

State of California  
Department of Fish and Wildlife  
**Memorandum**

**Date: 8 March 2022**

To: Leslie Alber;  
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Acting Sierra District Supervisor;  
North Central Region Fisheries

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

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**Subject: Amphibian monitoring in Tahoe National Forest, Nevada County**  
• ***Rana sierrae* monitoring in the Mossy Pond and Rattlesnake Creek areas**

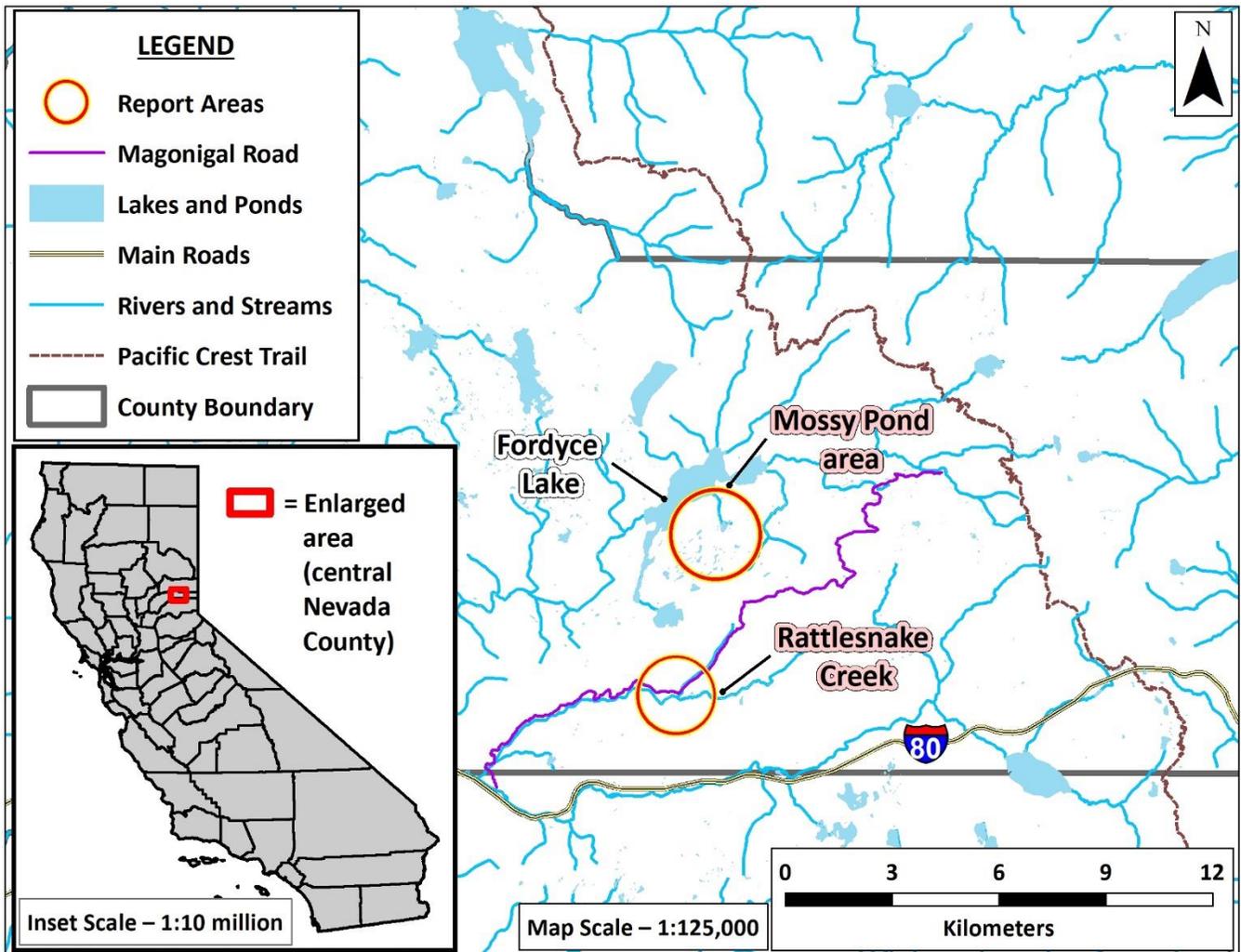


**ENVIRONMENTAL SETTING**

The Mossy Pond complex and Rattlesnake Creek are in Tahoe National Forest, north of Highway 80 in Nevada County (**Figure 1**). The sites are accessible via United States Forest Service (USFS) dirt roads and four-wheel drive trails. The Mossy Pond complex is composed of approximately 80 lakes, ponds, and small streams set on granite benches southeast of Fordyce Reservoir (Fordyce). Many of the waterbodies in the Mossy Pond complex support small Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF; **Figure 2**) populations. The Mossy Pond complex ranges in elevation from 6,400 feet (ft) (1,951 meters [m]) near Fordyce, to 8,098 ft (2,468 m) at the summit of Buzzard Roost. Various stream channels contain flowing water for brief periods each spring, but dwindle to intermittent pools during the rest of summer. United States Geological

Survey (USGS) field staff first detected SNYLF in the watershed in 1998 at Mossy Pond and Evelyn Lake; California Department of Fish and Wildlife (CDFW) began monitoring the population in 2001.

Rattlesnake Creek is located approximately 5 kilometers (km) south of the Mossy Pond complex. CDFW monitors a 2-km section of Rattlesnake Creek that flows east to west through USFS-owned land, the lower segment of a small tributary that flows from Magonigal Summit into Rattlesnake Creek, and a small pond approximately 40 m north of the creek (**Figure 1**). The Rattlesnake Creek area ranges in elevation from about 6,700 ft (2,042 m) at the lower end of the monitored segment of Rattlesnake Creek to 8,098 ft (2,468 m) at the summit of Buzzard Roost. The first official records for SNYLF in Rattlesnake Creek are from the 1960's (Brown et al. 2014). USGS field staff also detected SNYLF in 1995 and 1996, USFS staff began monitoring the area more regularly in 2003, and CDFW began collaborative monitoring with the USFS in 2009. In recent years, Tahoe National Forest (TNF) biologists have conducted most SNYLF monitoring in Rattlesnake Creek.



**Figure 1.** Mossy Pond and Rattlesnake Creek areas, Nevada County, CA. Areas discussed in this memorandum are circled.

## INTRODUCTION

The Aquatic Biodiversity Management Plan (ABMP) for the South Yuba River Management Unit (CDFW 2014) identifies sites occupied by SNYLF as amphibian resources and prescribes regular population monitoring. Periodic visual encounter surveys (VES) during the early 2000's suggested that the Mossy Pond SNYLF population could be headed toward extirpation. However, USFS surveys of the Mossy Pond outlet stream and surrounding areas, later followed by complete VES of wetted habitat by CDFW during summer 2013, suggested a robust metapopulation still present in the area. After assessing most available habitat, CDFW concluded that previous surveys had focused on areas less often occupied by SNYLF. CDFW and USFS discovered that SNYLF in the Mossy Pond area often occupy streams and ephemeral ponds.

Based on this new understanding of the SNLYF population in the Mossy Pond complex, CDFW initiated a capture-mark-recapture (CMR) study in 2014. Beginning in 2015, U.S. Fish and Wildlife Service (USFWS) awarded CDFW funds for this study through the endangered species recovery grant program (Section 6 of the U.S. Endangered Species Act of 1973; Federal Grant Award #F16AP00042). The most recent funding allowed CMR field work to continue through summer 2018. In 2019–2021, CDFW field staff returned to the Mossy Pond complex to conduct VES in the Mossy Pond study area and surrounding wetlands. In 2021, CDFW conducted the most extensive survey of the area since 2013; staff surveyed most waterbodies in the Mossy Pond area during eight separate survey days from 30 August to 28 September 2021.



