for Survival

The Department concludes the Petition contains a sufficient description of the types and conditions of habitats required for Cascades Frog survival, including the fact that it is a highly aquatic species with specialized needs.

D. <u>Distribution and Abundance</u>

1. Scientific Information in the Petition

The Petition contains the following information on the changes in Cascades Frog distribution and abundance in California on pages 8 through 12. Pope et al. (2014) conducted comprehensive reviews on the status of Cascades Frogs in California, and found that the species has become extremely rare in the Southern Cascades but remains “fairly widespread” in the Klamath Mountains. The Petition separates the discussion of Cascades Frog distribution and abundance in California by these two regions.

*Southern Cascades*

There were no formal surveys for Cascades Frogs in the Southern Cascades prior to 1980, but data from historical museum collections suggest the species was widespread and abundant, particularly in the vicinity of Lassen Volcanic National Park and the northwestern and southern portions of the Lassen National Forest (Pope et al. 2014). This area covered portions of the Pit River and most of the headwater tributaries of Hat, Deer, Mill, Battle, and Butte creeks, and upper North Fork and West Branch Feather River (Ibid.). Declines in the Southern Cascades populations were not recognized until the 1970s (Ibid.).

By the 1990s, Cascades Frogs had apparently disappeared from a large portion of formerly occupied sites. Fellers and Drost (1993) failed to detect the species at 16 historical localities, and only detected them at 1 of 50 sites (2%) surveyed. Jennings and Hayes (1994) estimated the species had been lost from approximately 99% of its historical range in the Lassen region. From 1993 to 2007, Fellers et al. (2008) conducted 1,873 amphibian surveys at 856 sites, encompassing all Cascades Frog habitats, within Lassen Volcanic National Park and Lassen National Forest. Cascades Frogs were found at only 6 sites over the 14 years of surveys, and a single frog was reported from an additional site (Ibid.). There was no evidence of reproduction at most sites, and reproduction in all but one remained lower than the annual reproductive output of one breeding pair for over 12 years (Ibid.). Three populations have been found to the south on private land and three to the north near Lassen National Forest (Pope and Larson n.d.).

In total, 12 sites have been documented to support Cascades Frogs in the Southern Cascades region since 1993 (Pope et al. 2014). Abundance estimates range from 5 individuals at Colby Creek to 150 individuals at Carter Meadow (Ibid.). Data from a mark-recapture study conducted between 2008 and 2011 indicated each population is slowly declining, and about half are at risk of extirpation, while the others are likely to continue declining (Ibid.). Cascades Frogs have not been detected in Lassen Volcanic National Park since 2008, in spite of multiple surveys of known occupied sites and suitable meadow habitats (Ibid.). The species appears to be extirpated from the park.

*Klamath Mountains*

By the 1970s, Cascades Frogs had been recorded from approximately 25 locations in the Shasta-Trinity National Forest, but few populations had been recorded from the Klamath National Forest, and there was no evidence of declines (Pope et al. 2014). Jennings and Hayes (1994) reported that the species seemed common in appropriate habitat in the Klamath Mountains region.

Between 1999 and 2002, occupancy and abundance data were collected for all mapped lakes, ponds, and wet meadows in the Trinity Alps Wilderness, Russian Wilderness, Marble Mountains Wilderness, Siskiyou Wilderness, Red Buttes Wilderness, Castle Crags Wilderness, and parts of the Shasta-Trinity and Klamath National Forests outside of wilderness areas (Welsh and Pope 2004). No Cascades frogs were found in the Siskiyou or Red Buttes wilderness areas (Ibid.). Occupancy (i.e., at least one of any life stage) and evidence of reproduction (i.e., observation of at least one egg mass or larvae) data from the remaining areas are summarized in Table 1.

Table 1. Summary of Cascades Frogs Population Data in the Klamath Mountains (from Welsh and Pope 2004, cited in Pope et al. 2014)

| Wilderness Area | Occupied (%) | n (sites) | Reproducing (%) | n (sites) |
|---|---|---|---|---|
| Trinity Alps | 58.7 | 223/380 | 30.5 | 116/380 |
| Russian | 31 | 17/54 | 5.5 | 3/54 |
| Marble Mountains | 32 | 80/250 | 11 | 28/250 |
| Castle Crags | 19 | 3/16 | - | - |
| Shasta-Trinity | 100 | 15/15 | - | - |

In 2008, 112 previously occupied sites in the Klamath Mountains were re-surveyed, and 79% were found to still support Cascades Frogs (Piovia-Scott et al. 2011, Pope et al. 2014). While no significant declines were noted, the abundances of some previously robust populations appeared low (Pope et al. 2014).

Of the 695 water bodies surveyed between 1999 to 2001 in the Trinity Alps, Russian, and Marble Mountain wilderness areas, the maximum number of adult Cascades Frogs seen at a water body was 32, and the mean number of adults encountered at occupied sites was only 4 (Welsh and Pope 2004). Since that survey effort, a 9-year mark-recapture study was conducted on 8 of these populations. At 5 of the sites, adult abundance was fewer than 25 individuals, while the other 3 appeared relatively robust (Garwood n.d., Pope 2008a). Pope and Piovia-Scott (2010) estimated two headwater lakes supported more than 500 Cascades Frogs in 2010; only one other site in the Trinity Alps is believed to support similar numbers (Pope et al. 2014).

The Cascades Frog populations in the Klamath Mountains have not experienced the same dramatic declines as those in the Southern Cascades, but low abundance and some extirpations are cause for concern (Pope et al. 2014).

2. Other Relevant Scientific Information

As previously noted in the Range section (A.2), a limited number of potentially suitable habitats that have not been surveyed occur slightly outside of the known range, which have the potential to slightly expand the distribution and potential abundance of this species if present (J. Garwood pers. comm.).

Aside from the observations denoted on the distribution map provided in the Petition on page 9 and those in Figure 1, little is known about the distribution and abundance of Cascades Frogs in the Mount Shasta region, which is located in the northeastern portion of the species' range in California.

3. Sufficiency of the Petition with regard to Distribution and Abundance

The Department concludes the Petition contains a sufficient description of what was known about historical and recent Cascades Frog distribution and abundance to indicate that both have declined across the species' range in California, to some extent, with the most precipitous declines occurring in the southern portion.

## E. Population Trend

1. Scientific Information in the Petition

The Petition contains the following information on Cascades Frog population trends in California on page 12.

Cascades Frog populations have declined significantly in the Southern Cascades region. The species appears to be extirpated from Lassen Volcanic National Park, where it was once considered abundant. After several intensive survey efforts, it appears that only 12 sites continue to support the species, all with low numbers that are slowly declining. Pope et al.

(2014) determined that without active management, some of these populations will disappear within 10 years, and the remainders are at risk of extirpation.

