**State of California**

# Memorandum

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## Subject: *RANA SIERRAE* POPULATION MONITORING AT THE MOUNT PLEASANT POPULATION

**ENVIRONMENTAL SETTING:**

Bucks Lake Wilderness is located in western Plumas County, south of Interstate 70 and north of Bucks Lake Reservoir, and consists of 9,695 hectares (Figure 1). The Pacific Crest Trail bisects the wilderness from north to south, and local elevations range from around 2,400 feet (730 meters [m]) above mean sea level near the northern border along the Feather River, to 7,067 feet (2,154 m) at the summit of Mount Pleasant. California Department of Fish and Wildlife (CDFW) crews observed two Sierra Nevada yellow-legged frog (*Rana sierrae*; SNYLF) populations in Bucks Lake Wilderness while conducting baseline surveys in 2003 and 2004. Surveys conducted in the intervening years have revealed one SNYLF population south of Silver Lake in the Rock Lake drainage; and a second population persisting in a small drainage with two ponds southeast of Mount Pleasant (Figure 1).

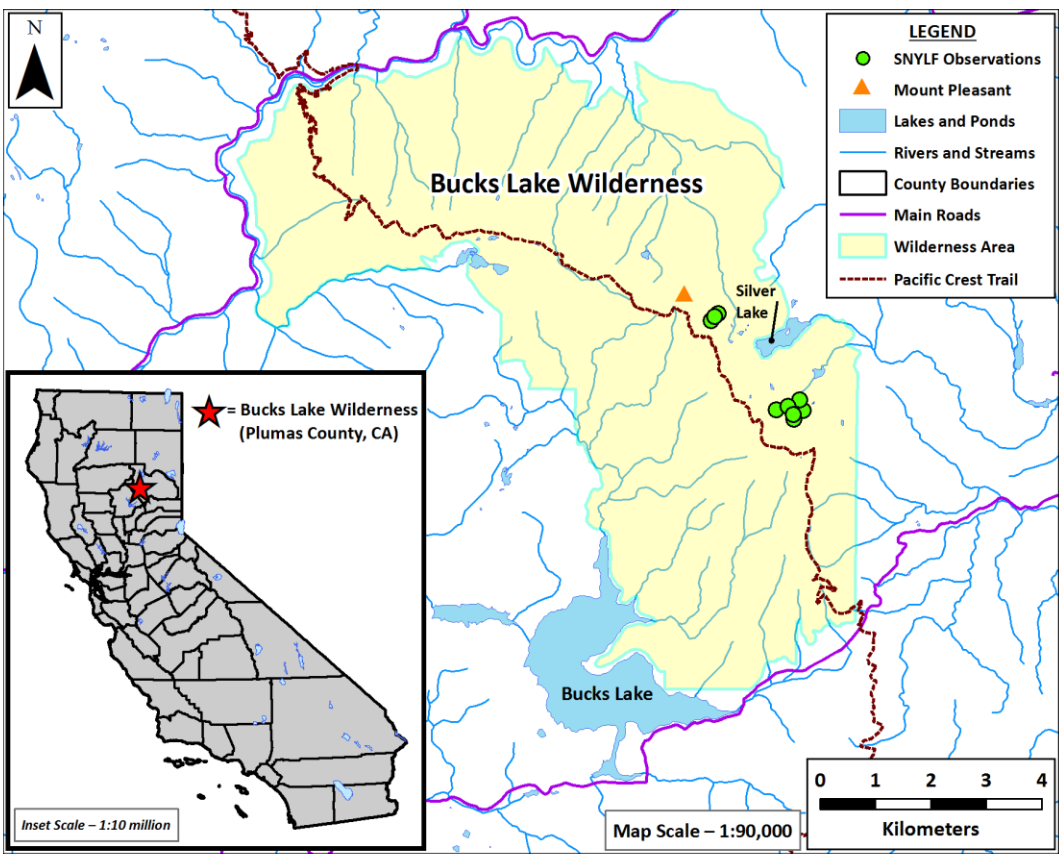



Figure 1: Bucks Lake Wilderness, Plumas County, CA. Green dots showing *Rana sierrae* (SNYLF) sites include positive detections by CDFW staff during visual encounter surveys (VES) between 2004 and 2017.