**Figure 2.** Three adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) huddled together on a small rock outcrop above a tiny pool in the Mossy Pond outlet stream in late summer 2021. This spot is fed by a miniscule seep of water that emerges from large boulders above where staff observed these frogs. The seep keeps this small ledge damp enough to provide desirable microhabitat, and staff consistently find adult SNYLF occupying this location. (CDFW)

CDFW has been monitoring Rattlesnake Creek (Site ID 51019) and an unnamed tributary to Rattlesnake Creek (Site ID 51021) since 2009. Staff have consistently observed all SNYLF life stages in Rattlesnake Creek and low numbers of post-metamorphic SNYLF (adults and subadults) in Site ID 51021. Additionally, CDFW has been monitoring a small pond north of Rattlesnake Creek (Site ID 13275) since 2004 (**Figure 14**). In 2021, CDFW and USFS field staff visited Rattlesnake Creek on a few separate occasions in late August and September to conduct monitoring and emergency salvage of SNYLF tadpoles stranded in rapidly drying pools (**Figure 3**). Staff moved approximately 1,100 tadpoles to larger nearby pools on Rattlesnake Creek. Additionally, staff translocated approximately 1,500 SNYLF tadpoles to Evelyn Lake, which is located approximately 4 km north of Rattlesnake Creek, in the Mossy Pond area. These emergency salvage activities are detailed in a separate memorandum, [Rana sierrae tadpole rescue at Rattlesnake Creek, Nevada County](#) (CDFW 2022a).



**Figure 3.** A CDFW staff member collecting Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) tadpoles from a tiny, rapidly drying pool in Rattlesnake Creek on 9 September 2021. A line of pollen, moss, and vegetation present on the large boulder at left clearly demarcates the recent average high-water mark of the creek. By September 2021, almost no water remained in most of Rattlesnake Creek. (CDFW)

## THREATS

### ***Marginal Habitat***

Mossy Pond has a nearly six-hectare surface area and a maximum recorded depth of 2.5 meters, though much of the pond is even shallower. Although there are multiple fishless ponds in the vicinity, CDFW has not detected evidence of SNYLF breeding at those other locations. Additionally, many of the fishless ponds are ephemeral, and these habitats desiccate completely by mid-summer during dry water years, which have been the majority during the past decade (CDEC 2022a, b). Field staff occasionally observe SNYLF larvae and egg masses at Mossy Pond and its outlet stream (**Figure 4**), both of which are shallow. Rattlesnake Creek is intermittent, with only a small amount of perennial aquatic habitat present by late summer, particularly during dry water years. Extended drought, severe winter conditions, or anthropogenic habitat disturbances present potential extirpation risks to the SNYLF populations in both areas.



**Figure 4.** One of only a few locations in the Mossy Pond outlet stream (Site ID 80138) containing water in late summer 2021. This area at the downstream end of the outlet stream appears to be spring fed, retaining a very small amount of water, even during dry years.

### ***Disease***

The fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) is present in the Mossy Pond area. *Bd* was initially detected via epithelial swabs collected by field staff in 2010 and 2011. Partner scientists screened the swabs for presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. The swab analyses detected very light to moderate *Bd* infection intensity. In 2021, staff collected an additional six epithelial swabs from adult SNYLF (four from the Mossy Pond outlet stream and two from Site ID 13106). In January 2022, partner scientists at the Sierra Nevada Aquatic Research Laboratory (SNARL) screened the new swabs for presence of *Bd* DNA using real-time qPCR analysis (Knapp and Lindauer 2020). The swab analyses detected

very light to moderate infection intensities. These designations of infection intensity are subjective; however, none of the six swabs showed high *Bd* loads (i.e., high enough to suspect increased likelihood of mortality from severe chytridiomycosis, the disease caused by *Bd*).

### **Introduced Fish**

CDFW formerly stocked Mossy Pond—on two occasions, in 1940 and 1966—and all named ponds in the vicinity with Brook Trout (*Salvelinus fontinalis*, BK), including Bigley (Site ID 13135), Evelyn (Site ID 13093), Freeman (Site ID 13135), Sectional Line (Site ID 13132), Talbot (Site ID 13113), Virginia (Site ID 13117), Lower Eastern Brook (Site ID 13140), and Upper Eastern Brook (Site ID 13144) Lakes (**Figure 7**, in the [VES OUTSIDE THE MOSSY POND STUDY AREA](#) section). Apart from Mossy Pond, these stocking events occurred consistently from about 1940 to 1999. In 2000, in response to range-wide declines of SNYLF and a departmental reassessment of stocking practices, CDFW halted stocking at ponds in the vicinity. During surveys in 2001, CDFW field staff detected BK at five lakes in the Mossy Pond complex (Site IDs 13113, 13117, 13130, 13140, and 13144), including one lake in which staff observed SNYLF (Site ID 13113). During follow-up gill net surveys in 2010, field staff did not capture any BK, which suggests that BK did not persist in the absence of stocking. Since 2010, staff have not detected any trout during gill netting and visual surveys in the Mossy Pond complex. However, various minnow species (mainly Lahontan Redside; *Richardsonius egregius*) are highly abundant in some lakes and stream segments, including Site IDs 13140, 13144, 13150, and 52594.

CDFW stocked Fordyce with Rainbow Trout (*Oncorhynchus mykiss*) through 2013 and Brown Trout (*Salmo trutta*) through 1999, and gill net survey data from 2014 suggested trout may persist in Fordyce without additional fish plants. Staff have detected SNYLF at the downstream end of the outlet stream draining from Mossy Pond into Fordyce. Fish do not present an immediate threat to most SNYLF in the Mossy Pond complex. However, given the proximity of trout, illegal movement of fish into currently fishless ponds that contain SNYLF presents a low probability risk. The main threat is that trout prevent SNYLF from being able to successfully breed and recruit in the largest aquatic habitat in the area; additionally, Fordyce may act as a population sink for migrating subadult SNYLF.

### **CAPTURE-MARK-RECAPTURE PROJECT**

The data collection portion of the Mossy Pond CMR study ended in 2018. CDFW staff may partner with other researchers to analyze data collected during the CMR study, applying analytical methods similar to other amphibian studies using the robust design model (e.g., Bailey et al. 2004, McCaffery and Maxell 2010, Fellers et al. 2013). For a complete description of the materials, methods, and initial results of the Mossy Pond CMR study, please consult the memorandum "[Capture-mark-recapture at Mossy Pond, Tahoe National Forest, Nevada County – Summary of activities in 2018](#)" (CDFW 2019a).

## **VES IN THE MOSSY POND STUDY AREA**

The Mossy Pond CMR study area consisted of an approximately one square-mile section of TNF, containing Mossy Pond, its seasonally flowing outlet stream, and 12 ephemeral ponds (**Figure 5**). Prior to 2014, VES effort in the Mossy Pond area varied, both in quantity and quality. During the study, from 2014–2018, surveys were more consistent, during which CDFW field staff visited Mossy Pond at least three times each summer. During each trip, staff surveyed 14 sites each day for three consecutive days, for a total of nine to 12 survey days per year. Therefore, the summary of VES results for years during the CMR study (2014–2018) include the one survey day with the highest number of SNYLF observations for that year (**Figure 6**).

