

State of California  
Department of Fish and Wildlife

# Memorandum

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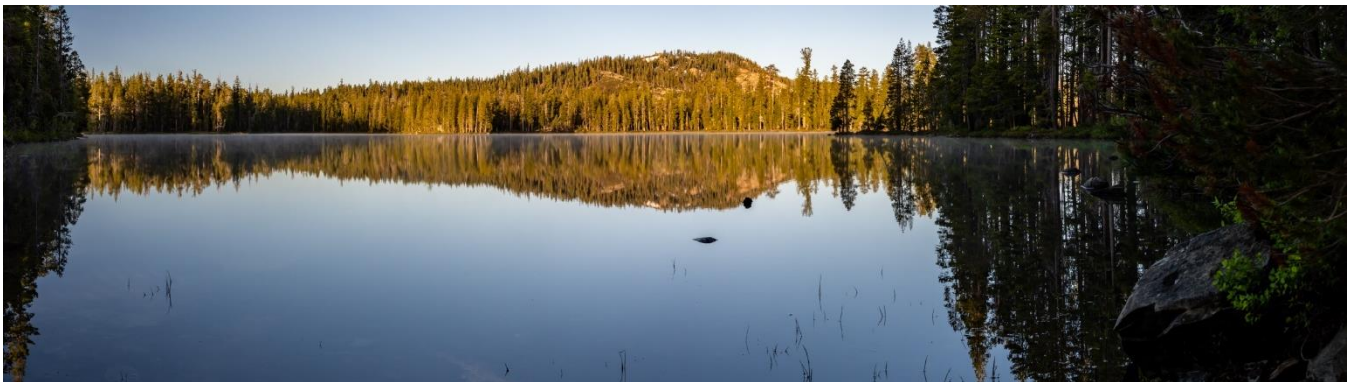
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Subject: Amphibian monitoring in Sierra County

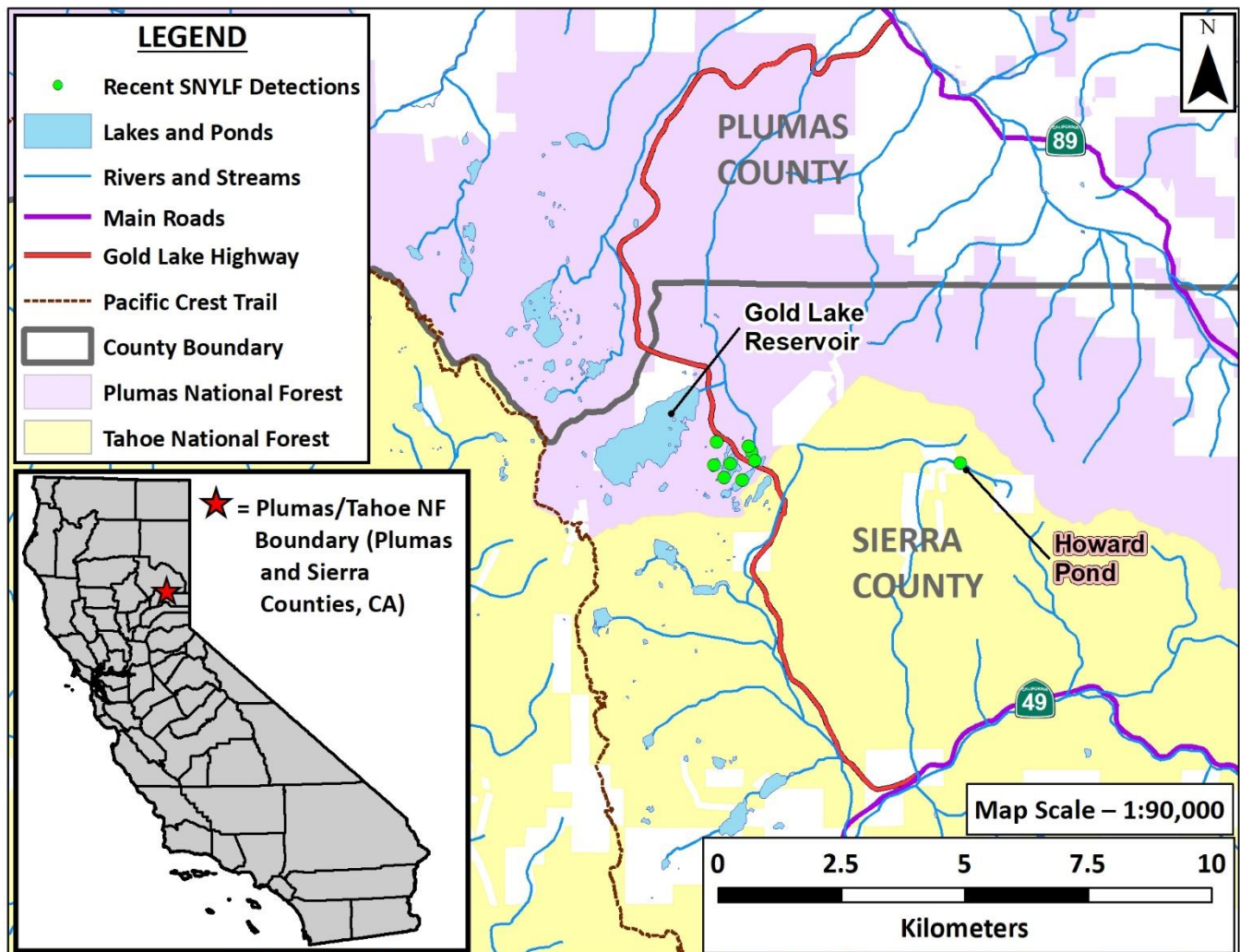
- *Rana sierrae* population monitoring along the Gold Lake Highway corridor



