

State of California
Department of Fish and Wildlife

Memorandum

Date: 15 April 2021

To: Sarah Mussulman,
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Sierra District Supervisor;
North Central Region Fisheries

From: Isaac Chellman, Environmental Scientist;
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High Mountain Lakes;
North Central Region Fisheries

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Subject: Native amphibian restoration and monitoring in Bucks Lake Wilderness.

- Gold Lake area *Rana sierrae* monitoring.
- *Rana sierrae* captive rearing and release.



California Department of Fish and Wildlife (CDFW) is focusing on two drainages surrounding Silver Lake in Bucks Lake Wilderness (**Figure 1**) to benefit state threatened and federally endangered Sierra Nevada Yellow-legged Frogs (*Rana sierrae*, SNYLF). Gold Lake is a site from which CDFW staff removed introduced Brook Trout (*Salvelinus fontinalis*; BK) to benefit SNYLF. The Gold Lake area (**Figure 2**) includes Gold Lake, Rock Lake, and tributaries. The Mount Pleasant area (**Figure 2**), which includes several small ponds, is located about 2 kilometers (km) northwest of the Gold Lake area. CDFW has designated both areas as Native Species Reserves (NSRs) in the Aquatic Biodiversity Management Plan for the Bucks Lake Wilderness Management Unit (ABMP; CDFW 2015).

Amphibian monitoring data from 2004–2020 suggest small, persisting SNYLF populations in both areas. However, the population sizes have remained low for years, and biologists have consistently observed a small number of dead SNYLF in the Mount Pleasant area. Additionally, SNYLF populations in Bucks Lake Wilderness are part of a genetic clade at high risk of extirpation (Vredenburg et al. 2007). Therefore, these populations are of particular conservation concern to CDFW.

The Interagency Conservation Strategy for Mountain Yellow-legged Frogs in the Sierra Nevada (hereafter “Strategy”; MYLF ITT 2018) highlights reintroductions as a principal method for SNYLF recovery. As a result, in September 2018, Plumas National Forest (PNF) staff from the Mount Hough Ranger District collected 64 larval and metamorphic SNYLF for captive rearing at the San Francisco (SF) Zoo. Zoo staff raised the SNYLF to maturity, and PNF and CDFW staff released a subset of these frogs (those large enough for release in 2019) back into the Gold Lake and Mount Pleasant areas on 28 June 2019. In October 2019, PNF staff collected an additional 42 larval SNYLF from the Mount Pleasant area for captive rearing at the SF Zoo. On 19 June 2020, PNF and CDFW staff released a subset of these frogs (those large enough for release in 2020), including all remaining individuals from the 2018 cohort. In June 2021, CDFW and PNF plan to release the remaining 23 captive-reared SNYLF currently housed at the SF Zoo. CDFW and PNF staff will continue annual amphibian monitoring to document SNYLF response to reintroductions and BK removal.

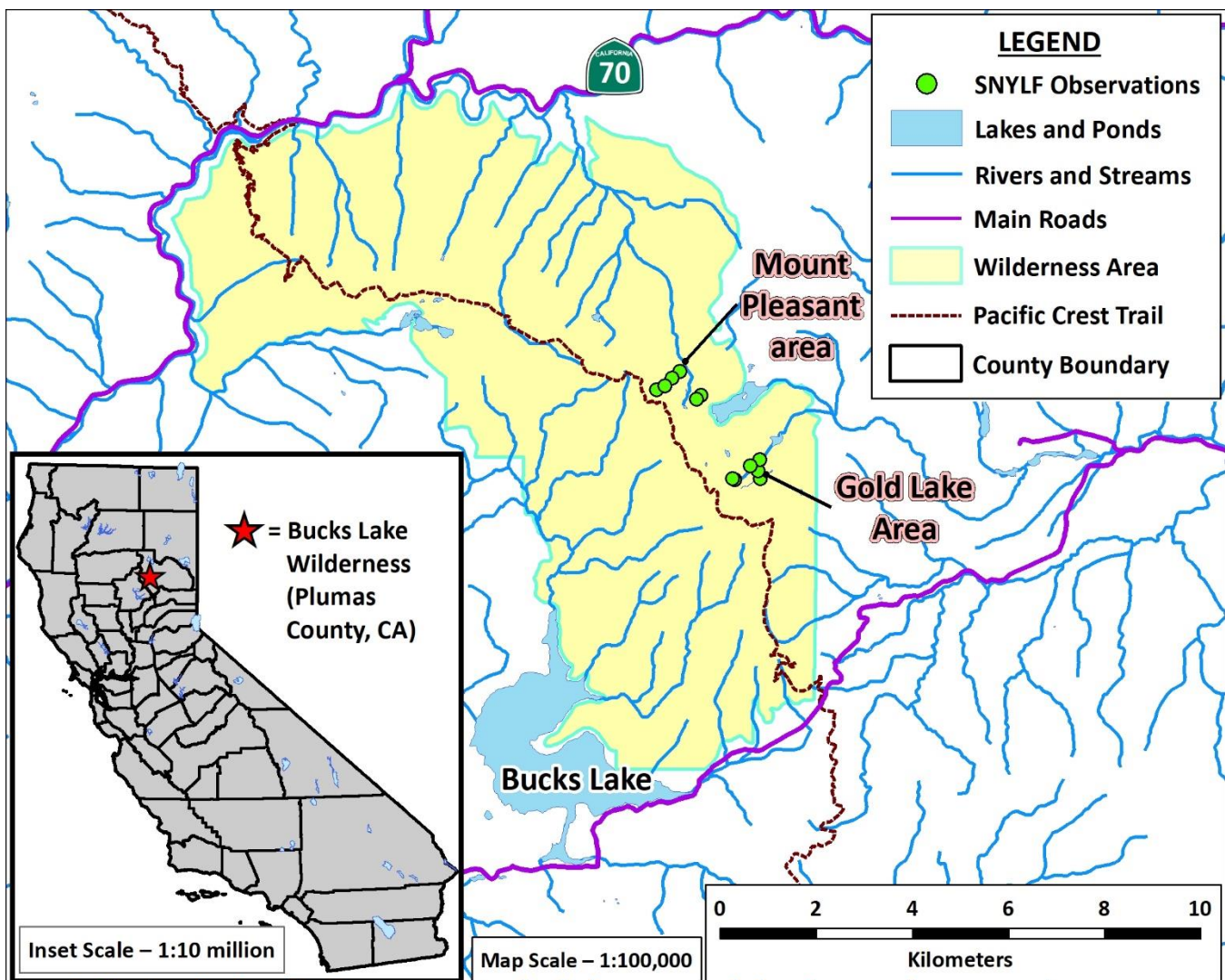


Figure 1. Bucks Lake Wilderness, Plumas County, CA. Green dots showing *Rana sierrae* (SNYLF) sites include positive detections by California Department of Fish and Wildlife (CDFW) and Plumas National Forest (PNF) staff during recent visual encounter surveys (VES; 2018–2020).