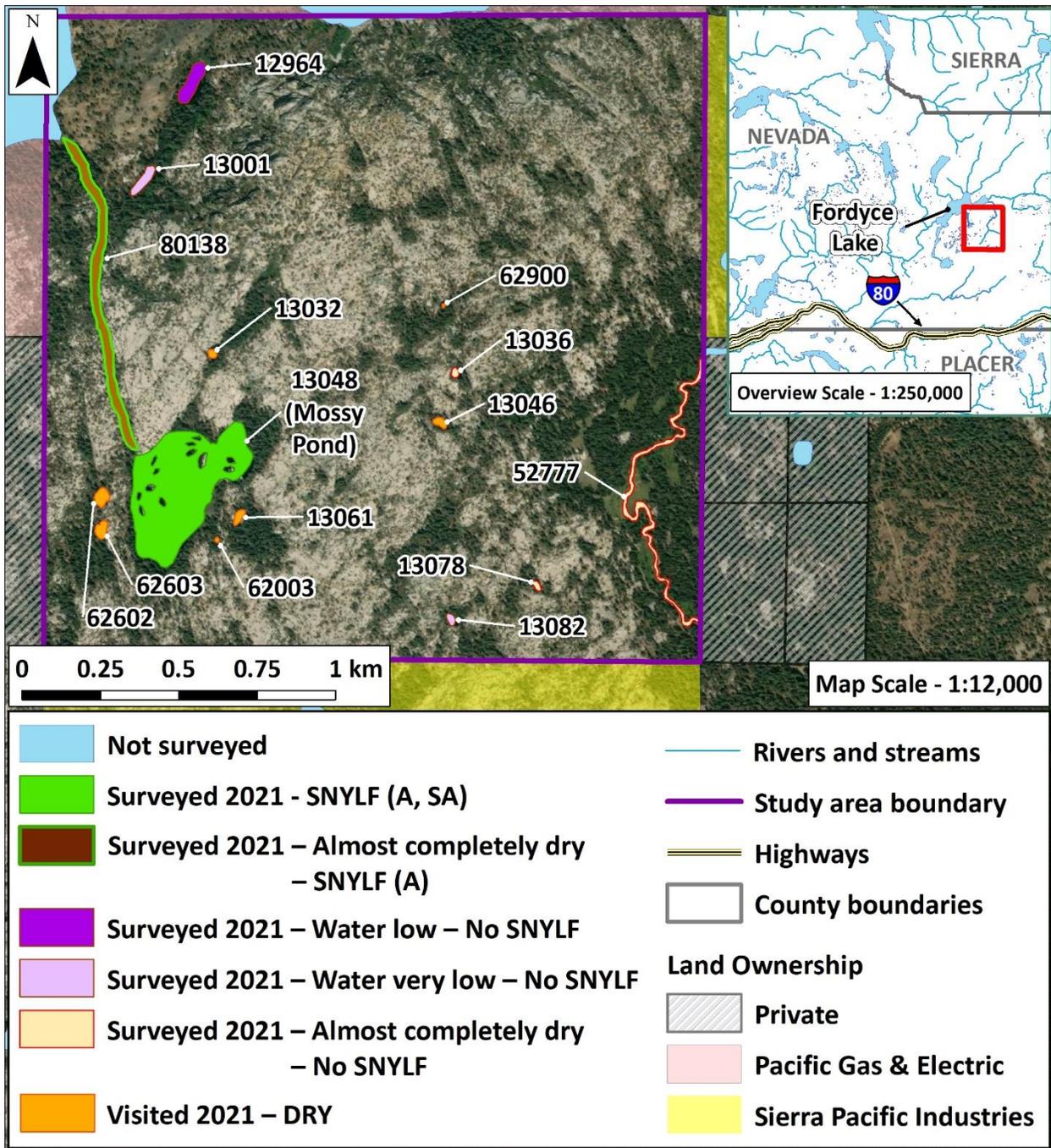
With the CMR study completed, CDFW and TNF staff surveyed the Mossy Pond study area once per summer from 2019–2021 using traditional VES methods (Heyer et al. 1994). During the 2021 VES, staff used dip nets or their hands to capture and scan all frogs large enough to have been marked with a passive integrated transponder (PIT) tag during the CMR study. If staff detected a tag, they recorded the PIT tag number, sex, and coordinates for the point of capture of each frog. Although the CMR study ended, subsequent data obtained from any marked adult SNYLF will contribute to the understanding of population dynamics in the Mossy Pond area, including SNYLF movement patterns and longevity.

When compared with the CMR study period, both adult and subadult SNYLF detections in 2021 were notably lower (**Figure 6**). However, fewer adult SNYLF detections do not necessarily suggest a true decline in the SNYLF population. The CMR study period provided several opportunities to detect SNYLF over the course of the summer. With at least nine surveys of the entire study area each year during the period 2014–2018, staff had a greater chance of any one survey corresponding with good survey conditions, more frogs available for detection, and/or the presence of recently metamorphosed subadults. Therefore, confounding factors that affect SNYLF detectability during VES, including weather conditions, time of year, habitat complexity, and observer bias were likely mitigated between 2014 and 2018 (Mazerolle et al. 2007).

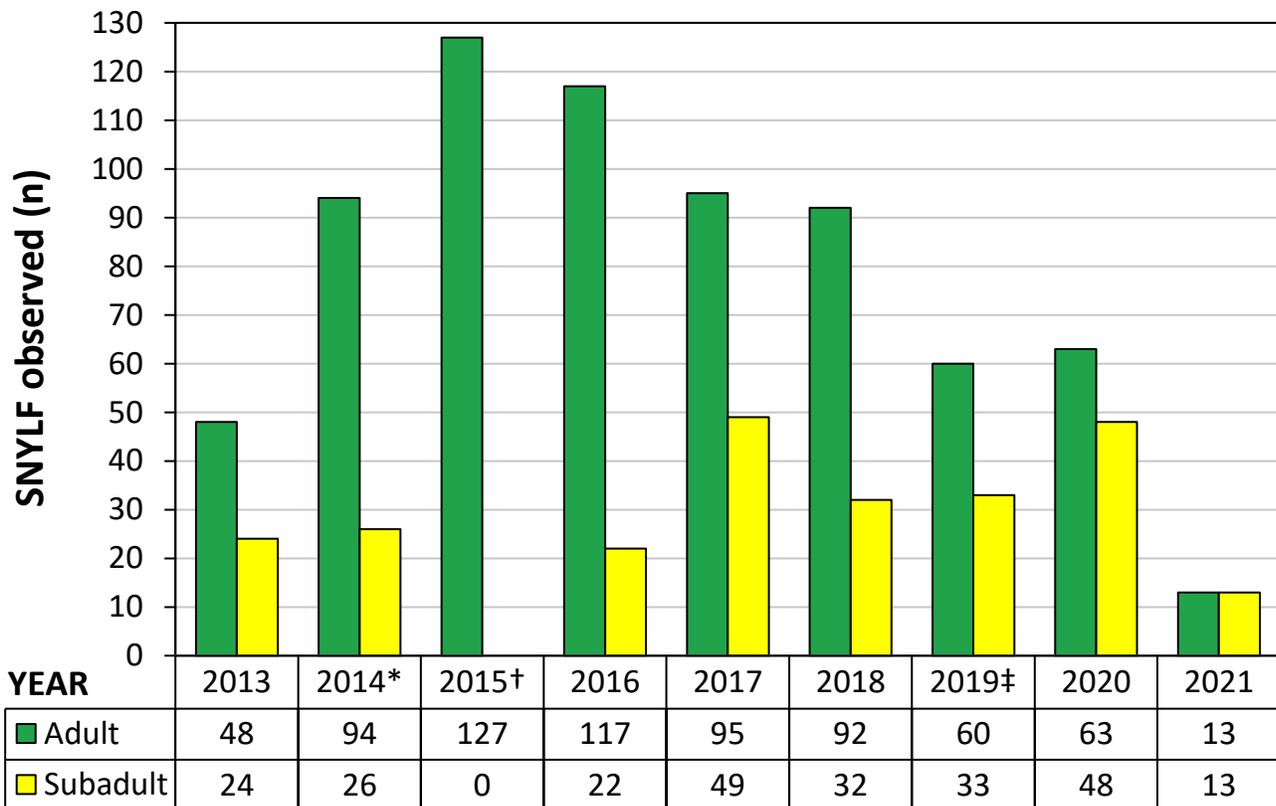
VES are a helpful measure for obtaining a general idea of SNYLF population status, but proper interpretation of the results requires consideration of the numerous assumptions inherent with VES (Heyer et al. 1994). CMR methods provide a more accurate method for estimating population parameters, such as abundance and survivorship, by incorporating detection probability (Williams et al. 2001).

The aforementioned considerations notwithstanding, the lack of SNYLF detections in the Mossy Pond study area is potential cause for concern. SNYLF detections in 2021 were the lowest seen by CDFW since before the CMR study began. CDFW does not know the cause for this potential decline, but frequent dry conditions for the past decade may play a role. During myriad trips to the area since 2013, CDFW has found that SNYLF in the Mossy Pond study area often occupy ephemeral stream and pond habitats. These habitats dry earlier in the season and remain

desiccated for longer periods during dry water years. Of the water years from 2012–2022, six have received precipitation well below the 1991–2020 average (2012–2013, 2013–2014, 2014–2015, 2017–2018, 2019–2020, 2020–2021; CDEC 2022a). As of February 2022, 2021–2022 is on a trajectory to be another below average water year, despite some beneficial bouts of precipitation in late October and December 2021 (CDEC 2022a). These frequent and extended dry periods may be a concern for the long-term persistence of SNYLF populations in some of these locations where frogs are occupying ephemeral habitats. These environmental concerns and other potential causes for reduced SNYLF detections are discussed further in the [VES OUTSIDE THE MOSSY POND STUDY AREA](#) section below.