Cascades Frogs are still widespread and relatively abundant in the Klamath Mountains region. Some recent extirpations have been documented, and some previously robust populations have declined. These instances are more common in the eastern portion of the region in the Castle Crags Wilderness and Klamath National Forest where population sizes are generally small.

Overall, the Cascades Frog's range has contracted at the southern end. Fellers and Drost (1993) and Jennings and Hayes (1994) estimated that the species had been extirpated from around 99% of the populations surrounding Mount Lassen and 50% of their total historical distribution in California. More recently, Fellers et al. (2008) noted that the range has contracted further.

2. Other Relevant Scientific Information

A long-term population monitoring study sponsored, in part, by the Department has been ongoing since 2003 in the Klamath Mountains (J. Garwood pers. obs.). Overall captures of adult and juvenile Cascades Frogs have decreased steadily through the duration of the study (Figure 2), indicating the population is in steady decline. In addition, annual Cascades Frog egg mass counts have ranged from 46 to 82 masses annually across 8 to 14 patches. The number of egg masses produced does not appear to be in steady decline, but the number of patches used for breeding within the population has steadily declined from 14 to 9 indicating patch-level extinctions.

3. Sufficiency of the Petition with regard to Population Trend

The Department concludes the Petition contains sufficient information to indicate that the overall trend in California populations of Cascades Frogs is declining, with the most precipitous declines occurring in the southern portion of the species' range.

## F. Factors Affecting the Ability to Survive and Reproduce and Degree and Immediacy of Threat

1. Scientific Information in the Petition

The Petition contains the following information on threats affecting the ability of Cascades Frogs to survive and their degree and immediacy on pages 12 through 25. These include airborne contaminants, climate change, disease, fire suppression, habitat loss and alteration, introduced fish, livestock grazing, recreational activities, and small population sizes.

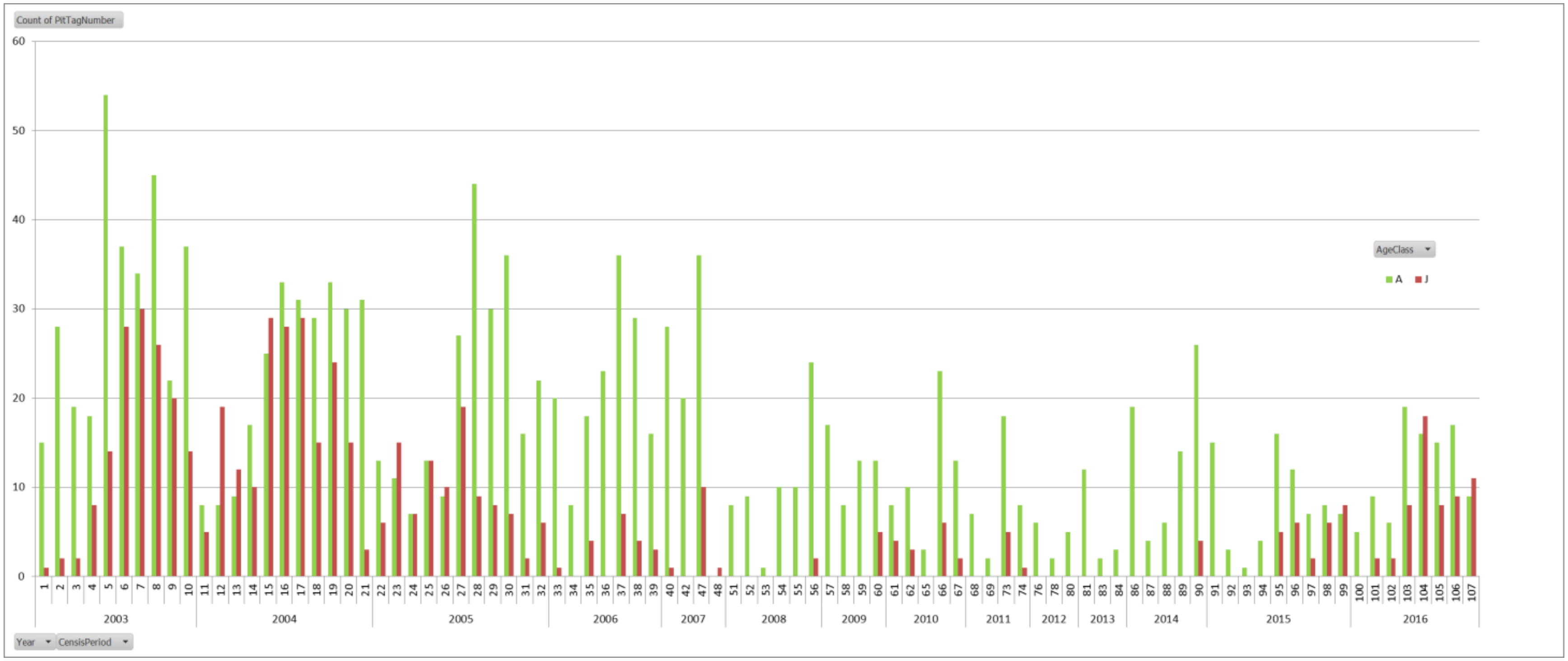


Figure 2. Captures of uniquely marked Cascades Frogs separated by age class, census period, and year across three habitat patches in Echo Lake Basin from 2003 to 2016, Klamath Mountains, CA. Green bars represent adult Cascades Frogs and red bars represent juveniles (J. Garwood pers. obs.).

*Airborne Contaminants*

Deposition of airborne agrochemical pollution from the Central Valley into the Sierra Nevada and southern Cascades is well-documented (Aston and Seiber 1997, Bradford et al. 2010, Datta et al. 1998, Davidson 2004, Davidson et al. 2002, Hageman et al. 2006, LeNoir et al.1999, McConnell et al. 1998) and has likely contributed to declines in Cascades Frog populations in some regions (Davidson 2004, Davidson et al. 2002). On average, 62.7 million kg (168 million lbs) of pesticides were applied each year to agricultural lands (primarily in the Central Valley) between 1998 and 2014 (CDPR 2017). In the Lassen region, approximately four times more agriculture land was located upwind of extirpated Cascades Frog population sites than extant ones (Davidson et al. 2002). Chlorpyrifos, dacthal, and endosulfans, banned organochlorines, and polycyclic aromatic hydrocarbons (PCBs) were found in Cascades Frog tissues, but there was no significant pattern in pesticide concentrations between Southern Cascades and Klamath Mountains Cascades Frog populations (Davidson et al. 2012).

