FGC - 670.1 (3/94)

A PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION

For action pursuant to Section 670.1, Title 14, California Code of Regulations (CCR) and Sections 2072 and 2073 of the Fish and Game Code relating to listing and delisting endangered and threatened species of plants and animals.

I. SPECIES BEING PETITIONED:

Common Name: Cascades frog

Scientific Name: (*Rana cascadae*)

II. RECOMMENDED ACTION:

(Check appropriate categories)

a. List **X**
As endangered or threatened

b. Change Status □

c. Or Delist □

III. AUTHOR OF PETITION:

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I hereby certify that, to the best of my knowledge, all statements made in this petition are true and complete.

Signature:

Date: March 1, 2017

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
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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

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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.

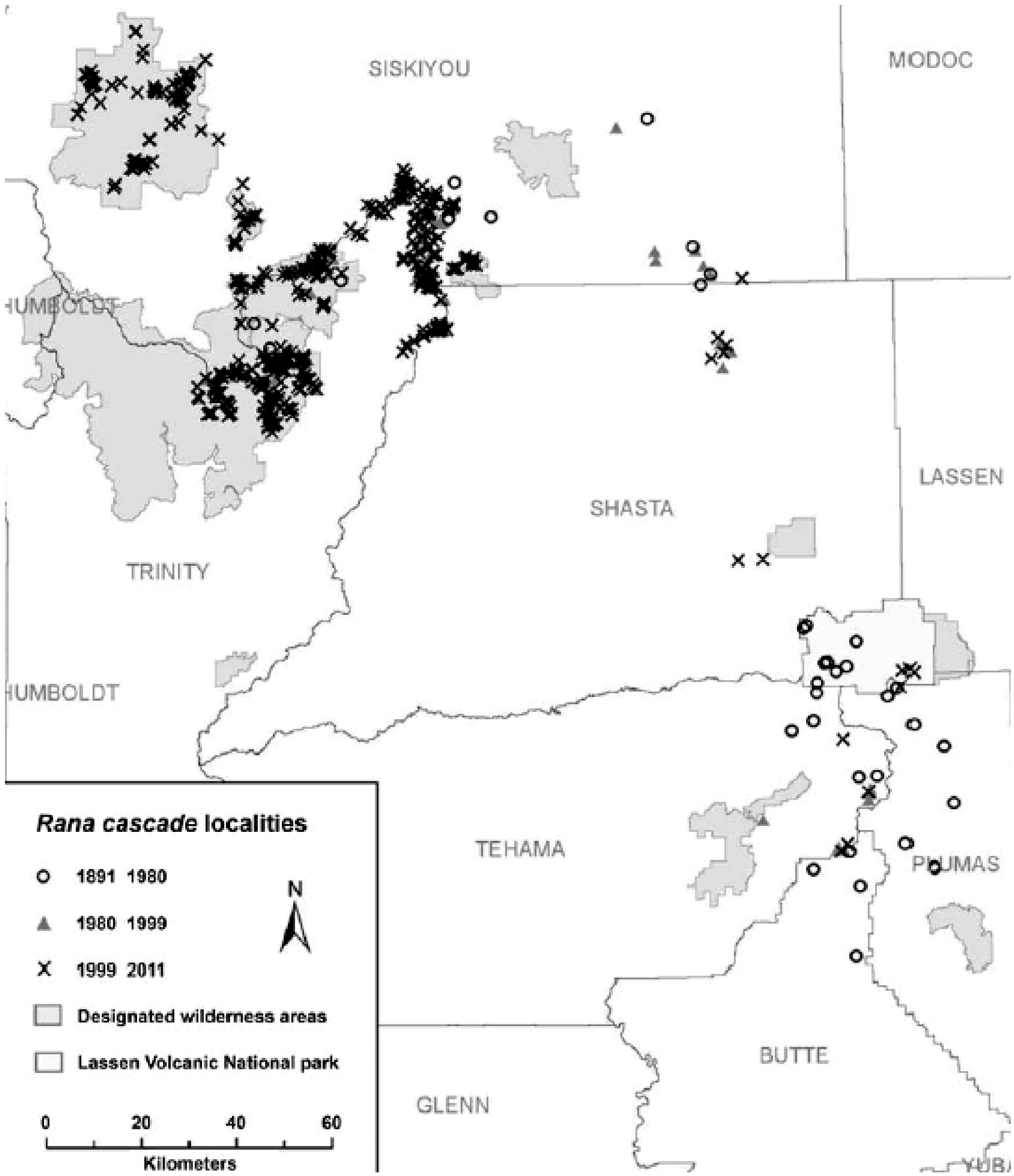

Figure 1: Recent and historical distribution of the Cascades frog (*Rana cascadae*) in California. This map contains known localities up to 2011. The sites in Trinity and Siskiyou Counties are in the Klamath Mountains and the sites in Shasta, Tehama, Butte, and Plumas Counties are in the southern Cascade 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).

<u>National Environmental Policy Act</u>

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.

<u>Aquatic Biodiversity Strategy</u>

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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