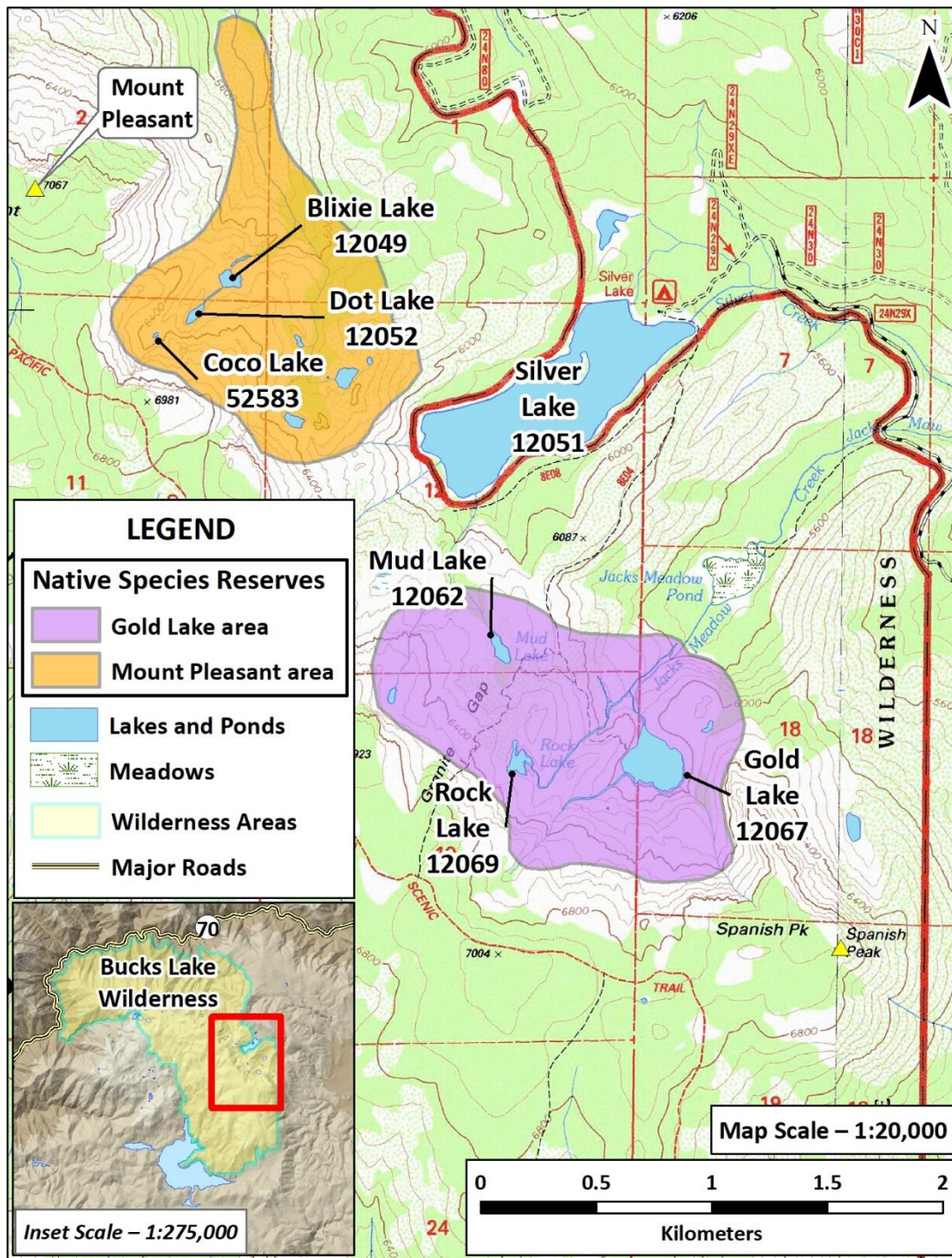


Figure 2. Focal areas for Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) management by California Department of Fish and Wildlife (CDFW) and Plumas National Forest (PNF) in Bucks Lake Wilderness, Plumas County, CA. The orange area highlights the Mount Pleasant Native Species Reserve (NSR) and the purple area highlights the Gold Lake NSR. CDFW and PNF biologists from the Mount Hough Ranger District regularly monitor the SNYLF populations in both areas. Numbers displayed are CDFW Site IDs.

ENVIRONMENTAL SETTING

Bucks Lake Wilderness is located in western Plumas County, south of state route 70 and north of Bucks Lake Reservoir. 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. CDFW staff initially observed SNYLF populations in Bucks Lake Wilderness while conducting baseline surveys in 2003 and 2004. Surveys conducted in the intervening years have identified two SNYLF populations: one south of Silver Lake in the Gold Lake area, and another persisting in a small drainage southeast of Mount Pleasant.

INTRODUCTION

Gold Lake (Site ID 12067; **Figure 3**) represents the only fish removal project to benefit SNYLF undertaken by CDFW in Plumas County. For detailed background on aquatic ecosystem management in the Bucks Lake Wilderness (**Figure 1**), [see the ABMP](#) (CDFW 2015). The ABMP identifies Gold Lake as one of the few, and possibly only, feasible habitat restoration opportunities available in Plumas and Sierra Counties (CDFW 2015). CDFW selected Gold Lake because 1) the site exhibits the physical habitat characteristics beneficial to state threatened and federally endangered SNYLF, 2) CDFW Environmental Scientists determined that BK eradication using mechanical methods is feasible, and 3) there is an extant SNYLF population in close proximity to Gold Lake.



Figure 3. Gold lake (Site ID 12067) on 18 August 2020. Gold Lake is the site from which CDFW removed non-native Brook Trout (*Salvelinus fontinalis*; BK) from 2015–2018. (CDFW).

Fish removal was complicated by Gold Lake being a popular recreational destination easily accessible from Silver Lake. Members of the local community strongly opposed the action. However, CDFW is mandated to conserve threatened and endangered species (Fish & G. Code, § 2050 et seq.), and Gold Lake offered the only feasible option known in Plumas County to improve habitat for an extant SNYLF population by mechanically removing non-native fish. Additionally, several other lakes are available for trout fishing in the vicinity, including Silver Lake, Lost Lake, Lower Three Lakes, Bucks Lake, Lower Bucks Lake, and Grizzly Forebay. There are numerous other fishing opportunities in Plumas County, including the Mount Hope area of Lassen National Forest to the west of Bucks Lake Wilderness, and approximately 20 different locations in Plumas County that are regularly stocked by CDFW.

Those interested in detailed background about fish removal at Gold Lake may consult the 2018 memorandum [“Gold Lake fish removal and Rock Lake *Rana sierrae* monitoring”](#) (CDFW 2018). Final BK removal results are in the 2019 memorandum [“Gold Lake and Mount Pleasant areas – *Rana sierrae* monitoring; Gold Lake fish removal update”](#) (CDFW 2019).

During a 2004 baseline visual encounter survey (VES) for SNYLF at Rock Lake (Site ID 12069; **Figure 4**), CDFW observed eight adults, seven juveniles, and 21 larvae – the only sign of breeding in the drainage. An 8-hour gill net set at Rock Lake yielded no fish. However, a 9-hour net set at nearby Gold Lake (**Figure 4**), which includes the only deep-water lake habitat in Bucks Lake Wilderness (29 m maximum recorded depth), captured eight BK and indicated a self-sustaining fishery. In accordance with the CDFW mission statement to balance native species diversity and recreational opportunity, Gold Lake was identified as a potential restoration site for SNYLF. Both Gold Lake and Rock Lake are beautiful northern Sierra Nevada lakes accessible via a short hike from Silver Lake trailhead, all factors that make for heavy recreational use of the area. Based on extensive surveys during the summers of 2002–2005, Rock Lake contains one of only three documented lake-based SNYLF populations in Plumas County.

The Mount Pleasant SNYLF population is another 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 VES, during which staff observed adult, subadult, and larval SNYLF at Dot Lake (Site ID 12052; **Figure 5**), plus adult SNYLF at Blixie Lake (Site ID 12049; **Figure 5**). In 2013, PNF staff surveyed the Mount Pleasant area and observed adult frogs in all wetted habitat, including eight adult SNYLF in Coco Lake (Site ID 52583; **Figure 5**; CDFW 2015).