## INTRODUCTION

The Mount Pleasant SNYLF population is one of only a few populations remaining at the northern extent of the species' range. Additionally, this population is one of even fewer lake-based populations in Plumas County. In 2004, CDFW conducted a baseline visual encounter survey (VES), during which crews observed adult, subadult, and larval SNYLF at Pond 12052, plus adult SNYLF at Pond 12049 (Figure 2). In 2013, U.S. Forest Service (USFS) crews surveyed the Mount Pleasant area and observed adult frogs in all wetted habitat, including eight adult SNYLF in a small, unmapped pond above Pond 12052 (Figure 3; USFS 2013).

## THREATS

- ***Marginal Habitats*** – The Mount Pleasant SNYLF population is small and isolated. These frog populations are persisting in only two small ponds and associated tributaries. The fishless Pond 12052 (Figure 4) has a maximum recorded depth of 3.6 m (whereas Pond 12049 [Figure 5], which contains dace, is nearly 10 m deep). SNYLF are also present in the Rock Lake drainage, located about 2.5 km to the southeast. Any disturbance, natural or otherwise, that threatens overwintering habitats presents a potential extirpation risk. Among the risks to the population are habitat disturbance by humans, possible exposure to severe winter conditions, and desiccation from drought conditions, any of which could eliminate these small SNYLF populations.

- ***Introduced Fish*** – Dace (*Rihinichthys* spp.) are present in Pond 12049. Dace may compete with, or directly harm, smaller life stages of SNYLF (e.g., eggs and larvae). However, little information is available regarding effects of dace on SNYLF (see Discussion).

- ***Disease*** – All SNYLF populations in Plumas County are chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*) positive. In 2008, 2010, and 2011, Ponds 12049 and 12052 were genetically sampled by epithelial swabs for the presence of *Bd.* Including nearby Rock Lake (to the south), a total of 27 swabs were collected and results for all three years indicate light to very light *Bd* zoospore loads at all sites. However, low numbers of dead SNYLF of various life stages have been observed consistently at Pond 12052, including during VES in 2004, 2005, 2010, 2015, and 2017. These observations suggest that there may be consistent, low-level *Bd*-induced mortality in this population.

- ***Loss of Genetic Diversity*** – The Bucks Lake Wilderness SNYLF populations represent a unique genetic unit (known as Clade 1; Vredenberg et al. 2007). Clade 1 is by far the most threatened of the three currently recognized genetic clades (as determined by mitochondrial DNA analysis; Vredenburg et al. 2007), due to few remaining extant populations, marginal habitats (e.g., small streams), and potential threats from multiple land uses (USFWS 2018). Clade 1 also includes some of the lowest elevation SNYLF populations in the range of the species. Additionally, populations in Clade 1 are widely separated from one another, which limits potential for gene flow between populations and increases risk for local extirpation. This isolation can lead to factors such as inbreeding depression, genetic drift, fixation of deleterious alleles, and loss of genetic diversity, all of which are population genetic factors exacerbated in small populations (Frankham et al. 2009).