## ENVIRONMENTAL SETTING

The Gold Lake Reservoir area is located in northern Sierra County, between the Gold Lake Highway and Pacific Crest Trail (**Figure 1**). Elevations in the area range from 6,400 feet (ft) (1,951 meters [m]) in elevation at Gold Lake Reservoir, to 7,500 ft (2,286 m) at an unnamed summit two kilometers (km) west of the reservoir. Most land in the Gold Lake Reservoir area is managed by Plumas National Forest (PNF), but the southeast section of the lake basin (including Snag Lake and a couple unnamed ponds) is managed by Tahoe National Forest (TNF; **Figure 2**). During visual encounter surveys (VES) in 2001, California Department of Fish and Wildlife (CDFW) crews observed Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) at four ponds in the area. Monitoring surveys conducted in the intervening years have revealed a small, but persisting, SNYLF population.

Howard Pond is also located in northern Sierra County, approximately 6 km east of Gold Lake Reservoir and 3.5 km east of the Gold Lake Highway (**Figure 1**). Local elevations range from 7,004 ft (2,197 m) at nearby Howard Creek Meadow, to 8,107 ft (2,471 m) at the summit of Haskell Peak, 2.5 km to the southeast. Most land around Howard Pond is managed by the TNF. However, a portion of the surrounding land, including the western edge of Howard Pond, is owned by Graeagle Land and Water Company (**Figure 3**).

