State of California
Department of Fish and Wildlife

Memorandum

Date: 23 April 2024

To: Leslie Alber, Senior Environmental Scientist;
Sierra District Supervisor;
North Central Region Fisheries

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

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Subject: Amphibian monitoring in Tahoe National Forest, Nevada County

- ***Rana sierrae* monitoring in the Mossy Pond area**

ENVIRONMENTAL SETTING

The Mossy Pond complex is located in Tahoe National Forest, north of Highway 80 in Nevada County (**Figure 1**). The site is 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). The series of closely associated lakes, small ponds, and ephemeral streams in the Mossy Pond complex support a low density metapopulation of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF; **Figure 2**). 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 until early summer, but dwindle to intermittent pools by mid-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.

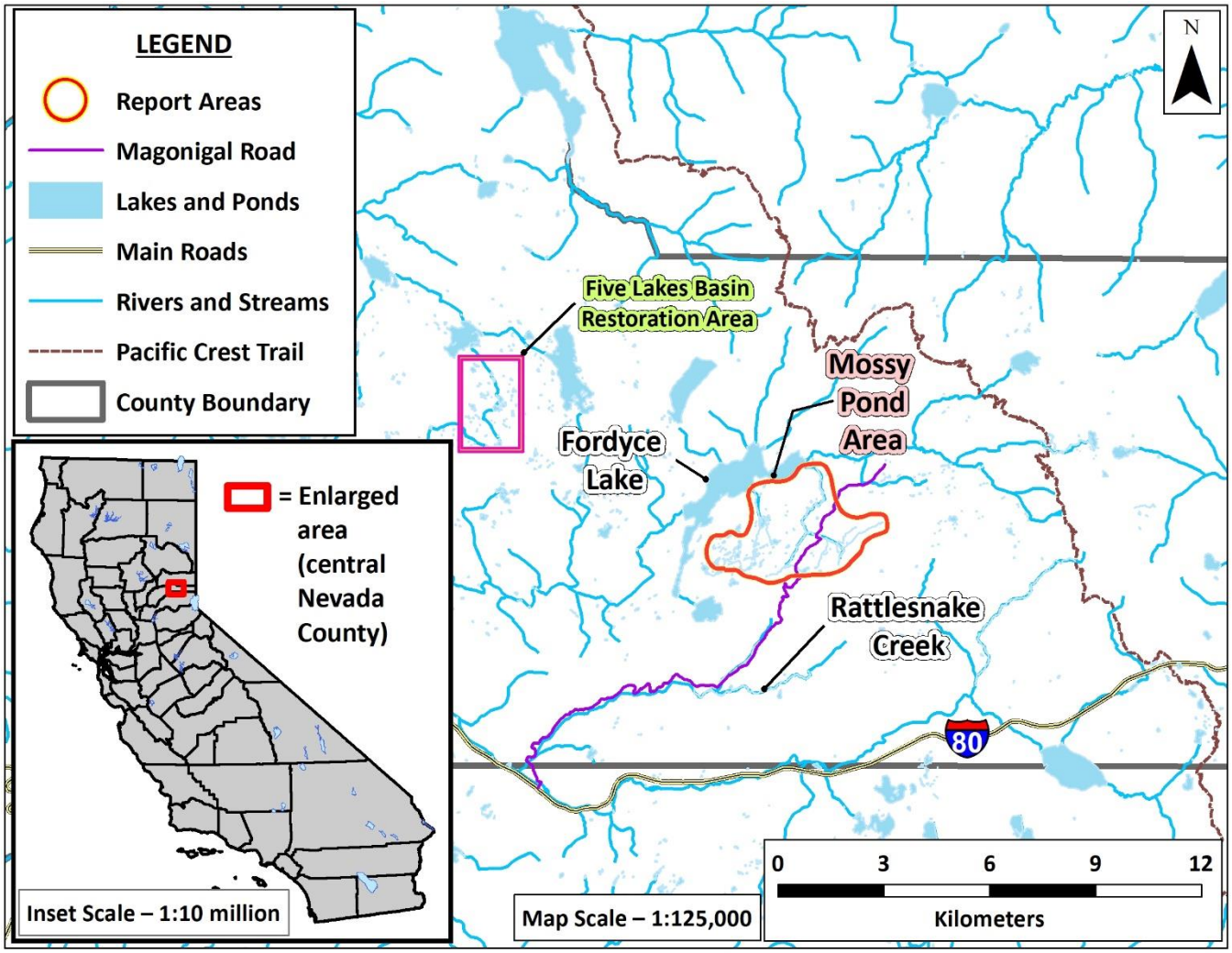


Figure 1. Mossy Pond area, Nevada County, CA. The area discussed in this memorandum is circled in red and yellow. The Five Lakes Basin and Rattlesnake Creek areas are also identified (see LOOKING AHEAD: 2024 section below).

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 2019–2023, 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. However, because CDFW conducted these surveys during late summer and early fall in a dry water year, many of the small ponds and stream segments were either dry or contained very low water levels. In 2022, CDFW and TNF staff surveyed the Mossy Pond area on three occasions, including two surveys earlier in the summer (late June and early July) than those CDFW conducted the year prior, and one occasion in early September, during each of which staff surveyed a subset of the ponds and stream segments in the area. In 2023, CDFW and TNF staff joined efforts and surveyed many locations in the greater Mossy Pond area over a three-day period, from 22 to 24 August. As part of this survey effort, staff surveyed many additional stream segments east of Magonigal Rd. CDFW and TNF staff had not previously surveyed these locations for SNYLF. The goal of expanding the survey area east of Magonigal Rd was to see if SNYLF occupied any of the ephemeral streams and small ponds further upstream, along drainages where staff have consistently detected SNYLF further downstream during previous years.

Figure 2. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) seeking shelter beneath a streamside boulder along the inlet to Fordyce Lake (Site ID 52597) in late August 2023. (CDFW)

THREATS

Marginal Habitat

Mossy Pond has an approximately six-hectare surface area and a maximum recorded depth of 2.5 meters, while much of the pond is 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 2024a, b). Field staff occasionally observe SNYLF larvae (and, more rarely, egg masses) at Mossy Pond, the Mossy Pond outlet stream (**Figure 3**), and within the eastern inlet to Fordyce Lake (**Figure 4**).