**Figure 5.** Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations and surface water status during visual encounter surveys (VES) in the Mossy Pond capture-mark-recapture (CMR) study area during late summer 2021. The CMR study occurred from 2014 to 2018. During VES, California Department of Fish and Wildlife (CDFW) staff capture all adult frogs observed and scans each adult for passive integrated transponder (PIT) tags inserted during the study period. However, in 2019, CDFW suspended marking any newly captured (i.e., unmarked) adults with PIT tags. Site conditions in summer 2021 were the driest CDFW has seen since September 2014, in the middle of severe drought. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: “A” = adults and “SA” = subadults.



**Figure 6.** Count of adult and subadult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during surveys in the Mossy Pond study area, 2013–2021. California Department of Fish and Wildlife (CDFW) began surveying some locations in the Mossy Pond area in 2001. However, earlier surveys only included a small subset of waterbodies and, therefore, counts were very low (i.e.,  $\leq 5$  adults seen during any given survey). Therefore, the histogram only presents results beginning in 2013, which is the first year field staff surveyed the entire Mossy Pond study area. In years when staff conducted more than one survey, results shown are from the one survey day with the largest number of SNYLF detections for the year.

\*First year of the Mossy Pond capture-mark-recapture (CMR) study. Results shown are from a visual encounter survey (VES) conducted separately from the CMR work in 2014.

†Staff did not begin documenting subadult SNYLF during CMR surveys until the final trip of the 2015 season (in September): from September 2015 onward, CDFW field staff consistently recorded subadult detections as part of the CMR survey protocol. Results shown for 2015 are from the survey day with the most detections of the summer (July 16, 2015), which is why no subadults are shown in the histogram. Results shown from 2015–2018 are from the CMR survey day with the most total SNYLF detections for that year.

‡Following completion of the CMR study in 2018, CDFW only visited the Mossy Pond study area once per year to assess the relative abundance and general status of the SNYLF population. Staff are no longer marking captured frogs but continue to record PIT tag numbers for recaptured frogs. Survey totals from 2019 onward also included a stream segment at the eastern edge of the study area that had not been included in the CMR study (Site ID 52777, see **Figure 5**).

## **VES OUTSIDE THE MOSSY POND STUDY AREA**

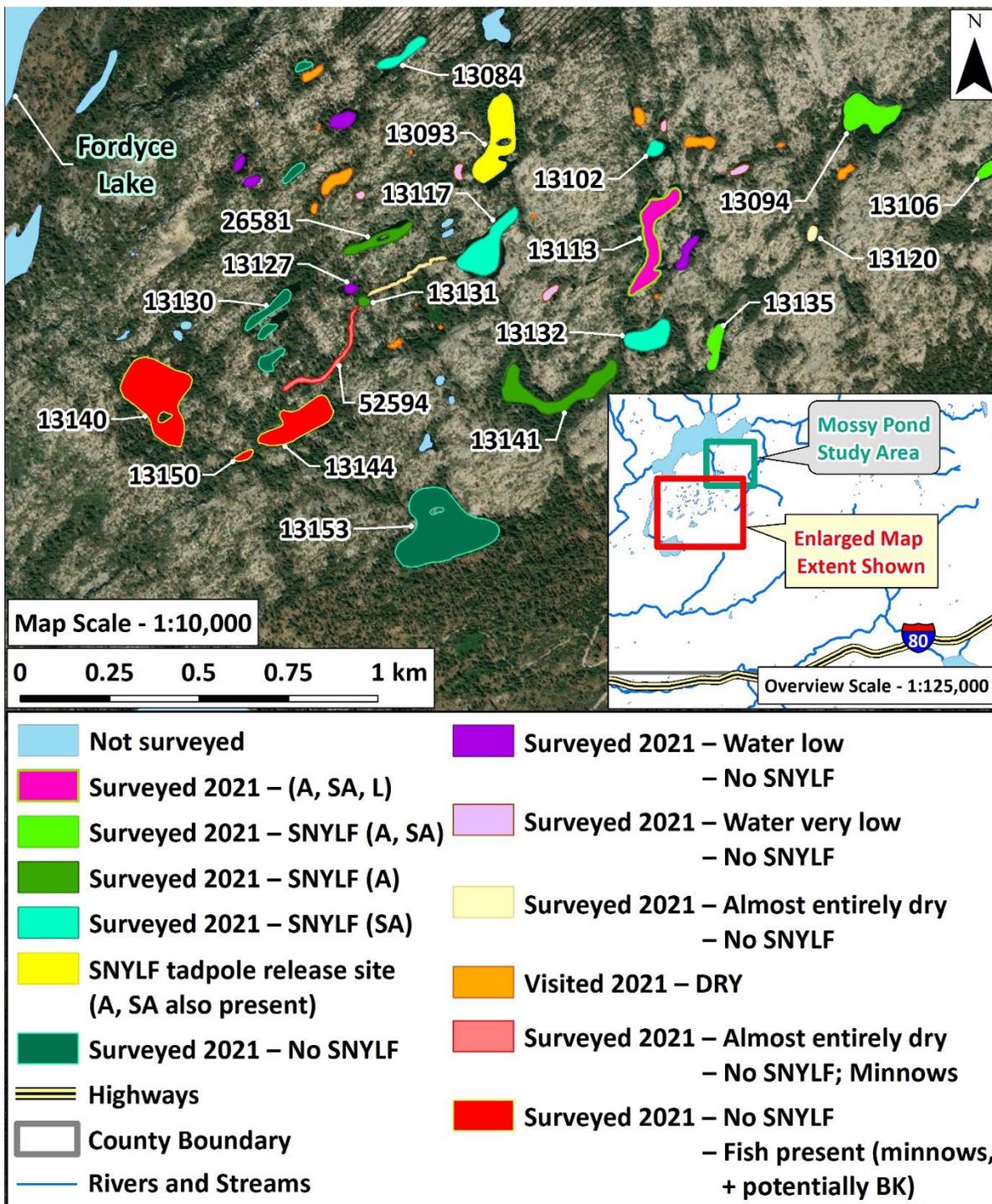
There are approximately 67 lakes, ponds, and stream segments in the Mossy Pond complex outside of the CMR study area (most of which are shown in **Figure 7**). Between 2001 and 2021, CDFW staff have observed SNYLF of various life stages in 33 of these waterbodies. Occasional monitoring data from the past 20 years indicate a relatively large SNYLF metapopulation. In 2021, CDFW staff observed relatively few post-metamorphic SNYLF outside of the study area, despite surveying 34 sites with surface water. Although staff detected more SNYLF subadults outside the CMR study when compared with more recent survey periods, staff observed fewer SNYLF adults than during any of the more extensive survey periods outside the study area in the past decade (**Figure 8**). However, the level of survey effort has varied substantially among survey periods (e.g., 55 sites were surveyed in 2013, the year with the most surveys, and only three sites were surveyed in 2015, the year with the least; **Figure 8**).

Additionally, environmental conditions during surveys have varied widely. Of the last four survey periods, two have occurred during far above average water years (2017 and 2019) and the other two have occurred during exceptionally dry water years (2020 and 2021) (CDEC 2022a, b). Winter 2020–2021 resulted in well below average accumulated snowpack (CDEC 2022b), and northern Sierra Nevada seasonal precipitation totals were 45% of the 1991–2020 average (CDEC 2022a). Timing of amphibian VES in 2021 compounded these dry conditions. On average, water levels in many aquatic habitats in the Sierra Nevada drop throughout the summer and early fall “dry season.” Therefore, late season drying was especially pronounced in 2021. The amphibian monitoring season in high elevations of the Sierra Nevada is typically June through September. In 2021, CDFW conducted most surveys outside of the Mossy Pond study area from mid- to late September, whereas surveys during previous seasons have typically occurred in July or August.

