
Photo courtesy of Walter Siegmund

Scientific Name:

Rana cascadae

Common Name:

Cascades Frog

G Rank:

G3

IUCN Red List:

Near Threatened

NATURAL HISTORY, BIOLOGY, AND STATUS

Range:

Pearl and Adams (2005) explain that Cascades frogs historically occupied moderate and high elevation (about 400–2,500 m) lentic habitats throughout the Cascade Range, from the very northern edge of California's Sierra Nevada to within 25 km of the British Columbia border (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 1994a). In Washington, Cascades frogs occur in the Pacific Coast, North Cascades, West Cascades and East Cascades ecoregions (Hallock and McAllister 2009).

Severe range contractions have been documented in the southern end of their 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 (Mt. Lassen and surroundings), and 50 percent of their total historical distribution in California. Since that time, further range contractions have occurred (Fellers et al. 2007). Its historic range might have included much lower altitudes (Leonard et al. 1993).

Habitat:

According to NatureServe (2011), Cascades frogs inhabit wet mountain meadows, sphagnum bogs, ponds, lakes, and streams, in open or patchy coniferous forests. Generally they are closely associated with water, but they sometimes move from one drainage to another by crossing over high mountain ridges. These frogs hibernate in mud at the bottom of ponds and in spring-water saturated ground up to at least 75 meters from a pond (Briggs 1987). Breeding sites are quiet ponds, where eggs are laid in open shallow water or among submerged vegetation. Adults and breeding can occur in anthropogenic wetland habitats such as pump chances (Quinn et al. 2001). The frogs habitats are being widely degraded by introduced fishes.

Biology:

The Cascades frog calls from above or below water's surface (Stebbins 1985). It is diurnal (active during the day) and breeds from March to mid-August, soon after pond ice begins to thaw (Stebbins 1985). Details on the natural history and biology of the Cascades frog are summarized by Pearl and Adams (2005) and Garwood and Welsch (2007).

Population Status:

The Cascades frog qualifies for endangered species status because it is "probably in significant decline" (Hammeron and Pearl 2004) due to threats such as introduced salmonids. The IUCN Red List ranks the species as Near Threatened but explains that it is close to qualifying to Vulnerable (Hammerson and Pearl 2004). The species was a candidate for federal protection until the FWS eliminated the C2 category, but it currently receives no federal protection under the ESA.

In California, surveys suggest that the Cascades frog is rare to nonexistent in most Californian portions of the historical range (G. Fellers, H. Welsh, personal communications, cited by Pearl and Adams 2005). Historic accounts and museum records indicate that the frog was previously abundant in the Mount Lassen area, California (Fellers et al. 2007). But this species has declined greatly and is now very rare (Fellers et al. 2007). 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). 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. (2007) and show that the situation has worsened significantly.

From 1993 to 2007, Fellers et al. (2007) 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 frogs at only six sites during 14 years of surveys, and obtained one report of a single frog at one additional locality. These occupied sites represented less than one percent of the historically suitable habitat within the Lassen region. They 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.

Declines have also occurred in Oregon (Nussbaum et al. 1983, Blaustein and Wake 1990, Fite et al. 1998, Olson 2001). AmphibiaWeb (2012): explains that the frog has "declined extremely in Oregon." Although abundant there in the early 1970's, 80 percent of 30 Oregon populations that A. Blaustein has monitored since the mid 1970's have disappeared (Blaustein and Wake 1990).

With extensive declines in California and Oregon, it is apparent that the frogs are declining from the south to the north. The species qualifies for endangered status despite the fact that it appears to be widespread across its historical habitat in Washington (Hallock and McAllister 2009) because the southern areas in which the frogs are declining constitute a significant portion of range.

THREATS

As explained below, potential causative factors in the decline of Cascades frogs include the introduction of fish into historically fishless habitats (e.g., Knapp and Matthews 2000, Knapp 2005, Welsh et al. 2006), disease (e.g., Fellers et al. 2001, Briggs et al. 2005), the downwind drift of airborne pesticides from agricultural areas (e.g., Davidson 2004, Fellers et al. 2004), and synergy among these and other factors (e.g., Blaustein et al. 2003).

Habitat alteration and destruction:

The Cascades frog is suffering from habitat loss and fragmentation. Declines in the Lassen Volcanic National Park are due in part to gradual loss of open meadows and associated aquatic habitats, and loss of breeding habitat due to drought (Fellers and Drost 1993). In this region, fire suppression and cessation of cattle grazing have increased the natural invasion of shrubs and trees into open meadows; former open breeding sites are now clogged with vegetation (Fellers and Drost 1993).

Disease or predation:

A troubling recent finding is that over 50 percent of sampled specimens were infected by chytrid fungus at a montane site in Washington (Gaulke et al. 2011). And that chytrid was detected at 64 percent of sites surveyed in the Klamath Mountains of California and that Cascades frogs were often infected (Piovia-Scott et al. 2011). While the frogs have experienced increased mortality from exposure to the fungus in the laboratory (Piovia-Scott et al. 2011, Garcia et al. 2006), 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).

Field experiments suggest that the oomycete fungus, *Saprolegnia ferax*, is related to embryonic mortality in Cascades frogs and are likely enhanced by other stressors such as ultraviolet radiation (Kiesecker and Blaustein 1995, 1997b). Romansic et al. (2007) found that juvenile

Cascades frogs exposed to *Saprolegnia* had significantly greater rates of mortality than unexposed controls.

Inadequacy of existing regulatory mechanisms:

Cascades frogs are considered a Species of Special Concern in California (California Department of Fish and Game 2011), and Sensitive-Vulnerable in Oregon (Oregon Natural Heritage Program 2008). The Cascades frog is also a Washington State Monitor species. These statuses reflect the fact that the species is suffering population declines but does not afford any legal protection.

According to Hammerson and Pearl (2004), some populations are within protected national park and wilderness areas in Oregon (such as Crater Lake National Park and the Three Sisters wilderness area), Washington (Olympic and Mount Rainier National Parks), and California (Mount Lassen and Trinity Alps). However, factors such as pesticide drift, UV radiation, and fish introductions are prominent threats even in montane protected areas.

Management agencies have not completed management plans that address the Cascades frog (Fellers et al. 2007). In California, the Department of Fish and Game has initiated a conservation strategy for protecting and enhancing native amphibian species while attempting to optimize recreational trout fishing opportunities (Garwood and Welch 2007). DFG has been implementing this conservation strategy in the Sierra Nevada Mountains through watershed-based management plans (http://www.dfg.ca.gov/habcon/conproj/big_pine.html, Milliron 2005). But these plans are focused on mountain (and Sierra) yellow-legged frogs (Garwood and Welsch 2007). Important differences between the ecology of Cascades frogs and mountain yellow-frogs make these plans inadequate to protect Cascades frogs (Garwood and Welsch 2007). In addition, there is no guarantee that this voluntary conservation plan will be fully implemented.

Other factors:

Introduced Species

Introduced salmonids are now widespread in high lakes throughout the range of Cascades frogs and represent a common predator of larvae and small adults, which is limiting its distribution in montane areas (Hayes and Jennings 1986, Fellers and Drost 1993, Jennings and Hayes 1994a, Simons 1998, Adams et al. 2001).

Non-native trout, including brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*), have been introduced throughout the range of the Cascades frog. These introductions occurred in formerly fishless lakes and streams where the frogs were once abundant. In the Klamath-Siskiyou region of northwestern California, Welsh et al. (2006) found that Cascades frog distribution negatively correlates with fish distribution, and the larvae occurred 3.7 times more frequently in lakes without trout. And 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 (2008) 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 2008).

