State of California
Department of Fish and Wildlife

Memorandum

Date: 2 February 2021

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

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

Cc: Region 2 Fish Files

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Subject: Native amphibian restoration and monitoring in Desolation Wilderness;

- ***Rana sierrae*** **monitoring in the Highland Lake drainage: update.**
- ***Rana sierrae*** **translocation from Highland Lake to 4-Q Lakes: 2018–2020 summary.**

SUMMARY

The Highland Lake drainage is a site from which California Department of Fish and Wildlife (CDFW) staff removed introduced Rainbow Trout (*Oncorhynchus mykiss*, RT) from 2012–2015 to benefit Sierra Nevada Yellow-legged Frogs (*Rana sierrae*, SNYLF). Amphibian monitoring data from 2003 through 2020 suggest a large and robust SNYLF population. For the past several years, the Highland Lake drainage has contained a sufficient adult SNYLF population to provide a source for translocations to nearby fishless aquatic habitats suitable for frogs. The Interagency Conservation Strategy for Mountain Yellow-legged Frogs in the Sierra Nevada (hereafter "Strategy"; MYLF ITT 2018) highlights translocations as a principal method for SNYLF recovery. As a result, in July 2018 and August 2019, CDFW and Eldorado National Forest (ENF) staff biologists translocated a total of 100 SNYLF adults from the Highland Lake drainage to 4-Q Lakes (60 adults in 2018 and 40 adults in 2019). Each year from 2018–2020, CDFW field staff revisited 4-Q Lakes two times to monitor the new SNYLF population. In total, CDFW has recaptured 54 of the 100 released SNYLF at least once since release at 4-Q Lakes. In 2020, CDFW observed the first signs of SNYLF breeding, including observing a recently hatched egg mass, tadpoles, and subadults. Additionally, all recaptured SNYLF had grown noticeably and appear to be in good body condition. In 2020, CDFW applied for additional funding through the U.S. Fish and Wildlife Service (USFWS) endangered species recovery grant program (Section 6 of the U.S. Endangered Species Act of 1973) to replicate the same translocation methods in 2021 and 2022. The grant was awarded by the USFWS in mid-January 2021 (Federal Grant Award #F21AP00483-00). Additionally, CDFW will continue annual monitoring to document SNYLF population status at both donor and recipient sites.

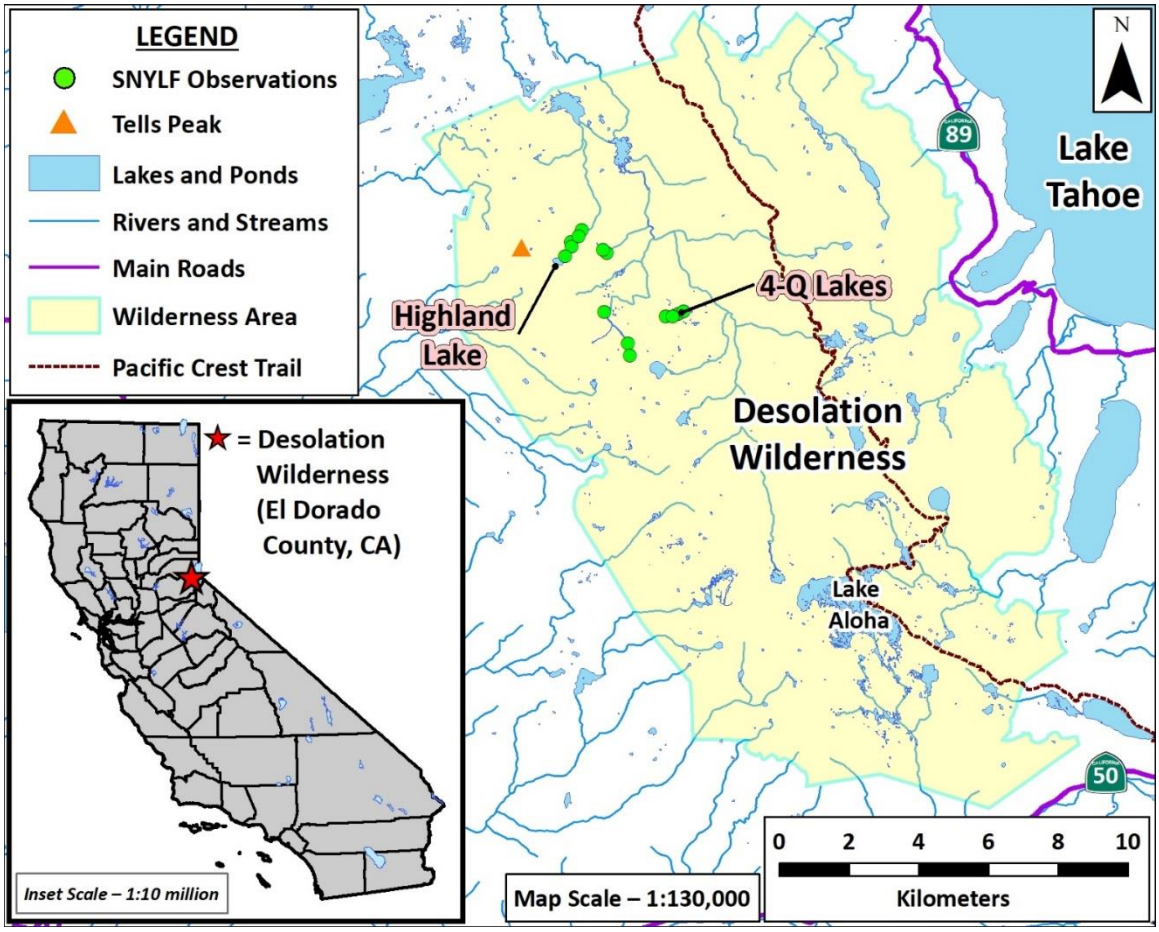


Figure 1. Desolation Wilderness, El Dorado County, CA. Green dots show sites in nearby watersheds with positive Sierra Nevada Yellow-legged Frog (*Rana sierrae*) detections during recent visual encounter surveys (VES).

ENVIRONMENTAL SETTING

Highland Lake and 4-Q Lakes are located in the Desolation Wilderness, northeast El Dorado County (**Figure 1**). Highland Lake sits in a granite cirque at approximately 7,800 feet in elevation and drains northeast into Rockbound Lake (**Figure 2**). No official trails access Highland Lake, but a use trail from nearby Forni Lake, which proceeds over a saddle just south of Tells Peak, indicates regular visitation by hikers. 4-Q Lakes are located approximately 3.5 km southeast of Highland Lake drainage. The site sits in a granite basin at approximately 7,500 feet in elevation and drains north into Rubicon Lake. The McConnell Lake Trail provides access to the site from the Leland/McConnell/Horseshoe Lakes drainage (to the west) and Camper Flat (to the east). ENF manages this section of Desolation Wilderness and the surrounding land.

INTRODUCTION

The Aquatic Biodiversity Management Plan (ABMP) for the Desolation Wilderness Management Unit (CDFG 2012) identifies Highland Lake (Site ID 13904; **Figure 2**), approximately one kilometer (km) of outlet stream (Site IDs 52648, 52649, 52650, 52670, and 52671), and three associated ponds (Site IDs 13892, 13896, and 13903) as a Native Species Reserve (NSR) for SNYLF (**Figures 3 and 4**).