Figure 3. One of only a few locations in the Mossy Pond outlet stream (Site ID 80138) containing water in late summer 2022. 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. Fordyce Lake is visible in the upper background. (CDFW)

Figure 4. View along the main inlet to Fordyce Lake (Site ID 50133) on 23 August 2023. Historically, this is one of the stream segments in which California Department of Fish and Wildlife (CDFW) staff detected the highest counts of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) in the Mossy Pond area. In 2022 and 2023, CDFW did not detect nearly as many SNYLF. (See **Figure 11**; CDFW)

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 13153), 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 8**, 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 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; **Figure 8**), 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 (e.g., Lahontan Redside; *Richardsonius egregius*) are abundant in some lakes and stream segments, including Site IDs 13140, 13144, 13150, and 52594 (**Figure 8**).

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 stocking. 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 2019).

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 at least once per summer from 2019–2023 using traditional VES methods (Heyer et al. 1994). During VES in 2023, staff used dip nets or their hands to attempt capturing and scanning all frogs large enough to have been marked with a passive integrated transponder (PIT) tag during the CMR study (i.e., adult frogs ≥50 mm snout-to-urostyle [SUL] length, which is a highly conservative lower end of potential size for SNYLF that are at least 6 years old). 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.

In 2023, staff detected five previously PIT-tagged adult frogs within the former Mossy Pond study area. These included two individuals at Site ID 13061, two individuals at Site ID 62603, and one individual at Site ID 53422 (**Figure 5**). One of the individuals recaptured at Site ID 62603 was a frog originally PIT-tagged on 17 July 2014. At the time staff originally PIT-tagged this frog, it was a mature adult (59 mm SUL and 27 grams in weight when first captured). Given that SNYLF tadpoles typically overwinter at least once prior to metamorphosis, and because it likely took this frog at least another year after metamorphosis to reach its size when originally captured in July 2014, this frog was likely at least 12 years old when recaptured in August 2023.

When compared with the CMR study period, both adult and subadult SNYLF detections from 2021 to 2023 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, and detections in 2022 and 2023 were not substantially higher. 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 2012–2023, eight have received precipitation well below the 1991–2020 average (2012–2015, 2018, and 2020–2022; CDEC 2024a). 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.

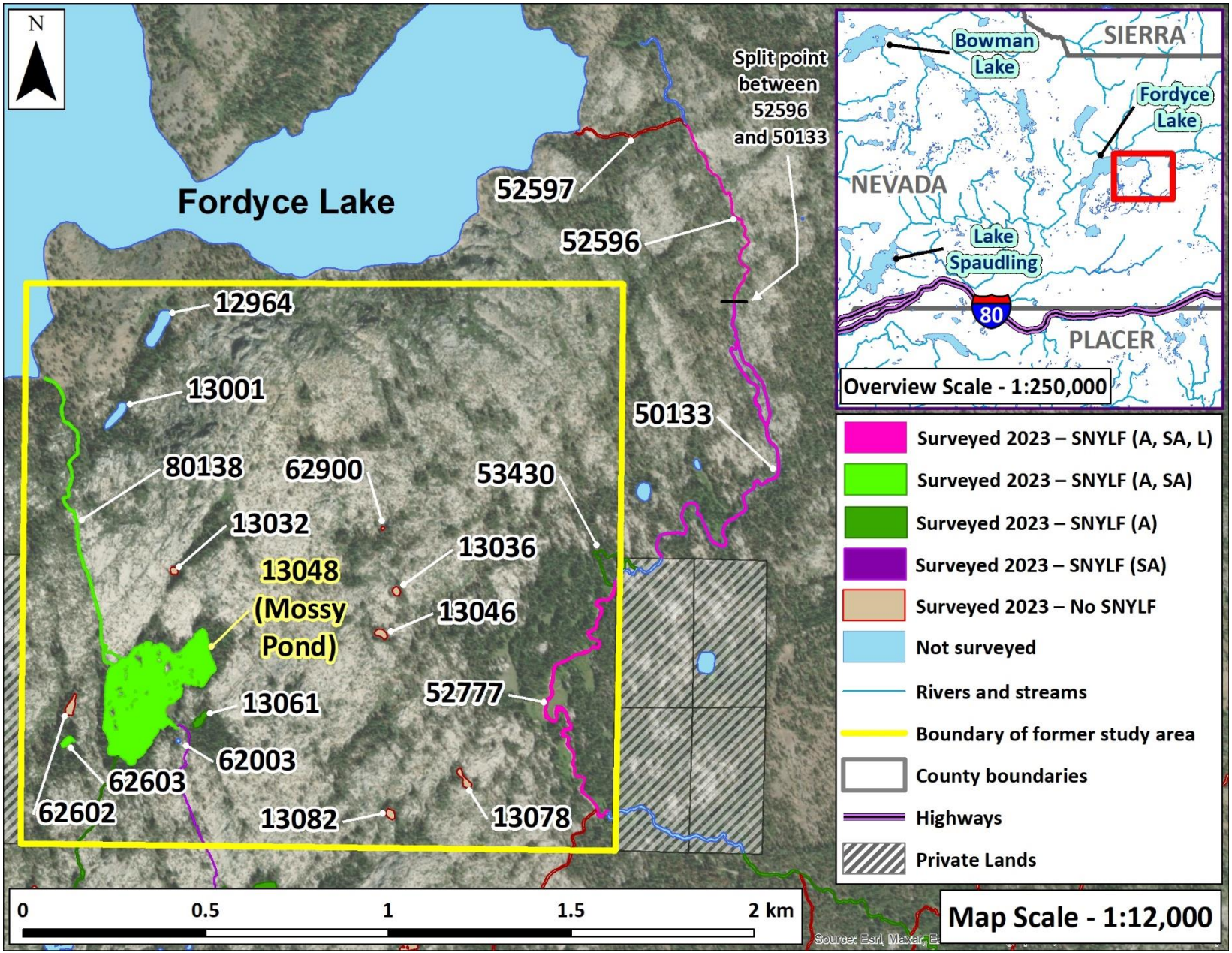
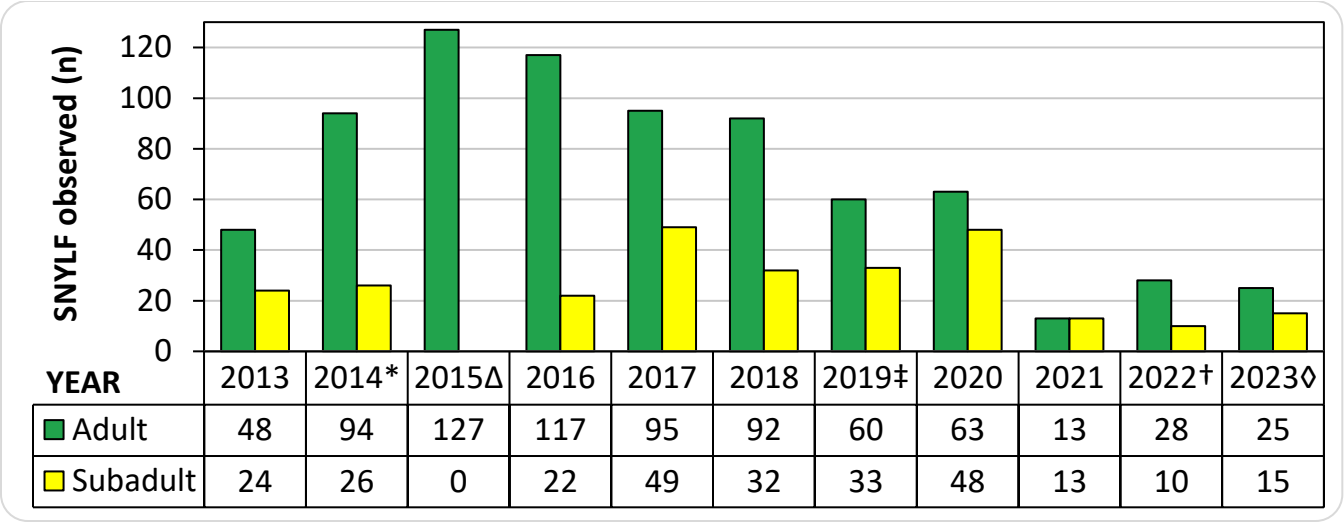