Effects from introduced fish can range from direct predation on frogs (Simons 1998), competition for food (Finlay and Vredenburg 2007), and indirectly through a shared predator (Zavaleta et al. 2001, Pope et al. in review, cited in Garwood and Welsch 2007). Joseph et al. (2010) suggest that reductions in the availability of emerging aquatic insects cause Cascades frogs to consume more terrestrial prey where trout are present. Thus, introduced trout influences native amphibians directly through predation and, indirectly, through pre-emptive resource competition.

Ultraviolet Radiation

Cowger (1988) explains that many researchers suspect that UV-B radiation is a likely cause of the Cascades frog's reduction in numbers (Fellers and Drost 1993, Blaustein et al. 1994, Blaustein and Wake 1995, Blaustein et al. 1995, Kiesecker and Blaustein 1995). Ozone depletion during the last century has allowed higher levels of UV-B to enter our atmosphere (Blaustein et al. 1994). Since ambient UV-B also increases with altitude, populations of organisms living at higher elevations are more affected by UV rays (Blaustein et al. 1995). Since the Cascades frog is only found at high altitudes and needs to thermoregulate to keep warm, it is exposed to a large amount of UV radiation.

Many organisms, including the Cascades frog, contain the enzyme photolyase which helps to repair DNA damaged by light (Blaustein et al. 1994, Blaustein and Wake 1995). However, the Cascades frog has relatively low levels of the photolyase enzyme (Blaustein et al. 1994). UV-B rays weaken the Cascades frog's immune system causing it to be more prone to bacterial and viral infections (Kiesecker and Blaustein 1995).

UV-B rays have been directly implicated as a cause of increasing bacterial *Saprolegina* infections in the Cascades frog which lead to mass population declines of the Cascades frog in some areas (Kiesecker and Blaustein 1995). Increased solar radiation also is likely damaging frog retinas (Fite et al. 1998). In addition, Romansic et al. (2009) found that UVB-exposed Cascades frog larvae displayed decreased growth, increased prevalence of deformities, and increased susceptibility to predation.

Pollution

Agrochemicals are a threat in some areas (Davidson et al. 2002). Fertilizers such as urea likely pose a threat; in laboratory studies, juveniles were unable to sense and avoid toxic levels (Hatch et al. 2001). Nitrites can affect behavior and metamorphosis of larvae (Marco and Blaustein 1999). Paulk and Wagner (2004) found that glyphosate and malathion significantly affect Cascades frog larvae mortality and development at levels below EPA-recommended maximum levels for surface water.

Small and isolated populations

Monson and Blouin (2004) found that the Cascasdes frog exhibits extreme isolation by distance with reduced gene flow at distances greater than 10 km. As such, populations that go extinct are unlikely to be re-colonized quickly, especially if they are greater than 10 km from the nearest population. Consistent with this conclusion is the observation that recolonization of one historic Cascades frog site was reported to have taken 12 years despite the presence of a population within 2 km (Blaustein et al. 1994). 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).

Additionally, 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 longterm viability, potentially leading to a genetic bottleneck.

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CENTER *for* BIOLOGICAL DIVERSITY *Because life is good.*

August 31, 2015

Submitted Via Federal E-Rulemaking Portal

Public Comments Processing
Attn: FWS–R1–ES–2015–0046
Division of Policy and Directives Management
U.S. Fish and Wildlife Service
4401 N. Fairfax Drive, MS 2042–PDM
Arlington, VA 22203

RE: Comments responding to the positive 90-day finding on a petition to list the Cascades frog (*Rana cascadae*) as a threatened or endangered species under the Endangered Species Act.

Please accept these comments in response to the positive 90-day finding on a petition to list the Cascades frog (*Rana cascadae*) as a threatened or endangered species under the Endangered Species Act. These comments are submitted on behalf of the Center for Biological Diversity, a national non-profit conservation organization with 900,000 members and supporters, including members and supporters in California, Oregon, and Washington. Our members are concerned about the survival of endangered plants and animals, and the Cascades frog holds scientific, moral, aesthetic, and other value to our members and staff.

I. BACKGROUND

Around the world, amphibian species are declining by unprecedented rates. The current extinction rate of amphibians is estimated to be 211 times the background rate (McCallum 2007, cited in Adams et al. 2013, p. 1). Highly sensitive to environmental changes, these vertebrates are vulnerable to habitat alteration, climate change, invasive species, disease, contaminants, and the interactions of all these factors together, all of which are highly prevalent in today's natural ecosystems (Collins and Crump 2009, cited in Adams et al. 2013, p. 3).

A comprehensive assessment on the status of amphibians in 2004 revealed that 31.7 percent of all amphibian species in the United States are declining (Stuart et al. 2004, cited in Adams et al. 2013, p. 1). Also worth noting is that the number of species considered imperiled by the International Union for the Conservation of Nature (IUCN) is highest in the western United States. New statistical analyses reveal, however, that even species considered "Least Concern" by the IUCN are occupying at least 2.7 percent fewer sites in the United States, indicating that IUCN status's may be underestimated for some species (Adams et al. 2013, p. 3), while species listed in the "Endangered", "Vulnerable", or "Near Threatened" categories had a mean annual trend of -11.6 percent site occupancy (Adams et al. 2013, p. 2). Cascades frogs are listed as "Near Threatened", with a note that its status needs review (2004).

In July of 2012, the Center for Biological Diversity petitioned to have 53 species of amphibians and reptiles listed on the Endangered Species Act (ESA, the Act) that are susceptible to the same threats faced by amphibian species declining worldwide. Among these was the Cascades frog (*Rana cascadae*), which lives in the Cascades Range from northern Washington down to northern California, the Klamath Mountains, and the Olympic Peninsula and have experienced alarming populations declines at the southern end of its range. On July 1, 2015, the U.S. Fish and Wildlife Service (FWS, the Service) issued a positive 90-day finding on the petition for Cascades frog and initiated a review process. The below comments are meant to provide updated information on the status and threats to Cascades frogs.

II. NATURAL HISTORY

A. Description

The Cascades frog (*Rana cascadae*) is a medium-sized member of the "true frog" family, Ranidae, which is brown, copper, tan, or olive green and spotted on the back with a yellowish underside to cream underside and dark mottling around the groin and a cream-colored striped extending from the jaw to the shoulders. They grow to between 1.75 and three inches in length, with females being larger than males (Stebbins 2003, cited in Nafis 2000-2013). Cascades frog tadpoles have oval bodies with dorsal eyes, and they grow to about five centimeters in length. They are dark brown with copper and pinkish specking, golden coloring on the sides and a finely speckled tail (Nafis 2000-2013). Cascades frog eggs are black above, white below, and spaced out in a gelatinous mass (Nafis 2000-2013).

B. Life History

Cascades frogs are long-living, late-maturing amphibians (Pope et al. 2014, p. 9). Survival rates in the Trinity Alps Wilderness matched what is expected for other long-lived species, between 68 and 93 percent (Pope 2008, cited in Pope et al. 2014, p. 10). Male frogs reach maturity between three and four years of age while female frogs mature between the fourth and fifth years (Garwood, n.d., Garwood and Larson, n.d., cited in Pope et al. 2014, p. 9). Cascades frogs can live from five to ten years (NatureServe 2015; Garwood n.d., in Pope et al. 2014, p. 9).