Paulk and Wagner (2004) reported that glyphosate and Malathion significantly adversely affected Cascades Frog larval survival and development at concentrations below the EPA-recommended maximum levels for surface water. Hatch et al. (2001) reported that juvenile Cascades Frogs were not able to sense or avoid toxic levels of fertilizers such as urea, and Marco and Blaustein (1999) reported that nitrites can affect Cascades Frog larval behavior and metamorphosis. In addition to the direct effects agricultural chemicals can have on amphibians, they may be interacting with other stressors in the environment, resulting in increased vulnerability to predators and disease, including weakening immune systems and facilitating chytridiomycosis (see “Disease” below) outbreaks (Blaustein et al. 2011, Bradford et al. 2011, Brühl et al. 2011, Davidson et al. 2007).

The degree to which airborne contaminants threaten the continued survival of Cascades Frogs is presumed to be low; however, complex interactions may exist between these chemicals and other stressors that have not been thoroughly examined (Pope et al. 2014). These effects are expected to be greatest in low- to mid-elevations downwind of agricultural areas (Ibid.).

*Climate Change*

As ectotherms, all aspects of amphibians’ life history are strongly influenced by the external environment, particularly temperature and moisture. Higher average temperatures, varying precipitation patterns, and alterations in disturbance regimes such as fire are already affecting many wildlife species across North America (Case et al. 2015, Chen et al. 2011, Parmesan 2006, Root et al. 2003). Among a set of 195 species of plants, mammals, birds, and herpetofauna (amphibians and reptiles) from the Pacific Northwest, Case et al. (2015) determined that herpetofauna were, on average, the most sensitive group to climate change. This result was primarily driven by the fact that 90% of the amphibians and reptiles studied relied on at least one habitat type that was highly sensitive to climate change, such as the seasonal wetlands Cascades Frogs occupy (Ibid.).

Climate-associated shifts in amphibian phenology (seasonal timing), geographic range, and host-pathogen interactions have been documented (Blaustein et al. 2010, Corn 2005, Li et al.

2013), and evidence is emerging that climate change may be contributing to population declines as well (Lowe 2012, Rohr and Palmer 2013). Li et al. (2013) synthesized the results of 14 long-term data sets on amphibian breeding timing in the U.S. and Europe and discovered that over half the populations under study were breeding earlier. Shifts in timing of breeding can have fitness and population-level consequences; amphibians that emerge earlier in the spring can be vulnerable to subsequent freeze events (Li et al. 2013). In addition, shifts in geographic range in response to climate change can be difficult for species like Cascades Frogs with restricted high-elevation ranges and specific habitat requirements (Ibid.).

Cascades Frogs inhabit montane wetlands, frequently using hydrologically intermediate ponds, which are naturally variable, holding water in most years but occasionally drying during droughts (Lawler et al. 2014, Ryan et al. 2014). Several studies predict a decreased availability of this habitat type as the distribution and composition of Pacific Northwest montane wetlands are altered by climate change (Lawler et al. 2014, Lee et al. 2015, Ryan et al. 2014). These projections are associated with changes in snowpack volume, runoff, direct precipitation, and evaporation (Hamlet et al. 2005, IPCC 2007, Ryan et al. 2014). Snowpack is estimated to have declined by more than 50% over the past century, snowmelt runoff and peak water availability are occurring earlier in the year, and soil moisture is receding (Hamlet et al. 2007, Mote et al. 2005, Ryan et al. 2014). Rising temperatures and decreased summer precipitation will continue to reduce mountain snowpack and increase evapotranspiration and soil-moisture stress in late summer months, potentially converting more than half of the intermediate montane wetlands into ephemeral wetlands by the 2080s (Lee et al. 2015). Lawler et al. (2014) concluded that Cascades Frogs had the highest risk of climate-change related declines of the three species of amphibians they studied in the Pacific Northwest. The predicted loss of high elevation, intermediate wetlands will force Cascades Frogs to move to larger, deeper lakes that are more likely to support non-native fish, which decrease abundance and survival (Ryan et al. 2014).

In the Cascades Range, Ryan et al. (2014) reported that wetland drawdown is occurring earlier and more rapidly, water availability is greatly reduced, complete drying is occurring more frequently, and summers have longer dry periods. This can lead to stranding and desiccation of Cascades Frog larvae and decreased larval densities, along with shifts in size at metamorphosis and reduced survival due to increased water temperatures (Lawler et al. 2014, Semlitsch et al. 1988). In addition, among the most important predictors of Cascades Frog occupancy at a site was the number of available pools (Cole and North 2014).

Climate change may facilitate or exacerbate other environmental stressors, leading to population declines (Lowe 2012, Rohr and Palmer 2013). For example, a more variable climate and more frequent extreme weather events due to climate change have the potential to increase the pathogenicity of chytrid, the fungus responsible for widespread amphibian declines (Li et al. 2013, Raffel et al. 2013).

The current drought in parts of the Pacific Northwest may be indicative of average future climatic conditions in the Cascades Frog range. In some areas, near complete reproductive failure has been observed as a result of premature drying in ponds that typically remain wetted throughout the year. Dead adults have also been observed in these areas.

The degree to which climate change threatens the continued survival of Cascades Frogs is potentially high, particularly for populations that breed in ephemeral wetlands and those in the Southern Cascades region where the species is already rare and, therefore, highly susceptible to environmental stochasticity (Pope et al. 2014).

*Disease*

Chytridiomycosis is the amphibian disease caused by the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*). The result of its global rate of infection and associated mortality has been described as “the most spectacular loss of vertebrate biodiversity due to disease in recorded history” (Skerratt et al. 2007). Symptoms of adult amphibians with chytridiomycosis include lethargy and reluctance to flee, skin abnormalities, loss of righting reflex, and extended back legs. In infected larvae, the jaw sheaths and tooth rows are abnormally formed or lack pigment, which likely inhibits foraging ability (Fellers et al. 2001). The species-specific impact of *Bd* varies and can be influenced by temperature, predation pressure, pesticide exposure, and UV-B radiation, as well as the virulence of the strain (Berger et al. 2005, Farrer et al. 2011, Fisher et al. 2009, Gahl et al. 2012, Piovia-Scott et al. 2015, Retallick and Meira 2007).

*Bd* occurs throughout the Cascades Frog’s range, and the species is susceptible to infection (Adams et al. 2010; Garcia et al. 2006; Piovia-Scott et al. 2011, 2015). In lab experiments, Cascades Frog metamorphs exposed to *Bd* experienced significant mortality (Garcia et al. 2006), but declines in wild populations in the presence of *Bd* are not universal (Piovia-Scott et al. 2011, Pope et al. 2011). The reasons why some *Bd* infected populations decline dramatically, while others remain relatively stable, are not well known (Pope et al. 2014), but a rapid decline at one site is presumed to be the result of a particularly virulent strain (Fellers et al. 2008, Piovia-Scott et al. 2015). Juvenile Cascades Frog abundance at Section Line Lake in the Klamath Mountains decreased from hundreds in 2010 to two in 2012, and adults began to decline three years later (Piovia-Scott et al. 2015). No other factors such as predation or desiccation were evident, but a virulent strain of *Bd* was identified, and the high rate of overwintering mortality was consistent with chytridiomycosis-associated declines (Ibid.).