Figure 5. [See figure caption at the beginning of the next page.]

Figure 5 (continued). Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations during visual encounter surveys (VES) in the former Mossy Pond capture-mark-recapture (CMR) study area during summer 2023. The CMR study occurred from 2014 to 2018. However, beginning in 2019, CDFW suspended marking any newly captured (i.e., unmarked) adults with PIT tags. During VES, California Department of Fish and Wildlife (CDFW) staff capture all adult frogs observed and scan each older adult (i.e., those individuals ≥50 mm snout-to-urostyle length) for passive integrated transponder (PIT) tags inserted during the study period. The results shown are from surveys by CDFW and TNF staff in late August. Staff surveyed all identified waterbodies in the entire study area. Additionally, the map displays results from surveys of the eastern inlet to Fordyce Lake, which is located just outside the study area, to the east. 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” = larva.



YEAR	2013	2014*	2015Δ	2016	2017	2018	2019‡	2020	2021	2022†	2023◊
Adult	48	94	127	117	95	92	60	63	13	28	25
Subadult	24	26	0	22	49	32	33	48	13	10	15

Figure 6. Count of adult and subadult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during surveys in the Mossy Pond study area, 2013–2023. 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., ≤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.

ΔStaff 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 often 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**).

†Survey totals in 2022 combine data from CDFW surveys in late June and Tahoe National Forest surveys in early July (see caption of **Figure 5** for details), with the exception of Site ID 52777, which CDFW staff surveyed in early September 2022.

◊Survey totals in 2023 include a small, ephemeral oxbow stream section (Site ID 53430), which is at the far northeasterly corner of the study area boundary, but was not included as part of the 2014–2018 CMR study. CDFW newly mapped this segment in 2023. [***End of figure caption***].

VES OUTSIDE THE MOSSY POND STUDY AREA

There are approximately 67 mapped lakes, ponds, and stream segments in the Mossy Pond complex outside of the CMR study area (**Figure 7**). Between 2001 and 2023, CDFW staff have observed SNYLF of various life stages in 34 of these waterbodies. Following the 2022 monitoring season, CDFW used high resolution aerial imagery to identify and map 35 additional ephemeral ponds and stream segments in locations adjacent to the former Mossy Pond study area. Most of these newly mapped locations are east of Mossy Pond (**Figure 7**). In 2023, CDFW staff added an additional three sites that were discovered during field surveys. Staff added all 38 new sites to geographic information system (GIS) layers of waterbodies used for survey planning. In late August 2023, CDFW conducted VES at most of these newly identified stream segments and ephemeral ponds (**Figures 8 and 9**). Staff detected SNYLF at five of the newly identified stream segments and ponds.

Occasional monitoring data indicated a relatively large SNYLF metapopulation in the greater Mossy Pond area. However, beginning in 2021, CDFW and TNF staff have observed comparatively fewer post-metamorphic SNYLF outside of the study area, despite surveying 34, 25, and 60 sites with surface water in 2021, 2022, and 2023, respectively. In 2023, staff observed fewer adults than during surveys in 2022. Although staff observed even fewer adult SNYLF in 2020 and 2021 when compared with 2023, it is important to note that staff surveyed far fewer sites in 2020 and 2021 (**Figure 10**). Despite variability in survey effort (in terms of the number of sites surveyed), time of year, and water year type (i.e., summers 2020–2022 followed winters with below average snowpack, while summer 2023 followed a winter with exceptionally large snowpack; CDEC 2024b), staff have still detected fewer post-metamorphic SNYLF when compared with surveys during the period from 2013 to 2019 (**Figure 10**).