Females will breed only once per year in the spring, as soon as the snow begins to melt (Nafis 2000-2013). Depending on the location, that could be anytime between March and August. Fertilization is external and eggs are laid in a mass of 300-800 eggs, partly submerged in shallow water. Tadpoles will develop over two to four months depending on water temperature (Nafis 2000-2013; Pope et al. 2014, p. 5).

C. Habitat Requirements

This frog occurs at 230-2500m of elevation – most often at higher elevations greater than 600m (Nafis 2000-2013) – in 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, cited in Pope et al. 2014, p. 5). 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. This makes eggs vulnerable to late freezes (Pope and Larson 2010, cited in Pope et al. 2014, p. 12). The reproduction site also must contain water long enough for egg and tadpole development, which takes about three to four months, depending on water temperature (Ibid.). Occasionally, tadpoles become stranded and die when all the water evaporates from sites with short hydroperiods (Garwood 2009, O'Hara 1981, Pope et al. 2011, Sype 1975, cited in Pope et al. 2014, p. 9). 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, Pope n.d.; Wollmuth et al. 1987, in Pope et al. 2014, p. 9); 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 and Larson, n.d., cited in Pope et al. 2014).

Overwintering habitat is considered to be almost as restrictive as breeding habitat (Garwood 2009, cited in Pope et al. 2014, p. 7). The frogs likely hunker down in 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, cited in Pope et al. 2014, p. 8). Unusually long winters may result in mortality if the frogs do not have enough energy stored up to make it through.

While 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, Bury and Major 1997, 2000, Garwood 2009, Pope et al. 2011, Fellers and Drost 1993, cited in Pope et al. 2014, p. 7). In the summer months, Cascades frogs may utilize streams more often (Garwood 2009, Pope et al. 2011, cited in Pope et al. 2014, p. 7). However, they 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, p. 145). Cascades frogs maintain site fidelity, where adults will move among unique breeding, feeding and overwintering habitats following a consistent annual pattern (Garwood 2009, cited in Pope et al. 2014, p. 9).

Cascades frog populations typically occur in a metapopulation structure, but genetic studies indicate high degrees of isolation for some local populations in relatively small geographic scales (Monsen and Blouin 2004, cited in Pope et al. 2014, p. 10). Population exchange likely drops after a distance of just 6.2 miles (ten kilometers) between populations (Ibid, p. 11).

III. RANGE AND POPULATION STATUS

The Cascades frog, as its name suggests, is distributed along the length of the Cascades Range from the top of Washington State within 15 miles of British Columbia to the northern edge of California's Sierra Nevada (Blaustein et al. 1995, Jennings and Hayes 1994, Pearl and Adams 2005, Stebbins 2003, cited in Pope et al. 2014, p. 4). According to NatureServe, the species has declined by 30 to 50 percent, with the most notable declines occurring in the southern portion of their range, while populations in the north seem to be stable.

A. California

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). Pope et al. (2014) recently conducted a comprehensive review on the status of Cascades frogs in California. The following information summarizes those results.

Cascades frogs historically ranged from the Shasta-Trinity region to the Modoc Plateau, south through the Lassen National Forest (NF) to the upper Feather River in California (Jennings and Hayes 1994, cited on p. 13). The southern Cascades, which comprise of about 40 percent of their California range, and the Klamath Mountains, which comprise of 60 percent, make up two disjunct populations of Cascades frogs, though the exact degree of isolation is unknown (p. 13).

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 (LVNP) and the northwestern and southern portions of Lassen NF (p. 13). Declines in these populations were not noted until the 1970s (p. 14). By the 1990s, surveys of LVNP sites that historically had frogs found few or no frogs, and Jennings and Hayes estimated that the species had disappeared from about 99 percent of its historical range in the Lassen region; only one of 32 historical Cascades frogs sites was still occupied in the 1990s (p. 14). Since 1993, 12 sites harboring Cascades frogs have been recorded, all with low numbers, ranging from five individuals at Colby creek to 150 at Carter Meadow in Lassen NF (p. 14). 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 (p. 14). No populations remain in LVNP, but some populations have been found south on private land and north near Lassen NF (Pope and Larson, n.d., on p. 14).

In the Klamath Mountains, Cascades frogs were known from about 25 localities in and around Shasta-Trinity NF in the 1970s, and few populations had been recorded in Klamath NF (p. 15). Surveys were carried out in the majority of their range in the Klamath Mountains from 1999-2002. Those results are summarized below.

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	-	-

In 2008, 112 sites where frogs were previously found were re-surveyed, and 79 percent were found to still support frog populations (Piovia-Scott et al. 2011, cited on p. 15). No major declines were noted, but the abundances of some previously robust populations seemed low. 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 (p. 16).

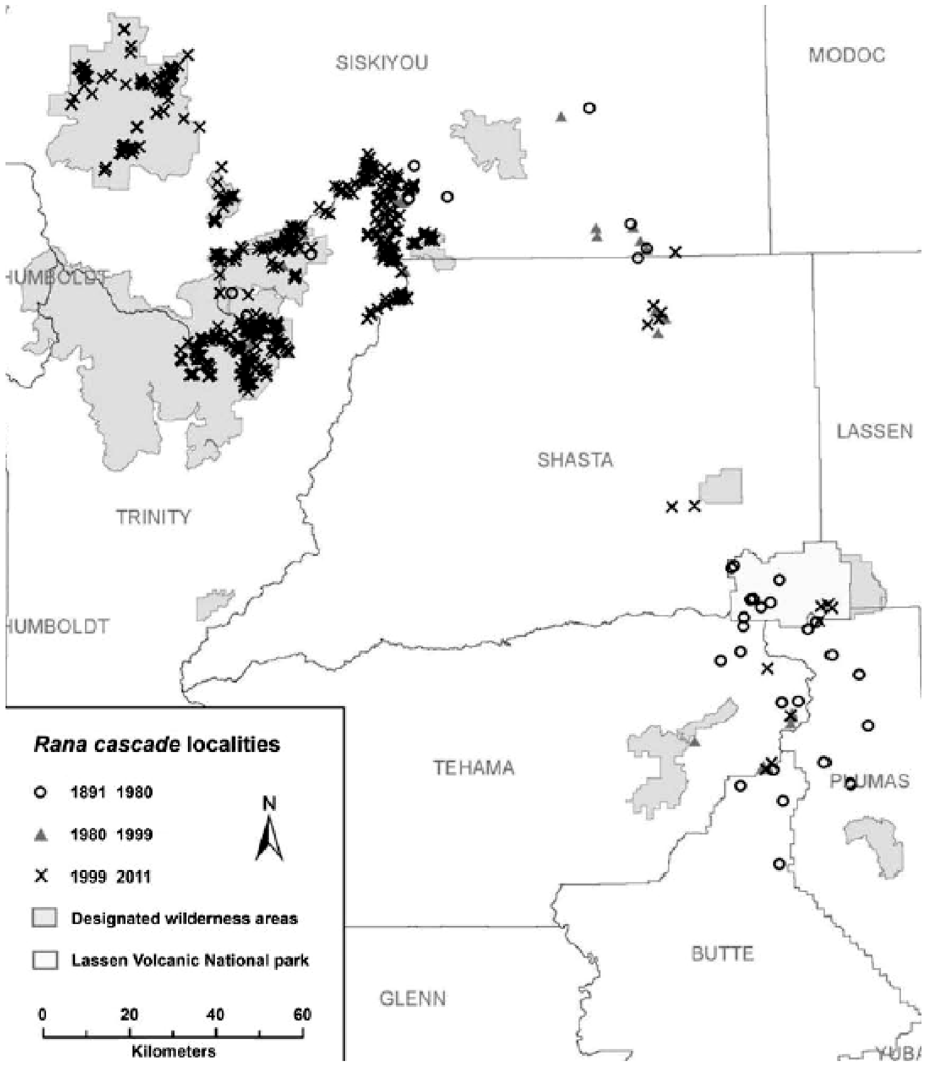

Figure 1: Recent and historical distribution of the Cascades frog (*Rana cascadae*) in California. This map contains known localities up to 2011. The sites in Trinity and Siskiyou Counties are in the Klamath Mountains and the sites in Shasta, Tehama, Butte, and Plumas Counties are in the southern Cascade Range. The southernmost grouping of points around Lassen Volcanic National Park is considered the Lassen region (Pope et al. 2014, Fig 1, p. 3).