CDFW stocked Highland Lake with RT from 1935 until 2000. The lake contains limited spawning habitat and the RT exhibited little natural reproduction. In 1955, CDFW constructed a stonemasonry streamflow maintenance dam at the outlet (USFS 1955, CDFG 1980). The dam forms an effective barrier to fish moving from the outlet stream into the lake, thereby further reducing spawning potential. In 1993, ENF biologists observed a very small SNYLF population in the Highland Lake outlet stream (USFS 1993). Staff also detected RT in Highland Lake and the outlet stream. Gill net surveys in 2003 and 2010 indicated that RT were persisting at low density in the absence of stocking. In the 2000's, CDFW managers, in partnership with ENF, determined that eradicating the low-density RT population using gill nets and backpack electrofishers would be feasible, and provide an opportunity to recover the SNYLF population in the Highland Lake drainage (CDFG 2012). As a result, in 2012, CDFW and ENF personnel began removing RT from Highland Lake to benefit SNYLF. Complete fish eradication of the NSR was determined in 2017, following two years without any fish captures or observations. Although field staff have not seen or captured any fish since 2015, CDFW will continue monitoring the site for presence of any latent non-native trout. Those interested in learning more details about fish removal in the Highland Lake drainage may consult the 2017 Highland Lake survey memo (CDFW 2018).

Now that fish removal is complete in the Highland Lake drainage, the SNYLF population has grown substantially, from only a handful of post-metamorphic frog detections in the 1990's, to an average of 470 adult observations, 310 subadult observations, and 799 larvae observations during visual encounter surveys (VES) each year from 2014 to 2020 (**Figures 5 and 6**). The large SNYLF population allows for translocating a subset of adult frogs to establish new SNYLF populations nearby. The Desolation Wilderness ABMP identifies 4-Q Lakes (located 3.5 km to the southeast; **Figure 1**) as a site to receive SNYLF translocated from the Highland Lake drainage (CDFG 2012). 4-Q Lakes provide an interconnected, fishless aquatic basin that may provide the foundation for establishing another healthy SNYLF population in the Upper Rubicon drainage.

From at least 1931 until 2000, CDFW regularly stocked the three largest 4-Q Lakes with Brook Trout (*Salvelinus fontinalis*; BK). During overnight gill net surveys in 2003, CDFW field staff captured six BK in the basin. However, subsequent gill net surveys in 2010 (one-night net set) and 2016 (one-month net set) returned zero fish, confirming that BK were not self-sustaining.

In addition to gill net surveys, CDFW completed VES of the entire 4-Q Lakes basin to check for potential occupancy by fish, SNYLF, or other special status herpetofauna. VES conducted by CDFW in 2003, 2015, and 2018 resulted in no SNYLF observations, although field staff did observe other amphibian and reptile species. Therefore, CDFW and ENF personnel had not observed SNYLF in 4-Q Lakes basin during any surveys prior to translocations in 2018. Given the habitat composition and relative nearness of extant populations, SNYLF likely occupied 4-Q Lakes before fish stocking began in 1931. However, CDFW is not aware of any museum or earlier survey records to confirm former SNYLF occupancy in 4-Q Lakes basin.

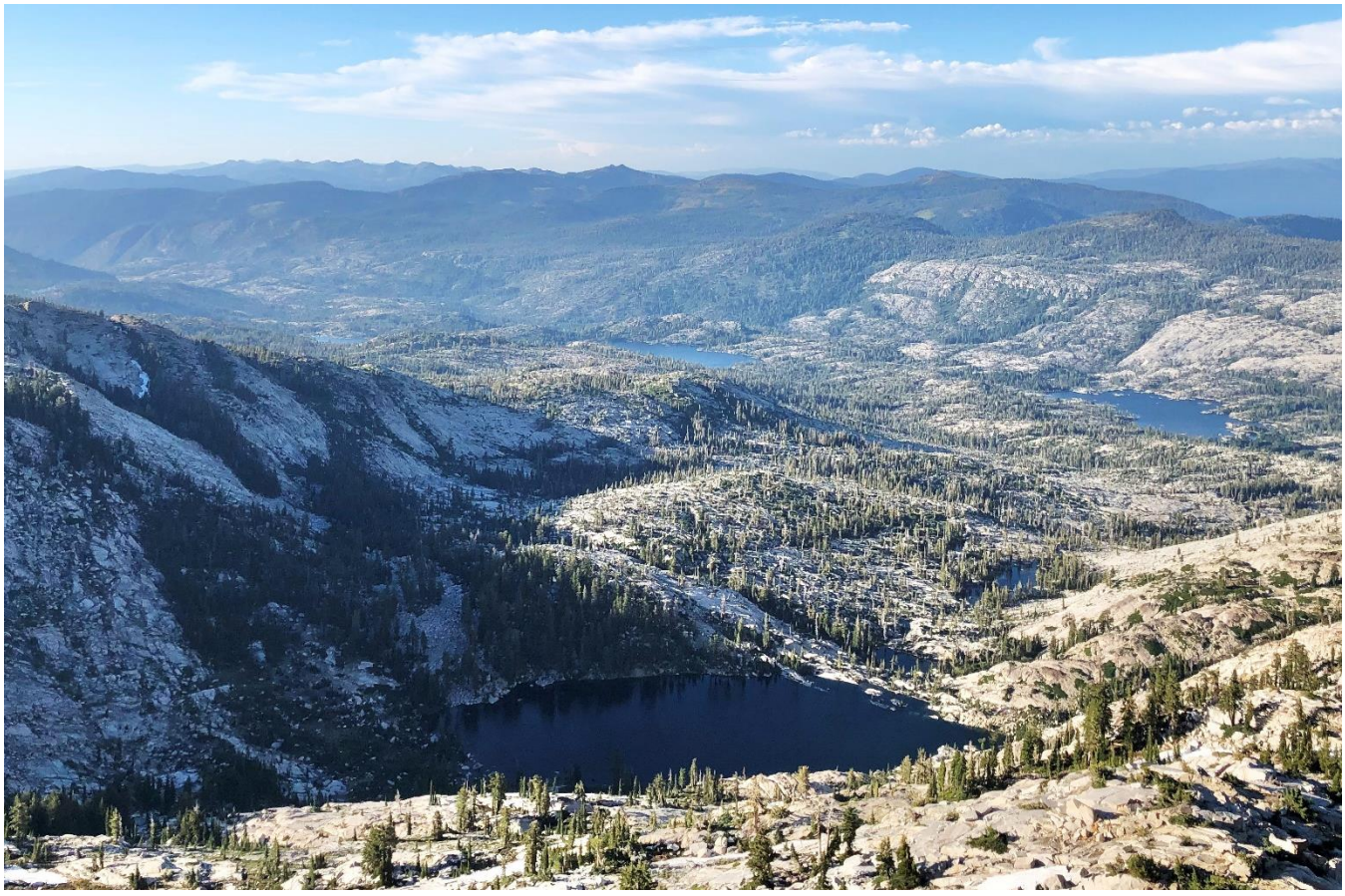


Figure 2. Highland Lake (foreground) and Rockbound Lake (background, center) on 7 August 2019, looking northeast. (CDFW)

Figure 3. An aggregation of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) at Highland Lake on 26 June 2018. (CDFW)