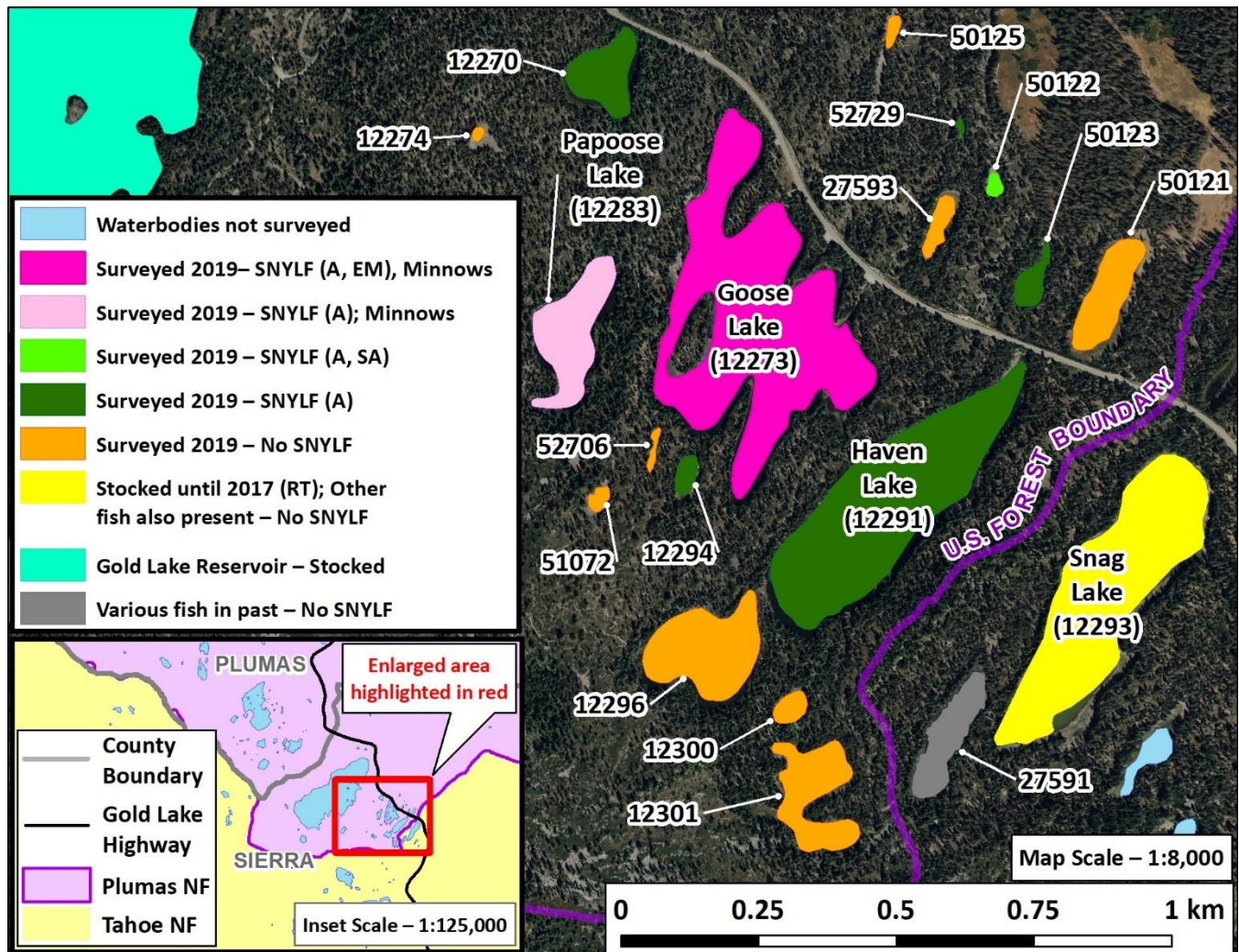


**Figure 1:** Gold Lake Highway area, Sierra County, CA. Green dots indicate positive detections of *Rana sierrae* (Sierra Nevada Yellow-legged Frog; SNYLF) by California Department of Fish and Wildlife (CDFW) staff during recent visual encounter surveys (VES). Plumas National Forest is shown in light purple and Tahoe National Forest is shown in light yellow. Gold Lake Highway is highlighted in red.



## INTRODUCTION

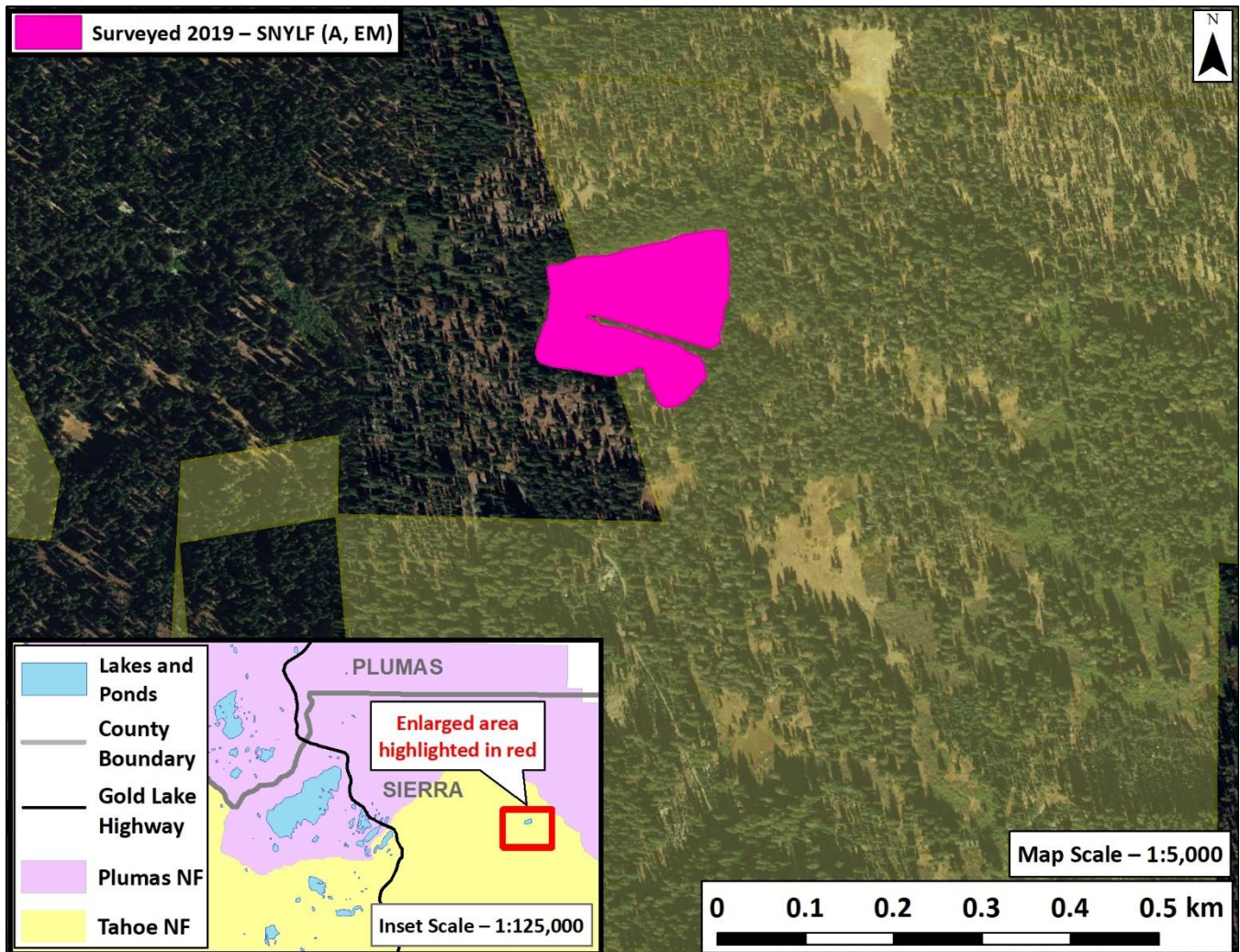
CDFW monitors the Gold Lake Reservoir area because it contains one of the few remaining SNYLF populations in the northern extent of the species' range. Additionally, this population is one of the few known extant SNYLF populations in Sierra County. In 2001, CDFW conducted baseline VES, during which crews observed adult and subadult SNYLF at Site ID 50122, subadult SNYLF at Goose Lake (Site ID 12273), and adult SNYLF at Haven Lake (Site ID 12291) and Site 50123. CDFW crews surveyed the area on two occasions in 2019: 19–20 June and 2 July. Between the two visits, CDFW staff surveyed 17 waterbodies, including two previously unnamed and unsurveyed ponds (Site ID's 52706 and 52729; **Figure 2**).