[*Main text continues on pg. 21, following Figures 7 – 10.*]

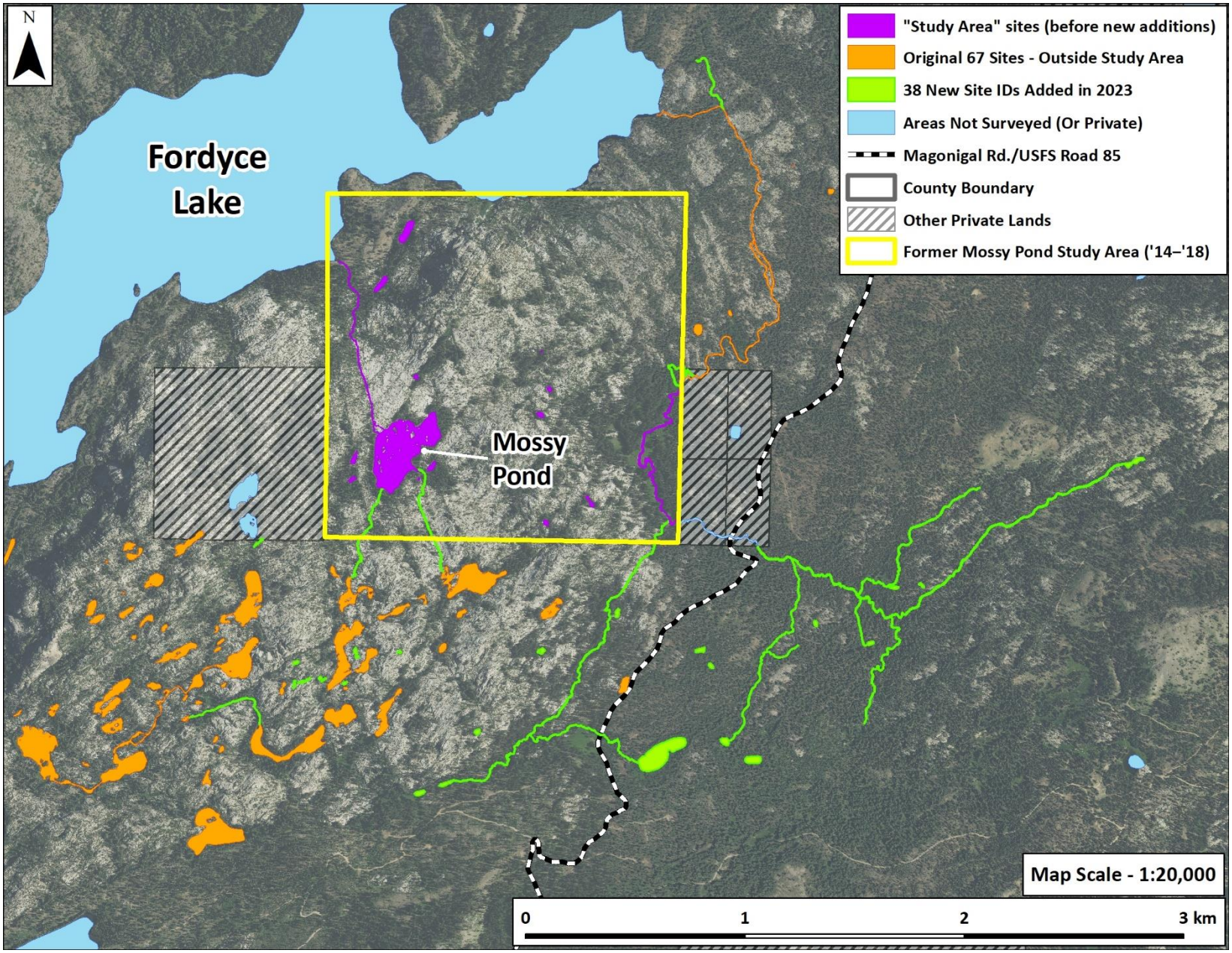


Figure 7. [See figure caption at the beginning of the next page.]

Figure 7 (continued). Schematic map showing waterbodies included in the 2014–2018 Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) capture-mark-recapture (CMR) surveys (and subsequent visual encounter survey monitoring during 2019–2023), referred to in this memorandum as the "Mossy Pond study area" (outlined in yellow with waterbodies displayed in purple), areas outside the study area (displayed in orange), and locations newly added to SNYLF survey efforts and the High Mountain Lakes GIS layer beginning in 2023 (displayed in green).