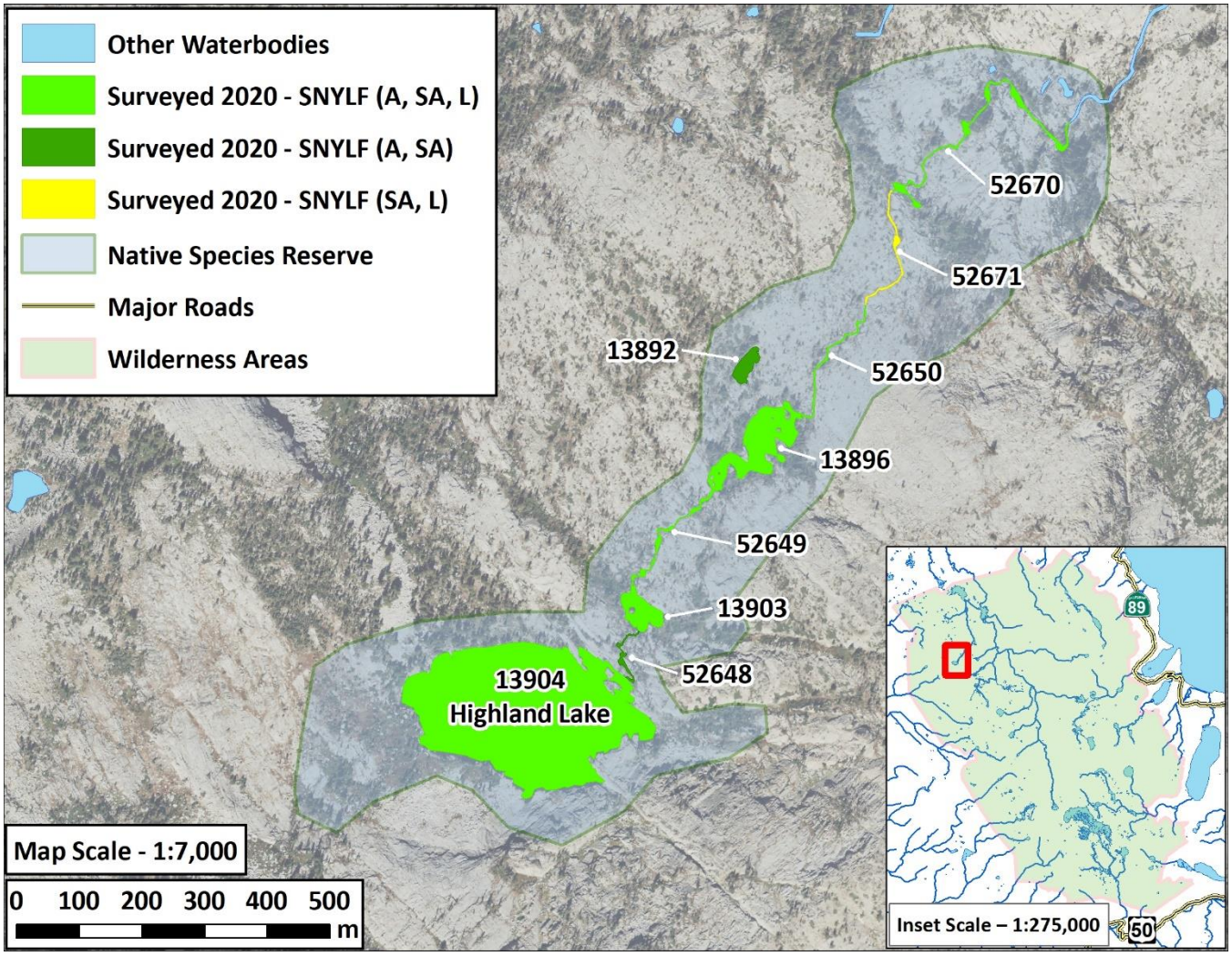


Figure 4. Highland Lake Native Species Reserve (NSR). CDFW staff have observed Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) throughout the drainage. During VES in August 2020, SNYLF were observed in all sites surveyed. Since results reported in 2019, CDFW updated several existing GIS polygons to more accurately reflect the composition of the depicted waterbodies. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: “A” = adults, “SA” = subadults, and “L” = larvae. Number labels shown are unique site identification codes that CDFW uses for data collection. All flowing waters drain northeast into Rockbound Lake (not shown).

THREATS

Disease

All SNYLF populations in El Dorado County are positive for chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*). CDFW sampled Site IDs 13903 and 13896 in 2009 and 2010 using epithelial swabs and had the swabs screened for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. Staff collected eight swabs and results from both years detected very light to moderate *Bd* infection intensity. In 2019, CDFW staff collected an additional 26 SNYLF epithelial swabs at Highland Lake (Site ID 13904). In fall 2020, 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 either no *Bd* (n = 6), or very light (n = 8), light (n = 9), to moderate infection (n = 3). These designations of infection intensity are subjective; however, no swabs collected from SNYLF at Highland Lake in 2019 had high *Bd* loads (i.e., *Bd* loads high enough to suspect increased likelihood of mortality from severe chytridiomycosis).

Loss of Genetic Diversity

VES data suggest that the Highland Lake drainage SNYLF population was very small and only recently underwent expansion. This potential population bottleneck may have resulted in negative genetic consequences for the population, including loss of genetic diversity, inbreeding depression, and fixation of deleterious alleles (Frankham et al. 2009). However, the true size of the Highland Lake drainage population, during the time-period when it was smallest, is unknown. Population genetic analyses are necessary to estimate the degree of genetic bottlenecking, if any.

Isolation

Geographic isolation can limit potential for gene flow between populations and increases risk of local extirpation. Isolated populations and small populations can suffer from similar negative genetic effects. Fortunately, the Highland Lake drainage population is not completely isolated. There are a few SNYLF populations relatively close to Highland Lake (including Lake Zitella, McConnell Lake, and Leland Lakes). Lake Zitella is the only location SNYLF could conceivably immigrate from in the near term, but the other populations are close enough to allow for rare instances of gene flow. This situation contrasts SNYLF populations at the northern extent of the species' range, most of which are greatly isolated from one another.

Introduced Fish

Highland Lake, its outlet, and two small ponds along the outlet stream formerly supported a small RT population. The main lakes in 4-Q Lakes basin also formerly contained BK, although the populations were not self-sustaining. Trout prey on SNYLF and are a potential source of competition for food (e.g., benthic macroinvertebrates). Additionally, RT may have been limiting successful SNYLF breeding and recruitment in Highland Lake and the ponds below, which supply the only deep-water habitat in the basin. In the absence of stocking, RT abundance declined, but sufficient natural reproduction was occurring in the inlet to Highland Lake and the upper segment of outlet stream to sustain a small trout population. Barriers to upstream fish

movement (e.g., the Highland Lake dam and natural waterfalls) impeded or excluded trout living in stream segments and ponds from moving into Highland Lake. Trout are still present below the natural barrier that demarcates the downstream end of the NSR. Illegal movement of trout into the stream channel above the barrier, the NSR ponds, or Highland Lake presents a potential extirpation risk for SNYLF. However, CDFW has mitigated the immediate threat from trout predation through fish removal efforts.

POPULATION STATUS: RESULTS

Although CDFW did not detect SNYLF in the watershed prior to 2008, ENF staff have been monitoring this population since 1993 (USFS 1993). VES data between 2013 and 2020 confirm that the population has increased dramatically (**Figures 5 and 6**). As the RT population declined, CDFW staff observed SNYLF moving into previously unoccupied microhabitats. Notably, as the RT population diminished, staff observed a large increase in tadpoles, particularly at Highland Lake, suggesting SNYLF have begun to successfully utilize additional breeding habitats.

In October 2014 and July 2015, CDFW staff observed SNYLF at two shallow ponds in which staff had not previously observed frogs. Coincidentally, nearby Lake Zitella (2 km southeast of the Highland Lake drainage) experienced a similar increase in SNYLF observations (CDFW 2020b). On 30 July 2015, CDFW and ENF staff surveyed all sites in the NSR. Results suggested a large increase in SNYLF abundance in the area (**Figures 5 and 6**). In 2016, CDFW field staff surveyed all sites in the NSR three times. In addition to observing another large increase in frogs, staff observed three egg masses in Highland Lake on 26 June 2016. Staff observed another single egg mass in Highland Lake in 2019. Prior to fish removal, field staff only observed egg masses in the outlet ponds, where the potential for desiccation or overwinter freezing reduced the likelihood that the larvae would recruit into the adult population.