B. Oregon

While population declines have been well documented in California, limited information is available in the published literature on the status of Cascades frogs in the Oregon Cascades. In 1990, Blaustein and Wake documented an 80 percent decline in the 30 populations of Cascades frogs they had monitored in the 1970s (p. 203), and according to AmphibiaWeb (2012) the Cascades frog has “declined extremely in Oregon”. Fite et al. (1998) estimated that 22 percent of historical Cascades frog populations have disappeared in Oregon (cited in NatureServe 2015).

Amphibian surveys in 2009 and 2010 in Oregon detected amphibians at 722 of the 1,693 monitored sites. Of these, Cascades frogs were found at seven: one in the Klamath Mountains and six in West Cascades (Tippery and Jones 2011, p. 8). The study does not mention whether a decline in Cascades frogs was noted from 2007 to 2010, the years in which these surveys have been occurring.

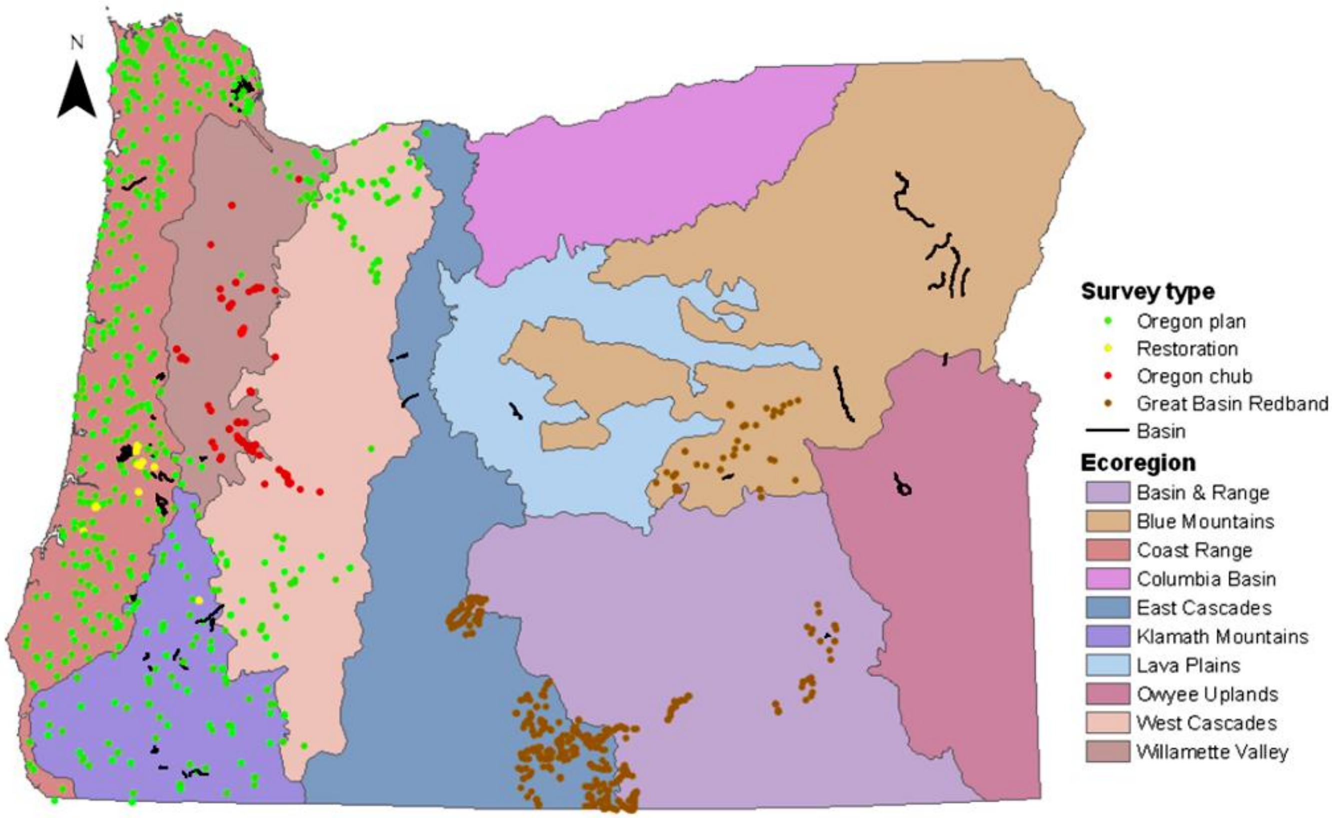

Figure 2: Oregon amphibian survey sites by type (Tippery and Jones 2011, Figure 1, p. 3).