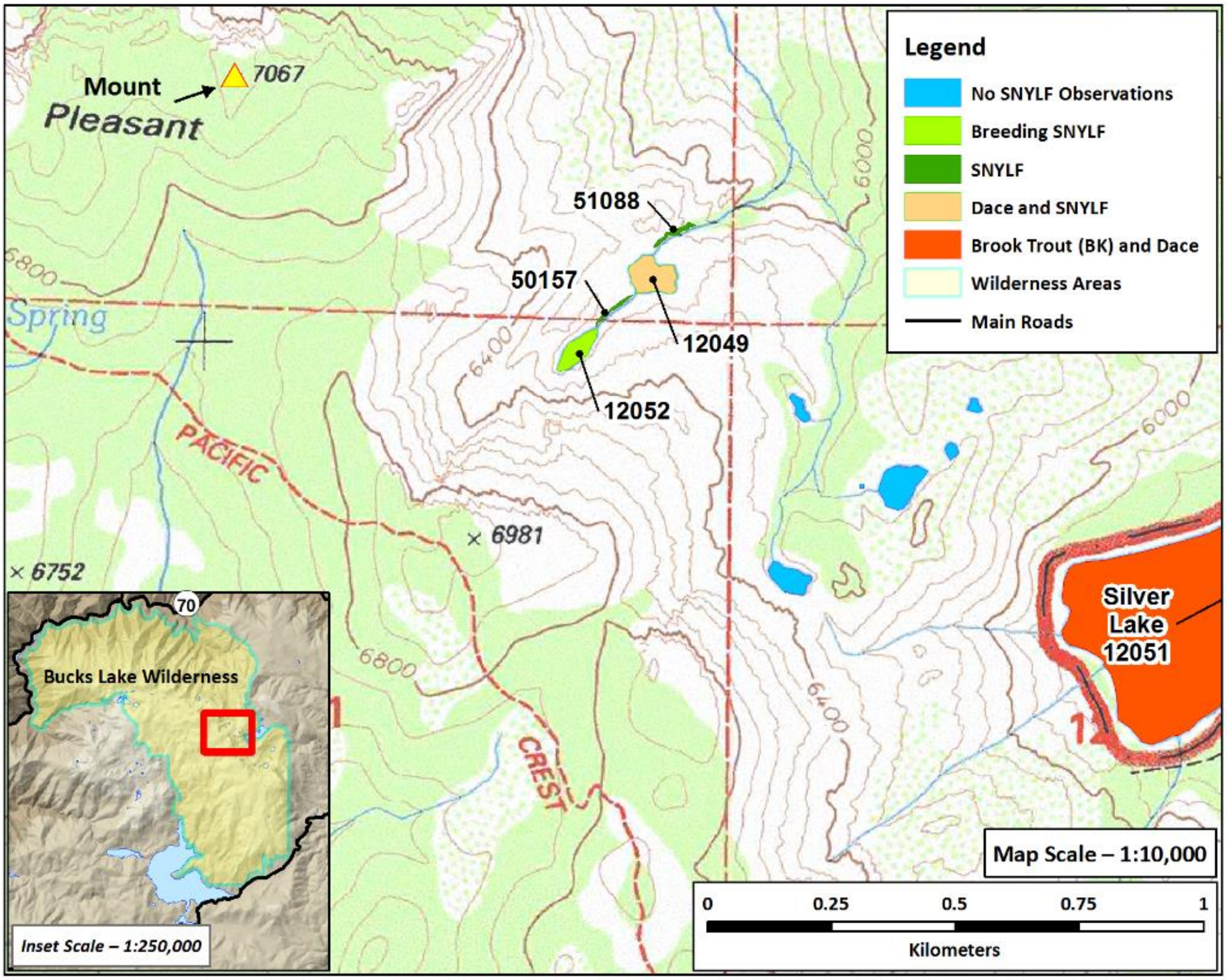



Figure 2: Mount Pleasant drainage in Bucks Lake Wilderness, Plumas County, CA. *Rana sierrae* (SNYLF) observations occurred during visual encounter surveys (VES) between 2004 and 2017. Pond 12052 is a consistent breeding site for SNYLF, whereas no egg masses or tadpoles have been observed in Pond 12049, which contains dace.

## VES AT MOUNT PLEASANT POPULATION

CDFW performed the baseline visual encounter surveys in the Bucks Lake Wilderness in 2004. Staff encountered a small breeding SNYLF population in the Mount Pleasant ponds, which consist of three small ponds and the associated tributary (the two primary ponds are shown in Figure 2 above; the third pond is unmapped, but visible in the lower left corner of Figure 3, on the next page). Fourteen years of monitoring data suggest this population is in decline (Figure 6). However, similarly to the Rock Lake SNYLF population, detections have remained relatively consistent, albeit low, since 2010. Observer bias, variation in survey conditions, and the low number of detections all make deriving trends difficult. CDFW will continue to survey the site at least every other year to monitor SNYLF population trends over time.