On 29 August 2017, CDFW staff surveyed all sites along the outlet stream except Site ID 13892, an off-channel pond not directly connected to the Highland Lake outlet (**Figure 4**). Less than two weeks later (10 September 2017), CDFW staff surveyed Highland Lake. Survey conditions were adequate during all 2017 surveys. However, there was consistent wind, including occasional strong gusts, on the day staff surveyed Highland Lake. The wind resulted in poor visibility, which likely accounts for the much lower number of SNYLF available for detection when compared with previous years.

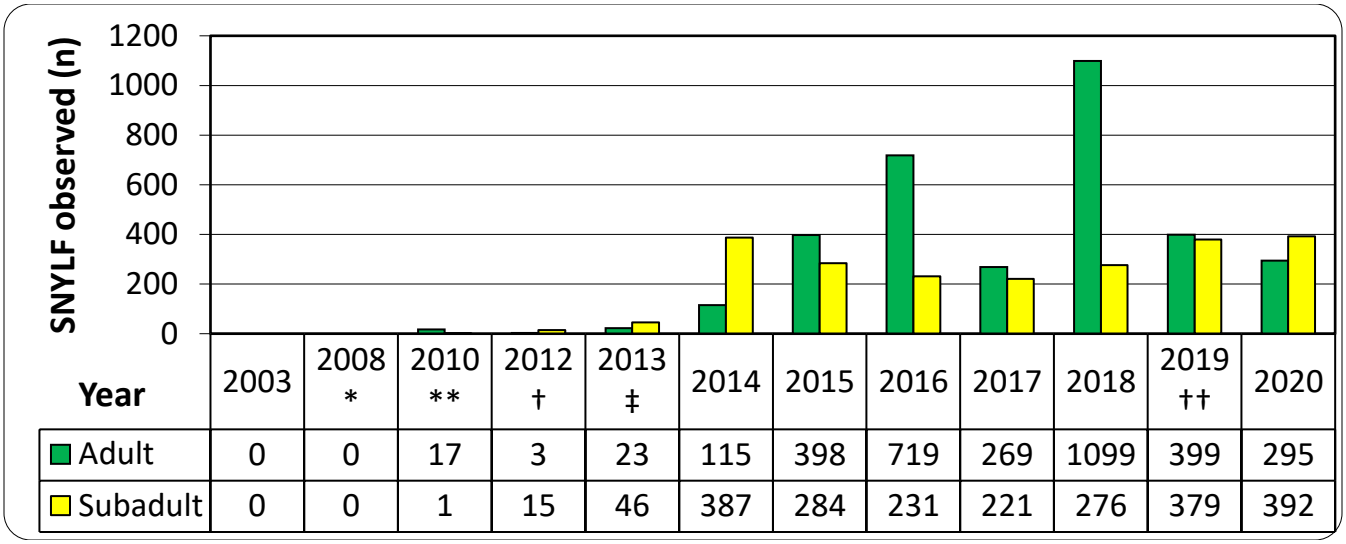
On 26 June 2018, CDFW staff surveyed the entire NSR (**Figure 4**). The goals of the VES were to determine the current population status and to estimate the number of adult SNYLF available for translocation to 4-Q Lakes the following week (CDFW 2020a). Survey conditions were sunny and warm, but light wind obscured visibility into the water. Despite the wind, field staff observed hundreds of SNYLF.

On 7 August 2019, CDFW staff, with assistance from ENF staff, surveyed all waterbodies in the NSR except the two most downstream segments of the Highland outlet stream, Site IDs 52670 and 52671 (**Figure 4**). The goals were the same as surveys in 2018: determine the current population status and estimate the number of adult SNYLF available for translocation to 4-Q

Lakes the following day. CDFW and ENF staff observed fewer SNYLF adults and larvae in 2019 when compared with 2018 (**Figures 5 and 6**). Despite fewer adult and larval SNYLF observations, CDFW observed more subadults in 2019 than in any prior year except 2014, during which CDFW staff observed comparable numbers of SNYLF subadults.

On 11 August 2020, CDFW staff surveyed the entire Highland Lake drainage (i.e., all waterbodies highlighted in **Figure 4**). Conditions were not ideal for VES. As often occurs in the Highland Lake drainage, consistent winds, including frequent strong gusts, were present on the survey day. These were similar circumstances to conditions experienced by CDFW staff during surveys in 2017. The wind likely played a large role in lower overall SNYLF detections when compared with the previous three years. Strong winds greatly limit visibility into the water for observing tadpoles and post-metamorphic frogs resting on the substrate. Additionally, high winds and frequent gusts appear to reduce basking behavior of post-metamorphic SNYLF, when compared with calmer conditions (pers. obs.). Therefore, the lower SNYLF detections in 2020 are very likely the result of environmental factors, rather than population decline.

Monitoring should continue to assess the long-term status of the Highland Lake drainage SNYLF population. During the next several years, CDFW plans to continue monitoring Highland Lake at least once per year. During translocation efforts, CDFW staff will also survey 4-Q Lakes, the translocation recipient site, multiple times each summer to monitor the status of the translocated SNYLF population. CDFW is planning another round of translocations, using the same methods implemented in 2018 and 2019, during summers 2021 and 2022, during which CDFW field staff plan to visit 4-Q lakes at least twice annually for VES (see details in the SNYLF TRANSLOCATION section below).



Year	2003	2008 *	2010 **	2012 †	2013 ‡	2014	2015	2016	2017	2018	2019 ††	2020
Adult	0	0	17	3	23	115	398	719	269	1099	399	295
Subadult	0	0	1	15	46	387	284	231	221	276	379	392

Figure 5. Number of adult and subadult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) in the Highland Lake drainage between 2003 and 2020. From 2014 to 2018, and in 2020, surveys occurred throughout the entire drainage, including Highland Lake, the outlet stream, and the two downstream ponds.

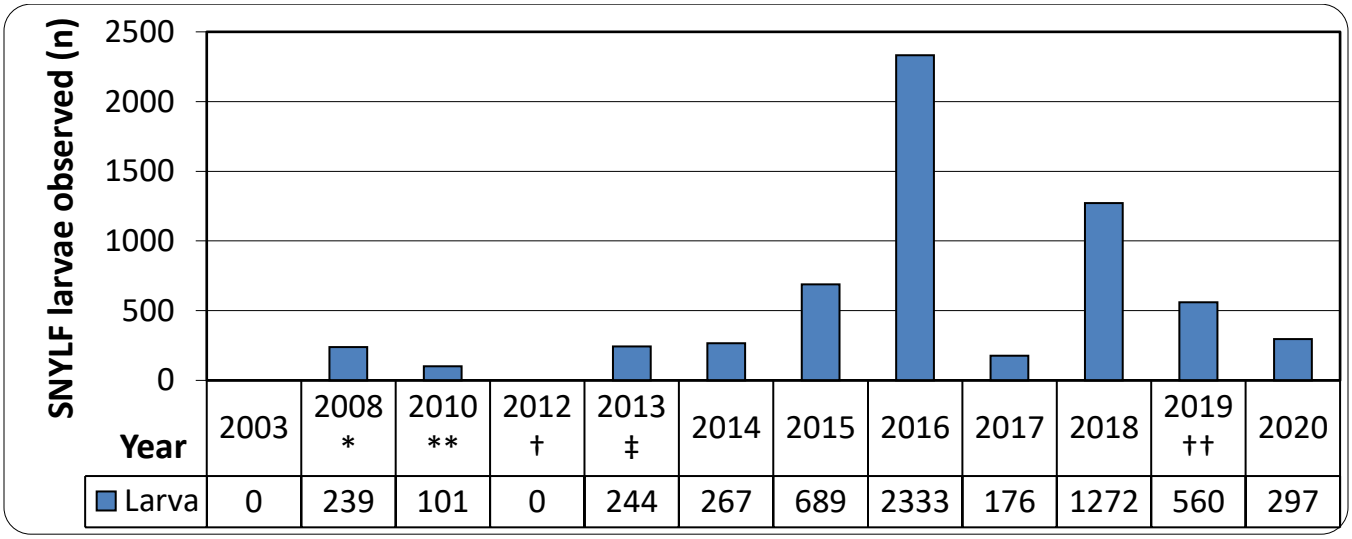
*2008 surveys only included Highland Lake and the larger downstream pond (Site ID 13896).