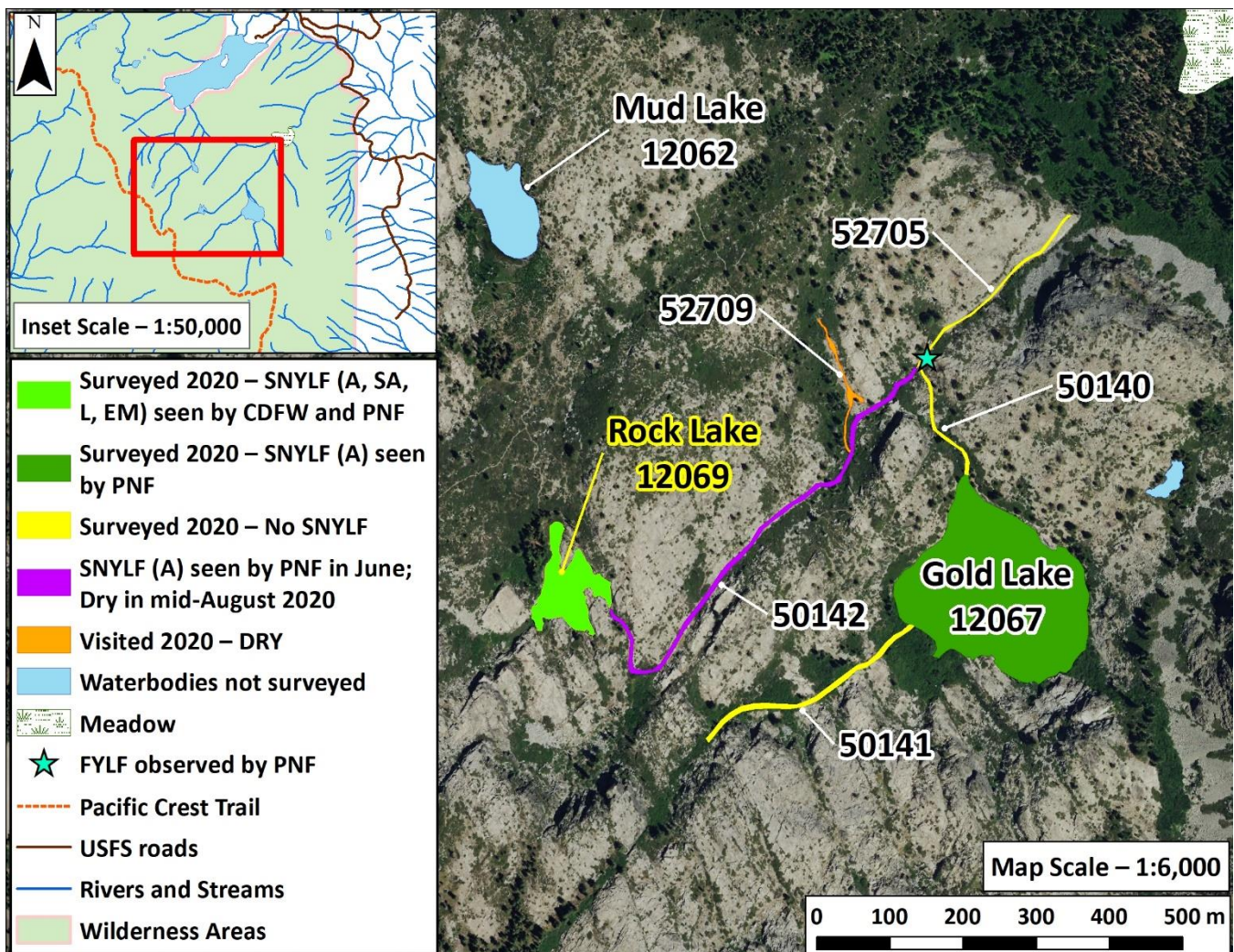


Figure 4. Gold Lake area, Bucks Lake Wilderness, Plumas County, CA. Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) and Foothill Yellow-legged Frog (*Rana boylei*; FYLF) observations occurred during visual encounter surveys (VES) in 2020. Since 2019, California Department of Fish and Wildlife (CDFW) updated several existing GIS polygons to more accurately reflect the depicted waterbodies. SNYLF letter codes in the legend, which indicate the life stage(s) observed during VES, are as follows: “A” = adults, “SA” = subadults, “L” = larvae, and “EM” = egg masses. Rock Lake is the only known SNYLF breeding location in the drainage. CDFW and Plumas National Forest (PNF) field staff consistently observe post-metamorphic SNYLF in the drainages downstream of Rock Lake and Gold Lake. In June 2020, PNF staff observed one FYLF adult at the confluence of the Gold Lake and Rock Lake outlets [blue star]. This individual was confirmed to be an adult FYLF through genetic analysis and tracking via Passive Integrated Transponder (PIT)-tagging (PNF 2021a). In 2018 and 2019, PNF staff collected early life stage SNYLF from Rock Lake (Site ID 12069, in yellow) and Dot Lake (Site ID 12052, which is northwest of Rock Lake; **Figure 5** below). Following each collection, biologists transported the SNYLF to the San Francisco Zoo for captive rearing. In 2019 and 2020, PNF and CDFW staff released portions of the captive-reared SNYLF (now adults) back into Rock Lake and Dot Lake. CDFW has designated the area displayed as a Native Species Reserve (NSR) in the Aquatic Biodiversity Management Plan for the Bucks Lake Wilderness Management Unit (CDFW 2015, pg. 28).