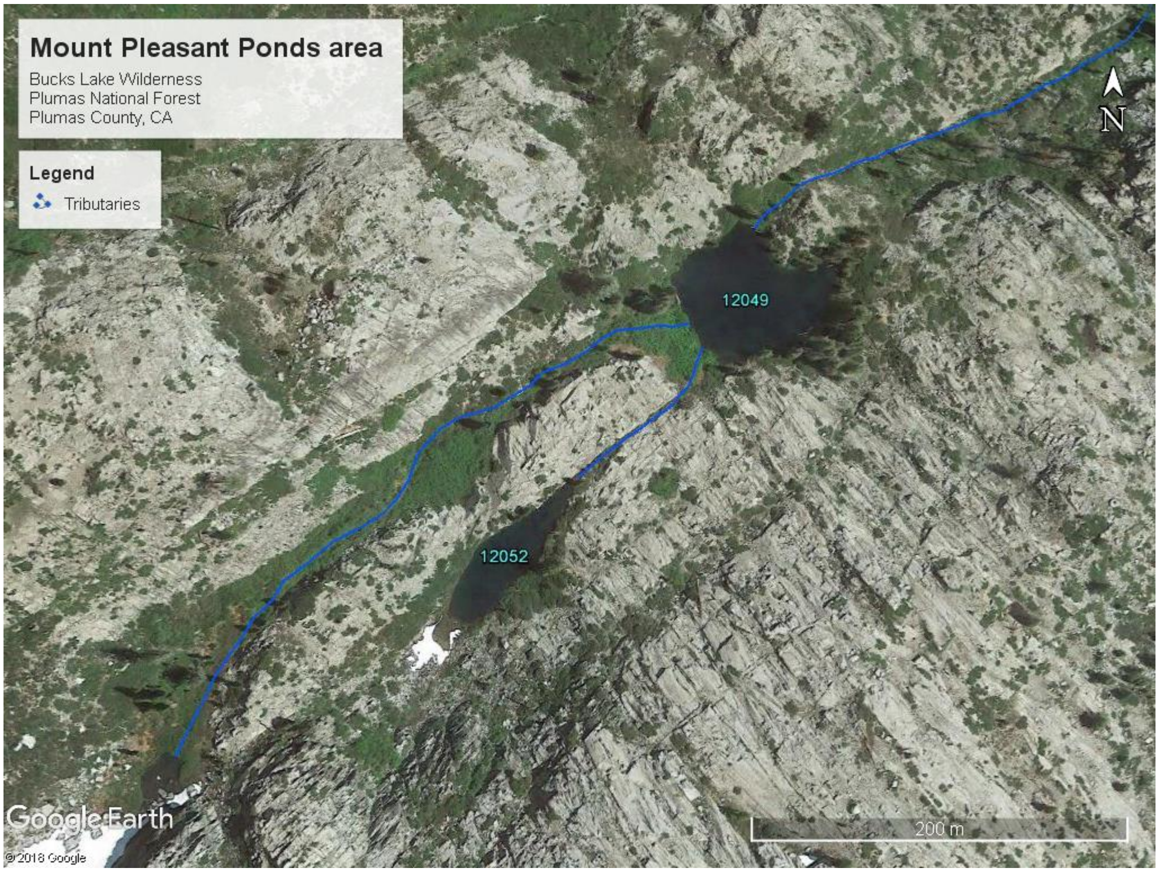


Figure 3. Aerial image of the Mount Pleasant ponds area, taken on 2 July 2017. (Google Earth)


Figure 4. Site 12052 in June 2017, looking west. (CDFW)