**Surveys in 2010 only included the two stream ponds (Site IDs 13896 and 13903).

†CDFW did not conduct formal surveys in 2012 (staff only noted anecdotal observations during gill net setting).

‡Surveys in 2013 only include Highland Lake and the two downstream ponds.

†† CDFW did not survey Site IDs 52670 and 52671 in 2019.



Year	2003	2008 *	2010 **	2012 †	2013 ‡	2014	2015	2016	2017	2018	2019 ††	2020
Larva	0	239	101	0	244	267	689	2333	176	1272	560	297

Figure 6. Number of larval Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) in the Highland Lake drainage between 2003 and 2020. (See **Figure 5** for caveats about surveys between 2008 and 2019.) Steady winds and occasional strong gusts during the Highland Lake survey on 10 September 2017, 7 August 2019, and 11 August 2020 made visibility into the lake difficult, which may account for the low larval SNYLF observations when compared with other recent survey years.

POPULATION STATUS: DISCUSSION

As part of a larger project to inventory fish and native amphibians throughout the Sierra Nevada (CDFG 2012), fish stocking at Highland Lake ceased in 2000. The decision to manage the watershed for native species, rather than fish, occurred years before active fish removal began. Based on the small number of RT captured during active removal, the fish population declined soon after CDFW stopped aerial plants at Highland Lake. Therefore, the SNYLF population increase may be partly attributable to the decrease in fish numbers in the absence of stocking. A decline in the RT population allowed SNYLF to begin breeding and feeding with less interference from an efficient predator. The observation of larval SNYLF in Highland Lake in 2008—four years before active fish removal began—supports this idea.

SNYLF benefitted from reduced fish densities in the watershed, but the subsequent population increase in a *Bd*-positive environment was initially uncertain, given the high variability in *Bd*-positive SNYLF population dynamics (Briggs et al. 2010). However, recent SNYLF population monitoring in other areas of the Sierra Nevada suggests that *Bd*-positive SNYLF populations can rebound in the absence of other stressors, such as trout (Knapp et al. 2016). In addition to fish removal, other environmental factors may have helped the SNYLF population rebound, including short winters, increased temperatures, and increased food availability during the 2012–2015 drought. Regardless, monitoring efforts over an eighteen-year period demonstrate that the SNYLF population in the Highland Lake watershed has made a dramatic comeback since management in the area switched from a focus on non-native trout stocking to a focus on restoring habitat for native amphibians.

Adult and larval SNYLF observations in the Highland Lake NSR in 2020 were fewer than those in the previous two years, and well below the average number of observations during VES from 2014 to 2019. The SNYLF population may be declining for unknown reasons. However, CDFW does not think the population is currently in decline because survey conditions are likely an important factor explaining differences in SNYLF detections. In 2020, skies were clear and air temperatures were warm, but steady winds with frequent strong gusts limited visibility into the water. Steady wind, which is common at Highland Lake, makes it especially difficult to see tadpoles in deeper water, and can reduce basking of post-metamorphic frogs. Similarly, winds during VES in 2017 and 2019 were often high, and CDFW staff observed fewer SNYLF, when compared with years during which less wind occurred during CDFW surveys at Highland Lake (e.g., 2016 and 2018).

In discussing results from 2019, CDFW guessed that harsh winter conditions may have partially accounted for lower SNYLF observations in 2019 (CDFW 2020a). However, this explanation is unlikely a factor for the comparatively lower observations during VES in 2020. The northern Sierra Nevada experienced below average total precipitation (CDEC 2020a) and snow water content (CDEC 2020b) during winter 2019–2020. Poor SNYLF survivorship is known to occur during long, harsh winters (Bradford 1983). However, winter conditions cannot fully account for the between year variability in SNYLF observations in the Highland Lake drainage. For example, if harsh winter conditions in 2016–2017 were the primary reason behind the low number of

SNYLF observed in September 2017, far fewer adult SNYLF would have been available for detection during CDFW surveys in June 2018 (**Figures 5 and 6**). Although another winter with above average precipitation and snowpack in 2018–2019 correlates with lower SNYLF detections the following summer, VES results from the past several years suggest that weather conditions on the day of surveying may be the largest environmental influence on between-year differences in SNYLF detections in the Highland Lake drainage.

Overall, visual encounter survey results can be difficult to compare, due to numerous factors, including weather conditions, time of year, and observer bias (Mazerolle et al. 2007). A particularly instructive example occurred in summer 2016, during which CDFW conducted three separate surveys of the Highland Lake drainage, in June, August, and September. When compared with other recent years, the June and September 2016 surveys at Highland Lake resulted in relatively few SNYLF detections (82 frogs and 13 larvae, then 130 frogs and 1 larva, respectively). These detection rates were comparable to observations at Highland Lake in September 2017 (102 frogs and 32 larvae). However, the August 2016 survey of Highland Lake resulted in dramatically higher SNYLF detections (693 frogs, 2,008 larvae). The higher SNYLF detections in August may have resulted from excellent survey conditions, coincidental timing with the height of summer SNYLF activity in the basin, more attentive surveying, or a combination of factors. These results help emphasize that VES are a helpful measure for quickly and cost-effectively determining general population status of SNYLF, but proper interpretation of the results requires consideration of the assumptions inherent with VES (Heyer et al. 1994).

In 2021, CDFW will again survey the entire Highland Lake drainage, including the lower stream segments. Additionally, CDFW plans to have field staff survey further downstream of previously monitored portions of the Highland Lake outlet stream, to determine if there may be resident SNYLF occurring farther down the drainage. If possible, CDFW plans to survey the basin during calmer conditions than those present during surveys in 2020, particularly because the results of pre-translocation VES will dictate the number of adult SNYLF that may be collected for translocation to 4-Q Lakes.

SNYLF TRANSLOCATION

For complete details about the translocations of SNYLF from Highland Lake to 4-Q Lakes in 2018 and 2019, including background on the translocation recipient site, consult the survey memo for the 2019 Highland-4Q Lakes VES and translocation (CDFW 2020a). Described below is a summary of the previous translocation efforts.

Translocation Summary

CDFW conducted two translocations of adult SNYLF from Highland Lake to 4-Q Lakes (**Figure 7**). The first, which took place in July 2018, involved moving 60 adults (26 males and 34 females); the second, which took place in August 2019, involved moving 40 adults (18 males and 22 females). Staff intentionally collected a female-biased sample to increase the odds of successful reproduction at the recipient site. Before each translocation, CDFW and ENF field staff conducted VES of the entire upper Highland Lake drainage to determine the current relative abundance of the SNYLF population (described in detail in the POPULATION STATUS: RESULTS and DISCUSSION sections above). In general, the interagency technical team recommends removing no more than 10% of observed adults at the source population per year (MYLF ITT 2018, Attachment 3). Given high reproductive potential and the inability to detect all individuals during VES, the 10% threshold is likely conservative (MYLF ITT 2018, Attachment 3). Therefore, if field staff observed fewer than 200 adult SNYLF in the Highland Lake drainage, less than 20 adults could be collected for the translocation. Given the time, effort, and coordination needed to accomplish these actions, CDFW managers have decided that it may not be worthwhile to undertake a translocation with fewer than 20 adult SNYLF. Conversely, to allow for adequate time for capture, processing, and moving in the same day, CDFW decided to collect a maximum of 60 adult SNYLF.