**Figure 2:** Gold Lake Reservoir area ponds in Plumas and Tahoe National Forests (PNF and TNF), Sierra County, CA. The purple boundary line demarcates PNF (to the west and north) and TNF (to the east and south). Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations occurred during visual encounter surveys (VES) in 2019. Goose Lake is a consistent breeding site for SNYLF, whereas field crews have not observed egg masses or tadpoles in any other ponds. Minnows are present in most of the larger ponds in the area. Haven Lake may still contain Brook Trout (*Salvelinus fontinalis*; BK). CDFW regularly stocks Gold Lake Reservoir with Brown Trout (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*). Numbers are CDFW Site IDs.

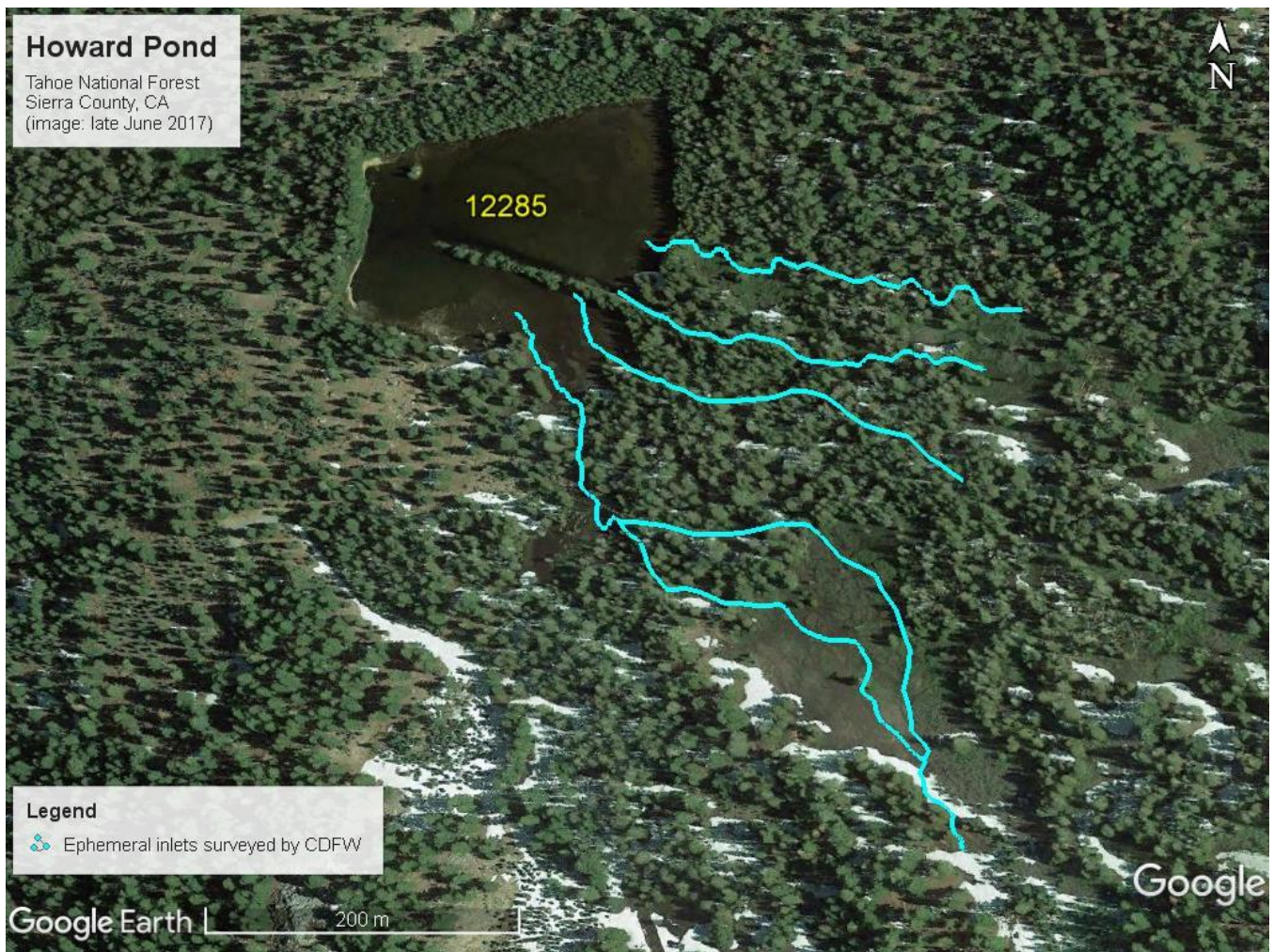


CDFW is interested in the Howard Pond population of Sierra Nevada yellow-legged frog (*Rana sierrae*; SNYLF) because it is one of the few remaining SNYLF populations in the northern extent of the species' range. Additionally, this population is one of the few known extant SNYLF populations in Sierra County. In recent years, Howard Pond has been surveyed by TNF field staff (USFS 2016). However, in 2019, TNF requested CDFW's assistance to survey the site. Therefore, on 2 July, CDFW staff surveyed Howard Pond for the first time. Given lingering snowpack from a big winter in 2018–2019, there was still some snow present in the surrounding landscape and water levels were high in Howard Pond. Therefore, CDFW staff surveyed multiple ephemeral inlets that were actively flowing during the site visit in early July (**Figure 4**).



**Figure 3.** Howard Pond, Tahoe National Forest (TNF), Sierra County, CA. Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations occurred during California Department of Fish and Wildlife (CDFW) visual encounter surveys (VES) in 2019. Land shaded in yellow is owned by TNF and land without shading is privately owned. The parcel situated on the western side of Howard Pond is owned by Graeagle Land and Water Company.





**Figure 4.** Aerial image of Howard Pond (circa late June 2017). During CDFW visual encounter surveys (VES) on 2 July 2019, water levels were similar, but less snow was present when compared with this image. However, of the past aerial imagery available via Google Earth, site conditions shown in this image most closely resemble conditions on 2 July 2019. Four primary ephemeral inlets were present during VES on 2 July 2019 (represented by turquoise lines). CDFW staff did not observe any herpetofauna in these stream segments. Flows in the inlet streams were high and the water temperatures ranged between 8 and 12° C.

## THREATS

### ***Marginal Habitats***

The Gold Lake Reservoir area and Howard Pond SNYLF populations are small and isolated. Most ponds, including those occupied by SNYLF, have a maximum depth of 4 m or less. Water levels at Howard Pond will occasionally drop to the point where less than half of the pond remains, when compared to full pool (Google Earth imagery, August 2012). The exception is Haven Lake, which has a maximum depth of 6 m. However, Haven Lake formerly contained Brook Trout (*Salvelinus fontinalis*, BK), which may still be present. Any disturbance, natural or otherwise, that threatens overwintering habitats presents a potential extirpation risk for SNYLF. Among the habitat risks are human disturbance, exposure to severe winter conditions, and desiccation from drought conditions, any of which could eliminate these small SNYLF populations.