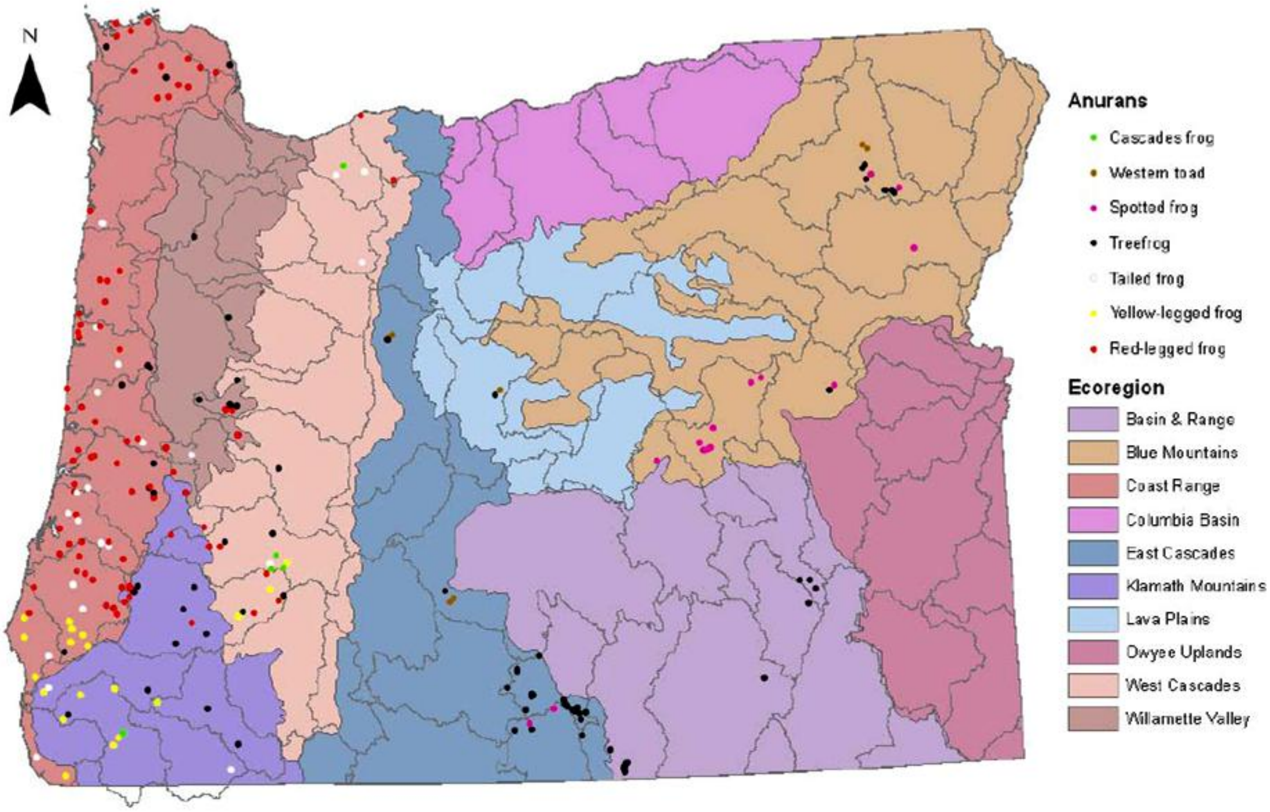

Figure 3: Locations where Cascades frogs were detected in 2009-2010 (Tippery and Jones 2011, p. 13).

C. Washington

Scant information exists on the population status of Cascades frogs in Washington. Generally, they are considered to be widespread and common in the state throughout the Cascades Range (Hallock and McAllister 2009; WADNR 2009). The USGS also found that Cascades frogs are common in high-elevation ponds on the Olympic Peninsula (USGS 2000, p. 70), and surveys in the mid- to late 1990s in Mount Rainier National Park indicated that those populations were stable **(**Adams et al. 2001, Tyler et al. 2002, cited in NatureServe 2015). There are no documented declines of the species in Washington; however, amphibian surveyors along Interstate 90 have noticed a decline in Cascades frog sightings over the last few years (Dr. Steve Wagner, personal communication), and recent drought has caused almost complete reproductive failure this year at monitored sites in the Olympics (Dr. Maureen Ryan, personal communication). Cascades frog habitat in Washington state face the same threats as elsewhere, and there is concern that the decline in the species will spread north (AmphibiaWeb 2012).

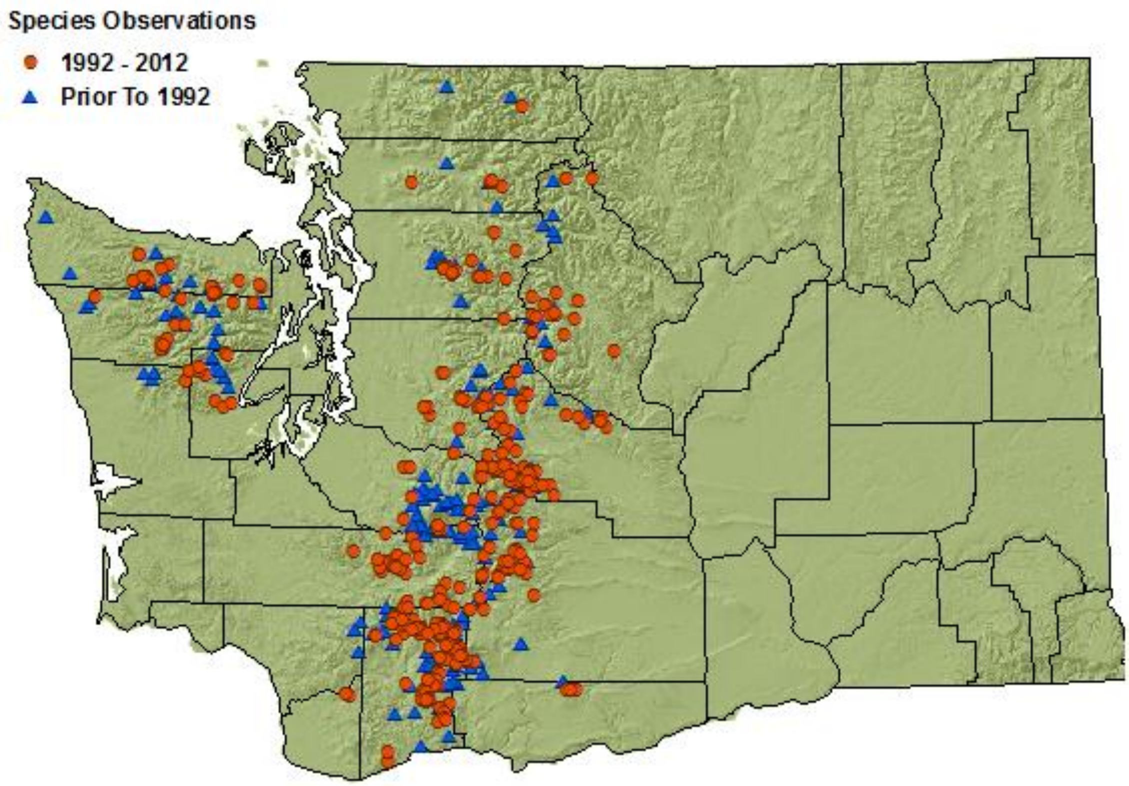

Figure 4: Known Distribution of Cascades Frogs in Washington (Washington Herps Atlas 2013, available at: http://www1.dnr.wa.gov/nhp/refdesk/herp/html/map_raca.html)

IV. THREATS

Like most amphibians in today's environment, Cascades frogs suffer from a number of environmental stressors which are causing population declines. Under the ESA, FWS is required to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range.

In making such a determination, FWS must analyze the species' status in light of five statutory listing factors:

> (A) the present or threatened destruction, modification, or curtailment of its habitat or range
> (B) overutilization for commercial, recreational, scientific, or educational purposes;
> (C) disease or predation;
> (D) the inadequacy of existing regulatory mechanisms;
> (E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1)-(5).

Cascades frogs are threatened by factors A, C, D, and E.

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

Cascades frogs are threatened by habitat loss and degradation. Climate change, fire suppression, and grazing throughout their range have and will continue to reduce the amount of suitable habitat for Cascades frogs.

1. Climate Change

Climate change presents enormous challenges for species conservation. Higher average temperatures, varying precipitation patterns, and alterations in disturbance regimes such as fire are already affecting species across North America, including Cascades frogs (Root et al. 2003, Parmesan 2006, Chen et al. 2011, cited in Case et al. 2015, p. 127). 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 it will have on 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, cited in Case et al. 2015, p. 132), 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 (p. 132). Indeed, 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 (p. 130).

