

(EPA 1989). Analysis of the Antarctic Vostok ice core has shown that over the past 160,000 years, temperatures have varied with fluctuations in the concentrations of greenhouse gases such as carbon dioxide and methane. Since the pre-industrial era, atmospheric concentrations of carbon dioxide have increased nearly 30 percent, methane concentrations have more than doubled, and nitrous oxide (another greenhouse gas) levels have risen approximately 15 percent. The burning of fossil fuels is the primary source of these increases. Global mean surface temperatures have increased 0.3–0.7 °C (0.6–1.2 °F) since the late 19th century (EPA 1997). Climate modeling indicates that the overall effects of global warming on California will include higher average temperatures in all seasons, higher total annual precipitation, and decreased spring and summer runoff due to decreases in snowpacks (EPA 1989, 1997). Decreases in spring and summer runoff could lead to the loss of breeding habitat for mountain yellow-legged frogs and increases in instances of stranding mortality of eggs and tadpoles.

Changes in temperature may also affect virulence of pathogens to a different degree than the amphibian immune systems are able to respond (Carey *et al.* 1999) and may make mountain yellow-legged frogs more susceptible to disease. Global warming could also affect the distribution of pathogens and their vectors, exposing mountain yellow-legged frogs (potentially with weakened immune systems as a result of other environmental stressors) to new pathogens (Blaustein *et al.* 2001). An experimental increase in stream water temperature was shown to decrease density and biomass in invertebrates (Hogg and Williams 1996); thus, global warming might have a negative impact on the mountain yellow-legged frog prey base.

Ambient ultraviolet-b (UV-B) radiation (280–320 nanometers (11.0–12.6 microinches)) has increased at north temperate latitudes in the past two decades (Adams *et al.* 2001). If UV-B radiation is contributing to amphibian population declines, the declines would likely be greater at higher elevations and at more southerly latitudes where UV-B exposure is greatest, where the thinner atmosphere allows greater penetration of UV-B (Davidson *et al.* 2001; Davidson *et al.*, 2002). In California, where there is a north-to-south gradient of increasing UV-B exposure, amphibian declines would also likely be more prevalent at southerly latitudes (Davidson *et al.*

2001; Davidson *et al.*, 2002). Melanic pigment on the upper surfaces of amphibian eggs and larvae protects these sensitive life stages against UV-B damage, an important protection for normal development of amphibians exposed to sunlight, especially at high elevations in clear and shallow waters (Stebbins and Cohen 1995). Blaustein *et al.* (1994c) observed decreased hatching success in several species of amphibian embryos (the mountain yellow-legged frog was not tested) exposed to increased UV-B radiation, indicating that this may be a cause of amphibian declines. Juveniles and adults may be exposed to increased UV-B levels as they heat themselves by basking in the sun (Stebbins and Cohen 1995). In a spatial test of the hypothesis that UV-B has contributed to decline of the mountain yellow-legged frog in the Sierra Nevada, Davidson *et al.* (2002) concluded that patterns of this species decline are inconsistent with the predictions of where UV-B related population declines would occur. Greater numbers of extant populations of this species were present at higher elevations than at lower elevations, and population decline was greater in the northern portion of the range of this species than it was in the southern portion. Though it does not appear that UV-B is a factor in the decline of the mountain yellow-legged frog, the absence of the predicted pattern for UV-B-caused decline should not be taken as proof that UV-B is not affecting the mountain yellow-legged frogs, given the potential for one or more factors that cause population declines to mask other factors (Davidson *et al.*, 2002).

### Finding

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats faced by this species. We reviewed the petition, information available in our files, other published and unpublished information submitted to us during the public comment period following our 90-day petition finding, and consulted with recognized mountain yellow-legged frog experts and other Federal and State resource agencies. On the basis of the best scientific and commercial information available, we find that listing the Sierra Nevada DPS of the mountain yellow-legged frog is warranted, but is precluded by higher priority listing actions.

In making this finding, we recognize that there have been declines in the distribution and abundance of the Sierra Nevada DPS of the mountain yellow-legged frog, primarily attributed to the

introduction and subsequent predation of non-native fishes, as documented in the body of scientific research on the distributions of introduced trout in relation to mountain yellow-legged frogs (Bradford 1989; Bradford *et al.* 1993, 1994a, 1998; Knapp 1994, 1996; Drost and Fellers 1996; Knapp and Matthews 2000; Knapp *et al.* 2001). Direct predation of non-native fishes on mountain yellow-legged frogs has resulted in range-wide population declines and local extirpations. Furthermore, the result of these extirpations is that the remaining populations are fragmented and isolated, making them vulnerable to further declines and local extirpations from other factors. Populations that go extinct following habitat fragmentation and populations isolation are unlikely to be recolonized due to both the isolation from, and lack of, habitat connectivity to potential source populations.

For example, in reviewing documented mountain yellow-legged frog declines over the last 5 years in Sequoia and Kings National Parks, we found a 39 percent extinction rate of the frog where fish have not been stocked since the late 1970s. In comparison, over the last 7 years in the Sierra National Forest's John Muir Wilderness Area, there has been a 61 percent extinction rate where fish stocking has continued. This high rate of extinction over a 5 to 7 year time frame suggests the species' extinction within a few decades (assuming that the rate of extinction and recolonization observed over this time period accurately reflects the long-term rates) (R. Knapp, *in litt.* 2002.).

The isolation of remaining mountain yellow-legged frog populations and habitat fragmentation as a result of non-native fish introductions has made remaining populations vulnerable to extinction from random events such as disease. Disease has only recently been recognized as an important factor in the decline of this species. It appears, however, that disease will continue to play an important role in the decline of this species. It is likely that disease, specifically chytrid fungus, has contributed to the recently observed declines in Sequoia and Kings Canyon National Parks and in the Sierra National Forest's John Muir Wilderness Area (R. Knapp, *in litt.* 2002). Although the life history and modes of transmission of chytrid fungus are not well understood, it appears that this pathogen is widespread throughout the range of the mountain yellow-legged frog within the Sierra Nevada, it is persistent in ecosystems, and it is