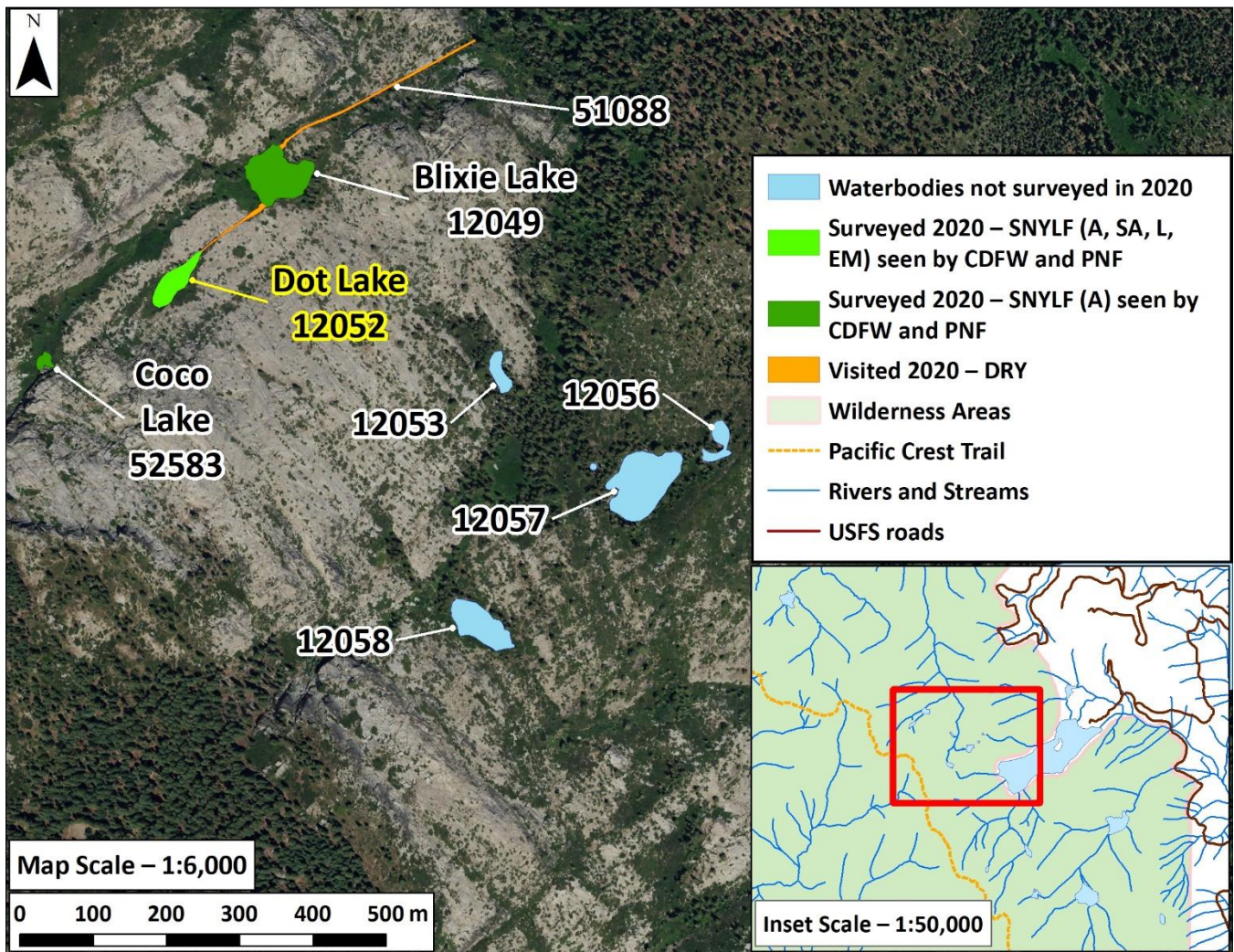


Figure 5. Mount Pleasant drainage, Bucks Lake Wilderness, Plumas County, CA. Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations occurred during recent visual encounter surveys (VES). Since results reported from 2019, California Department of Fish and Wildlife (CDFW) updated several existing GIS polygons to more accurately reflect the composition of the depicted waterbodies. SNYLF letter codes in the legend, which indicate the life stage(s) observed during VES, are as follows: “A” = adults, “SA” = subadults, “L” = larvae, and “EM” = egg masses. CDFW staff observed adult and subadult SNYLF at Dot Lake and adult SNYLF at Blixie Lake. Plumas National Forest (PNF) staff observed the SNYLF larvae and egg masses at Dot Lake. In 2018 and 2019, PNF staff collected early life stage SNYLF from Dot Lake (Site ID 12052, in yellow) and Rock Lake (Site ID 12069, which is southeast of Dot Lake; **Figure 4** above). Following each collection, biologists transported the SNYLF to the San Francisco Zoo for captive rearing. In 2019 and 2020, PNF and CDFW staff released portions of the captive-reared SNYLF (now adults) back into Dot Lake and Rock Lake. CDFW has designated the area displayed as a Native Species Reserve (NSR) in the Aquatic Biodiversity Management Plan for the Bucks Lake Wilderness Management Unit (CDFW 2015, pg. 28).

THREATS

Marginal Habitats

VES data show that the Gold Lake and Mount Pleasant area SNYLF populations are currently reproducing in Rock Lake and Dot Lake, both of which are small, isolated, and shallow (**Figure 2**). 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 (e.g., the 2012–2015 drought, which lowered water levels in many small ponds throughout the Sierra Nevada), any one of which could eliminate these small SNYLF populations.

Introduced Fish

Gold Lake formerly contained a self-sustaining BK population. However, in 2015, CDFW initiated mechanical fish removal using gill nets. CDFW field staff have not observed BK in Gold Lake since July 2016 (CDFW 2018). During summer 2018, CDFW field staff observed BK in isolated pools along the Gold Lake outlet stream, which CDFW subsequently removed by electrofishing (CDFW 2019). These pools are below the Gold Lake streamflow maintenance dam, which provides a barrier to upstream fish movement. Trout may have been precluding SNYLF from successful breeding and recruitment in Gold Lake, which is the only additional deep-water habitat near the breeding SNYLF site at Rock Lake. Furthermore, Speckled Dace (*Rhinichthys osculus*; DC-S) are present in Gold Lake and Blixie Lake. Speckled 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 DC-S on SNYLF (for more in-depth discussion of potential interactions between early life stage SNYLF and minnows, please refer to the discussion section of the 2020 [Native amphibian restoration and monitoring in Bucks Lake Wilderness](#) memorandum; CDFW 2020).

Disease

All SNYLF populations in Plumas County are chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*) positive. In 2008, 2010, and 2011, SNYLF captured at Rock Lake, Dot Lake, and Blixie Lake were genetically sampled with epithelial swabs for the presence of *Bd*. Field staff collected 27 swabs, which partner scientists screened for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. Results for all three years indicated very light to moderate *Bd* zoospore loads. In 2018, PNF analyzed 20 additional swabs collected from SNYLF at Dot Lake (n = 14) and Rock Lake (n = 6). Most of the swabbed frogs at Dot Lake were recent metamorphs, which are typically the life stage most susceptible to *Bd* (Rachowicz et al. 2006), whereas four of the six swabs from Rock Lake were collected from adults. Results from the swabs collected in 2018 indicated moderate to high *Bd* zoospore loads. However, high *Bd* loads are typical for recent SNYLF metamorphs, even in populations persisting with *Bd* (Ellison et al. 2019; R. Knapp, pers. comm.). In 2020, CDFW staff collected one swab from an adult frog in the Mount Pleasant drainage, which partner scientists analyzed in fall 2020. Results indicated a light *Bd* load.

CDFW and PNF staff have consistently observed low numbers of dead SNYLF of various life stages at Dot Lake, including during VES in 2004, 2005, 2010, 2015, 2017, and 2018 (the latter observation by PNF staff). These observations suggest that there may be consistent *Bd*-induced mortality in this population. CDFW and PNF staff have not observed any recent signs of *Bd*

epizootic events in the Gold Lake or Mount Pleasant areas. However, VES results suggest that the Mount Pleasant population may have experienced a major die-off during a *Bd*-induced epizootic event sometime between 2005 and 2008 (CDFW 2019). A similar die-off may have occurred around the same time in the Gold Lake area, but VES do not suggest as pronounced a decline as the one suggested by Mount Pleasant observational data. The Gold Lake and Mount Pleasant SNYLF populations may have not been previously exposed to *Bd* before these potential outbreaks.

Loss of Genetic Diversity

The Bucks Lake Wilderness SNYLF populations are found within a unique genetic unit (Clade 1; **Figure 6**; Vredenburg et al. 2007, MYLF ITT 2018). Clade 1 is the most threatened of the three currently recognized genetic clades, due to few remaining extant populations, marginal habitats, and potential threats from multiple land uses (MYLF ITT 2018). Clade 1 also includes some of the lowest elevation SNYLF populations in the species' range. Additionally, populations in Clade 1 are widely separated from one another, which limits 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).