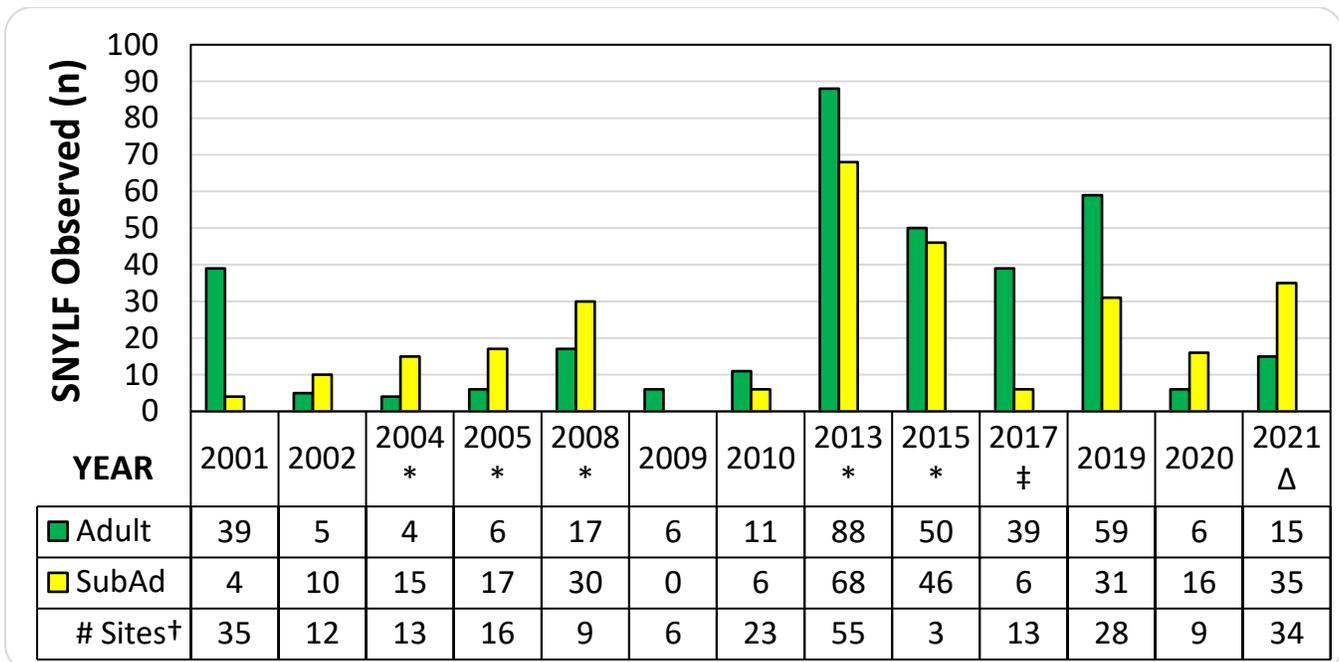
Finally, among the survey locations outside the study area, CDFW staff have historically observed most post-metamorphic SNYLF at one particular site: an ephemeral stream segment to the east of the Mossy Pond study area. Due to various factors, CDFW has not surveyed this location since 2015. Therefore, the one location that has often boosted SNYLF totals during VES outside the study area has not been included among recent surveys.

Despite these differences in survey effort and site conditions, even comparing VES results between years during which the same locations are surveyed during similar times of year can be misleading, because VES detections can vary widely due to the factors mentioned above in the [VES IN THE MOSSY POND STUDY AREA](#) section. Therefore, evaluating the true SNYLF population status is difficult from VES data alone.

*[Main text continues on pg. 14, following Figures 7 and 8.]*



**Figure 7.** Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations, fish detections, and surface water status during visual encounter surveys (VES) in the Mossy Pond complex, outside of the study area, in summer 2021. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: “A” = adults, “SA” = subadults, and “L” = larvae. CDFW conducted surveys later than typical (1–28 September), and the Mossy Pond area was incredibly dry during the 2021 survey period. Lake water levels were low and many small ponds were dry.



**Figure 8.** Counts of adult and subadult Sierra Nevada Yellow-legged Frogs (SNYLF) detected during surveys outside of the Mossy Pond capture-mark-recapture (CMR) study area from 2001–2021. These results are derived from a collection of 67 labeled (i.e., locations that have associated Site IDs) lakes, ponds, and streams outside of the Mossy Pond study area that California Department of Fish and Wildlife (CDFW) staff have surveyed at least once (and often several times) during the past 20 years.

†The last row of the data table displays the number of sites (out of the 67 total identified waterbodies) surveyed each year. Survey effort, as measured by the number of sites surveyed, varies substantially between survey years.

\*During these years, one location—Site ID 50133 (a stream segment east of the study area)—accounted for a majority of SNYLF observations. CDFW has not surveyed Site ID 50133 since 2015.

‡Surveys in 2017 were not traditional visual encounter surveys (VES). CDFW staff were looking for SNYLF marked with passive integrated transponder (PIT) tags (used to provide a unique identifier for adult SNYLF captured during the Mossy Pond CMR study) that had moved outside of the CMR study area. The surveys in 2017 were confined to ponds closest to the southern and eastern borders of the study area.

$\Delta$ The 2020–2021 water year was exceptionally dry and CDFW conducted surveys late in the monitoring season (staff surveyed 10 of 34 ponds on 1–2 September, and the remaining 24 ponds during four different site visits 14–28 September). In 2021, the survey total does not include 13 sites that were completely dry during the survey period (see **Figure 7** for locations of dry ponds, shown in orange). Counts of post-metamorphic frogs shown in 2021 do not include dead individuals detected by CDFW. In 2021, staff observed six dead subadults and one dead adult among 34 ponds surveyed in late summer and early fall.

While acknowledging these challenges, CDFW suspects that environmental conditions may be largely responsible for the relatively low SNYLF detections that staff observed in 2021. During the survey period, water levels at all waterbodies were low. Despite the lower water levels, larger ponds were not at risk of desiccation (**Figure 9**). However, smaller ponds had very low water levels (**Figure 10**). Many of the smallest ponds, only some of which are ephemeral during more “average” water years, had critically low water levels (**Figures 11 and 12**), and most of these ponds likely dried completely by late September 2021. Additionally, all stream channels in the greater Mossy Pond area were completely dry or contained a few isolated pools (**Figure 13**).

As discussed in the [INTRODUCTION](#), CDFW has found that SNYLF in this area often occupy small, ephemeral waterbodies, seemingly preferentially over more perennial habitats available nearby. The widespread desiccation of these ephemeral habitats may have caused some SNYLF to seek refuge in locations with more protection from wind and dry atmospheric conditions (e.g., in thick vegetation, debris piles, and loosely consolidated rock within stream channels and pond margins), resulting in fewer frogs being available for detection. Additionally, the extremely dry conditions may have led some SNYLF to initiate reduction in seasonal activity earlier than usual, and/or estivate during a time period when they may have otherwise been active during a more average water year.



**Figure 9.** Site ID 13117 on 15 September 2021. This site is one of the larger ponds outside of the Mossy Pond study area. (CDFW)



**Figure 10.** Site ID 13127 on 15 September 2021. Many of the smaller ponds in the Mossy Pond area were in similar hydrologic condition. By late summer 2021, water levels were very low in most small ponds in the area. (CDFW)



**Figure 11.** Site ID 13131 on 15 September 2021. This is one of many sites that contained very little water by late summer 2021. However, despite the critically low water level, CDFW staff observed three Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) adults occupying the small pool on the right. This pool was still approximately 0.5 m deep and contained a lot of good cover habitat for SNYLF. By late summer 2021, water levels were very low in most small ponds in the area. (CDFW)



**Figure 12.** Site ID 13120 on 1 September 2021. From a distance, this site appears to be completely dry. However, the pond contained a very small amount of water covered with a thick coating of pollen and other organic debris. This pond likely dried completely by mid-September. (CDFW)



**Figure 13.** Site ID 52594 on 15 September 2021. This photo is a fitting representation of hydrologic condition in most larger stream segments in the Mossy Pond area in late summer 2021. If present in any stream channels, water was confined to a handful of small pools. (CDFW)

Another potential concern for the Mossy Pond area SNYLF population is *Bd*-induced mortality. In 2021, staff observed seven dead SNYLF among the 34 sites surveyed outside the study area. Six of the dead individuals were subadults and one was an adult. The cause of these mortalities is unknown, but *Bd* may be a factor in at least some of the observed mortalities. However, as with most SNYLF populations in the northern Sierra Nevada, *Bd* has likely been present in the Mossy Pond area for a long time (Knapp et al. 2016), and [epithelial swabs have revealed \*Bd\* presence in the area since at least 2010](#). Therefore, although an epizootic outbreak resulting in mass mortality is unlikely, enzootic *Bd* dynamics may be resulting in low level, compensatory mortality in the Mossy Pond area SNYLF population (Briggs et al. 2010). This source of occasional mortality may more often affect recent metamorphs and subadults, which are known to be more susceptible to *Bd*-induced mortality (Rachowicz et al. 2006). These known disease dynamics correlate with staff finding mostly young frogs among observed mortalities in 2021.