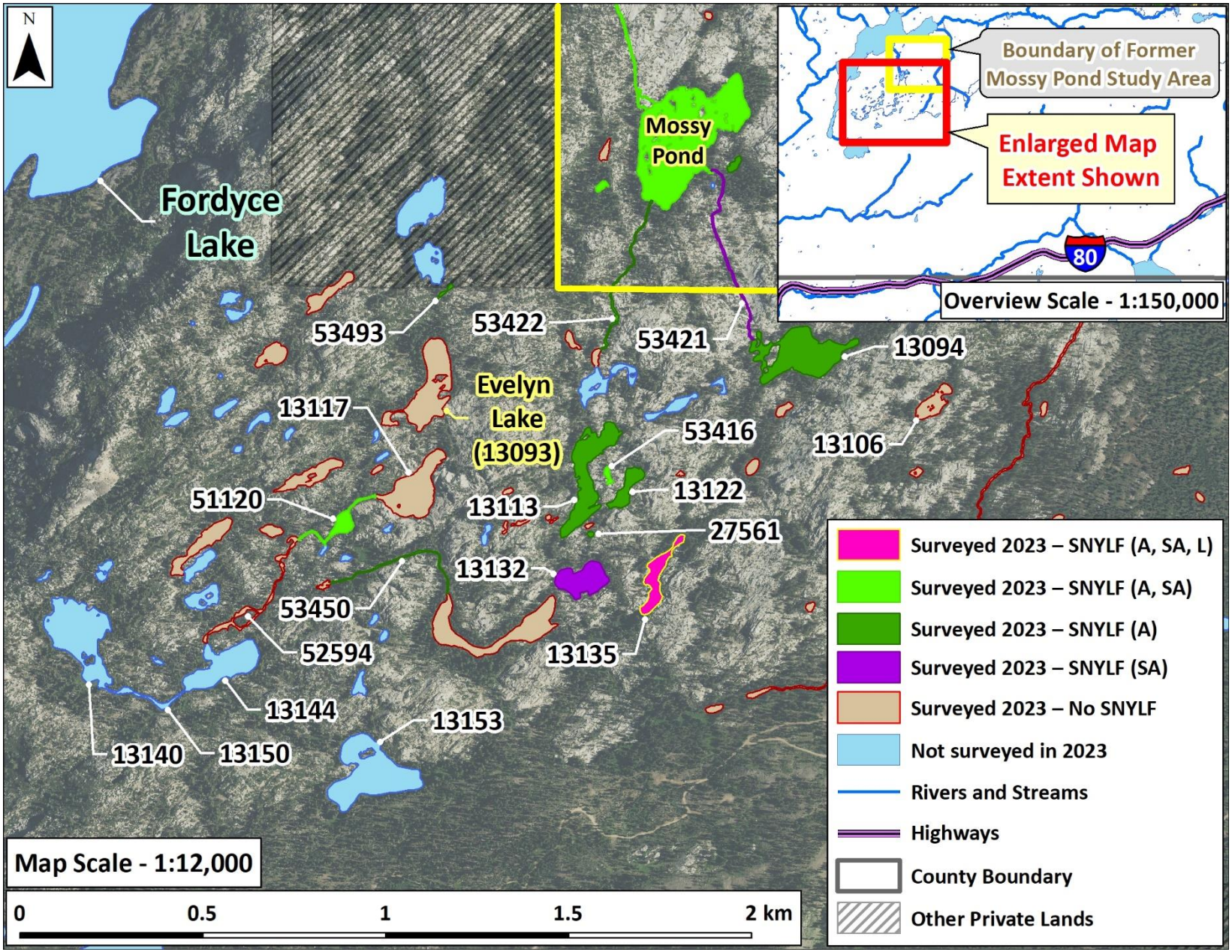


Figure 8. [See figure caption at the beginning of the next page.]

Figure 8 (continued). Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations during visual encounter surveys (VES) in the Mossy Pond complex, southwest of the former study area, in late August 2023. The label for Site ID 13093 (Evelyn Lake) is highlighted in yellow to indicate that this is the location into which California Department of Fish and Wildlife (CDFW) and Tahoe National Forest (TNF) staff released approximately 1,500 SNYLF tadpoles rescued from rapidly drying pools in Rattlesnake Creek (see **Figure 1**) during fall 2021 (CDFW 2022). 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 and TNF partners joined together to conduct surveys over a three-day period (August 22–24).

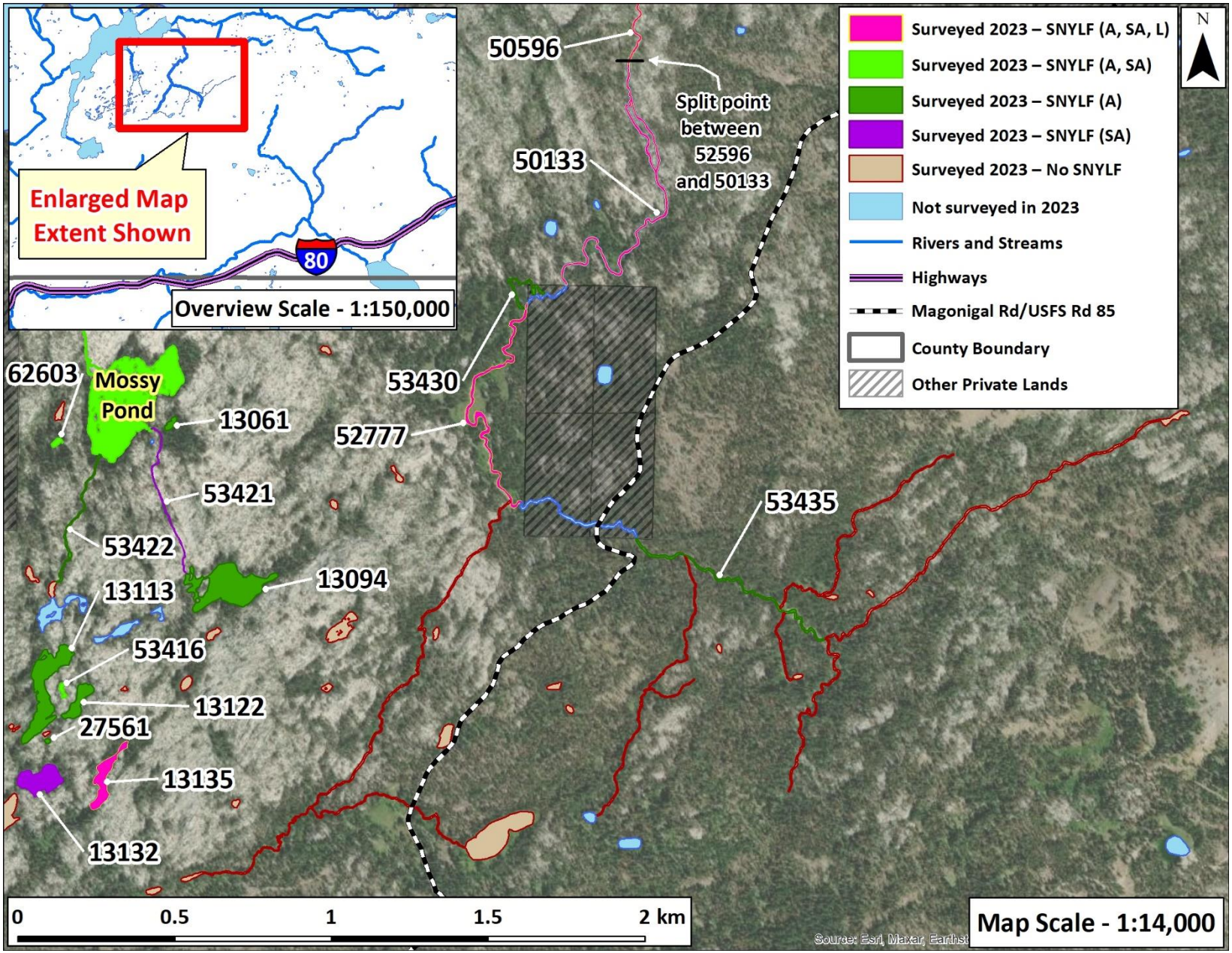
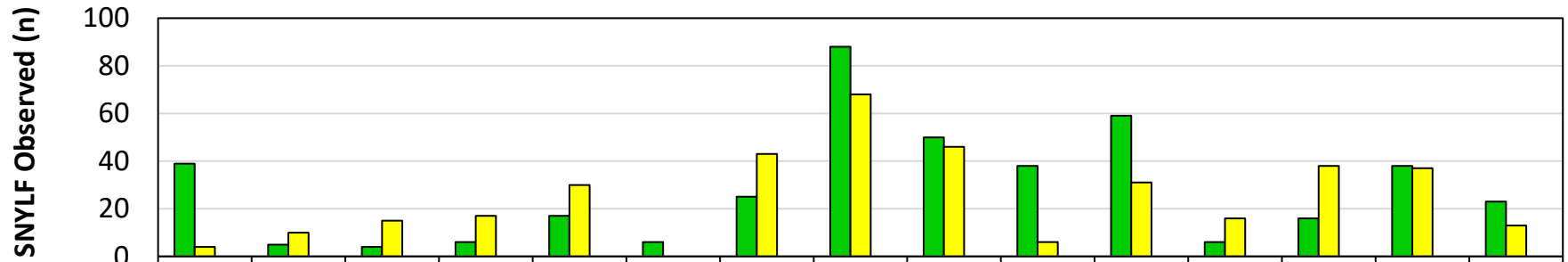