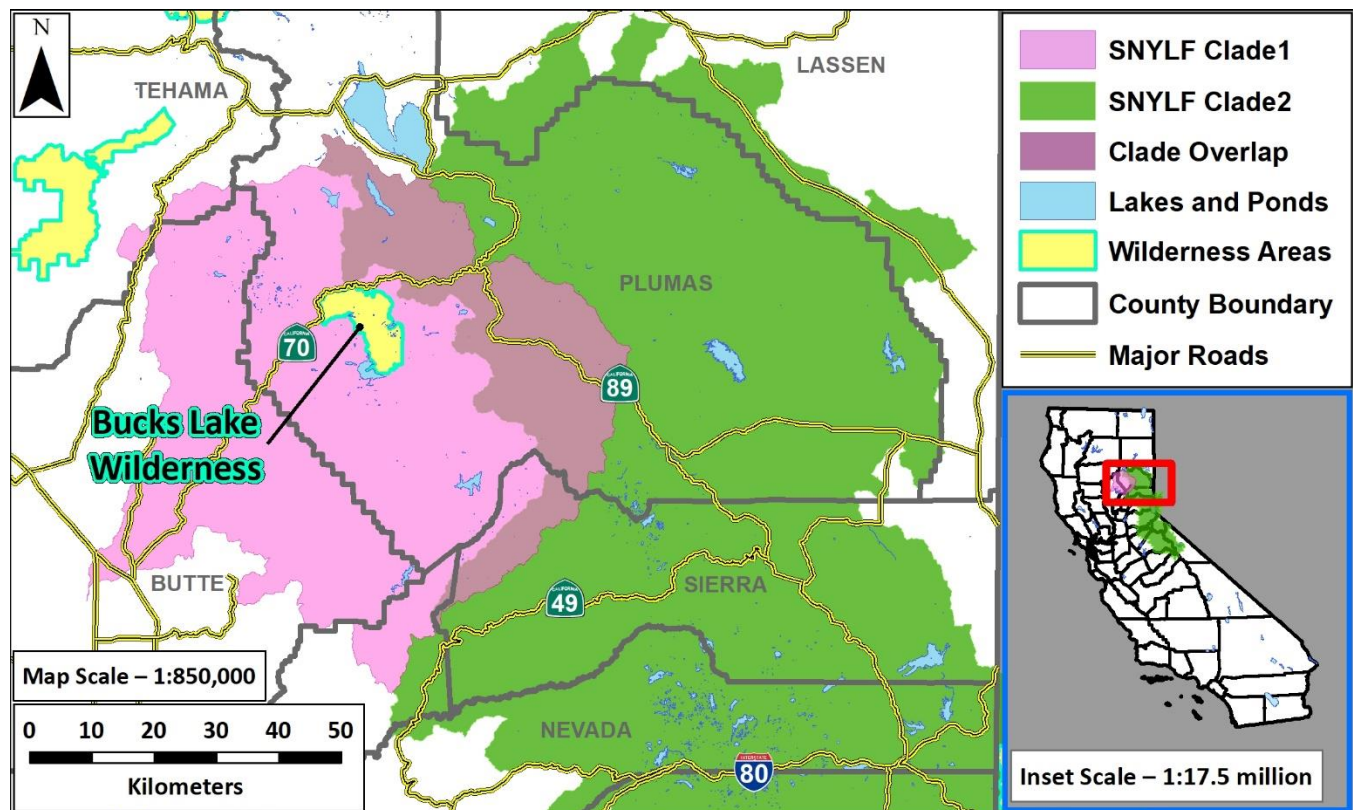


Figure 6. Currently recognized Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) boundaries for genetic clades 1 and 2. These clades were established based on DNA analyses from one mitochondrial gene (Vredenburg et al. 2007). Given the locations from which genetic samples were derived for Vredenburg et al. 2007, and historic population losses—particularly at the northern extent of the SNYLF range, precise clade boundaries are unknown. Therefore, there is some overlap in currently recognized clade boundaries.

VES IN THE GOLD LAKE AREA

CDFW performed the baseline VES in the Gold Lake area in 2004, during which staff encountered a small breeding SNYLF population. Fifteen years of periodic monitoring data suggest that this population may be slowly declining (**Figure 7**). SNYLF detections of all life stages 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.

For several years, PNF and CDFW field staff have been marking newly captured adult SNYLF (≥ 40 mm snout-to-urostyle length [SUL]) in the Gold Lake area with passive integrated transponder (PIT) tags, which provide a unique identifier for keeping track of individuals. Staff first scan each captured adult with a PIT tag reader, which displays a unique identification code when a PIT tag is detected, to determine if the frog is marked (i.e., a recapture). Field staff then record the global positioning system (GPS) point, SUL, weight, and the frog's sex. If the adult is a recapture, staff release the frog without further processing. For new adult captures, in addition to the data collected above, staff insert an 8 x 1.4 mm PIT tag under the dorsal skin (using methods recommended by McAllister et al. 2004), scan and record the PIT tag number, and release the frog at the point of capture. PIT tags can be used to monitor demographic trends in the population using capture-mark-recapture (CMR) analyses (Williams et al. 2001). Additional details on CMR results from Bucks Lake Wilderness are discussed below in the [SNYLF CAPTURE-MARK-RECAPTURE](#) section.

In 2020, CDFW surveyed the Gold Lake area once. The survey included Gold Lake (Site ID 12067; **Figure 3**), Rock Lake (Site ID 12069; **Figure 8**), and surrounding stream segments (Site IDs 50140, 50141, 50142, 52705, and 52709; **Figure 4**). CDFW staff observed one adult and eight subadult SNYLF at Rock Lake. As part of the captive rearing and release (discussed below), PNF partners surveyed portions of the Gold Lake and Mount Pleasant areas on several occasions in summer 2020. PNF staff observed SNYLF of all life stages in Rock Lake, several adult SNYLF in the Rock Lake outlet (close to Rock Lake) in June, and one adult SNYLF at Gold Lake in early November.

Surprisingly, in late June, PNF staff observed an adult Foothill Yellow-legged Frog (*Rana boylei*; FYLF) at the confluence of the Gold Lake and Rock Lake outlet streams. This was the first time a FYLF has been detected in Bucks Lake Wilderness (PNF 2021b). The individual was confirmed to be an adult FYLF through previous genetic analysis (circa 2016) and tracking via PIT-tagging (PNF 2021a). FYLF are known to occur further downstream, in Silver Creek. However, most observations have occurred at approximately 4,000 ft. [1,220 m] in elevation, several km downstream from the detection site, which occurred at an elevation of about 5,820 ft. [1,774 m]. CDFW and PNF do not think there is a resident FYLF population in Bucks Lake Wilderness. Rather, this is a lone individual that has moved upstream remarkably far from the core population for reasons unknown.

Both CDFW and PNF will continue surveying the area at least once each year, keeping records on the location and identity of recaptured adult SNYLF (or FYLF), and PIT tag any newly captured adults. These data will help CDFW better understand the status and trends of the Gold Lake area SNYLF population.