### **Introduced Fish**

Golden Shiner (*Notemigonus crysoleucas*), Lahontan Redside (*Richardsonius egregius*; LRS), and Speckled Dace (*Rhinichthys osculus*) are present at most ponds in the Gold Lake Reservoir area. These minnow species may compete with, or directly harm, smaller life stages of SNYLF (e.g., eggs and larvae). However, little information is available regarding effects of minnows on SNYLF (see Discussion). Brook Trout may also be present in Haven Lake: BK were captured during an overnight gill net set in 2001 and CDFW has not conducted subsequent overnight gill net surveys at Haven Lake. Additionally, Haven Lake is the deepest waterbody in the cluster of ponds east of Gold Lake Reservoir. Therefore, BK may be persisting in Haven Lake, despite a lack of visual detections during amphibian monitoring. Nearby Snag Lake contains self-sustaining Brown Bullhead (*Ameiurus nebulosus*), and possibly BK and Rainbow Trout (*Oncorhynchus mykiss*; RT). CDFW stocked Snag Lake with BK until 2000 and RT until 2017. The persistent fish populations in Snag Lake may preclude any SNYLF reproduction and reduce the likelihood of post-metamorphic frog occupancy (Knapp and Matthews 2000). CDFW regularly stocks the largest lake in the area, Gold Lake Reservoir, with RT and Brown Trout (*Salmo trutta*). Monitoring data show that Gold Lake Reservoir contains self-sustaining populations of Lake Trout (*Salvelinus namaycush*), BK, and LRS (CDFW, unpubl. data).

### **Disease**

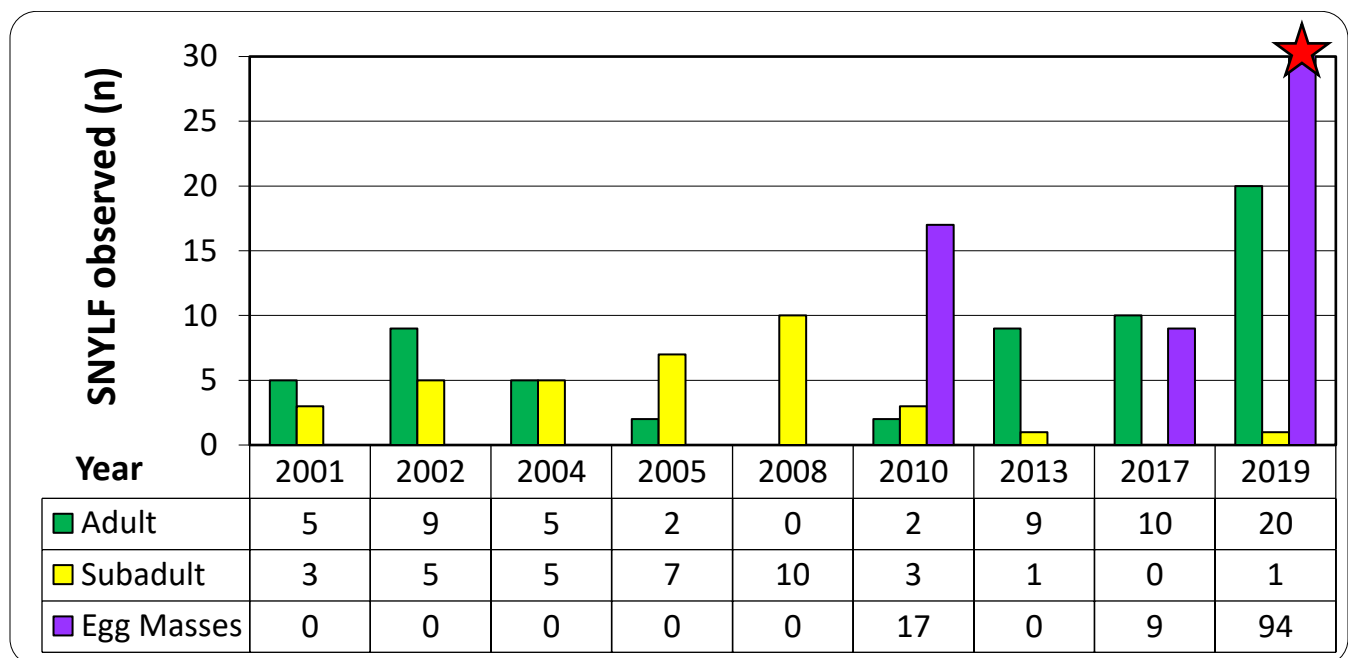
All SNYLF populations in Sierra County are chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*) positive. In 2008 and 2010, field crews genetically sampled SNYLF collected at Goose Lake with epithelial swabs and screened them for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR). Crews collected two swabs in 2008 and four swabs in 2010. Results for both years were highly variable: *Bd* zoospore loads were zero in some samples, light in most, and one was heavy. Additionally, at Goose Lake, CDFW staff observed three dead SNYLF during surveys in 2017 and four dead SNYLF adults during surveys in 2019. The cause of death cannot be determined, but these observations may suggest that there is consistent, low-level *Bd*-induced mortality in this population. However, other causes may also be contributing to the consistent low abundance observed in this SNYLF population, including overwinter mortality in 2016–2017 and 2018–2019 (during both of which there were high precipitation totals and late season snowpack) and the other factors discussed in this section.