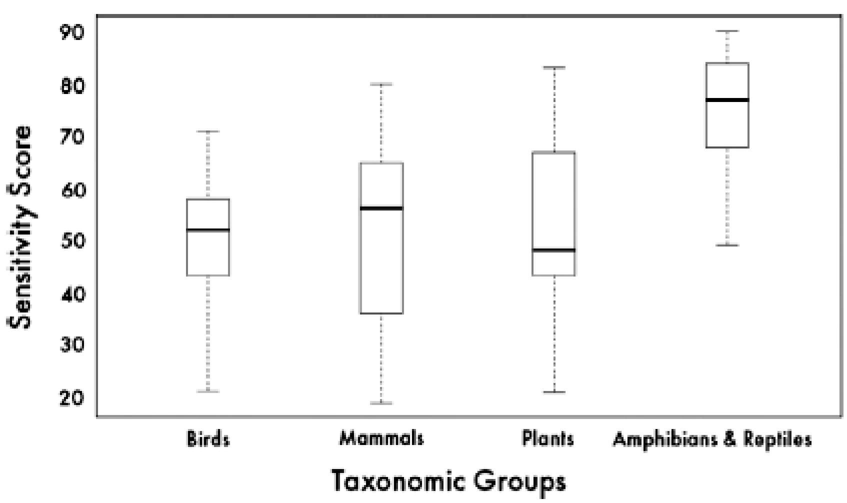

Figure 5: Boxplot of the median relative sensitivity scores (represented by heavy lines) and ranges (represented by whiskers) for four taxonomic groups. Boxes represent 25–75% of the distribution and sample sizes vary by taxonomic group; birds = 113, mammals = 35, plants = 27, and amphibian and reptile = 20 (Case et al. 2015, Fig. 1, p. 130).

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 four out of five (Case et al. 2015, App. D). For context, the overall average sensitivity score for reptiles and amphibians was 76 (Case et al. 2015, p. 130). 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, p. 132).

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 declines (i.e., 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 US 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 dessication 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. (2010) projected 50% or greater climate-induced turnover of amphibian species in many regions of the US by the later part of the century (see Figure 3 of Lawler).

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, p. 235; Lee et al., in press). Because these habitats are naturally variable, they are extremely vulnerable to climate change (reviewed in Ryan et al. 2014, p. 235 and Lee et al., in press). 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, p. 236; Lee et al., in press; Lawler et al. 2014, unpaginated).

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 United States over the next century (Hamlet et al. 2005, IPCC 2007, cited in Ryan et al. 2014, p. 236). 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, cited in Ryan et al. 2014). Climate projections indicate a significant reduction in the range of snow-dominated landscapes in most of the western United States, with the exception of regions with much higher elevations such as the Rockies (Klos et al. 2014, p. 4562). Additionally, snowmelt runoff and peak water availability is occurring earlier in the spring, and soil moisture is receding (Hamlet et al. 2007, cited in 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 (reviewed in

Lee et al., in press). 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., in press).

In the Cascades Range and the Olympics 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, p. 236). 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 (Ryan et al. 2014, Walls et al. 2013, cited in Lee et al., in press). 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 (Walls et al. 2013, Smith 1987, Semlitsch et al. 1988, cited in Lee et al., in press; Lawler et al. 2014, unpaginated). Indeed, 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 (p. 142).

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 chytridiomycosis (chytrid fungus) which is driving amphibian declines worldwide (Rohr and Raffel 2010, 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 (i.e., 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, unpaginated). 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 frogs (*See* Section IV.B. "Other Factors"; Ryan et al. 2014, p. 235). Plus, climate impacts are likely to also interact with other threats such as disease and pollution (Lee et al., in press).

The current drought in the Pacific Northwest provides an analog for what is predicted under climate change projections. Already, scientists have observed near complete reproductive failure at monitored 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). Combining habitat alterations brought on by climate change with previously hypothesized threats to Cascades frog habitat such as the alteration of fire regimes (Fellers and Drost 1993, p. 179-180), the increased likelihood of higher-intensity fires (Pope et al. 2014, p.

28), and cattle grazing reducing wetland pools through sedimentation (Cole and North 2014, p. 145), will lead to a significant reduction in habitat availability.

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

Although the trade in amphibians and reptiles threaten many species through overutilization, it is not known to be a threat for Cascades frogs. However, trade in these species could be exacerbating the spread of diseases such as *Batrachochytrium dendrobatidis* (*Bd*).

C. Disease and Predation

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, cited in Piovia-Scott et al. 2015, p. 1570). 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 (Piovia-Scott et al. 2015, p. 1570; Pope et al. 2014, p. 25-26). Plus, 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, cited in Piovia-Scott et al. 2015, p. 1570).

Cascades frogs are susceptible to *Bd* (Garcia et al. 2006, cited in Piovia-Scott et al. 2015, p. 1571), and *Bd* occurs throughout its range (Adams et al. 2010, Piovia-Scott et al. 2011, cited in Piovia-Scott et al. 2015, p. 1571). *Bd* exposure experiments resulted in significant mortality rates for Cascades frog metamorphs (Garcia et al. 2006, p. 166); however, declines in Cascades frogs in nature due to *Bd* are not universal (Piovia-Scott et al. 2011, Pope et al. 2011, cited in Pope et al. 2014, p. 25). The reasons for why some populations dramatically suffer while others remain stable are not well known (Pope et al. 2014, p. 25-26).

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, cited in Piovia-Scott et al. 2015, p. 1575). At Section Line Lake in the Klamath Mountains where Cascades frogs were infected with this viral strain, juvenile abundance decreased by more than 99 percent between 2009 and 2012. Hundreds of juveniles in 2010 dwindled to two seen in 2012 (Piovia-Scott et al. 2015, p. 1575). Adults began to decline three years following the collapse of juvenile abundance (Ibid.). 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 (Ibid.).

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, p. 26), especially given the finding that larger populations of Cascades frogs likely increase their resistance to the disease (Knapp et al. 2011, cited in Pope et al. 2014, p. 25). So, efforts to increase 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, p. 25).

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 it has caused die-offs of Cascades frogs in Oregon (Blaustein et al. 1994, Kiesecker and Blaustein 1997, cited in Pope et al. 2014, p. 26). Prevalence of *Saprolegnia* has increased due to movement of hatchery-raised fishes (*See* Section IV.E.1.; Blaustein et al. 1994, cited in Bucciarelli et al. 2014, p. 620), and because *Saprolegnia* strains have also been found to vary in virulence, introduced fishes may transmit a strain more virulent to amphibians (Bucciarelli et al. 2014, p. 620). The spread *S. ferax* is especially concerning when combined with UV-B radiation (*See* Section IV.E.2.; Kiesecker and Blaustein 1995, cited in Pope et al. 2014, p. 26), 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. The is supported by the increased mortality of toad embryos from *Saprolegnia* infection during El Nino/Southern Oscillation (ENSO) events which decreased winter precipitation and snowpack, thus increased exposure to UV-B radiation (Kiesecker et al. 2001, cited in Bucciarelli et al. 2014, p. 620).

Predation is also a threat to Cascades frogs. Introduced fish species prey on Cascades frogs and cause hyperpredation, which ICF Jones and Stokes (2010) defines as when nonnative prey facilitates predators, which then suppresses native prey (p. 4-90) (*See* Section IV.E.1.). 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, p. 36). Glossiphoniidae and Erpobdellidae leeches are known to prey on Cascades frog eggs in Oregon (Chivers et al. 2001, cited in Stead and Pope 2010, p. 36), and *H. marmorata* is known to eat tadpoles (Riggs and Ulner 1983, cited in Stead and Pope 2010, p. 36). 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, p. 36-37).

D. Inadequacies of Existing Regulatory Mechanisms

There are no existing regulatory mechanisms that provide adequate protection for the Cascades frog. The Cascades frog is listed as a Sensitive-Vulnerable species in Oregon (ODFW 2008, p. 12), a Species of Special Concern in California (California Department of Fish and Game 2011), and a State Monitor Species in Washington (http://wdfw.wa.gov/conservation/endangered/status/SM/). None of these statuses are meant to provide protection to the Cascades Frog, but instead monitor their status in each state. Programs designed to conserve species on these various lists are mostly voluntary.