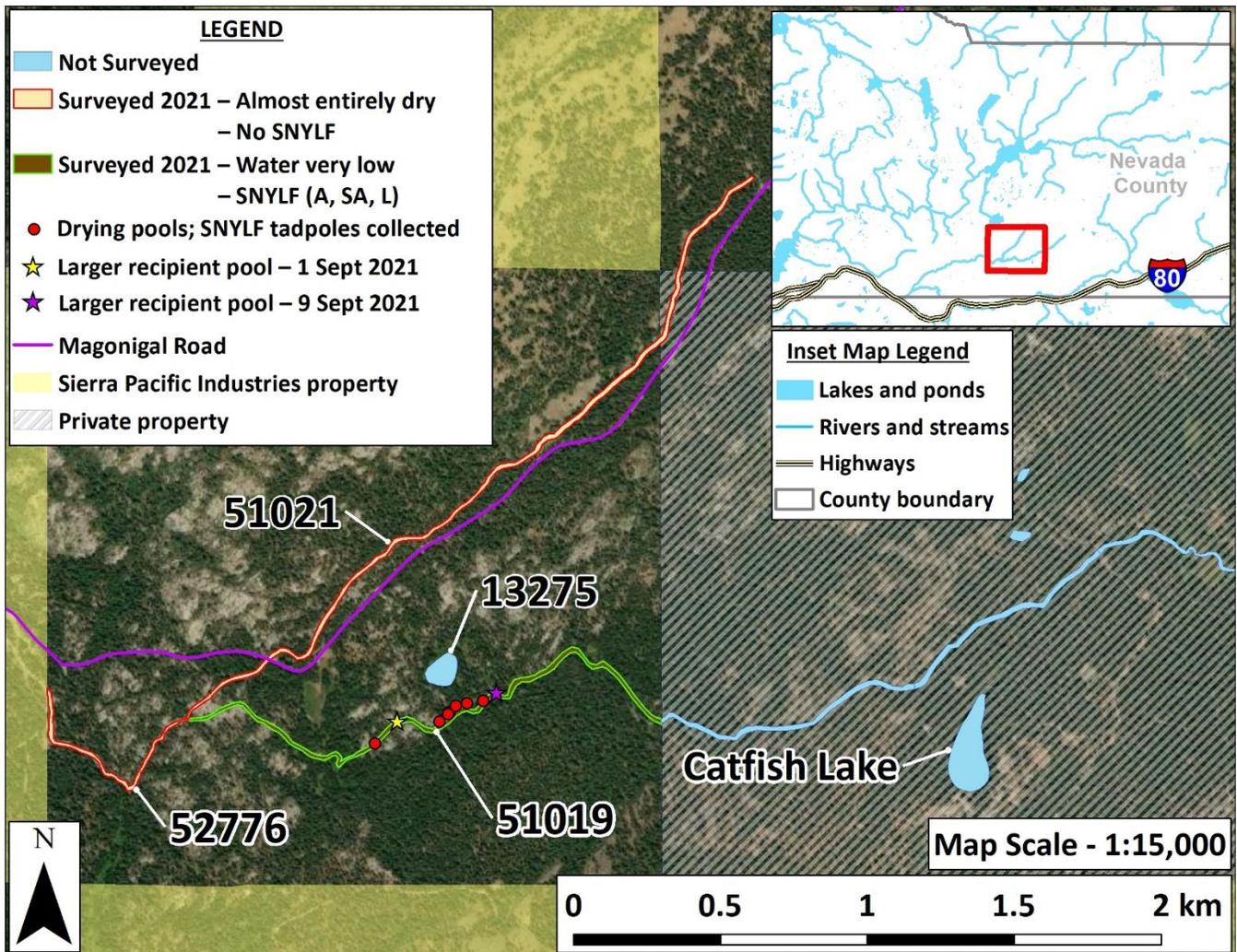
In 2017, 2019, 2020, and 2021, staff captured adult SNYLF in a subset of ponds adjacent to the study area to check for PIT tags and identify any frogs that may have migrated out of the study area. In 2021, staff did not capture any adult SNYLF that were marked during the 2014–2018 CMR study period. However, in 2017, 2019, and 2020, staff detected one adult SNYLF at Site ID 13094 that moved out of the Mossy Pond study area. PIT tags revealed that the frog captured in 2017 and 2020 was the same individual, and the frog captured in 2019 was a different individual. The individual captured in 2017 and 2020 was a large adult female. Before 2017, this female had most recently been captured in September 2014, along the eastern shore of Mossy Pond. The individual CDFW staff captured in 2019 was a different adult female, last captured in July 2015 at the base of the Mossy Pond outlet stream (Site ID 80138; **Figure 5**). This frog likely traveled at least 1.75 km horizontal distance (and, more likely, at least 2 km along the closest path of travel via available water courses) and 200 m in vertical elevation gain along steep terrain between observations in 2015 and 2019. During the Mossy Pond CMR study, this frog was recaptured five times between September 2014 and July 2015, each time within a 40-m radius of its original capture location at the downstream end of Site ID 80138.

## **VES IN THE RATTLESNAKE CREEK AREA**

In late August 2021, TNF staff noted critically low water levels throughout Rattlesnake Creek. Several rapidly drying pools contained stranded SNYLF tadpoles in danger of desiccation before the return of autumn rains. On 1 September 2021, TNF staff received permission from CDFW and USFWS to move a subset of tadpoles ( $n \approx 700$ ) to a large pool in a nearby section of Rattlesnake Creek. On 9 September 2021, CDFW staff joined TNF to move additional tadpoles ( $n \approx 400$ ) to another perennial pool in Rattlesnake Creek (**Figure 14**). CDFW and TNF staff translocated the remaining SNYLF collected from stranded pools in Rattlesnake Creek ( $n \approx 1,500$ ) to Evelyn Lake (Site ID 13093; **Figure 7**, in yellow), which is located approximately 4 km north, in the Mossy Pond area. These emergency salvage activities are detailed in a separate memorandum, [Rana sierrae tadpole rescue at Rattlesnake Creek, Nevada County](#).

On 14 September (five days post tadpole translocation), CDFW revisited Evelyn Lake to attempt locating tadpoles and documenting the status of any tadpoles found. During the survey, CDFW staff did not detect any tadpoles. This result is somewhat surprising, given the large number of tadpoles released at the site less than a week before. However, the lack of tadpole observations is not completely unexpected. CDFW has found that SNYLF tadpoles can be extremely difficult to detect during VES at many known occupied sites in the northern Sierra Nevada, including Mossy Pond. There are numerous locations where staff often detect post-metamorphic SNYLF, but not tadpoles. Despite the lack of tadpole detections, staff observed 14 young subadults SNYLF at the site. These subadults did not appear to be freshly metamorphosed individuals from the tadpole cohort released only five days earlier. During the same survey, staff observed three additional dead subadults, which are included in the mortality total discussed in the [VES OUTSIDE THE MOSSY POND STUDY AREA](#) section above. CDFW does not know the cause for mortality, but chytridiomycosis is a probable cause (Rachowicz et al. 2006). Interestingly, while joining CDFW for VES in the Mossy Pond area on 1 September, two TNF staff surveyed Evelyn Lake and only detected a single SNYLF adult at the site. The size of the subadults staff observed on 14 September suggests that these subadults may have already been present at Evelyn Lake on 1 September, but were unavailable for detection. An alternative explanation is that these subadults moved to Evelyn Lake from a nearby pond between 1 and 14 September.