For each translocation, field staff collected adults (**Figure 8**) via hand capture or dip nets, identified sex, implanted a passive integrated transponder (PIT) tag to provide a unique identifier for each individual, measured snout-to-urostyle (SUL) length, and recorded weight (**Figure 9**). Staff placed each frog into its own plastic container with multiple holes for ventilation and stored the containers on snow in the shade to prevent frogs from overheating (**Figures 10 and 11**). Once the collection was complete, staff packed the contained frogs into hard-sided plastic bear-proof canisters. Staff then placed the canisters into backpacks, along with bagged snow and foam insulating pads, to maintain cool temperatures for the frogs during transport. Staff also placed digital temperature loggers inside of the canisters to provide constant temperature read-outs. Once securely packed, the field staff hiked the frogs for approximately 2 hours to 4-Q Lakes **(Figures 7 and 12**). Once at the site, staff released frogs at three different release points along the southern shore of the middle 4-Q Lakes (Site IDs 13922 and 13932; **Figures 13–15**). All frogs appeared healthy upon release.

CDFW did not undertake any frog translocations in 2020. However, field staff visited 4-Q Lakes twice to monitor the SNYLF population (described below).

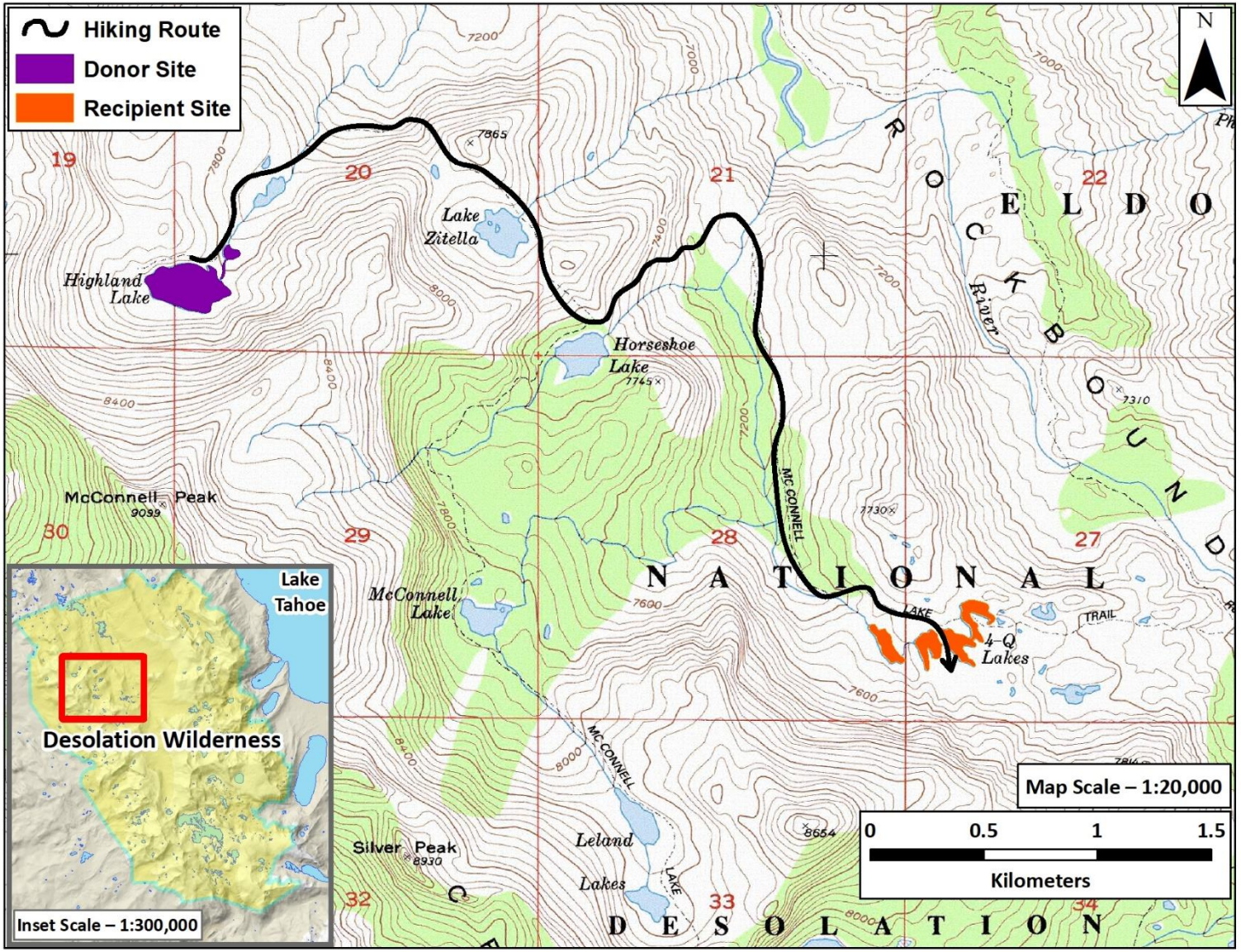


Figure 7. Path of travel for the Sierra Nevada Yellow-legged Frog (*Rana sierrae*) translocations from Highland Lake (donor site) to 4-Q Lakes (recipient site). Travel distance between the two sites via the route shown is approximately 6 kilometers (3.7 miles). The hike takes about two hours to complete.

Follow-up Surveys

During each summer from 2018–2020, CDFW staff conducted post-translocation surveys to assess if the frogs: 1) had moved from the original release sites, 2) appeared in good health, 3) were behaving normally, and 4) had successfully reproduced. In addition to the translocations, CDFW revisited 4-Q Lakes twice during each year, 2018–2020 (**Table 1**).

In 2020, CDFW surveyed 4-Q Lakes basin on 16–17 June and 11–12 August. During each visit, staff surveyed the main 4-Q Lakes, any nearby ponds that retained water (i.e., those within ~250 meters of the main lakes), and the outlet stream. CDFW staff observed 20 SNYLF individuals in June (six males and 14 females) and 16 or 17 SNYLF individuals in August (six or seven males and 10 females). The only reason for the uncertainty in the number of individuals observed in August is because the PIT tag of two adult male SNYLF captures (one on 11 August, another on 12 August) would not properly scan. CDFW staff think it is very likely both captures were the same individual frog because the locations of each capture were relatively close together and both captures were a frog of the same sex, weight, and SUL. Therefore, all subsequent summary data presented here consolidates those two observations into one individual frog detection.

Of the SNYLF observed in June, six were also captured in August. Therefore, combining both surveys, CDFW observed 30 (10 males and 20 females) of the total 100 released adult SNYLF in 2020. Of these 30 frogs, six were translocated to 4-Q in 2018, 22 were translocated to 4-Q in 2019, and the translocation year of two is unknown. The translocation year of two frogs was unknown because one had an unreadable PIT tag and another had a PIT tag number that was not originally recorded among translocated frogs. (The different PIT tag number is likely attributable to user and/or equipment error during the tagging and recording process.) When combining data for all follow-up surveys at 4-Q Lakes from 2018–2020, CDFW has observed 54 of the 100 released adult SNYLF individuals at least once (**Table 1**). Thirty of those frogs were last seen in 2020, 10 were last seen in 2019, and 14 were last seen in 2018.