Figure 9. [See figure caption at the beginning of the next page.]

Figure 9 (continued). Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) observations during visual encounter surveys (VES) in the Mossy Pond complex, east of the former study area, in late August 2023. 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 and Tahoe National Forest (TNF) partners joined together to conduct surveys over a three-day period (August 22–24). This was the first time CDFW and TNF staff had surveyed the stream segments upstream of Site ID 52777. Staff only observed one adult SNYLF in these newly surveyed locations (at Site ID 53435).



YEAR	2001	2002	2004*	2005*	2008*	2009	2010*	2013*	2015*	2017‡	2019	2020	2021Δ	2022†	2023◊
Adult	39	5	4	6	17	6	25	88	50	38	59	6	16	38	23
Subadult	4	10	15	17	30	0	43	68	46	6	31	16	38	37	13
# Sites	30	11	15	15	7	6	22	51	2	11	25	7	34	25	60

Figure 10. Counts of adult and subadult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during surveys outside of the Mossy Pond capture-mark-recapture (CMR) study area from 2001–2022. Survey effort, as measured by the number of sites surveyed, has varied substantially between survey years (see final table row).

*During these years, one location—Site ID 50133 (a stream segment east of the study area; see **Figure 5**)— accounted for a majority of SNYLF observations.

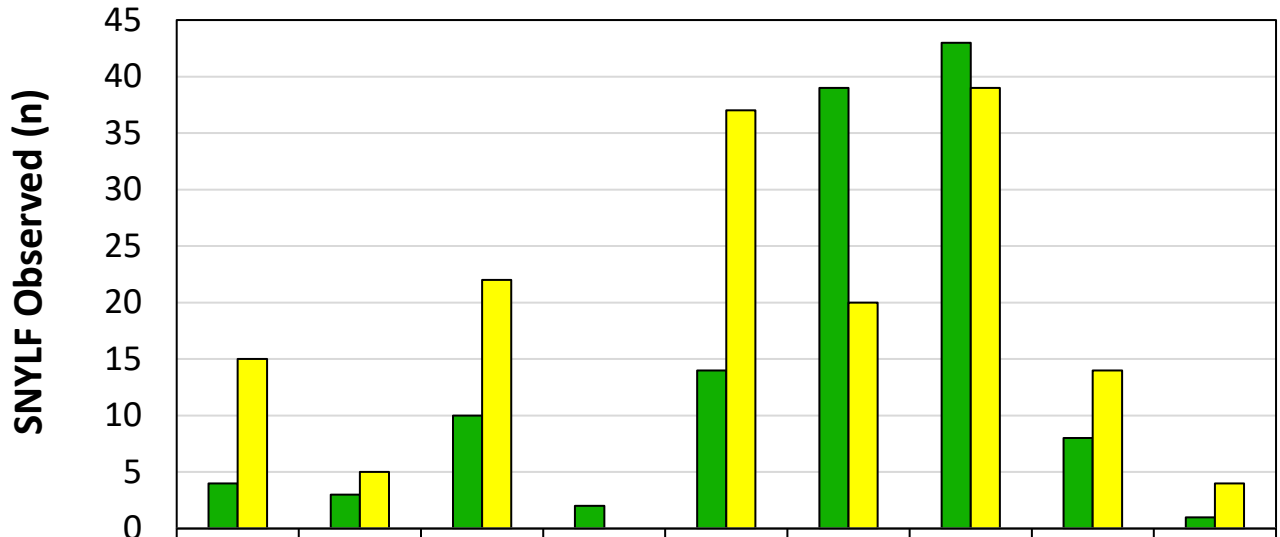
‡Surveys in 2017 were not traditional visual encounter surveys (VES). CDFW staff were looking for SNYLF marked with passive integrated transponder (PIT) tags that may have moved outside of the CMR study area. Surveys in 2017 were confined to ponds closest to the southern and eastern borders of the study area.

ΔThe 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). Counts of post-metamorphic frogs shown in 2021 do not include dead individuals detected by CDFW (n = 6).

†Survey totals in 2022 combine data from CDFW surveys in late June and Tahoe National Forest (TNF) surveys in early July, with the exception of three Site IDs (50133, 52596, and 52597; **Figure 5**), which CDFW staff surveyed in early September 2022.