The significant decline in Cascades Frog populations in the southern portion of their range due to *Bd* and the prevalence of the disease throughout the species’ range is cause for concern (Pope et al. 2014). It appears that larger populations of frogs may increase resistance to *Bd* (Knapp et al. 2011), so efforts aimed at increasing Cascades Frog population sizes, such as removing predatory trout, may be crucial to ensuring the species’ survival (Ibid.). In addition, there is some evidence that treatment with antifungal drugs, such as Itraconazole, increases survival of *Bd*-infected Cascades Frogs (Hardy et al. 2015).

Other infectious diseases may also negatively affect Cascades Frogs in California. For example, *Saprolegnia ferax* is a species of water mold that commonly infects fish that can spread to amphibians and has caused die-offs of the species in Oregon (Blaustein et al. 1994, Kiesecker and Blaustein 1997). Prevalence of *Saprolegnia* in the wild has increased due to introduction of hatchery-raised fish (Blaustein et al. 1994), and this practice has the potential to transmit more virulent strains to amphibians (Bucciarelli et al. 2014). *Saprolegnia*-associated mortality may be greater with increased exposure to UV-B radiation, which is likely to occur more frequently as wetlands shrink due to climate change (Bucciarelli et al. 2014, Kiesecker and Blaustein 1995).

The degree to which disease threatens the continued survival of Cascades Frogs is considered to be high. *Bd* is present across the species' range and appears to be significantly reducing juvenile survival in many populations, which increases the risk of population extirpations (Pope et al. 2014).

*Fire Suppression*

Fire suppression activities in California have the potential to adversely affect Cascades Frogs, although this subject has not been well studied and most evidence is anecdotal (Pilliod et al. 2003). Fire suppression activities that could directly impact Cascades Frogs include water drafting from ponds and streams, application of fire retardant, and construction of fuel breaks. These activities could also result in indirect impacts to the species through changes in aquatic and riparian habitats via sedimentation, alteration in downed woody debris, and reduction in amounts of vegetation associated with required habitats (potentially producing both positive and negative effects). In spite of this, no known impacts to Cascades Frogs from fire suppression activities have been documented. These activities occur regularly in the lower elevations of the Cascades Frog range and near the wildland-urban interface, putting the remaining populations in the Southern Cascades region at greater risk than those in the Klamath Mountains region, which is primarily subalpine, with long fire return intervals, and largely in wilderness areas. Fire crews and other fire personnel attempt to minimize impacts to aquatic and semiaquatic species and their habitats, but inadvertent impacts may still occur.

Construction of fire lines or firebreaks can be extensive and mimic habitat changes associated with roads and road construction. Sedimentation associated with unpaved roads can be greater than from logging or fire (Rieman and Clayton 1997). Restoration activities like installation of water bars and revegetation can reduce erosion (Pilliod et al. 2003). Using mechanized equipment in wilderness areas for fire suppression is not permitted.

Application of ammonia-based fire retardant and surfactant-based fire suppressant from air tankers or fire engines has the potential to adversely affect Cascades Frogs because some are toxic to aquatic organisms (Buhl and Hamilton 2000, Gaikowski et al. 1996, McDonald et al. 1996). Tanker pilots are directed to avoid aerial application of retardant or foam within 91 m (300 ft) of waterways (USDA 2011), although accidental contamination is still possible.

Potential large-scale indirect effects of fire suppression activities on Cascades Frog habitat include decreased water input and altered peak flows into wetlands as well as increased sediment yield. Fire suppression activities over the past century have led to dense forests with very high fuel loads. Dense forests can reduce snowpack and take up water for transpiration, resulting in reduced water yields downslope (Kattelmann 1996). In addition, fire suppression can increase the natural invasion of shrubs and trees into open meadows, clogging formerly open breeding habitat with vegetation (Fellers and Drost 1993). Cascades Frogs may be losing suitable habitat in Lassen Volcanic National Park in part due to woody vegetation encroachment (Ibid.). The Forest Service began actively removing fuel loads in an effort to reduce the frequency and intensity of wildfires. Catastrophic fire can produce some of the most extreme and extensive alterations to watershed condition of any type of disturbance (Kattelmann 1996).

The degree to which fire suppression activities threaten the continued survival of Cascades Frogs differs by location. It is unlikely to be high in wilderness and high-elevation areas with sparse vegetation, where mechanized equipment is not permitted and fire suppression activities are rare. However, it is potentially high in the Southern Cascades region, because so few populations and limited numbers of animals remain (Pope et al. 2014).

*Habitat Loss and Alteration*

Vegetation and fuels management, water development and diversion, mining, and road effects can degrade or destroy Cascades Frog habitat.

Timber harvest, fuels management, salvage logging, and prescribed fire can impact Cascades Frogs (Pope et al. 2014). These activities change vegetation structure, the shade it produces, and woody debris, which can alter the quality of breeding, active-season, refuge, and overwintering habitat quality (Ibid.). They can also affect soil stability, erosion, and sediment loading to aquatic habitats (Ibid.). The effects of controlled burns for fuel reduction on Cascades Frogs are not well understood (Pilliod et al. 2003). Prescribed fire may benefit the species if it reduces encroachment of woody vegetation into meadows or the likelihood of a catastrophic fire, but it can be hazardous if undertaken in areas with granitic soils. Erosion rates of burned areas on granitic soils can be 66 times as great as in undisturbed watersheds and can elevate annual sediment yields for 10 years or more (Megahan et al. 1995).

Water developments, such as dams and diversions, can dramatically alter aquatic habitats (Harris et al. 1987, Moyle and Randall 1998). Dams can raise the levels of existing lakes or ponds or flood meadow habitat, eliminating, or potentially creating, Cascades Frog habitat. Diversions can modify the hydrology and water retention at a site potentially affecting breeding habitat. Most major water developments and diversions occur at lower elevations (Moyle and Randall 1998), but hydroelectric power generation and water storage reservoirs also occur in higher elevation areas within the Cascades Frog's range, such as Lake Almanor and Butte Valley Reservoir in the Southern Cascades region and Shasta and Trinity dams in the Klamath Mountains region (Pope et al. 2014). There are about 15 small lakes and meadow systems within the species' historical range in California that have some form of hydrological development, the majority of which consist of small dam structures that raise the water level of an existing water body.

Suction-dredge gold mining in streams and rivers can impact habitat by increasing suspended sediment, rearranging stream substrate, altering stream geomorphology, and directly trapping or killing aquatic organisms, including Cascades Frogs (CDFG 2011). All instream suction-dredge mining has been suspended since 2009 in California; however, the legacy impacts of historic hydraulic mining continue, including altered stream geomorphology and release of contaminants such as acid, cadmium, mercury, and asbestos in waterways (Larson 1996).