In keeping with the female-skewed sex ratios for the releases (1.27 females:1 male), sex ratios among recaptures during follow-up surveys have been dominated by females. During post-translocation surveys from 2018–2020, CDFW has observed a total of 32 female and 22 male individuals. These ratios among overall recaptures (1.45 females:1 male) closely correspond with the sex ratios of total released frogs (1.27 females:1 male). However, among recaptures in 2020, the sex ratio was even more female-dominated, with a sex ratio of 2 females:1 male.

All frogs detected during follow-up surveys at 4-Q Lakes have appeared to be healthy and behaving normally. Additionally, all recaptured SNYLF have grown noticeably since their initial translocation, suggesting that SNYLF are healthy and feeding well in their new habitat. Growth, in terms of increased SUL and mass, was particularly pronounced in females, which grew approximately twice as much as males (**Table 2**). In fact, among SNYLF recaptures originally released in 2019, the difference in mass at translocation and mass in 2020 was about three times as large in females when compared with males (**Table 2**). Finally, SNYLF released at 4-Q Lakes have continue to spread throughout from their original release points and now occupy many areas in 4-Q Lakes basin (**Figure 15**).

Table 1. Dates of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) translocations and follow-up surveys at 4-Q Lakes, Desolation Wilderness, between 2018 and 2020; and number of adult SNYLF translocated or recaptured during each event. SNYLF numbers shown in each row (females, males, and total) are the number of unique individuals recaptured during each visit (i.e., not capture events, since some SNYLF individuals were caught more than once during each trip). The grand total row displays total SNYLF individuals that have been recaptured at least once since the first follow-up survey in July 2018. For tallies in 2020 showing the original year of translocation (in grey), CDFW omitted two individuals because one had an unreadable passive integrated transponder (PIT) tag and another had a PIT tag number that was not originally recorded among translocated frogs. (The different PIT tag number is likely attributable to user and/or equipment error during the tagging and recording process.)

Year	Dates	Females	Males	Total	Notes
2018	**3 July**	**34**	**26**	**60**	**Translocation #1**
2018	17–18 July	5	7	12	
2018	21 Aug	13	2	15	
2018		***14***	***8***	***22***	***Total individuals observed in 2018***
2019	6 Aug	5	4	9	
2019	**8 Aug**	**22**	**18**	**40**	**Translocation #2**
2019	4 Sept	10	9	19	
2019	*4 Sept*	*2*	*2*	*4*	*Frogs released in 2018; all 4 also seen on 6 Aug 2019*
		8	*7*	*15*	*Frogs released in 2019*
2019		***13***	***11***	**24**	***Total individuals observed in 2019***
2020	16–17 June	14	6	20	
2020	11–12 Aug	10	6	16	
2020	*Combined*	*4*	*2*	*6*	*Frogs released in 2018*
		15	*7*	*22*	*Frogs released in 2019*
		1	*1*	*2*	*Frogs with unknown release year (see table heading)*
2020		***20***	***10***	***30***	***Total individuals observed in 2020***
	2018–2020	*16*	*11*	*27*	*Frogs released in 2018*
		15	*10*	*25*	*Frogs released in 2019*
		1	*1*	*2*	*Frogs with unknown release year (see table heading)*
		32	***22***	***54***	***Grand total individuals recaptured at 4-Q: 2018–2020***

Table 2. Average growth summary statistics—partitioned by sex (F = female, M = male)—for adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) translocated from Highland Lake to 4-Q Lakes in 2018 and 2019. Measurements displayed are original ("trans" = measurement on the day of translocation) and most recent ("2020" = measurement taken during most recent capture event in July or August 2020) average snout-to-urostyle length (SUL, in mm) and average weight (mass, in g) of the 28 unique individuals captured in 2020 for which California Department of Fish and Wildlife (CDFW) had original measurements. CDFW omitted two individuals recaptured at 4-Q Lakes in 2020 because one had an unreadable passive integrated transponder (PIT) tag and another had a PIT tag number that was not originally recorded among translocated frogs. (The different PIT tag number is likely attributable to user and/or equipment error during the tagging and recording process.) Both SUL and mass have a column showing the difference between the original and most recent measurements of each row ("diff"). The first column displays the number of individual SNYLF measurements incorporated in each average value within a row. All adult SNYLF measured in 2020 had grown substantially since being translocated. On average, among individuals that were recaptured, females had grown at least twice as much as males since translocation, in both SUL and mass.

sex (year translocated); sample size	*SUL (trans)*	*SUL (2020)*	*SUL (diff)*	*Mass (trans)*	*Mass (2020)*	*Mass (diff)*
F (all); n = 19	52.8 mm	65.9 mm	+13.1 mm	19.2 g	33.7 g	+14.5 g
M (all); n = 9	51.3 mm	58.7 mm	+7.4 mm	16.9 g	22.3 g	+5.4 g
F (2018); n = 4	46.4 mm	69.0 mm	+22.6 mm	13.6 g	37.8 g	+24.2 g
M (2018); n = 2	48.2 mm	60.5 mm	+12.3 mm	12.5 g	24.5 g	+12 g
F (2019); n = 15	54.5 mm	65.1 mm	+10.6 mm	20.7 g	32.7 g	+12 g
M (2019); n = 7	52.2 mm	58.1 mm	+ 5.9 mm	18.2 g	21.7 g	+3.5 g

Reproduction

Since this translocation project began, one of the benchmarks CDFW established for achieving initial success was seeing signs of successful SNYLF reproduction at 4-Q Lakes. Fortunately, during the survey trip in June 2020, field staff observed a recently hatched SNYLF egg mass at Site ID 13922 (**Figure 16**) and one large tadpole, which evaded follow-up detection. During the second visit in August, CDFW staff observed more early life stage SNYLF, including at least five tadpoles and 14 subadults. The total number of tadpoles and subadults is not known because these life stages are unmarked. However, when totaling counts of early life stage SNYLF detections from one pass of each waterbody during the same survey day, the total is 5 larvae and 14 subadults.

These observations are particularly exciting because they provide definitive evidence that the newly established SNYLF population at 4-Q Lakes is successfully reproducing. Additionally, the presence of subadults in August 2020 strongly suggests that reproduction first occurred at 4-Q Lakes in early 2019 (given that SNYLF often require at least one winter before metamorphosis), which was the first opportunity that newly translocated SNYLF would have been able to breed. The SNYLF breeding season typically occurs in late spring/early summer (depending on conditions at the site). Therefore, SNYLF translocated in summer 2018 would not have first bred until late spring 2019 at the earliest.

Looking ahead: 2021

CDFW was recently awarded a new federal grant via the USFWS endangered species recovery grant program (Section 6 of the U.S. Endangered Species Act of 1973; Federal Grant Award #F21AP00483-00) to continue this work. Therefore, in summer 2021, CDFW and ENF staff plan to visit Highland Lake in early summer to survey the drainage and obtain current information on the relative abundance of SNYLF in the basin. These surveys will determine how many adults may be available for a third translocation. If field staff observe at least 200 adults in the Highland Lake drainage, CDFW will once again undertake another translocation, using the same methods described earlier. The new Section 6 grant will also provide funding for another translocation in summer 2022, plus consistent follow-up surveys annually for the next three years (2021–2023) to maintain detailed demographic information on 4-Q Lakes populations.