◊The site total in 2023 include surveys of numerous stream segments and small ponds east of Magonigal Road (see **Figure 9**). These locations are areas not previously surveyed by CDFW or TNF. CDFW wanted to see if staff could detect additional SNYLF in these areas, given the close proximity to the Mossy Pond area. In 2023, staff only detected one adult SNYLF in these newly surveyed locations east of Magonigal Road. [***End of figure caption.***]

Among the survey locations outside the study area, CDFW staff have historically observed most post-metamorphic SNYLF at one site: an ephemeral stream to the east of the Mossy Pond study area that drains into the eastern side of Fordyce Lake (Site IDs 50133, 52596, and 52597; **Figure 5**). CDFW staff have surveyed Site ID 50133 occasionally since 2004. In 2013, CDFW added two additional survey segments along this same stream reach (Site IDs 52596 and 52597), which are located between Fordyce Lake and the downstream end of Site ID 50133. CDFW conducted VES at this location in late August 2023. Staff detected very few SNYLF in this stream segment when compared with surveys in 2010, 2013, and 2015 (**Figure 11**). However, some caveats need to be considered when interpreting the results, which are discussed more below **Figure 11.**



YEAR	2004	2005	2008	2009	2010	2013	2015	2022	2023
Adult	4	3	10	2	14	39	43	8	1
Subadult	15	5	22	0	37	20	39	14	4

Figure 11. Counts of adult and subadult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during surveys of Site ID 50133 (a segment of stream that flows into the eastern side of Fordyce Lake) from 2004–2023. Historically, this one stream segment has accounted for a majority of SNYLF detections among waterbodies surrounding the former Mossy Pond study area. In 2022, CDFW staff surveyed this site twice: on 30 June and 8 September. Results displayed above are from the survey on 8 September. In 2023, CDFW and Tahoe National Forest staff surveyed this site on 23 August. [***End of figure caption***.]

Another factor to consider when interpreting survey results from the entire Mossy Pond area are environmental conditions, which have varied widely. Of the last six survey periods, half have occurred during far above average water years (2017, 2019, and 2023) and the other half have occurred during exceptionally dry water years (2020–2022; CDEC 2024a, b). Potential effects of the more recent dry years may be compounded, given that a majority of water years

since 2012 have resulted in well below average precipitation and snowpack (2012–2015, 2018, and 2020–2022; CDEC 2024a, b). When recent above average water years have occurred (2011, 2017, 2019, and 2023), they have been followed by at least one—but more often multiple—dry water years. Winter 2021–2022 was the third year in a row with well below average accumulated snowpack (CDEC 2024b), with the 1 April 2022 northern Sierra Nevada snow water content being only 26% of average (CDEC 2023c), although northern Sierra Nevada 2021–2022 water year precipitation totals were higher than the two prior water years, at approximately 81% of the 1991–2020 average (CDEC 2024a).

Although surveys in 2023 occurred in late August, water levels were higher than average in the Mossy Pond area (**Figure 12**). These hydrologic conditions resulted from a combination of above average winter snowpack and more recent (and atypical) summer precipitation events. Prior to surveys of the Mossy Pond area in August, the area received 2.1 inches of precipitation over an eight-day period. About an inch of this precipitation fell on 21–22 August, soon before surveys began (data obtained from the nearest weather station that records daily precipitation, the Central Sierra Snow Lab [CSL], which is located at the same elevation as Mossy Pond [6,900 ft; 2,103 m] and only 10 km to the southeast; CDEC 2024d). Many ponds visited still contained surface water, and many stream channels—nearly all of which dry almost completely by late summer—were still flowing during surveys (**Figure 13**).

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.

While acknowledging these challenges, CDFW suspects that environmental conditions may be at least partly responsible for the relatively low SNYLF detections that staff have observed in recent years. Although water levels were relatively high during surveys in late June 2022 and late August 2023, a majority of water years during the past decade have been very dry. These drought conditions have led to shorter hydroperiods during the active season for SNYLF. When accumulated across multiple years over the past decade, drought may be causing an increase in the frequency of local SNYLF extirpations within the Mossy Pond metapopulation, particularly among populations occupying smaller, more isolated ponds and ephemeral stream channels. The environmental stresses of drought on SNYLF populations are compounded with historic non-native trout stocking in the area, and continued *Bd*-induced mortality.

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. In 2021, CDFW suspected that 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 during surveys that staff conducted in September 2021. Additionally, CDFW suspects that 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.

These potential explanations for reduced SNYLF detections do not apply to the relatively low number of SNYLF that staff observed during surveys in 2022 and 2023. However, as discussed above, multiple years of dry conditions may have decreased survivorship among SNYLF in the Mossy Pond area, in part through stranding frogs in suboptimal habitats during protracted dry periods. Overwinter mortality during drought conditions, via environmental factors such as direct freezing or increased odds of anoxic conditions in shallow ponds (Bradford 1983, Fellers et al. 2007, Hammond et al. 2021), or periods of *Bd*-induced overwinter mortality (Briggs et al. 2005, Rumschlag and Boone 2018), may have also contributed to the recent decline in SNYLF detections. Finally, the prevalence of dry site conditions during the past decade may have contributed to increased late summer and early fall *Bd*-induced mortality among Mossy Pond area SNYLF, through factors such as increased chances of *Bd* susceptibility among frogs confined to small, isolated, and stagnant stream pools or drying ponds (Tunstall 2012, Kupferberg et al. 2021). More discussion of *Bd* and SNYLF in the Mossy Pond area continues at the bottom of page 24.

Figure 12. Site ID 62603 on 22 August 2023. During some past survey periods, this small pond near Mossy Pond has been nearly dry by late summer. In late summer 2023, water levels were higher than average for the time of year in the Mossy Pond area, following a winter with above average snowpack (CDEC 2024b) and recent precipitation (CDEC 2024d). (CDFW)

Figure 13. A large pool at the upstream end of Site ID 52596 on 23 August 2023. [*Note*: the water levels observed at this location are nearly identical to water levels observed much earlier in the summer during the prior year. See Figure 11 of CDFW 2023b, which shows a view from the same location on 30 June 2022.] On 23 August 2023, water was still flowing in this stream segment (flows enter the pool on the far left of the photograph and exit at the top right). (CDFW)

The endemic state of *Bd* in most of the Sierra Nevada (Briggs et al. 2005, Padgett-Flohr and Hopkins 2009, Knapp et al. 2016, Vredenburg et al. 2019) and widespread detections of the pathogen in nearly all extant SNYLF populations sampled during the past 10–15 years (CDFG 2011; CDFW, unpubl. data), suggest that epizootic *Bd*-induced mass mortality events, such as those that often occur in populations newly exposed to the pathogen (Vredenburg et al. 2010), are unlikely among *Bd*-positive SNYLF populations such as the Mossy Pond area, where epithelial swabs have revealed *Bd* presence since at least 2010 (CDFG 2011, plus see *Disease* section above). However, *Bd* may still be an ongoing source of mortality in the Mossy Pond area, despite SNYLF persisting with the disease (Rachowicz et al. 2006, Briggs et al. 2010). Enzootic *Bd* dynamics may be resulting in consistent rates of mortality in the Mossy Pond area