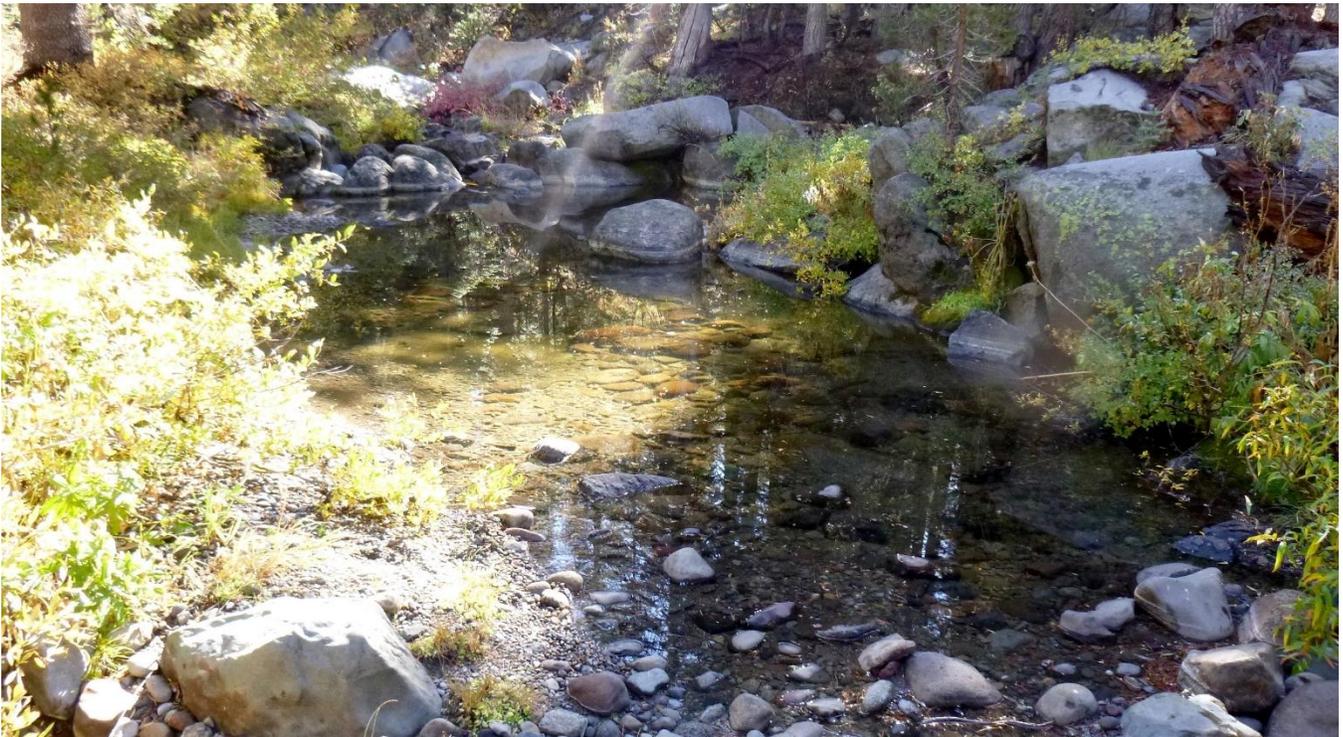
On 17 and 28 September 2021, CDFW staff revisited Rattlesnake Creek to monitor the tadpole salvage/collection and recipient pools. As expected, staff detected very few SNYLF tadpoles in the disconnected salvage pools during the follow-up surveys (n = 11 SNYLF tadpoles on 28 September). Between 10 and 28 September, the region received approximately one inch of rain during a series of small precipitation events (CDEC 2022c). The precipitation prevented some salvage pools from drying completely (**Figure 15**), and slightly raised water levels in the larger recipient pools (**Figure 16**). Additionally, the recent rain, most of which had fallen on 10 September (0.4 inches; CDEC 2022c), had connected the upstream salvage/collection pool to the upstream recipient pool (**Figure 17**), so some relocated SNYLF tadpoles had migrated back downstream via the stream channel that had recently reemerged in this one short section of Rattlesnake Creek. **Figure 18** shows the upstream salvage/collection pool on 17 September, following two small rain events that raised the water level noticeably from the critically low water level staff observed on 9 September. Despite the recent rains, the other pools from which CDFW and TNF staff had collected tadpoles for salvage were still disconnected and very small during site visits on 17 and 28 September.



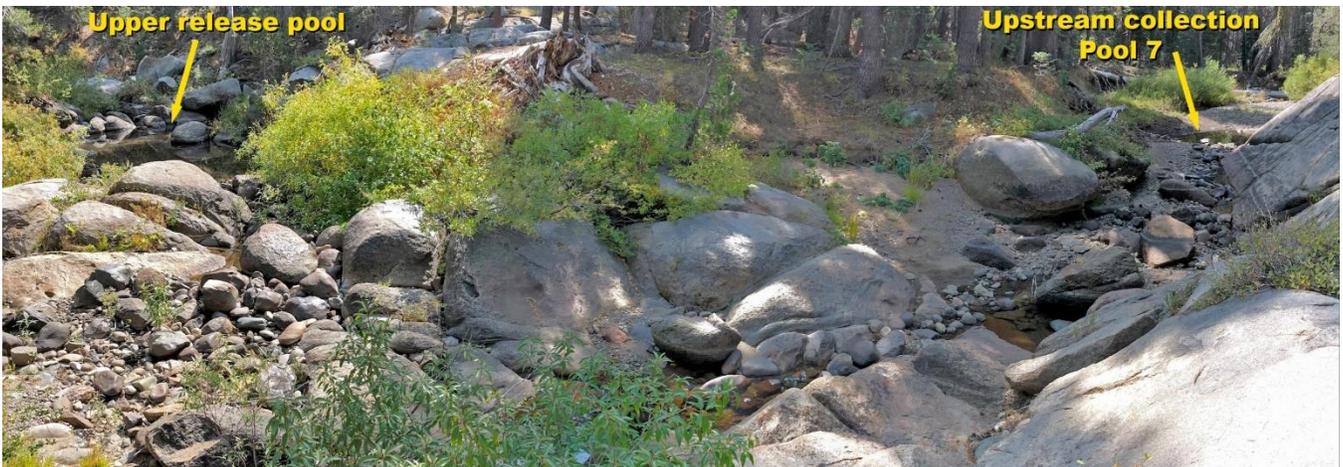
**Figure 14.** Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations from visual encounter surveys (VES) in the Rattlesnake Creek area in summer 2021. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: “A” = adults, “SA” = subadults, and “L” = larvae.



**Figure 15.** A tiny pool in Rattlesnake Creek on 28 September 2021. California Department of Fish and Wildlife (CDFW) and Tahoe National Forest (TNF) staff had collected Sierra Nevada Yellow-legged Frog (*Rana sierrae*) tadpoles from this pool on 9 September 2021. (The same pool, as observed on 9 September, is shown in **Figure 3**.) A series of small precipitation events in mid-September helped prevent this pool from drying completely during the intervening weeks.



**Figure 16.** The upper Sierra Nevada Yellow-legged Frog (*Rana sierrae*) tadpole release pool on 28 September 2021 (shown as a purple star in **Figure 14**). This pool retains water late in the season, even during dry water years. A series of small rain events in mid-September 2021 helped maintain the water level in this pool. (CDFW)



**Figure 17.** Panorama view of Rattlesnake Creek on 17 September 2021. The upper recipient pool, into which California Department of Fish and Wildlife (CDFW) and Tahoe National Forest (TNF) staff moved approximately 400 tadpoles on 9 September 2021, is shown on the far left. The upper-most salvage/collection pool (Pool 7), from which CDFW and TNF collected tadpoles on 9 September, is shown on the far right. After a few small rain events that occurred after the tadpole rescues, the upper release pool became reconnected to Pool 7 via a small channel. This stream connection contained Sierra Nevada Yellow-legged Frog (*Rana sierrae*) tadpoles on 17 September 2021. (CDFW)