For each adult captured during monitoring visits to 4-Q Lakes, staff will record PIT tag, sex, location coordinates, weight, and length measurements (staff will only record weight and length measurements once per season for each individual). Now that new SNYLF recruitment may be occurring, beginning in 2021, CDFW will PIT tag any new adults observed at 4-Q Lakes. These data will be used for capture-mark-recapture (CMR) analysis to determine abundance and survivorship in the SNYLF population more accurately (Mazerolle et al. 2007). CDFW plans to visit 4-Q Lakes at least twice following the translocation planned for 2021. Correspondingly, even if field staff find that the number of adult SNYLF available in the Highland Lake drainage is below the threshold needed to undertake a translocation without risking harm to the source population, CDFW will still carry out monitoring surveys at 4-Q Lakes. Given the conservation importance of this population, CDFW needs current information obtained by yearly monitoring.

Figure 8. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake in summer 2019. (CDFW)

Figure 9. CDFW field staff weighing an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake in 2018. (CDFW)

Figure 10. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) inside its individual transport container. Field staff housed each adult SNYLF inside one of these containers, in which there were ventilation holes and a piece of wetted, unbleached paper towel to help retain moisture during transport. Lids with ventilation holes covered containers during storage and transport. (CDFW)

Figure 11. Adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF), housed inside plastic containers sitting inside hard-sided plastic bear canisters, awaiting translocation to 4-Q Lakes. Field staff kept SNYLF in the shade and on snow to remain cool during captivity. (CDFW)

Figure 12. California Department of Fish and Wildlife (CDFW) and Eldorado National Forest (ENF) field staff carrying Sierra Nevada Yellow-legged Frog (*Rana sierrae*) adults (housed individually inside bear canisters, inside backpacks) from the Highland Lake drainage to 4-Q Lakes on 3 July 2018. (CDFW)

Figure 13. California Department of Fish and Wildlife (CDFW) staff member releasing an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at 4-Q lakes on 8 August 2019. (CDFW)

Figure 14. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) soon after being released at 4-Q Lakes on 8 August 2019.

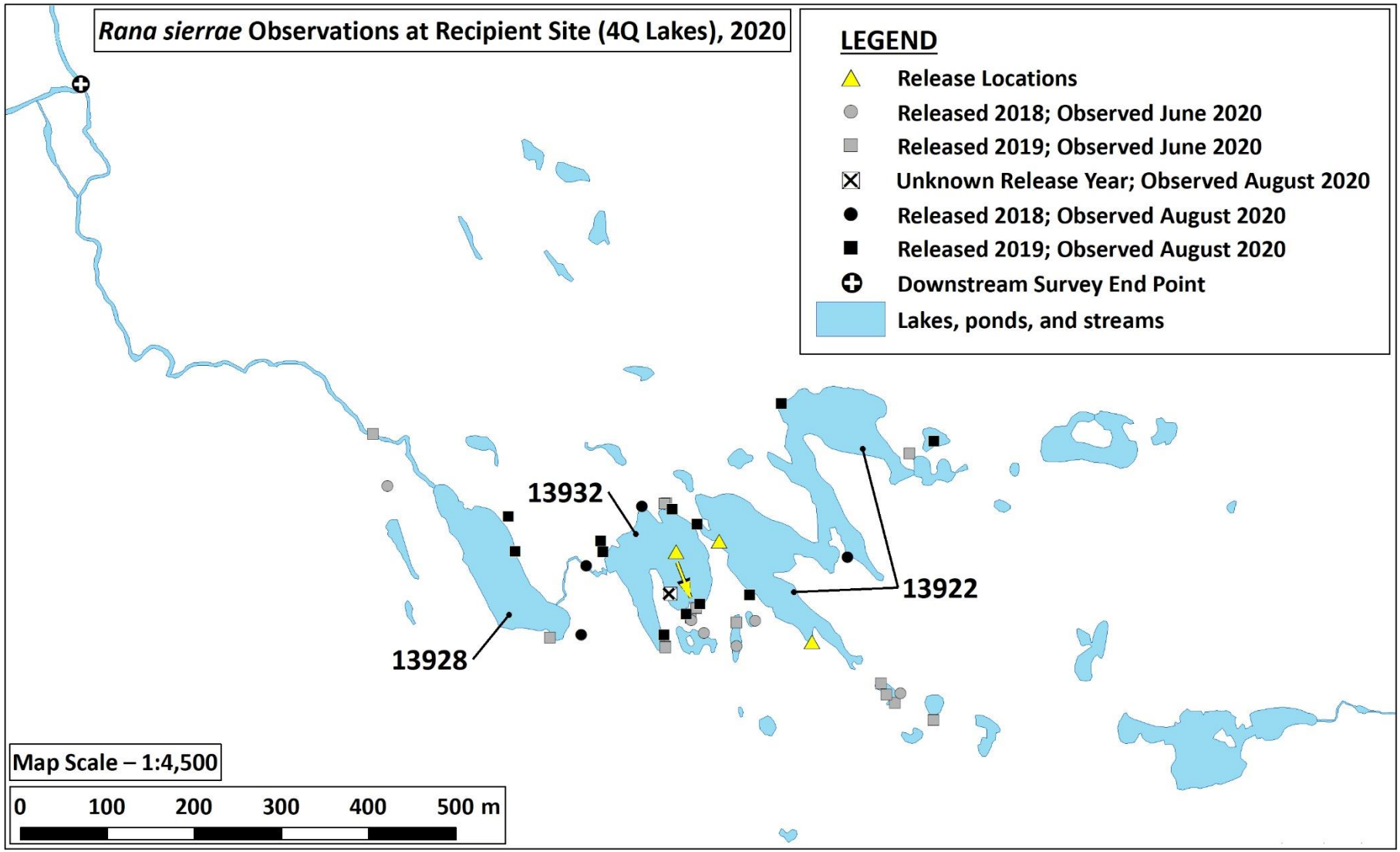


Figure 15. [See figure caption on the next page.]

Figure 15 (continued). Map showing locations of all adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) individuals detected by California Department of Fish and Wildlife (CDFW) field staff during visual encounter surveys (VES) in 2020. Number labels shown are unique site identification codes that CDFW uses for data collection. Since results reported in 2019, CDFW updated several existing polygons, and added other small ponds to the GIS layer, to reflect the composition of the depicted waterbodies more accurately. The map shows locations where adult SNYLF translocated from Highland Lake were released in 2018 (n = 60; 26 males, 34 females) and 2019 (n = 40; 18 males, 22 females) (yellow triangles; in 2020, several SNYLF observations occurred close to the western release site, so the triangle icon is offset and a yellow arrow points to the release location).

CDFW conducted surveys on 16–17 June 2020 (grey shapes) and 11–12 August 2020 (black shapes). CDFW staff observed 20 SNYLF individuals in June (grey circles indicate frogs released in 2018, grey squares indicate frogs released in 2019) and 16 or 17 SNYLF individuals in August (black circles indicate frogs released in 2018, black squares indicate frogs released in 2019; and the square with an "X" indicates the SNYLF with an unreadable passive integrated transponder [PIT] tag; see below). Of the SNYLF observed in June, six or seven were also captured in August. Therefore, combining both surveys, CDFW observed 30 or 31 of the total 100 released adult SNYLF (30 or 31% of released frogs) in 2020. The only reason for the uncertainty in the number of individuals observed is because the PIT tag of two adult SNYLF captured in August would not properly scan. CDFW staff think it is very likely both captures were the same individual frog (i.e., the captures occurred on different days, but the locations of each capture were relatively close together and both captures were a frog of the same sex, weight, and snout-to-urostyle length).

Figure 16. Photo of a recently hatched out Sierra Nevada Yellow-legged Frog (*Rana sierrae*) egg mass at Site ID 13922 on 17 June 2020.

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