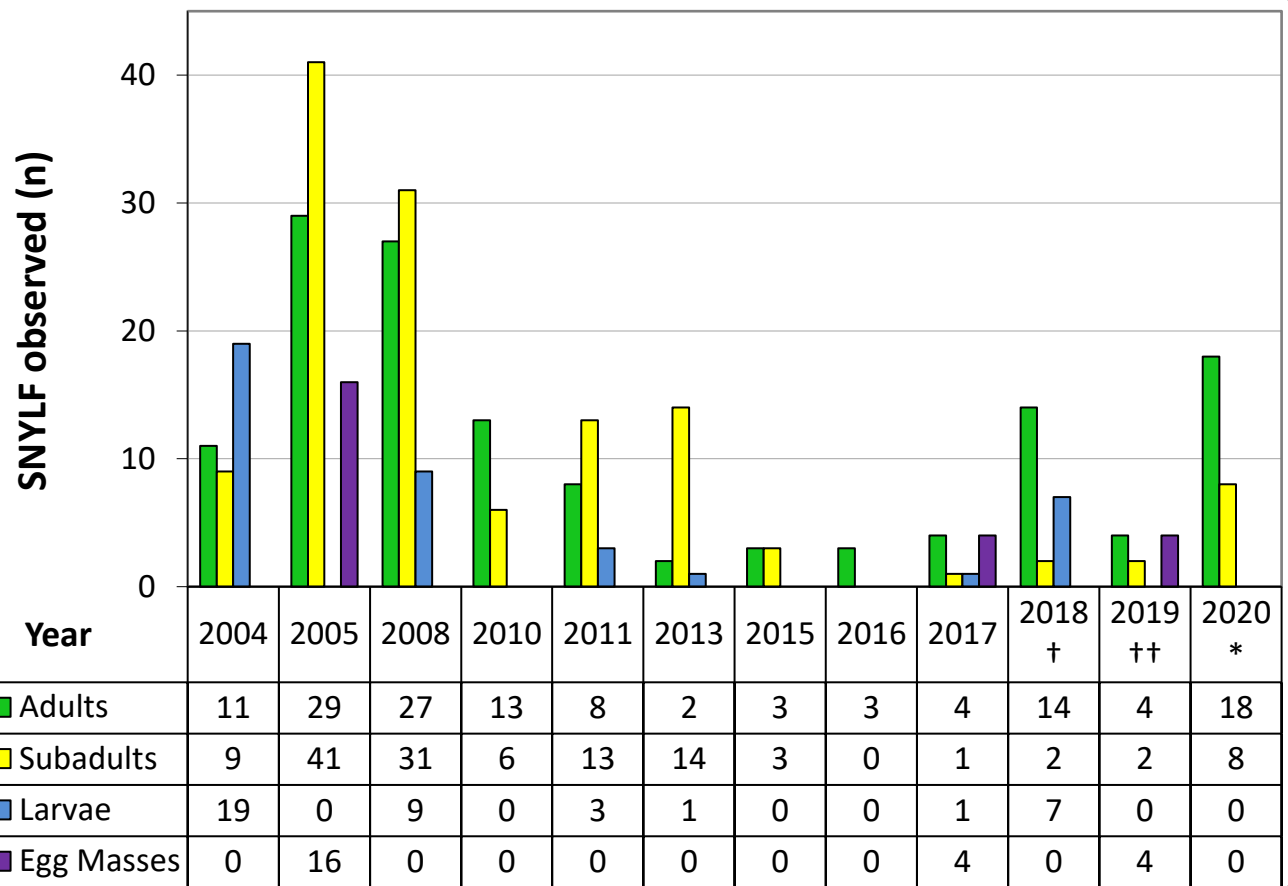


Figure 7. Histogram of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) detections during visual encounter surveys (VES) by life stage and year in the Gold Lake area. Survey data includes SNYLF detections at Rock Lake (Site ID 12069), Gold Lake (Site ID 12067), and the associated stream segments (Site IDs 50140, 50141, 50142, 52705, and 52709). California Department of Fish and Wildlife (CDFW) and Plumas National Forest (PNF) field staff have detected most SNYLF at Rock Lake and in the outlet stream close to Rock Lake (i.e., upstream end of Site ID 50142). SNYLF detections at Gold Lake and the connected streams have been composed primarily of adults. If more than one VES was conducted in a given year (2015, 2016, 2018, and 2019), the data shown are from the survey day resulting in the highest number of SNYLF detections. CDFW only conducted VES at the following sites during the years listed: Gold Lake during all years shown except 2008; Site ID 50140 in 2005, 2010–2013, 2016, and 2018–2020; Site ID 50141 in 2005, 2010–2011, 2018, and 2020; and Site ID 50142 in 2011–2013, 2016–2018, and 2020.

[†]Totals in 2018 include SNYLF detected by PNF staff. CDFW did not add stream segment 52705 (the segment below the confluence of the Rock and Gold Lake outlets) until 2018.

^{††}Totals in 2019 include SNYLF detected by PNF staff. In 2019, only PNF staff surveyed Rock Lake. *Total does not include young adult SNYLF released at Rock Lake in 2019 (n = 19).*

^{*}Adult SNYLF observations in 2020 include PNF detections. Since all adults are PIT-tagged (i.e., captured adults are either known recaptures or new individuals that received a PIT tag once caught), the total reflects all unique adult individuals captured by PNF and CDFW in 2020. *Total does not include young adult SNYLF released at Rock Lake in 2020 (n = 19).*



Figure 8. Rock Lake (Site ID 12069) on 18 August 2020. On 19 June 2020, California Department of Fish and Wildlife (CDFW) and Plumas National Forest (PNF) biologists released 19 captive-reared Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) adults, most of which were originally collected from Dot Lake (Site ID 12052) as late stage tadpoles. Most signs of SNYLF breeding (including observations of egg masses, larvae, and recently metamorphosed SNYLF) in the Gold Lake area have occurred at Rock Lake.

VES IN THE MOUNT PLEASANT AREA

CDFW performed the baseline VES in the Mount Pleasant NSR in 2004, during which staff encountered a small breeding SNYLF population. Fourteen years of monitoring data suggest this population is declining (**Figure 9**). Most signs of breeding, including observations of egg masses, larvae, and recent metamorphic SNYLF, have occurred in Dot Lake (Site ID 12052; **Figure 10**). However, similarly to the Gold Lake NSR SNYLF population, detections have remained relatively consistent, albeit low, since 2010. In part due to these low detections, PNF and CDFW staff have undertaken the same adult SNYLF PIT-tagging methods described above in the [VES IN THE GOLD LAKE AREA](#) section.

CDFW staff surveyed the Mount Pleasant area once in 2020. The survey included Dot Lake, Blixie Lake (Site ID 12049; **Figure 11**), the stream segment that connects Dot and Blixie (Site ID 50157), Coco Lake (Site ID 52853; **Figure 12**). Staff observed two adult and two subadult SNYLF at Dot Lake and two adult SNYLF at Blixie Lake. As part of the captive rearing and release ([discussed below](#)), PNF partners surveyed portions of the Gold Lake and Mount Pleasant areas on several occasions in summer 2020. PNF staff observed SNYLF of all life stages at Dot Lake, and adult SNYLF at Coco Lake and Blixie Lake (PNF 2021b).

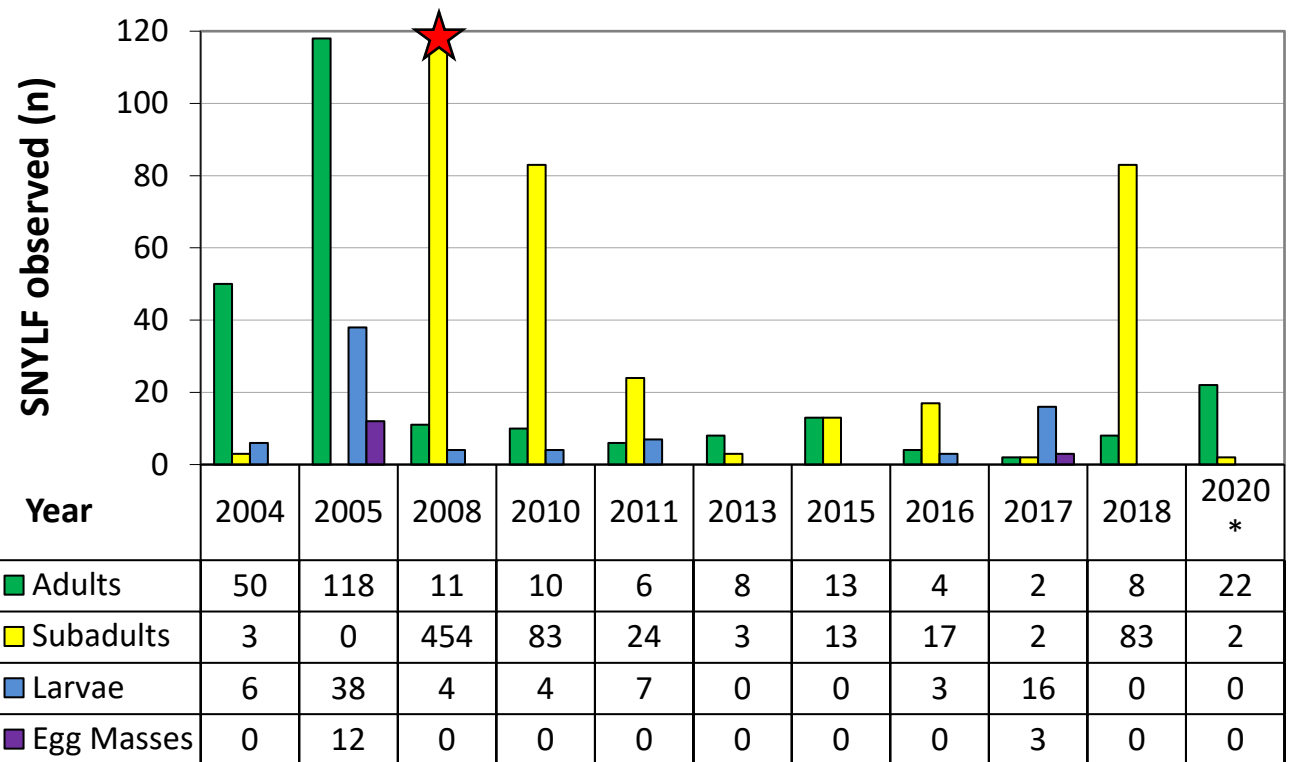


Figure 9. Histogram of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) detections during visual encounter surveys (VES) by life stage and year in the Mount Pleasant area. Survey data includes SNYLF detections at Blixie Lake (Site ID 12049), Dot Lake (Site ID 12052), Coco Lake† (Site ID 52583), two nearby ponds (Site IDs 12056 and 12057), and the associated stream segments (Site IDs 50157 and 50158). The red star over the subadult count in 2008 indicates an outlier above the y-axis scale (see table). The high subadult counts during VES in 2008, 2010, and 2018 may be due to survey timing coinciding with late stage SNYLF tadpoles metamorphosed into young subadult frogs. Only a small subset of early life stages typically survive to sexual maturity and recently metamorphosed frogs are very susceptible to mortality from chytridiomycosis, the disease caused by the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*). These factors could explain why the VES detections were low in subsequent years, despite the large number of subadults seen.