Most populations of Cascades Frogs are likely not directly affected by roads, but the indirect impacts of roads on the species' habitats and dispersal ability may be significant (Pope et al. 2014). Roads have the potential to change soil density, temperature, soil water content, light input, dust, surface water flow, pattern of runoff, and rates of sedimentation, and may also serve as barriers to movement that could prevent recolonization of extirpated sites (Trombulak and Frissell 2000). Six major highways (Interstate 5 and Highways 32, 36, 44, 89, and 299) partly or completely fragment portions of the Cascades Frog's range in California. In addition, paved, dirt, and gravel roads and trails occur throughout the species' range. Road crossings of water courses have the potential to block in-channel movements and dispersal events if culverts are too steep, become blocked by debris, or become disconnected from the streambed.

The degree to which habitat loss and alteration caused by these factors threaten the continued survival of Cascades Frogs is considered to be low with the exception of population isolation and habitat alteration caused by roads, which may be moderate on private lands and on the Lassen and Klamath national forests (Pope et al. 2014).

*Introduced Fish*

The impacts of stocking non-native fish into historically fishless waters on ecosystem functions and native species assembles, particularly amphibians, have been well documented (Bradford 1989, Hartel et al. 2007, Hartman et al. 2013, Knapp 2005, Knapp and Matthews 2000, Knapp et al. 2001, Pilliod and Peterson 2001, Ryan et al. 2014, Schindler et al. 2001, Vredenburg 2004, Welsh et al. 2006). This impact is widespread; non-native trout and other salmonids occupy approximately 95% of large mountain lakes and 60% of smaller ponds and lakes that were formerly fishless in the western U.S. (Bahls 1992). The majority of large and deep lakes in the Klamath Mountains and Southern Cascades support non-native populations of brook trout (*Salvelinus fontinalis*) or rainbow trout (*Oncorhynchus mykiss*) (Pope et al. 2014, Welsh et al. 2006).

Introduced fishes can affect amphibians in a number of ways. Introduced fish and native species compete for resources such as invertebrate prey (Bucciarelli et al. 2014, Finlay and Vredenburg 2007). Joseph et al. (2011) reported that adult Cascades Frogs co-occurring with introduced trout had smaller proportions of aquatic invertebrate prey in their stomachs than those occupying areas without trout. Introduced fish also directly prey upon native amphibians (Finlay and Vredenburg 2007, Simons 1998). Hartman et al. (2013) observed that, in the presence of trout, Cascades Frog larvae were most often found in shallow, vegetated areas that serve as a refuge from fish. The presence of nonnative fish can also lead to an increase in other predators. For example, in the Klamath Mountains, the Aquatic Gartersnake (*Thamnophis atratus*) was able to expand its range as a result of more prey availability (introduced fish), thus facilitating opportunities to also increase predation upon Cascades Frogs (Pope et al. 2008).

Several studies have documented a "fish" effect on Cascades Frog abundance and distribution. Welsh et al. (2006) reported that Cascades Frog distribution was negatively correlated with fish distribution, and Cascades Frog larvae were 3.7 times more likely to occur in lakes without trout. Garwood and Welsh (2007) reported that the density of Cascades Frogs was 6.3 times higher in a fishless stream than a similar one containing a high density of trout. Pope (2008a) reported that, within 3 years of removing fish from 3 lakes, Cascades Frog densities increased 13.6 times and juvenile survival increased from 59% to 94%. Cole and North (2014) reported that the presence of trout was one of the strongest factors predicting presence of Cascades Frogs, and at higher elevations where trout were absent, Cascades Frogs dominated the aquatic species assemblage. Given climate change predictions, it can be expected that as higher elevation, intermediate wetlands dry up, Cascades Frogs will be forced to move into deeper waterbodies that are more likely to be occupied by fish, and the shallow refuges that protect larvae will likely also dry up, forcing the species into deeper waters with less protection (Pope et al. 2014, Ryan et al. 2014).

The declines of Cascades Frog populations, as well as two other native amphibians in California, prompted a lawsuit that concluded in a ruling that the Department must consider the impacts of fish stocking on the environment and native ecosystems. The resulting Environmental Impact Statement (ICF Jones and Stokes 2010) determined that the impacts of non-native trout on Cascades Frogs were “potentially significant.” There were 175 trout stocking locations within the Cascades Frog’s range in California (ICF Jones and Stokes 2010). Although stocking has since ceased in areas known to support Cascades Frogs (ICF Jones and Stokes 2010, Pope et al. 2014), many populations of stocked fish are likely self-sustaining (Pope et al. 2014).

The degree to which introduced fish and other predators threaten the continued existence of Cascades Frogs is considered to be high and widespread (Pope et al. 2014). The adverse impacts of introduced fish on Cascades Frog presence and densities have been demonstrated in the Klamath Mountains region, strongly suggesting they also contributed to declines in the Southern Cascades region (Ibid.). In addition, the interactions of introduced fish with other stressors, such as climate change and disease, may also be high (Ibid.).

*Livestock Grazing*

Seasonal cattle and sheep grazing have occurred in California for over two centuries, and the impacts on native ecosystems have been well documented (Fleischner 1994, Menke et al. 1996). These impacts include loss of native species, changes in species composition, alteration of hydrological function, including lowered water tables, soil deterioration, degradation of fish and aquatic insect habitat, and changes in ecosystem structure and function (Belsky et al. 1999, Fleischner 1994, Flenniken et al. 2001, Kauffman and Krueger 1984). There are no published studies that have directly examined the impacts of livestock grazing on Cascades Frogs, but negative impacts to other high elevation wetland ecosystems and Ranid frog habitats have been reported, include reducing vegetative cover, creating excess nitrogen pollution, increasing siltation of breeding ponds, and altering the local hydrology through erosion (Jennings 1996, Jennings and Hayes 1994).

Livestock grazing still occurs across most of the Cascades Frog’s range, but the extent and numbers on public lands have been reduced dramatically compared to past practices. Meadow sites occupied by Cascades Frogs on private lands in the Southern Cascades region are still grazed by livestock, as is much of the species’ range in the Klamath Mountains region, although, although portions of the wilderness areas are inaccessible to cattle or are not permitted for grazing. Long-term impacts of historical grazing practices are difficult to quantify, but where it has resulted in channel incision and lowered water tables, there may be less available Cascades Frog breeding habitat or it may dry up more rapidly (Pope et al. 2011). Risks from current grazing practices include trampling and water quality degradation, which are a greater threat to already small populations such as those in the Southern Cascades region (Pope et al. 2014).