SNYLF population, particularly among recent metamorphs and subadults, which are known to be highly susceptible to *Bd*-induced mortality (Rachowicz et al. 2006). 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. In 2022, CDFW made similar observations, all at Evelyn Lake (Site ID 13093), where staff detected one dead tadpole on 28 June and seven dead subadults on 8 September. However, the subadults detected on 8 September were all highly decomposed, so staff were not able to definitively determine species ID (i.e., the mortalities may have been Sierran Chorus Frogs). In 2023, staff only detected one potential dead adult SNYLF (the frog was highly decomposed, so species identification was not definitive). The cause of these mortalities is unknown, but *Bd* may be a factor in at least some of the observed mortalities. The known *Bd* dynamics discussed above correlate with staff finding mostly young frogs among observed mortalities in 2021 and 2022.

In 2017 and 2019–2023, 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 2022 and 2023, staff did not capture any adult SNYLF outside of the former Mossy Pond study area 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.

LOOKING AHEAD: 2024

In fall 2022, CDFW completed non-native trout removal from Five Lakes Basin, which is a location into which CDFW originally planned to reestablish SNYLF using individuals translocated from the Mossy Pond area (CDFW 2023a). Five Lakes Basin is located approximately 8 km west of Mossy Pond, directly north of the Black Buttes (**Figure 1**). In 2013, the Mountain Yellow-legged Frog Interagency Technical Team (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).

Under original terms of the endangered species recovery grant (Federal Grant Award #F19AP00750) for the Five Lakes Basin non-native trout removal and SNYLF reintroduction, CDFW planned to translocate SNYLF back into Five Lakes Basin during summer 2022, using adult frogs collected 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 MYLF ITT (2018). However, VES in the Mossy Pond area in late summer and fall 2021, early summer 2022, late summer 2022, and late summer 2023 have revealed fewer adult SNYLF than anticipated (see results detailed in the VES IN THE MOSSY POND STUDY AREA and VES OUTSIDE THE MOSSY POND STUDY AREA earlier in this memorandum). In 2023, CDFW and TNF staff detected <50 total adult SNYLF during VES at approximately 75 sites in the greater Mossy Pond area. Since CDFW plans to collect at least 20 adult SNYLF to undertake the translocation effort, and the grant terms dictate that no more than 20% of adults observed during VES will be collected, CDFW would have needed to detect at least 100 adult SNYLF during surveys of the Mossy Pond area in order to collect adults for translocation to Five Lakes Basin. Therefore, given these recent survey results, CDFW will not be able to collect adult SNYLF without the potential for unacceptable risk to the persistence and health of the Mossy Pond source population.

Given these recent VES results and the need to limit unnecessary risk to the source population, CDFW will be pursuing an alternative option for reintroducing SNYLF to Five Lakes Basin. After discussion with the CDFW Statewide Amphibian and Reptile Conservation coordinator, supervisory staff in the Region 2 Fisheries Program, TNF partners, and USFWS, CDFW plans to collect early life stage SNYLF (egg masses, tadpoles, and/or recent metamorphs) from Rattlesnake Creek (**Figure 1**) for captive-rearing and later release into Five Lakes Basin. Captive-rearing would be undertaken by local zoo partners (e.g., the San Francisco or Oakland Zoo),

who have staffing, facilities, and experience rearing SNYLF. Captive-reared SNYLF would be raised to maturity, PIT-tagged, and released as adults into Five Lakes Basin. CDFW plans to seek funding for this work through the next State Wildlife Grant (SWG) solicitation.

Rattlesnake Creek would be a preferred alternative to Mossy Pond for collecting early life stage SNYLF because CDFW and TNF staff have detected comparatively far fewer tadpoles in the Mossy Pond area, most of which have been observed at Site IDs 50133, 52596, and 52597 (**Figure 5**). Given consistent SNYLF breeding at Rattlesnake Creek and ability to more easily collect early life stages, CDFW would plan to collect portions of egg masses (if detected during late spring) or a subset (≤20%) of tadpoles observed during VES in late summer, which staff would conduct soon before a potential tadpole collection.

In summer 2024, CDFW plans to survey a subset of locations in the Mossy Pond area with the highest detections of SNYLF during past surveys (e.g., Mossy Pond and the adjacent ponds, plus Site IDs 80138, 52596, 52597, 50133, and 52777). Given the large amount of recent survey effort and relatively low SNYLF detections for three years in a row (**Figures 6 and 10**), and resulting shift in plans to no longer translocate adult SNYLF from the Mossy Pond area to Five Lakes Basin, planned surveys in summer 2024 will serve the purpose of maintaining recent information on the general status of the population. CDFW does not plan to have a large crew at the site for multiple days, but rather a smaller crew for two days of surveying. CDFW plans to time surveys to correspond with quality survey conditions during mid-summer. Winter 2023–2024 resulted in slightly above average snow water content (approximately 110% of average on 1 April 2024) and slightly below average precipitation (CDEC 2024a, b). These conditions may result in quality amphibian survey conditions during summer 2024.

VES IN THE RATTLESNAKE CREEK AREA

CDFW plans to survey the Rattlesnake Creek area in summer 2024. CDFW staff most recently visited Rattlesnake Creek in early September 2022, primarily to check on habitat conditions and make sure no SNYLF tadpoles were becoming stranded in drying pools (see CDFW 2023b). In 2024, CDFW plans to survey a larger section of Rattlesnake Creek to obtain a current estimate of relative SNYLF abundance. CDFW plans to conduct these surveys in late spring/early summer (to attempt locating egg masses) and/or late summer, at which time water levels will be lower, stream flows have stopped, SNYLF are more consolidated into remaining aquatic habitats, and staff are more likely to detect tadpoles in stream pools. Depending on the availability of potential alternative funding sources and zoo capacity at the time of surveys, CDFW may consider collecting a subset of early life stages for captive-rearing in 2024. Otherwise, staff will plan to collect early life stage SNYLF from Rattlesnake Creek in 2025, pending funding acquisition during the next SWG cycle.

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