### **Loss of Genetic Diversity**

The Gold Lake Reservoir area and Howard Pond SNYLF populations are highly isolated from the nearest robust SNYLF populations. Outside of the Gold Lake corridor, the closest known extant SNYLF populations, which are also small, are located about 30 km southeast, in the Independence Creek area. The closest large SNYLF metapopulations is over 35 km away in Nevada County. This geographic isolation effectively eliminates gene flow between populations and increases risk for local extirpation. Isolated populations can also suffer from inbreeding depression, genetic drift, fixation of deleterious alleles, and loss of genetic diversity, all of which are population genetic factors exacerbated when the population is small (Frankham et al. 2009).

## VES AT GOLD LAKE RESERVOIR AREA

CDFW performed baseline VES in the Gold Lake Reservoir area in 2001. Staff encountered a small breeding SNYLF population occupying four ponds. Nineteen years of occasional monitoring data suggest the Gold Lake Reservoir area SNYLF population is currently stable, despite its small size (**Figure 5**). The primary location of interest for SNYLF conservation is Goose Lake (**Figure 6**), in which CDFW and PNF personnel have occasionally observed egg masses (**Figure 7**). Detections have remained relatively consistent, albeit low, since CDFW began survey efforts in 2001. Observations of SNYLF adults and egg masses were greater in 2019 than in any other previous survey year. However, observer bias, variation in survey effort, weather conditions, habitat complexity, and the low number of detections all make deriving trends difficult. For example, in 2019, CDFW surveyed 17 ponds in the Gold Lake Reservoir area, whereas CDFW staff only surveyed three ponds in 2017. CDFW will continue to survey the Gold Lake Reservoir area at least every other year to monitor SNYLF population trends over time. CDFW plans to survey the Gold Lake Reservoir area in 2020.



**Figure 5:** California Department of Fish and Wildlife (CDFW) visual encounter survey (VES) data displayed by life stage at Gold Lake Reservoir area ponds from 2001 through 2019. Goose Lake (Site ID 12273) is the only waterbody in which CDFW staff have observed SNYLF egg masses and the only waterbody surveyed during every visit to the area. CDFW staff did not survey the following locations: Haven Lake (Site ID 12291) in 2008, 2013, and 2017; Papoose Lake (Site ID 12283) in 2004, 2005, and 2008; and Sites 50122 and 50133 in 2002, 2004, 2005, 2013, and 2017.

★ [red star] Indicates an outlier value beyond the range of the figure (94 egg masses).





**Figure 6:** Goose Lake (Site ID 12273), looking west from the mouth of an outlet stream on the eastern shore, on 19 June 2019. (CDFW)



**Figure 7:** One of numerous Sierra Nevada Yellow-legged Frog (*Rana sierrae*) egg masses found in the vicinity of a partially submerged, fallen tree at Goose Lake (Site ID 12273) on 19 June 2019. (CDFW)



## VES AT HOWARD POND

Biologists from TNF have been monitoring the SNYLF population at Howard Pond (**Figure 8**) and its tributaries since 2001. Depending on the survey, TNF biologists observed up to 15 SNYLF adults and nearly 100 larvae. Therefore, available records suggest a small, yet stable, breeding SNYLF population (TNF, unpubl. data).



**Figure 8:** Howard Pond (Site ID 12285), looking west, on 2 July 2019.

In 2019, CDFW field staff observed seven adult SNYLF (**Figure 9**), three larvae, and approximately 30 egg masses at Howard Pond (**Figure 10**). The number of SNYLF adults and larvae CDFW staff observed in 2019 was consistent with observations by TNF in previous years, which suggests that the Howard Pond SNYLF population may be stable. This was the first survey effort during which field staff have observed egg masses at Howard Pond. In previous years, surveys may have occurred too late in the summer to detect egg masses. The number of SNYLF egg masses CDFW staff observed is an approximation because many of the egg masses were located underneath cover, where they could only be detected by touch and not observed directly. However, staff found it effective to use tactile sensation to gently estimate the number of egg masses located under cover.

In addition to surveying the main pond, CDFW staff surveyed four inlet channels to Howard Pond (**Figure 4**). CDFW staff did not detect SNYLF of any life stage in these inlet stream segments or in the wet meadow areas through which a couple of the stream reaches passed. TNF spatial records suggested that a portion of past SNYLF detections in the Howard Pond area occurred in the primary inlet stream, which flows through a meadow located east of the pond (**Figure 4**).