The degree to which livestock grazing threatens the continued survival of Cascades Frogs is presumed to be low. Although livestock grazing is still fairly widespread across the Cascades Frog's range in California and effects from previous grazing may be extensive, the practice has not been permitted for over 10 years in most breeding habitats on public lands in the Lassen region, where the species has experienced the most extreme declines, and livestock numbers have been reduced on other public lands within the Cascades Frog's range (Pope et al. 2014). However, where livestock grazing still occurs in the Southern Cascades region, negative impacts could reduce the likelihood of persistence due to already small population sizes (Ibid.).

*Recreational Activities*

Approximately two-thirds of the Cascades Frog's range in California occurs on public lands; approximately 5% on national park lands and 62% on national forest lands (USDA 2001b). Approximately half of the national forest lands are designated as wilderness areas, where recreation is dispersed and limited to non-motorized activities such as hiking, fishing, and camping. On the other half, recreational use can involve motorized activities such as off-highway vehicle use, which may have the potential for greater impacts. Of the one-third of the species' range that occurs on private lands, most is owned by timber companies with limited public recreation, but there are some campsites and lodges with heavy recreational use.

There are no published studies that have directly examined the effect of recreational activities on Cascades Frogs, but potential impacts can be inferred from reports on similar habitats or species. Mid- to high-mountain lakes, streams, ponds, and wet meadows are popular recreational destinations that provide fishing and swimming opportunities and are connected through trail networks and campsites. Construction and use of trails and camps disturbs vegetation and soil structure, and anglers often create shoreline trails for access to fishing spots even at remote wilderness lakes, which can result in erosion that increases sedimentation in pools (Boyle and Samson 1985, Brönmark and Hansson 2002, Garton et al. 1977, Knight and Cole 1991). Recreational packstock (horses and mules used to assist travel in remote areas) grazing in alpine meadow habitat can adversely affect habitat quality, particularly important shallow water areas around breeding ponds and lakes, and can directly trample all life stages of frogs (Cole et al. 2004, Moore et al. 2000, Olson-Rutz et al. 1996).

Recreational activities may degrade habitat quality or frequently disturb normal basking and feeding behaviors, which can increase the production of glucocorticoid stress hormones in frogs, the long-term effects of which include suppression of growth, reproduction, and immune system functions (Moore and Jessop 2003). Stress hormones in amphibians are also elevated by exposure to *Bd* and cause increases in metabolic rates that are energetically costly (Peterson 2012, Wack et al. 2012), and the effect of environmental stress on frogs exposed to

*Bd* appears to result in lower energy stores and survival compared to unstressed frogs (Peterson 2012).

The degree to which recreational activities threaten the continued survival of Cascades Frogs is presumed to be low to moderate. Over most of the species' range, recreational activities are light and dispersed, but in some high-use areas like lakes that are not within designated wilderness and have road access, they may have measurable impacts to Cascades Frogs and their habitats (Pope et al. 2014). Recreational impacts also interact synergistically with other stressors to increase stress, which reduces the health and resilience of Cascades Frog populations (Pope et al. 2014).

*Small Population Sizes*

Small population size, combined with genetic isolation, increases a species' risk of extinction. Isolated sites are less likely to support Cascades Frog populations over the long-term and are less likely to be recolonized once the population is extirpated (Pope et al. 2014). Therefore, increasing population sizes and habitat connectivity are important factors in ensuring the long-term viability of Cascades Frogs.

Monsen and Blouin (2004) reported that Cascades Frogs exhibit extreme genetic isolation over relatively short distances compared to other frog species; gene flow is reduced at distances of as little as 10 km (6.2 mi). Montane habitats may promote this type of isolation, particularly for species like Cascades Frogs that have a limited active season and specialized habitat requirements, which make long-distance movements risky and infrequent (Ibid.). Recolonization of a historically occupied site in Oregon reportedly took 12 years, even though a population of Cascades Frogs was located within 2 km (1.2 mi) of the site (Blaustein et al. 1994).

The degree to which small population sizes threaten the continued survival of Cascades Frogs is potentially high in the Lassen area of the Southern Cascades region due to lack of connectivity among the remaining populations, which could lead to a genetic bottleneck (Young and Clarke 2000).

2. Other Relevant Scientific Information

Marijuana (*Cannabis* spp.) cultivation may also pose a threat to Cascades Frog survival. Marijuana cultivation is concentrated in Northern California throughout the lower elevation portion of the Cascades Frog's range, especially in habitats below 1500 m (5000 ft). Water diversions associated with illegal Marijuana cultivation can be a significant threat to desiccation-intolerant amphibian species (Bauer et al. 2015), including the highly aquatic Cascades Frog. Increased inputs of nutrients from fertilizers, toxins from pesticides, and other pollutants also potentially threaten existing Cascades Frog habitats, although these impacts have not been directly studied.

If beaver populations had declined historically in parts of the Cascades Frog's range, it may have contributed to loss or modification of breeding habitat. Cunningham et al. (2007) showed that as beavers have recolonized areas of their former range in North America, they have increased the number and diversity of available breeding sites in the landscape for pond-breeding amphibians. Cascades Frogs are known to occur in habitats modified by beavers in the Lassen region (Pope et al. 2011).

3. Sufficiency of the Petition with regard to Factors Affecting the Ability to Survive and Reproduce and Degree and Immediacy of Threat

The Department concludes that the Petition contains sufficient information to suggest that Cascades Frogs are adversely affected by historical habitat damage and a number of on-going and future threats such as habitat degradation and loss, climate change, disease, and introduced fish, that may be synergistically acting together to threaten the species' continued survival.

## G. Impact of Existing Management Efforts

1. Information in the Petition

The Petition contains the following information on the impact of existing management efforts on the Cascades Frog on pages 26 through 29.

*Federal Regulatory Mechanisms*

The Center for Biological Diversity petitioned the Cascades Frog for listing under the federal Endangered Species Act (CBD 2012), and the U.S. Fish and Wildlife Service determined that the petition possessed substantial information indicating listing may be warranted (USFWS 2015), but the agency does not expect to make a determination on whether or not to propose the species for listing until 2022 at the earliest (USFWS 2016b). Other federal regulatory mechanisms that could potentially provide some form of protection for the Cascades Frog include occurrence on federally protected land and consideration under the National Environmental Policy Act. There are no federal Habitat Conservation Plans in California that cover the Cascades Frog (USFWS 2017).

*Occurrence on National Forests and National Parks/National Environmental Policy Act*

Populations of Cascades Frogs that occur on federal lands are mostly protected from development, although other activities on these lands have the potential for harm and may threaten their long-term survival. In spite of management policies on federal lands that are designed to protect natural resources, amphibians are still declining in these areas, and the policies and practices do not provide protection from threats such as airborne contaminants and non-native predators (Adams et al. 2013). For example, even though non-native fish are no longer stocked in occupied Cascades Frog habitat (ICF Jones and Stokes 2010), there do not appear to be any current efforts to eradicate self-sustaining populations on federal lands within their range.