CDFW field staff surveyed Dot Lake during every year shown. CDFW only conducted VES at the following sites during the years listed: Blixie Lake during all years shown except for 2005; Site 50157 in 2005, 2010–2013, 2016–2017, and 2020; Sites 12056 and 12057 in 2012 and 2018; and Site 51088 in 2011, 2015, and 2016. In 2020, staff briefly observed the upstream end of Site ID 51088 and the stream appeared to be completely dry.

†CDFW did not add Coco Lake, which Plumas National Forest staff have occasionally monitored, until 2018.

*Adult SNYLF observations in 2020 include PNF detections. Since all adults are PIT-tagged (i.e., captured adults are either known recaptures or new individuals that received a PIT tag once caught), the total reflects all unique adult individuals captured by PNF and CDFW in 2020. *Total does not include young adult SNYLF released at Dot Lake in 2020 (n = 19).*



Figure 10. Dot Lake (Site ID 12052) on 19 August 2020. On 19 June 2020, California Department of Fish and Wildlife (CDFW) and Plumas National Forest (PNF) biologists released 19 captive-reared Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) adults at the site. Most signs of Sierra Nevada SNYLF breeding (including observations of egg masses, larvae, and recent metamorphic SNYLF) in the Mount Pleasant area have occurred at Dot Lake.



Figure 11. Blixie Lake (Site ID 12049) on 19 August 2020. The North Complex wildfire had just started burning two days before the survey, and smoke quickly descended into the basin during the afternoon of 19 August, soon before California Department of Fish and Wildlife completed surveys of the Mount Pleasant drainage. (CDFW)



Figure 12. Coco Lake (Site ID 52853) on 19 August 2020.

SNYLF CAPTIVE REARING AND RELEASE

The consistent low number of SNYLF detections in the Mount Pleasant and Gold Lake areas has been concerning to both CDFW and PNF. During VES in August 2018, CDFW field staff observed very few SNYLF in both the Mount Pleasant and Gold Lake areas. Although observer bias and variation in survey conditions can affect the number of SNYLF detected during any given VES, the low numbers were troubling, especially when observed in already threatened populations. In response to these observations and long-term trends, PNF personnel, in collaboration with CDFW and the U.S. Fish and Wildlife Service (USFWS), undertook a collection of early life stage SNYLF from Dot Lake (Site ID 12052; **Figures 5 and 10**) and Rock Lake (Site ID 12069; **Figures 4 and 8**) for captive rearing (a.k.a., “headstarting”) at the SF Zoo. The Strategy highlights captive rearing as one of the primary actions to restore SNYLF populations (MYLF ITT 2018, pgs. 17–19). CDFW also mentions the potential for translocations (which are one of the methods, along with captive rearing, broadly considered under “Reintroductions” in the Strategy) in the Mount Pleasant area in the Bucks Lake Wilderness ABMP (CDFW 2015, pg. 20).

During VES in early September 2018 to locate early life stage SNYLF for captive rearing at the SF Zoo, PNF staff observed more SNYLF than CDFW had detected in August 2018. These early September 2018 surveys by PNF were fortunately timed because they coincided with the emergence of very recently metamorphosed SNYLF, which had likely not been available for detection during surveys the previous month. PNF staff collected 60 recently metamorphosed SNYLF at Dot Lake, plus four early life stage SNYLF at Rock Lake. On 6 September 2018, PNF staff transported all 64 collected SNYLF to the SF Zoo. Once at the zoo, staff treated the young frogs

with an antifungal drug called itraconazole, which clears *Bd* infection. The SNYLF were raised to maturity at the zoo and 42 captive-reared frogs were mature enough for release back into Bucks Lake Wilderness in summer 2019. On 8 October 2019, PNF staff collected an additional 42 larval SNYLF from Dot Lake for captive rearing at the SF Zoo. The SNYLF were raised to maturity at the zoo and 38 captive-reared frogs were mature enough for release back into Bucks Lake wilderness in summer 2020 (PNF 2021b).

CDFW and PNF staff release all captive-reared SNYLF back into the sites from which young frogs were originally collected. However, since staff detected nearly all early life stage SNYLF at Dot Lake, most captive-reared SNYLF that staff released back into Rock Lake were originally collected from Dot Lake. Given that Dot Lake and Rock Lake are close together (< 2.5 km), contain very similar habitat, and both contain *Bd*-positive SNYLF populations (see [Disease](#) section above), moving captive-reared frogs from Dot Lake to Rock Lake poses negligible risk to the resident SNYLF populations or local environment. Additionally, recent population genetic analyses indicate that little genetic substructuring exists between SNYLF populations located in such close proximity (Rothstein et al. 2020). Therefore, CDFW, PNF, USFWS, and partner scientists have determined that short distance movements like those undertaken between Dot Lake and Rock Lake are an appropriate conservation measure for SNYLF (MYLF ITT 2018).

On 28 June 2019, CDFW and PNF biologists released 40 young adult SNYLF (18 females and 22 males) back into the Bucks Lake Wilderness after being cleared of *Bd* infection and raised to maturity at the SF Zoo. These 40 individuals are a subset of the 64 individuals that were collected by PNF staff on 6 September 2018. CDFW staff picked up 42 SNYLF from SF Zoo staff on the morning of 28 June 2019 and transported them to the PNF Mount Hough Ranger Station. There, the frogs were split into two groups, each containing 9 females and 12 males. CDFW and PNF staff took one group to Rock Lake and one group to Dot Lake for release. Before release, each frog's PIT tag was scanned (**Figure 13**) and snout-urostyle length (SUL) and weight measurements were taken. Twenty-one frogs were successfully reintroduced to Dot Lake and nineteen to Rock Lake. Two frogs intended for release into Rock Lake perished after brief exposure to excessive sunlight while in transport containers. The mortality incident was very unfortunate, but an occurrence that will be easily preventable in the future. CDFW staff informed the U.S. Fish and Wildlife Service of the mortality incident immediately after returning from the field. The 40 remaining frogs were all in good condition and returned to their original habitat.

On 19 June 2020, CDFW and PNF biologists used the methods described above to release another 38 adult SNYLF (23 females, 12 males, and 3 of unknown sex) back into Bucks Lake Wilderness. SNYLF released in 2020 included the remaining frogs from the cohort originally collected in 2018 ($n = 20$), plus a subset of frogs that had been collected as late stage tadpoles in October 2019 (i.e., those large enough for release in June 2020; $n = 18$). Of the 38 frogs, staff released half ($n = 19$) into Dot Lake and the other half into Rock Lake (**Figure 14**). When divided up SNYLF into the two release groups, CDFW and PNF staff allotted 13 females/unknowns and 6 males to each site. All 38 SNYLF were behaving normally and appeared to be in excellent body condition during the release.

As of December 2020, SF Zoo is caring for 23 remaining SNYLF, which CDFW and PNF staff plan to release into Bucks Lake Wilderness in early summer 2021.

SNYLF CAPTURE-MARK-RECAPTURE

U.S. Forest Service (USFS) personnel have been PIT-tagging adult SNYLF for monitoring purposes in Bucks Lake wilderness since 2015. The initial tagging efforts were subsequently halted due to changes in research direction and personnel. More recent PIT-tagging work undertaken by current PNF and CDFW staff, beginning in 2017 and expanding in 2018, seeks to PIT tag all newly captured (untagged) adults in the Gold Lake and Mount Pleasant areas. Data presented here only include adult SNYLF PIT-tagged from 2018 onward, which is the period during which there has been more consistent surveying and tagging effort. PIT-tagging will allow CDFW and PNF to more accurately keep track of SNYLF population demographics over time through CMR analyses. Additionally, PIT-tagging will allow biologists to learn more about the potential benefits of the recent SNYLF headstarting work, discussed in the previous section.

A brief summary of PIT-tagging effort by PNF and CDFW during summer and early fall 2018, 2019, and 2020 is below (**Table 1**).