**Figure 9.** An adult male Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observed at Howard Pond on 2 July 2019. CDFW staff observed several adult male SNYLF in the same small area, close to recently laid SNYLF egg masses. (CDFW)



**Figure 10.** A dense cluster of recently laid Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) egg masses CDFW staff observed at Howard Pond on 2 July 2019. During the survey, CDFW staff observed all SNYLF egg masses in the same location. CDFW staff also observed several adult male SNYLF in the same area. (CDFW)



## DISCUSSION

### ***SNYLF mortalities at Goose Lake***

Observations of dead SNYLF adults at Goose Lake are disconcerting, but not exceptional. CDFW staff have observed low numbers of SNYLF mortalities during multiple seasons in other locations (e.g., Dot Lake in Bucks Lake Wilderness; CDFW 2020). The causes of death may be the result of many possible factors, including disease (Briggs et al. 2010, Smith et al. 2017), environmental conditions (Bradford et al. 1983), attempted predation (Feldman and Wilkinson 2000), or breeding competition (i.e., drownings during amplexus caused by overzealous males; Sztatecsny et al. 2006). Mortalities in SNYLF are often attributed to *Bd*, which has been present in this location since at least 2008 (see [Disease](#) section above). However, an alternative explanation for the dead SNYLF adults CDFW staff observed may be severe weather conditions.

Precipitation and snowfall totals during winter 2018–2019 were high. Snow water content was approximately 160% of the April 1<sup>st</sup> average (CDWR 2020a) and water year precipitation levels were 136% of the 1966–2015 average (CDWR 2020b). In 2019, spring temperatures in the area of Gold Lake were consistently warm by mid-April (NOAA 2020). However, in mid-May, the northern Sierra Nevada experienced a sudden drop in temperature and increase in precipitation, which fell in the Gold Lake area as snow (CDWR 2020a, b, c). This period of late spring cold and precipitation occurred after nearly a month with very little precipitation (CDWR 2020b, c). CDFW hypothesizes that SNYLF may have emerged during April and early May to breed, but the frogs were then caught in a period, lasting at least a week, during which unseasonably cold and snowy conditions may have caused some post-metamorphic SNYLF mortality. Although environmental conditions may have been responsible for the observed SNYLF mortalities, CDFW plans to collect skin swabs from any adult SNYLF that can be captured during the next visit to Goose Lake. These swabs will be analyzed for the presence and quantity (zoospore load) of *Bd* to provide evidence of whether periodic disease outbreaks may be occurring in this population.

### ***Minnows and SNYLF***

Most SNYLF-containing ponds in the Gold Lake Reservoir area also support Golden Shiner and/or other minnow species. The only known exceptions are the small ponds north of Gold Lake Highway that do not appear to contain fish. CDFW does not know if minnows affect SNYLF egg masses or tadpoles, and, therefore, influence recruitment to the adult life stage. However, CDFW and USFS field crews have observed SNYLF egg masses in Goose Lake in 2010, 2016, 2017, and 2019. CDFW crews observed 17 SNYLF egg masses in 2010, nine in 2017, and 94 during the most recent survey in 2019. Therefore, the presence of minnows does not preclude SNYLF breeding. However, minnows may limit SNYLF development and recruitment into the adult population. Little quantitative data are available regarding direct interactions between minnows and early life stage SNYLF.

There is some evidence that other cyprinids can cause reduced survival and growth in amphibians. For example, a mesocosm study found that Fathead Minnows (*Pimephales*

*promelas*) reduced the survival and growth rates of salamander larvae through competition and inflicting injury (Pearson and Goater 2009). Other small fish species have been linked with sublethal effects on amphibians, including Mosquitofish (*Gambusia* sp.; Pyke and White 2000; studies summarized in Kats and Ferrer 2003). Experimental evidence has shown that Three-spined Sticklebacks (*Gasterosteus aculeatus*) cause limb and tail damage in larval Western Toads (*Anaxyrus boreas*) identical to damage observed in the field (Bowerman et al. 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 affecting larval amphibians further complicates isolating potential effects of minnows. 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 minnows and SNYLF, CDFW and/or USFS will continue to monitor the Gold Lake Reservoir area populations to attempt detecting evidence of recruitment (particularly tadpoles) and observe potential interactions between minnows and SNYLF. This site, in combination with SNYLF populations in Bucks Lake Wilderness (some of which are also sympatric with minnows) 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 Gold Lake Reservoir area to assess SNYLF population status (i.e., determine relative abundance, look for signs of continued breeding and recruitment, collect skin swabs for *Bd* and assess distribution of SNYLF on the landscape). CDFW will continue to monitor the Howard Pond population at least biennially if TNF biologists are unable to survey the site due other priorities or limited personnel availability. 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 on frog populations (e.g., limited breeding success, reduced size at metamorphosis, limb damage).



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