The national forest lands within the Cascades Frog's range in California have forest plans that provide direction on management and protection of aquatic and riparian-dependent species (Pope et al. 2014). In multiple-use areas (most non-wilderness areas), riparian management zones are designated around all waterbodies and fluvial systems to emphasize their protection and to help maintain their ecological integrity. Generally, only activities that promote maintenance and restoration of these ecosystems and their functions are permitted within the riparian management zones, but timber harvest, road building, livestock grazing, and other activities that may degrade Cascades Frog habitat are not prohibited under the plans.

The Forest Service adopted the Sierra Nevada Forest Plan Amendment in 2001, which contains an Aquatic Conservation Strategy focused on reducing some threats to amphibians, including the Cascades Frog. Some of these measures include changes to livestock grazing and non-native fish stocking practices, but the plan also contains activities such as fire and fuels management that may increase risk of habitat degradation for Cascades Frogs. Efforts to weaken the environmental protections, and increase the amount of logging allowed, under the Sierra Nevada Forest Plan Amendment have been on-going since its adoption.

One of the products of the Sierra Nevada Forest Plan Amendment was publication of a conservation assessment for the Cascades Frog, in cooperation with other federal agencies, state agencies, universities, and research scientists (Pope et al. 2014, USDA 2001a). Conservation Assessments provide only management recommendations, not mandated habitat protections. The conservation assessment is envisioned to be the first of a three-phase process that also includes a conservation strategy and a conservation agreement, but given the fact that the conservation assessment took over a decade to produce, actions and protections in the planned conservation strategy and agreement will likely not be afforded to the species anytime soon.

The Cascades Frog is designated as a Sensitive Species by the Pacific Southwest Region (Region 5) of the Forest Service (USDA 1998). Under Forest Service policy, Sensitive Species are to be managed in a way that ensures their viability and precludes trends toward endangerment that would warrant federal listing. All Forest Service planned, funded, executed, or permitted programs and activities are reviewed under the National Environmental Policy Act (NEPA, 42 U.S.C.4321-4370a) for possible adverse effects on Sensitive Species, through a Biological Assessment and Evaluation. The NEPA process requires federal agencies to describe a proposed action, consider alternatives, identify and disclose potential environmental impacts of each alternative, and involve the public in the decision-making process. However, neither the Sensitive Species designation nor the NEPA process requires avoidance of impacts, just consideration and disclosure, so even if the determination is that Cascades Frogs will be harmed or destroyed, the action may be undertaken.

Lassen Volcanic National Park is the only national park within the Cascades Frog range in California, and its Resource Management Plan (NPS 1999) acknowledges the species' decline and provides guidance relevant to Cascades Frog conservation. These include maintaining and rehabilitating aquatic systems; protecting and monitoring populations of sensitive species; promoting cooperation among federal, state, and private entities in preserving ecosystem health; eliminating or controlling damaging non-native species; and restoring, to the extent feasible, extirpated species. However, the Cascades Frog is now extirpated from Lassen Volcanic National Park, and because fish stocking began before the park was established, it is unclear which species of fish were native to each system. Even though stocking ceased completely in 1992, 16% (9 of 57) of the park's lakes still supported introduced trout as of 2004 (Stead et al. 2005).

*State Regulatory Mechanisms*

The Cascades Frog is listed as a Species of Special Concern by the state of California (CDFW 2017b). This is an administrative designation that reflects the fact that the species is in decline but does not afford any substantive or legal protection. Other state regulatory mechanisms that could potentially provide some form of protection for the Cascades Frog include a state aquatic biodiversity strategy and consideration under the California Environmental Quality Act. There are no Natural Community Conservation Plans that cover the Cascades Frog (CDFW 2017c).

*Aquatic Biodiversity Strategy*

The Department developed a strategy for maintaining aquatic biodiversity in high-elevation wilderness ecosystems, including protecting and enhancing native amphibian assemblages, while trying to optimize recreational trout fishing opportunities (Garwood and Welsh 2007). The Department began implementing this conservation strategy in 1999 in the Sierra Nevada Mountains through development of watershed-based management plans focused on Sierra Nevada and Southern Mountain Yellow-legged Frogs (*R. sierrae* and *R. muscosa*, respectively), but differences between the ecology of these species and the Cascades Frogs rendered the watershed plans inadequate to protect Cascades Frogs (Ibid.).

*California Environmental Quality Act*

The California Environmental Quality Act (CEQA, California Public Resources Code §§ 21000-21177) requires state agencies, local governments, and special districts to evaluate and disclose impacts from projects in the state. Under CEQA, Species of Special Concern must be considered during the environmental review process, with an analysis of the project impacts on the species, only if they meet the criteria of sensitivity under Section 15380 of the CEQA Guidelines. However, project impacts to Cascades Frogs would not need to be analyzed if project proponents determined there are insignificant impacts (e.g., if the project does not have population-level or regional effects or impacts a small proportion of the species' range).

In addition to promoting environmental protection through procedural and informational means, CEQA has substantive mandates that can benefit declining or otherwise imperiled species. Public agencies are required to deny approval of a project with significant adverse effects when feasible alternatives or feasible mitigation measures can substantially lessen such effects. However, this mandate is rarely implemented, and lead agencies may approve projects despite remaining significant adverse impacts after all mitigation measures and alternatives deemed feasible have been adopted, if it finds that social or economic factors outweigh the environmental costs. CEQA is not, nor was it ever intended to be, a habitat protection mechanism.

*Summary*

Existing federal or state regulatory mechanisms do not adequately protect Cascades Frog populations or their habitats. Without state listing, significant conservation efforts for the Cascades Frog, reintroduction of the species at unoccupied historic sites, and implementation of frog habitat restoration projects are unlikely to occur.

2. Other Relevant Information

The Department is in possession of additional information on existing management efforts for the Cascades Frog, specifically relating to introduced fish management and eradication. As stated in the Petition, fish stocking by the Department in waters known to support Cascades Frogs has ceased (ICF Jones and Stokes 2010). This has a direct bearing on Cascades Frog conservation. Some waterbodies in the Cascades Frog range lack spawning habitats and others are known to suffer from oxygen depletions caused by periodic eutrophic conditions (B. Aguilar pers. comm.). Although the Department has not assessed many of these waters since the change in stocking management, some fish populations are not self-sustaining and have likely gone extinct.

From 2003 to 2008, a fish removal experiment was conducted in four lakes across the Klamath Mountains that support extant Cascades Frog populations (Pope 2008a). Results from the Pope (2008a) experiment are covered in detail within the Petition. Currently, two of the four lakes have remained fishless as a result of the research project (K. Pope pers. comm.).