Cascades frogs occur in many National Parks and other federal lands, which mean their habitat is mostly protected from development. However, fish stocking programs are widespread throughout its range with no regard as to how it is affecting frog populations, except in California where stocking has been halted where Cascades frogs occur (ICF Jones and Stokes 2010). But even there, we are unaware of any current effort to remove the fish that have already established self-sustaining populations within Cascades frog habitat. In Washington, fish stocking is not only widespread, but now mandatory in certain areas such as North Cascades National Park (H.R.1158 North Cascades National Park Service Complex Fish Stocking Act 2014). This decision was made regardless of the threats it poses on native species such as the Cascades frog. Only the Endangered Species Act can protect species from such actions. Other monitoring programs in the Northwest such as the Northwest Forest Species Monitoring does not include the Cascades frog and therefore does not afford it protections and may even make decisions harmful to the species due its lack of monitoring for it. 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 (p. 4).

E. Other Factors

1. Introduced Species

Nonnative trout and other salmonids occupy 95 percent of large mountain lakes and 60 percent of smaller ponds and lakes in the western United States that were formerly fishless (Bahls 1992, cited in Ryan et al. 2014, p. 235). The widespread introductions of these species have had severe consequences on ecosystem functions and native species assemblages (Knapp et al. 2001, Schindler et al. 2001, cited in Ryan et al. 2014, p. 235; Bradford 1989, Knapp 2005, Knapp and Matthews 2000, Welsh et al. 2006, cited in Pope et al. 2014, p. 29). The impacts that introduced trout have on amphibians are particularly severe (Pilliod and Peterson 2001, Vredenburg 2004, Hartel et al. 2007, cited in Hartman et al. 2013, p. 764). The stocking of predatory fishes have lead to the endangered listings of two other frogs in the true frog family, the mountain yellow-legged frog (*Rana muscosa*) and Sierra Nevada yellow-legged frog (*Rana sierra*) (Ryan et al. 2014, p. 235), and other high elevation amphibians, including Cascades frogs (Welsh et al. 2006, cited in Pope et al. 2014, p. 29), have suffered population declines as a result of the combination of *Bd* and fish stocking (Knapp et al. 2003, Morgan et al. 2007, Piovia-Scott et al. 2011, cited in Cole and North 2014; Hartman et al. 2013, p. 764).

Introduced fishes alter amphibian assemblages through multiple mechanisms. Introduced fish and native species compete for resources such as invertebrate prey (ICF Jones and Stokes 2010, p. 4-90; Finlay and Vredenburg 2007, cited in Bucciarelli et al. 2014, p. 618). 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, cited in Bucciarelli et al. 2014, p. 618). Introduced fish may also prey directly upon native amphibians, driving population declines (ICF Jones and Stokes 2010, p. 4-90; Finlay and Vredenburg 2007, cited in Bucciarelli et al. 2014, p. 618). 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, p. 768). 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, p. 4-90).

Because most montane species are unable to adapt to the presence of nonnative fish (Knapp et al. 2001, cited in Ryan et al. 2014, p. 235), fish introduction often leads to a direct loss of range in amphibian species, and this is true of the Cascades frog. In a species assemblage study of the Klamath Mountains, nonnative trout had an exclusively negative correlation with Cascades frog occupancy (Cole and North 2014, p. 143). This study determined that nonnative trout presence was one of the most important factors in determining Cascades frog distribution (Ibid.). Indeed, at higher elevations where trout were absent, assemblages were dominated by Cascades frogs (Ibid., p. 142). 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 United States, 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, p. 235; Pope et al. 2014, p. 30).

The declines of Cascades frog populations as well as two other native amphibians in California lead to a successful lawsuit that ruled that the California Department of Fish and Wildlife must consider the impacts of fish stocking to the environment and native ecosystems (Knapp and Matthews 2000, Vredenburg 2004, Welsh et al. 2006, cited in Hartman et al. 2013, p. 764). The resulting Environmental Impact Statement (ICF Jones and Stokes 2010) concluded that the impacts of nonnative trout on Cascades frogs were "potentially significant" (p. 4-91). There are 175 trout stocking locations within the range of the Cascades frog in California (Ibid., p. 4-90). Although new stocking has since ceased anywhere known to support Cascades frogs (ICF Jones and Stokes 2010, cited in Pope et al. 2014, p. 29), many populations of stocked fish are likely self-sustaining (Pope et al. 2014, p. 29). 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, cited in Pope et al. 2014, p. 29). Stocking still occurs throughout the Cascades in Oregon and Washington.
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, p. 146), especially when faced with other, less manageable, threats such as climate change and disease (Ryan et al. 2014, p. 238). Previous fish removals have resulted in the rapid recolonization of native amphibians and invertebrates (Drake and Naiman 2000, Knapp et al. 2005, cited in Ryan et al. 2014, p. 238) including the Cascades frog (Pope 2008, cited in Pope et al. 2014, p. 30). Survival, recruitment, and population densities of Cascades frog all rapidly increased when fish were removed from lakes in the Klamath Mountains (Ibid.).

2. Pollution

Agrochemicals are a threat to Cascades frog survival, and pollution of these chemicals has likely contributed to the population declines seen in some regions (Davidson et al. 2002, p. 1594). Fertilizers such as urea likely pose a threat; in laboratory studies, juveniles were unable to sense and avoid toxic levels (Hatch et al. 2001, p. 2328, 2333). Nitrites can affect behavior and metamorphosis of larvae (Marco and Blaustein 1999, p. 948). Paulk and Wagner (2004) found that glyphosate and malathion significantly affect Cascades frog larvae 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 (Blaustein et al. 2011, Davidson et al. 2007, cited in Pope et al. 2014, p. 23). Pesticides could be weakening the immune system and facilitating chytrid outbreaks (Bradford et al. 2011, Mann et al. 2009, cited in Bruhl et al. 2011).

In California, the agrochemical pollution from the Central Valley to the Sierra Nevada and southern Cascades has been documented (Aston and Seiber 1997, Bradford et al. 2010, Datta et al. 1998, Hageman et al. 2006, Lenoir et al. 1999, McConnell et al. 1998, Davidson 2004, Davidson et al. 2002, cited in Pope et al. 2014, p. 18). Between 106 and 152 million pounds of pesticides were used in the Central Valley between 1990 and 2002 (CDPR 1989-2003). 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 populations are still present (Pope et al. 2014, p. 18). 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, cited in Pope et al. 2014, p. 18). 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, cited in Pope et al. 2014, p. 23).

3. UV-B Radiation

The human-caused depletion of the ozone layer has increased the levels of UV-B radiation at the Earth’s surface (Belden et al. 2003, p. 409; Palen et al. 2005, p. 1227; Palen et al. 2002, p. 2951). Harmful levels of UV-B radiation can have lethal and sublethal effects on a variety of organisms, but they vary in their susceptibility depending on the species and life history stage (reviewed in Belden et al. 2003, p. 409-410), and is likely contributing to the decline of amphibians (Palen et al. 2002, p. 2951), including several in the Pacific Northwest (Palen et al. 2005, p. 1227). UV-B radiation can reduce hatching success and larval growth rates, elevate morphological abnormalities, and increase susceptibility to fungal pathogens (reviewed in Palen et al. 2002, p. 2951). Direct lethal effects on amphibian embryos due to UV-B exposure has been well documented in the field (Blaustein et al. 1998, cited in Belden et al. 2003, p. 410).