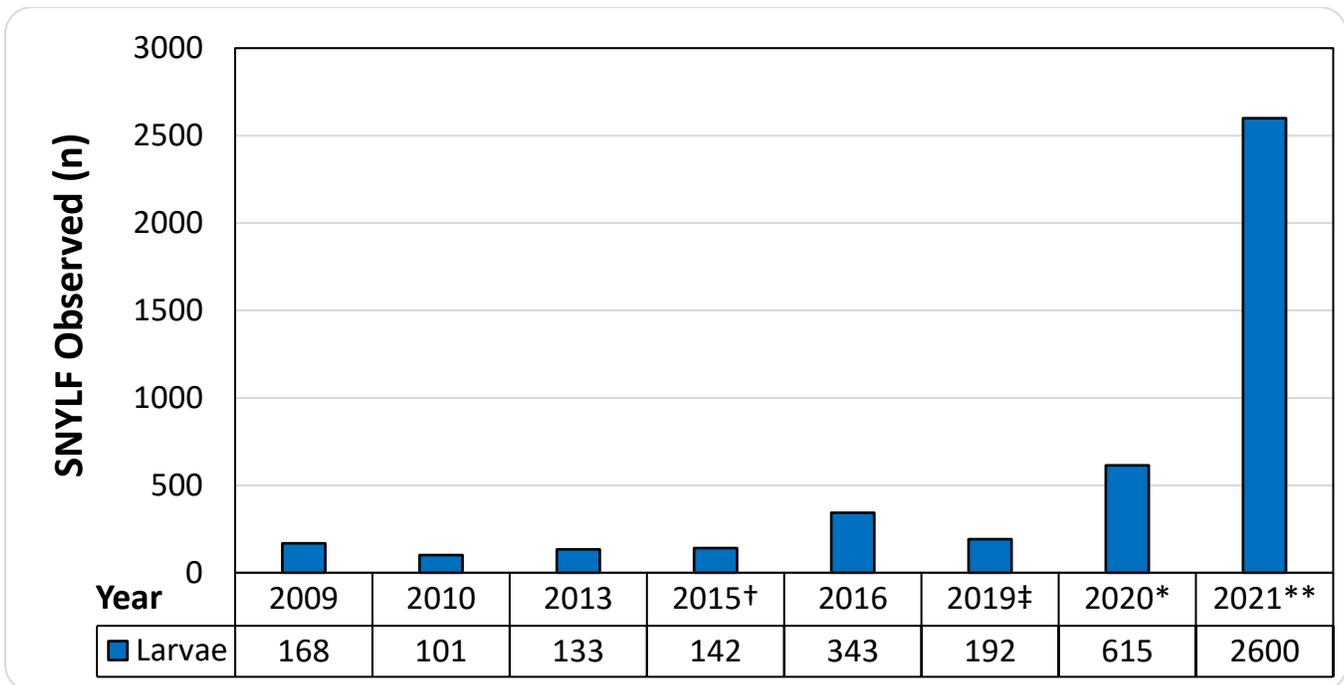


**Figure 18.** The upper Sierra Nevada Yellow-legged Frog (*Rana sierrae*) tadpole salvage pool (labeled Pool 7 in **Figure 17**) on 17 September 2021. A few small rain events in mid-September partially refilled the pool, so water levels were noticeably higher than during the tadpole collection on 9 September 2021.

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In previous years, CDFW conducted VES throughout Rattlesnake Creek, including Site IDs 13275, 51019, 51021, and 52776. However, in 2021, staff did not survey the entire creek in the usual manner (i.e., to get an estimate of relative abundance using VES). Instead, after observing the critically low water levels and high likelihood of SNYLF tadpole stranding, staff focused on locating small pools at risk of desiccation that contained SNYLF. However, during these efforts, staff observed post-metamorphic SNYLF in several locations that retained water along Site ID 51019 (**Figure 14**). For past post-metamorphic SNYLF counts in Rattlesnake Creek, see the [2020 Mossy Pond and Rattlesnake Creek survey memorandum](#) (CDFW 2021).

In 2021, staff observed far more SNYLF larvae in Rattlesnake Creek than during previous years. Given the methods used (direct collection using aquarium nets) and circumstances under which the tadpoles were observed (seen within very small, isolated pools), this result is unsurprising. CDFW expected that directly collecting tadpoles from small pools using numerous passes of small aquarium nets would result in higher tadpole detections than during previous years when staff used single pass VES to detect SNYLF. However, despite this expectation, the quantity of tadpoles that staff observed in 2021 ended up being higher than CDFW or TNF anticipated (**Figure 19**). SNYLF tadpoles are skittish, and most individuals will rapidly seek cover if they see an observer approaching. SNYLF tadpoles also have cryptic coloration and patterns. Given these attributes, individuals can be difficult to detect, particularly when hiding within and beneath substrate. Therefore, although a portion of individuals may be in the open and available for detection, particularly if observers approach cautiously, many other individuals may be unavailable for detection during VES. Net collection allowed staff to locate most individuals in every pool, which results in a nearly complete census of SNYLF tadpoles within the collection pools.



**Figure 19.** Counts of larval Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during surveys in the Rattlesnake Creek area from 2009–2021. The histogram includes observations from Sites IDs 51019, 51021, and 52776. California Department of Fish and Wildlife (CDFW) staff have not observed any SNYLF at Site ID 13275 since 2004, during which CDFW staff observed eight adults, 200 recently metamorphosed frogs, 220 larvae, and four egg masses.

†In 2015, surveys occurred in mid-September, and weather conditions were poor, including overcast with occasional hail. Additionally, 2015 was an exceptionally dry year, following the lowest snowpack since weather records began (CDEC 2022b). Therefore, apart from occasional pools, little water remained in Rattlesnake Creek. Although little water was available compared with other years, the low water likely concentrated SNYLF larvae into small pools with undisturbed surfaces, in which CDFW staff could easily observe larvae. These conditions may partially explain why larval SNYLF detections in 2015 were more comparable with other survey years, whereas post-metamorphic SNYLF detections were substantially lower.

‡From 2019 onward, the histogram includes SNYLF observations from Site ID 52776. Site ID 52776 was first surveyed and assigned a Site ID number in 2019.

\*CDFW field staff did not survey Site ID 50121 in 2020.

\*\*Surveys in 2021 were not traditional, single pass visual encounter surveys (VES). Instead, CDFW and Tahoe National Forest staff conducted an emergency salvage effort, where staff collected tadpoles from small, rapidly drying pools using aquarium dip nets and translocated the tadpoles to more perennial aquatic habitat. These methods resulted in a near census of tadpoles within the small pools sampled, which greatly increased detections when compared with traditional VES.

## **LOOKING AHEAD: 2022**

In summer 2020, CDFW began removing non-native trout from Five Lakes Basin, which is a location into which CDFW plans to reestablish SNYLF translocated from the Mossy Pond area. Translocation is a well-established method to attempt supplementing or reestablishing SNYLF populations in the Sierra Nevada, and one of the primary recovery techniques recommended by the Mountain Yellow-legged Frog Interagency Technical Team (MYLF ITT) (2018).

Five Lakes Basin is located approximately 8 km west of Mossy Pond, directly north of the Black Buttes. In 2013, the MYLF ITT discussed using the Mossy Pond SNYLF population as a source for translocations to the Five Lakes Basin area. The following year, the project was formally proposed in the ABMP for the South Yuba River Management Unit, which highlighted Five Lakes Basin as a priority area for non-native fish removal to help reestablish a SNYLF population on TNF (CDFW 2014). Subsequently, the MYLF ITT finalized the “[Interagency Conservation Strategy for Mountain Yellow-legged Frogs in the Sierra Nevada](#)” (Strategy; MYLF ITT 2018), which lists non-native fish removal and translocations into Five Lakes Basin as part of the species conservation action plan (MYLF ITT 2018; Attachment 1, pg. 30; Attachment 2, pg. 4).

In 2018, CDFW staff completed a site assessment of Five Lakes Basin and anticipated that non-native fish removal would be feasible, given low fish densities, simple habitat structure, small waterbody sizes, and tributaries that often dry completely by mid-summer (CDFW 2019b). Those interested in details of the Five Lake Basin assessment and VES may consult the memorandum “[Native aquatic resource management in the Black Buttes area](#)” (CDFW 2019b). Current VES data suggest that SNYLF are likely extirpated from Five Lakes Basin. Although CDFW staff observed one SNYLF adult in the lower section of Five Lakes Basin in 2018 (CDFW 2019b), staff have detected no SNYLF during numerous subsequent visits to Five Lakes Basin from 2019 to 2021. Given that the Five Lakes Basin SNYLF population is effectively extirpated, reestablishing a SNYLF population will require translocations from the greater Mossy Pond area.

In December 2019, U.S. Fish and Wildlife Service (USFWS) awarded CDFW funds for the project through the endangered species recovery grant program (Section 6 of the U.S. Endangered Species Act of 1973; Federal Grant Award #F19AP00750). This project first involves using mechanical methods (gill nets and backpack electrofishers) to remove non-native trout from Five Lakes Basin, which CDFW staff began in 2020. In 2021, CDFW captured zero fish in the main cluster of lakes in Five Lakes Basin and staff have not captured fish from Glacier Lake since July 2021 (CDFW 2022b). Therefore, CDFW anticipates that Five Lakes Basin may now be fishless. Therefore, CDFW may translocate SNYLF from the Mossy Pond area to Five Lakes Basin during summer 2022, depending on the results of continuing gill net efforts in Five Lakes Basin and SNYLF VES in the Mossy Pond area in early summer 2022. The translocation would be conducted by staff with many years of experience conducting SNYLF translocations using well established protocols (e.g., MYLF ITT 2018, Attachment 3).

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