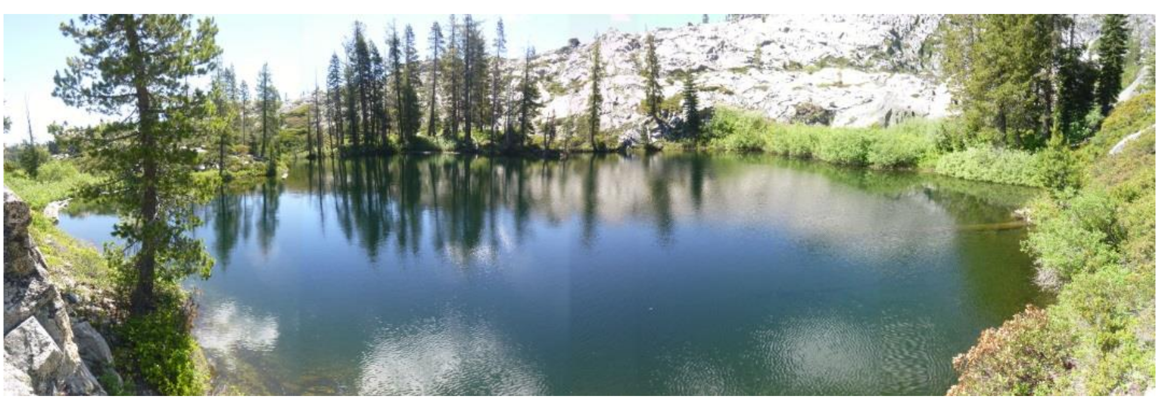
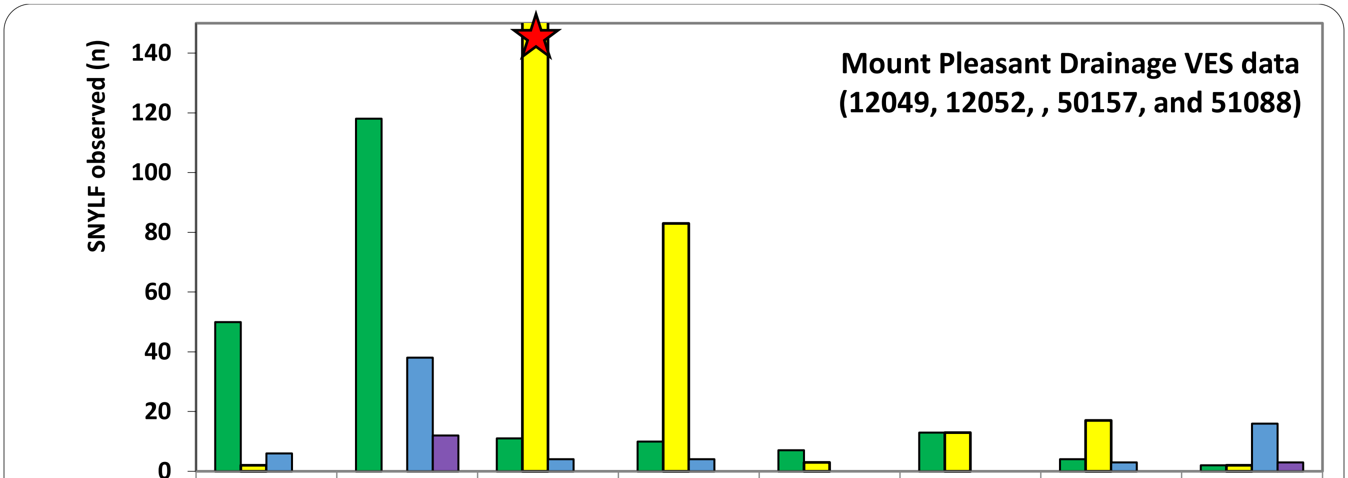


Figure 5: Site 12049 in June 2017, looking southeast. (CDFW)




| Year | 2004 | 2005 | 2008 | 2010 | 2013 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| Adult | 50 | 118 | 11 | 10 | 7 | 13 | 4 | 2 |
| Subadult | 2 | 0 | 454 | 83 | 3 | 13 | 17 | 2 |
| Larvae | 6 | 38 | 4 | 4 | 0 | 0 | 3 | 16 |
| Egg masses | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 3 |

Figure 6: Visual encounter survey (VES) data displayed by life stage at Mount Pleasant Lakes from 2004 through 2017. The red star over the subadult count in 2008 indicates an outlier above the scale displayed. During the 2008 survey, 448 subadults were observed in Pond 12052. SNYLF observations in this drainage have remained consistently low since 2010. Following initial surveys in 2004 and 2005, CDFW staff observed relatively high subadult counts during VES in 2008 and 2010. However, this spike in subadult observations may have been due to coincidental survey timing (i.e., soon after a cohort of late stage SNYLF tadpoles metamorphosed into young subadult frogs). Only a small subset of these young frogs typically survive to sexual maturity. Additionally, recent metamorph cohorts are often the life stage most susceptible to *Bd*-induced mortality. These factors could partially explain why the VES detections were so low in subsequent years, despite the relatively large number of subadults seen in 2008 and 2010. Additionally, the 2012 to 2015 drought, which may have limited successful reproduction, recruitment, and dispersal, may also account for the more limited observations in recent years.