Cascades frogs are among the list of amphibians threatened by UV-B radiation through direct and indirect effects of exposure, but the exact mechanisms and severity of UV-B caused declines are poorly understood (Pope et al. 2014, p. 100-102). Some studies suggest that Cascades frogs may be more susceptible to UV-B induced mortality than other amphibians. Blaustein et al. (1994) found that when experimentally exposed to ambient levels of UV-B, Cascades frog embryos experience increased mortality (cited in Belden et al. 2003, p. 410). Blaustein et al. (1998) also found that four other frog species may have two to five times the amount of the UV-B damage repair enzyme photolyase as Cascades frogs (cited in Pope et al. 2014, p. 101). And although the impacts UV-B on adult anurans is poorly studied, retinal damage was observed in exposed adult Cascades frogs (Fite et al. 1998, cited in Pope et al. 2014, p. 101).

At the same time, Palen et al. (2005) found that Cascades frogs were less physiologically susceptible to harmful effects of UV-B radiation than other species, but that they lacked the behavioral response that may limit their exposure, thus increasing their vulnerability (p. 1233). Similarly, Belden et al. (2003) hypothesized that Cascades frog larvae may not be able to perceive UV-B radiation and therefore are not able to evolve a physiological response (p. 414). This suggests that *R. cascadae*, being a high elevation species, may face environmental trade-offs between limiting potentially lethal UV-B exposure and selecting warm habitats to speed up developmental rates (Belden et al. 2003, p. 414). However, if UV-B exposure was as harmful as predicted by these studies, one would expect to find a decrease in frog occupancy with elevation, as exposure to UV-B increases, but no such trend has been examined (Davidson et al. 2002, cited in Pope et al. 2014, p. 102).

While the direct impacts of UV-B radiation on Cascades frogs are already debated, the cumulative effects of UV-B and other threats are even less understood, and potentially much more concerning. Kats et al. (2000) observed a decrease in response to predator cues in Cascades frog tadpoles when exposed to UV-B (cited in Belden et al. 2003, p. 410). Combined with the high prevalence of introduced trout species within the frog's range, this could contribute to population declines. UV-B induced mortality can also be caused by the combination of radiation exposure and infection of fungal pathogens such as *Saprolegnia ferax* (Kiesecker and Blaustein 1995, cited in Palen et al. 2002, p. 2952, Pope et al. 2014, p. 102). Finally, changes in precipitation patterns due to climate change will lead to shallower waters, altering rates of development and opening up the species to an increase in UV-B exposure, unless they move to deeper lakes that also contain introduced trout (Belden et al. 2003, p. 409; Ryan et al. 2014). For these reasons, UV-B radiation should be considered an important factor in assessing the declines and recovery of Cascades frogs.

4. Small Population Size and Metapopulation Dynamics

Montane habitats tend to promote strong genetic isolation among frog populations (reviewed in Monsen and Blouin 2004, p. 833), and small population sizes of already declining populations, such as in the Lassen area of California, reduces the species' longterm viability (Feller et al. 2008, p. 33). 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, p. 832). These population dynamics make them vulnerable to not only genetic isolation (ODFW 2005, p. 337) but also to chance events where local extirpations have a low likelihood of recolonization (Pope et al. 2014, p. 11). 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, cited in Pope et al. 2014, p. 10). Adult frogs rarely move more than a couple miles (Monsen and Bouin 2004, p. 832), and isolated sites are less likely to support Cascades frogs for the long term

(Pope et al. 2014, p. 10). Therefore, population recovery and habitat connectivity are important factors in ensuring the long term viability of Cascades frogs.

V. SIGNIFICANT PORTION OF RANGE AND DISTINCT POPULATION SEGMENTS

The ESA broadly defines "species" as "any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (16 U.S.C. § 1532(16)). The FWS and National Marine Fisheries Service (NMFS) published a policy to define a "distinct population segment" (DPS), specifying three elements they consider in determining the status of a possible DPS as endangered or threatened. These are: (1) The discreteness of the population segment in relation to the remainder of the species to which it belongs; (2) The significance of the population segment to the species to which it belongs; and (3) The population segment's conservation status in relation to the Act's standards for listing (61 Fed. Reg. 4722, 4725 (Feb. 7, 1996)) (hereafter, DPS Policy).

Genetic data indicate that Cascades frogs could be potentially divided into several DPSs, including: California's populations, the Oregon and Washington Cascades populations, and the Olympic populations (Monsen and Blouin 2003, p. 3282). The strongest argument for distinctiveness, though, can be made between the populations of California and Oregon/Washington (Ibid., p. 3283). With the severe population declines noted in California, with a lesser degree of declines (but same degree of threats) occurring in the northern two states, this could be the most significant separation of distinct populations for conservation purposes. Therefore, should the Service not find that a listing for the entire species is warranted, we request that the following evidence be considered to have the California population listed as a DPS.

A. Discreteness

Under the DPS Policy, a population segment is discrete if it satisfies either of the following criteria:

i. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation. The policy further clarifies that a population need not have "absolute reproductive isolation" to be recognized as discrete.

ii. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act (61 FR 4725).

a. The California population of Cascades frogs (*Rana cascadae*) is discrete because it is markedly separate from other populations of the same taxon due to genetic, physical, ecological, and behavioral factors.

Genetic evidence indicates that California's populations of Cascades frogs have been isolated from Oregon and Washington's populations for approximately two million years. 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, cited in Monsen and Blouin 2003, p. 3283) including several amphibians (Daugherty et al. 1983, Good 1989, Good and Wake 1992, Howard et al. 1993, Nielson et al. 2001, cited in Monsen and Blouin 2003, p. 3283). California's Cascade frogs were most likely separated, and never experienced secondary contact, during the last glacial maximum (Ibid.). 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. The California populations of Cascades frogs therefore meet the definition of discreteness under the DPS policy.

B. Significance

Under the DPS policy, a population is considered significant based on, but not limited to, the following factors:

i. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,

ii. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,

iii. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or

iv. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

a. California populations of Cascades frogs differ from other Cascades frogs in their genetic characteristics

California's Cascades frog populations differ from Oregon and Washington's in their genetic characteristics. These populations' mtDNA differ from there northern counterparts by 3.2 percent and show significant divergence of allele frequencies at nuclear loci (Monsen and Blouin 2003, p. 3283). A substantial divergence in the nuclear genome between California's and Oregon and Washington's population is supported by the inability to amplify two of seven microsatellite loci (Ibid.). Monsen and Blouin (2003) therefore conclude that these genetic differences alone are substantial enough to warrant a DPS classification (p. 3283).

b. Loss of California's Cascades frog populations would result in a significant gap in the range of the taxon

Severe population declines have been documented for the Cascades frog in a significant portion of its range. This species is near extirpation throughout much of California, and its population structure will not allow for re-colonization from neighboring communities. If the frogs disappear completely from the southern Cascades of California, the Oregon populations will not likely aid in recolonization, as genetic exchange drops after just 10km and isolated sites are less likely to support the species. Therefore, extirpation of California's populations will result in the loss of important genetic characteristics and the permanent exclusion of the species from the state of California, and significant proportion of its range throughout the Pacific Northwest.

VI. CONCLUSION

Cascades frogs (*Rana cascadae*) have experienced significant population declines and face severe threats throughout their range. Given the current amphibian crisis, we cannot afford to let another species slip away. We request that Service conduct its review and finalize a listing under the Endangered Species Act as quickly as possible.

Thank you for taking our comments into consideration.

Sincerely,

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