Overall, among the SNYLF that have been marked and released since 2018, recapture rates have been low, particularly among zoo-reared frogs. For example, only one zoo-reared adult released in 2019 was relocated during follow-up surveys the same season (a frog observed in Dot Lake). Similarly, of those adults released in 2019, only one was observed again in 2020 (a frog observed in Rock Lake in late June 2020). However, same season recaptures in 2020 were more common. Of the 38 zoo-reared individuals released in June 2020, seven were observed again at least once later in the summer and early fall (three in Dot Lake and four in Rock Lake; **Table 1**). Similar proportions of wild frogs have been recaptured during the same season (**Table 1**).

Although recaptures have so far been highly limited among the zoo-reared frogs, CMR work with SNYLF in other locations (e.g., Mossy Pond in Tahoe National Forest and Desolation Valley in Eldorado National Forest; CDFW unpubl. data) has demonstrated that SNYLF will often go undetected during surveys one year and later be available for detection in following years. Such an example is also provided among wild frogs from Bucks Lake Wilderness. For example, of the seven wild frogs PIT-tagged in the Mount Pleasant area in 2018, five were not observed during surveys in 2019, but were recaptured during surveys in 2020. Of the remaining two Mount Pleasant area SNYLF marked in 2018, staff observed one in both 2019 and 2020, and staff have not observed the other since 2018. These data demonstrate that more zoo-reared SNYLF may still be extant on the landscape and detected during future surveys in Bucks Lake Wilderness.

Continued CMR work is needed to obtain a better understanding of survival among the captive-reared SNYLF. This work will also provide useful information on abundance, growth, and movement of SNYLF within the Gold Lake and Mount Pleasant areas. Therefore, CDFW and PNF staff plan to continue this work annually.

Table 1. Summary of released and wild caught adult (≥ 40 mm snout-to-urostyle length) Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) PIT-tagged in the Mount Pleasant and Gold Lake areas of Bucks Lake Wilderness between 2018 and 2020. Data are divided into SNYLF captive-reared at the San Francisco Zoo (Zoo Frogs), and wild caught SNYLF (Wild Frogs). The “# Same summer recaps” tallies include the total number of SNYLF individuals, of those individuals that were released (zoo frogs) or newly tagged (wild frogs) in the given year, that were recaptured during the same summer. The remaining columns of data highlight the number of recaptured SNYLF that 1) survived at least one winter, 2) were available for detection during survey periods in the following year(s), and 3) were detected by observers.

ZOO FROGS	Released in Dot	Released in Rock	# Same summer recaps – Mt. Pleasant Drainage	# Same summer recaps – Rock/Gold Drainage	# Released in 2019 observed in 2020 – Mt. Pleasant Drainage	# Released in 2019 observed in 2020 – Gold/Rock Drainage				
2019	21	19	1	0						
2020	19	19	3	4	0	1				
WILD FROGS	Newly tagged – Mt. Pleasant	Newly tagged – Gold/Rock	# Same summer recaps – Mt. Pleasant Drainage	# Same summer recaps – Rock/Gold Drainage	# Tagged in 2018 observed in 2019 – Mt. Pleasant Drainage	# Tagged in 2018 observed in 2019 – Gold/Rock Drainage	# Tagged in 2018 observed in 2020 – Mt. Pleasant Drainage	# Tagged in 2018 observed in 2020 – Gold/Rock Drainage	# Tagged in 2019 observed in 2020 – Mt. Pleasant Drainage	# Tagged in 2019 observed in 2020 – Gold/Rock Drainage
2018	7	10	3	4						
2019	12	1	1	1	1	1				
2020	8	10	2	1			6	0	5	1



Figure 13. A Plumas National Forest biologist scanning a young adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) with a passive integrated transponder (PIT) tag reader prior to its release in Dot Lake on 28 June 2019. (CDFW)



Figure 14. A California Department of Fish and Wildlife (CDFW) biologist releases a captive reared young adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) at Rock Lake on 19 June 2020. (CDFW)

DISCUSSION

The SNYLF headstarting efforts discussed in this memorandum have only recently started. Therefore, there is no current evidence for any notable recruitment pulse in the Gold Lake and Mount Pleasant SNYLF populations in response to captive rearing and release in 2019 and 2020. Based on similar efforts with SNYLF in other parts of the Sierra Nevada, the slow start is not surprising. SNYLF are long-lived and tadpoles often take at least two years to metamorphose. Under the right conditions, captive-rearing work has demonstrated that SNYLF can metamorphose in one year, but the timeline for SNYLF development in the captive environment likely represents an upper limit on growth rates. Any individual component of those conditions (e.g., controlled climate, constant supply of high quality food, lack of predators, active disease mitigation, etc.), let alone all factors, is often not present in the wild. However, SNYLF may naturally experience rapid development in relatively low elevation populations like Bucks Lake Wilderness (~6,000 ft. [~1,830 m]), particularly during drought periods with long growing seasons and relatively mild winters (e.g., the 2012–2016 drought, and winters 2017–2018 and 2019–2020). Despite some longer warm periods in recent years, most SNYLF in the Bucks Lake Wilderness populations likely overwinter at least once before metamorphosis. Therefore, more time is needed to observe potential benefits of headstarting.

Population augmentation—in the form of conservation efforts such as headstarting, translocations, or *in situ* rearing—can take years to manifest, or may require many separate augmentations, before there is a detectable increase in abundance (Joseph and Knapp 2018). Delays in population growth are likely the result of many factors, including limited recruitment. Low recruitment appears to be a consistent attribute of SNYLF populations in the northern Sierra Nevada, in which many populations are stream-based (Brown et al. 2020). Current SNYLF research in Yosemite, being conducted by University of California, Santa Barbara (UCSB) scientists, suggests that recruitment is often rare and episodic, despite reproduction (T. Smith, pers. comm.). *Bd*-induced mortality, particularly among highly susceptible early life stages (Rachowicz et al. 2006), is one factor often leading to low recruitment in SNYLF populations. However, other factors can also limit recruitment, including severe winters (Bradford 1983, Joseph and Knapp 2018), snake predation (Jennings et al. 1992, Matthews et al. 2002; T. Smith, pers. comm.), and—where they overlap with SNYLF—non-native fish (Knapp and Matthews 2000).

Given the close proximity and hydrologic connection of Gold Lake and Rock Lake, CDFW is not planning to conduct short distance translocations of SNYLF from the Rock Lake drainage to Gold Lake. CDFW and PNF surveys in recent years have already resulted in an increase in SNYLF observations in the Gold Lake drainage. Most recently, in fall 2020, PNF staff observed an adult SNYLF in Gold Lake. SNYLF will likely continue migrating toward Gold Lake via the streams connecting to Rock Lake. However, as opportunities allow—based on SNYLF population status, funding, zoo capacity, and availability of personnel—CDFW and PNF may collect additional early life stage frogs for future captive rearing efforts to help further augment the Bucks Lake Wilderness SNYLF populations.

RECOMMENDATIONS

CDFW, in partnership with PNF, will continue monitoring the Gold Lake and Mount Pleasant area 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). CDFW and PNF will also continue PIT-tagging adult SNYLF to obtain more detailed abundance and survival data on wild and zoo-reared frogs. Additionally, staff will focus on locating additional SNYLF that may be moving out of Rock Lake and into Gold Lake or its tributaries. These efforts will require thorough VES in challenging terrain, such as stream channels with dense willow growth and steep, rocky substrates with abundant 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 known about the interactions of smaller forage fish and amphibians, especially potential sublethal effects (e.g., limited breeding success, reduced size at metamorphosis, limb damage) on frog populations.

If surveys over the next several years suggest that releases of captive-reared SNYLF in 2019–2021 are resulting in population growth, CDFW may also work with PNF and zoo partners to collect additional early life stage SNYLF for future captive rearing efforts. Success of captive rearing efforts may be determined in several ways, including staff observing, 1) released adult SNYLF persisting after the first winter following release, 2) additional signs of breeding (higher counts of egg masses, tadpoles, and/or recently metamorphosed frogs), and 3) evidence of new recruitment into the adult population. Augmenting these populations through captive rearing and enhancing deep-water habitat through the successful removal of introduced trout has increased the odds of long-term SNYLF persistence in Bucks Lake Wilderness.

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