## DISCUSSION

Pond 12049 appears to contain a robust dace population. CDFW does not know what affect dace may have on SNYLF breeding (e.g., potential for dace to prey on or damage egg masses and early life stage tadpoles). The lack of any observed SNYLF egg masses or tadpoles in this pond provides some circumstantial evidence that dace may preclude successful SNYLF breeding. Conversely, Goose Lake, located at the southern edge of Plumas National Forest in Sierra County, contains an abundant dace population sympatric with SNYLF. CDFW and USFS staff regularly monitor Goose Lake and the other waterbodies in the drainage east of Gold Lake reservoir. During recent surveys, in addition to observations of SNYLF adults and subadults, staff have observed egg masses in 2010, 2016, and 2017. CDFW crews observed nine SNYLF egg masses during the recent surveys in 2017, and crews detected 17 egg masses in 2010. CDFW is not aware of additional fishless deep water breeding habitat in the area, and VES results suggest that the SNYLF population in this area appears to be doing well. Therefore, the presence of dace clearly does not preclude SNYLF breeding. However, little quantitative data are available regarding direct interactions between dace and early life stage SNYLF.

There is some evidence that other cyprinids can cause reduced survival and growth in amphibians. For example, a study involving the use of mesocosms and aquaria to investigate potential effects of fathead minnows (*Pimephales promelas*) on egg masses and larval southern long-toed salamanders (*Ambystoma macrodactylum sigillatum*) found that minnows reduced the survival and growth rates of salamander larvae (Pearson and Goater 2009). The minnows did not appear to actively consume recent hatchling salamander larvae, but minnows did attack limbs and cause other sublethal effects (e.g., smaller size at metamorphosis and increased time spent in refugia). Fathead minnows were also hypothesized to have outcompeted salamander larvae for zooplankton, on which both species will feed (Pearson and Goater 2009). Other small, often highly abundant, fish species have also been linked with sublethal effects on amphibians, including mosquitofish (*Gambusia* sp.), which have been shown to cause injuries, reduced size at metamorphosis, and decreasing activity in larval anurans (Pyke and White 2000; plus, see studies summarized in Kats and Ferrer 2003). Three-spined sticklebacks (*Gasterosteus aculeatus*) have also been demonstrated during experiments to cause limb and tail damage in larval western toads (*Anaxyrus boreas*) identical to damage observed in the field (Bowerman et al. 2010). Although some researchers dispute drawing conclusions from experimental trials using unnatural aquarium and mesocosm settings (e.g., Skelly and Benard 2010), others have argued that these experiments are extremely useful, especially when combined with multiple lines of evidence from field-based observations and experiments (Johnson and Bowerman 2010). Undoubtedly, numerous fish species can affect amphibian larvae in different ways, and many of those effects may be deleterious, if not necessarily lethal (Wells 2007 pgs. 657–659).

The evidence for other common aquatic predators causing damage and mortality in larval amphibians further complicates isolating potential effects of dace. For example, various species of dragonfly nymphs are voracious predators of amphibian larvae (See Table 14.2 in Wells 2007; Ballengée and Sessions 2009, Bowerman et al. 2010). Additionally, other amphibian larvae found in the northern Sierra Nevada are known to prey on conspecifics (e.g., *Ambystoma macrodactylum*; Wildy et al. 1998, Wildy et al. 2001).

In light of these complications and unknowns regarding interactions between dace and SNYLF, CDFW and/or USFS will need to monitor the Pond 12049 population to attempt detecting evidence of breeding (i.e., egg masses and tadpoles), and observe potential interactions between dace and SNYLF. This site also could provide a unique opportunity for CDFW to study the ecological interactions of native cyprinids and early life stage SNYLF.

## RECOMMENDATIONS

CDFW will continue monitoring the Mount Pleasant SNYLF populations every year to assess population status (i.e., determine relative abundance, look for signs of continued breeding and recruitment, and assess distribution of SNYLF on the landscape). These efforts will require thorough VES in challenging terrain, such as stream channels with dense willow growth and steep, rocky substrates with many possible sources of refugia for SNYLF. Additionally, CDFW may work with local zoo and university partners to develop a research project (e.g., a graduate research masters study) on the interactions between cyprinids and SNYLF, especially early life stages, such as eggs and recently hatched larvae. The interactions of large predatory fish (e.g., trout) and SNYLF are well-studied, but there is much less currently known about the interactions of smaller forage fish and amphibians, especially studies investigating potential sublethal effects (e.g., limited breeding success, reduced size at metamorphosis, limb damage) on frog populations.

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