Starting in 2014, following the recommendation of a draft basin management plan, the Department began a fish removal project in Echo Lake Basin, Klamath Mountains. The goal of this project is to restore approximately 70% of the available aquatic habitat for Cascades Frogs. This basin was chosen for restoration based on its exceptional Cascades Frog habitats and because it maintains persisting Cascades Frog populations. The basin has been part of a long-term Cascades Frog population monitoring program initiated in 2003 (Garwood and Welsh 2007). Habitats containing brook trout include Echo Lake and approximately 1.6 km (1 mi) of stream channels occurring below the lake. Since the inception of the fish removal project, 724 brook trout have been removed from the lake and streams, with complete removal expected in 2017 (Demianew et al. 2016). The Department is tracking the numerical response of native amphibian populations in response to the removal of brook trout with a before-after-control-impact study design.

3. Sufficiency of the Petition with regard to Impacts of Existing Management Efforts

The Department concludes the Petition contains sufficient information to suggest that existing regulatory mechanisms and management efforts do not adequately protect Cascades Frogs from impacts that threaten their long-term survival.

## H. Suggestions for Future Management

### 1. Information in the Petition

The Petition contains the following suggestions for future management of the Cascades Frog on page 30.

*Remove Invasive Fish*: Remove trout within the species' range to increase the amount of fishless habitat available, and continue to not stock in waters supporting Cascades Frogs.

*Investigate Disease Treatment*: Research the effectiveness of various methods to reduce the mortality rate of Bd, and determine the feasibility of treatment in the wild.

*Modify Fuel Management and Livestock Grazing*: Determine the effects of vegetation and fuels management and livestock grazing on Cascades Frogs, and modify management practices and grazing leases accordingly to protect and restore the species' habitat.

*Restore Habitat*: Determine the effectiveness of restoration and habitat enhancement methods such as modifying breeding pools, removing livestock, thinning riparian vegetation to increase basking opportunities, or thinning lodgepole pines adjacent to breeding pools; monitor populations pre- and post-restoration; prioritize sites for restoration actions.

*Restrict Pesticide Use*: Determine where and when pesticide uses should be restricted to prevent exposure to Cascades Frogs.

*Reduce Recreational Impacts*: Encourage diffuse recreation and limit camping at lakes inhabited by Cascades Frogs on federal lands.

*Consider a Captive Breeding Program*: Begin a captive breeding program to provide donors for reintroductions if local populations become extirpated.

*Reintroduce Populations*: Explore reintroduction into appropriate habitat within the historical range, and investigate the feasibility of translocation or reintroduction of captive raised Cascades Frogs, particularly in Lassen Volcanic National Park.

*Monitor Populations*: Institute a long-term, rangewide program to monitor extant Cascades Frog populations.

### 2. Other Relevant Information

The following recommendations are adapted from Thomson et al. (2016) *California Amphibian and Reptile Species of Special Concern*.

*Conduct a detailed genetics study*: Characterize the degree and extent of intraspecific variation and use that information to designate management units and to inform population reintroduction and augmentation efforts. Note that a current population genetics study is being conducted by the University of Wisconsin-Madison (B. Hardy pers. comm.).

*Quantify interactive effects of threats*: Better understanding of the relative weight of each threat (e.g., climate change, *Bd*, introduced fish, etc.) and their interactions may be useful in developing conservation strategies.

3. Sufficiency of the Petition with regard to Suggestions for Future Management

The Department concludes the Petition contains sufficient scientific information on additional management actions that may aid in maintaining and increasing self-sustaining populations of Cascades Frogs in California.

## I. Availability and Sources of Information

1. Information in the Petition

The Petition contains a 17-page bibliography of literature cited on pages 31 through 47, the vast majority of which were provided to the Department on a CD.

2. Other Relevant Information

The Department used publicly available information and provided citations. The Department also used unpublished reports and personal communications that can be provided upon request. The Department did not receive any information from the public during the Petition Evaluation period pursuant to Fish and Game Code Section 2073.4.

3. Sufficiency of the Petition with regard to Availability and Sources of Information

The Department concludes the Petition contains sufficient sources of information that are readily available to attempt to determine the status of the Cascades Frog.

## J. Detailed Distribution Map

1. Information in the Petition

The Petition contains a detailed map of the distribution of Cascades Frogs in California on page 9, which depicts known localities up to 2011 and distinguishes between sites that were confirmed to be occupied between the following years: 1891-1980, 1980-1999, 1999-2011 (Pope et al. 2014). All localities within the map provided by the petition fall within the Department's Cascades Frog 2016 range map (CDFW 2016).

2. Other Relevant Information

The Department's range map for Cascades Frog (Figure 1) is based on the work in Thompson et al (2016). There are subtle differences in the distribution of Cascades Frog observations in Thomson et al. (2016) and those in the Petition's map (Pope et al. 2014); however, none of these substantively change the known distribution of the species.

3. Sufficiency of the Petition with regard to a Detailed Distribution Map

The Department concludes the Petition provides a sufficiently detailed map of the historical and contemporary distribution of Cascades Frogs in California.

## IV. Status of the Species

The Cascades Frog occupies mid- to high-elevation wetlands in the Klamath Mountains and Southern Cascades, and every life stage is closely associated with aquatic habitats. The species' distribution and abundance have declined in parts of its range in California, most dramatically in the Southern Cascades/Lassen region where few populations remain and nearly all are very small. Populations within the Klamath Mountains region are still relatively widespread and appear to be mostly stable, even with seemingly low overall population sizes. The Cascades Frog's breeding cycle is closely tied to snowmelt, and successful reproduction requires breeding habitats to remain stable for several months during embryonic and larval development. The direct and interactive effects of climate change, disease, and introduced fish appear to be the primary threats to continued survival of the species. Additional possible threats, which may be more severe at lower elevations and in areas with very small populations, include airborne contaminants, recreational activities, livestock grazing, fire suppression activities, and roads.

Having reviewed and evaluated the Petition on its face and in relation to other relevant information, including the material referenced in the Petition and other information in possessed or received by the Department, the Department has determined that there is sufficient scientific information available at this time to indicate that the petitioned action may be warranted and recommends that the Petition be accepted and considered. (See Fish & G. Code, § 2073.5, subd. (a)(2); Cal. Code Regs., tit. 14, § 670.1, subd. (d).)

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Personal Communications

Aguilar, Bernard. Environmental Scientist, California Department of Fish and Wildlife, Redding, CA. Phone conversation on April 11, 2017.

Garwood, Justin. M.S. Environmental Scientist, California Department of Fish and Wildlife, Arcata, CA. Phone conversation on April 11, 2017.

Hardy, Bennett. M.S. Student, Department of Biological Sciences, University of Wisconsin-Milwaukee, WI. Electronic mail received April 13, 2017.

Pope, Karen, Ph.D. Research Wildlife Biologist. USFS Pacific Southwest Research Station, Arcata, CA. Electronic mail received April 13, 2017.