State of California
Department of Fish and Wildlife

Memorandum

Date: 3 March 2020

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

From: Isaac Chellman, Environmental Scientist;
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High Mountain Lakes;
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Subject: Native amphibian restoration and monitoring in Desolation Wilderness; *Rana sierrae* monitoring and translocation at Highland Lake and 4-Q Lakes.

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 2019 suggest a large and robust SNYLF population. For the past several years, the Highland Lake drainage SNYLF population has contained a sufficient number of adults to provide a source for translocations to nearby fishless aquatic habitat that is 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, CDFW and Eldorado National Forest (ENF) staff biologists translocated SNYLF adults from the Highland Lake drainage to 4-Q Lakes. CDFW and ENF repeated these translocation efforts in August 2019. Additionally, CDFW will continue yearly amphibian monitoring to document SNYLF population status at both donor and recipient sites.

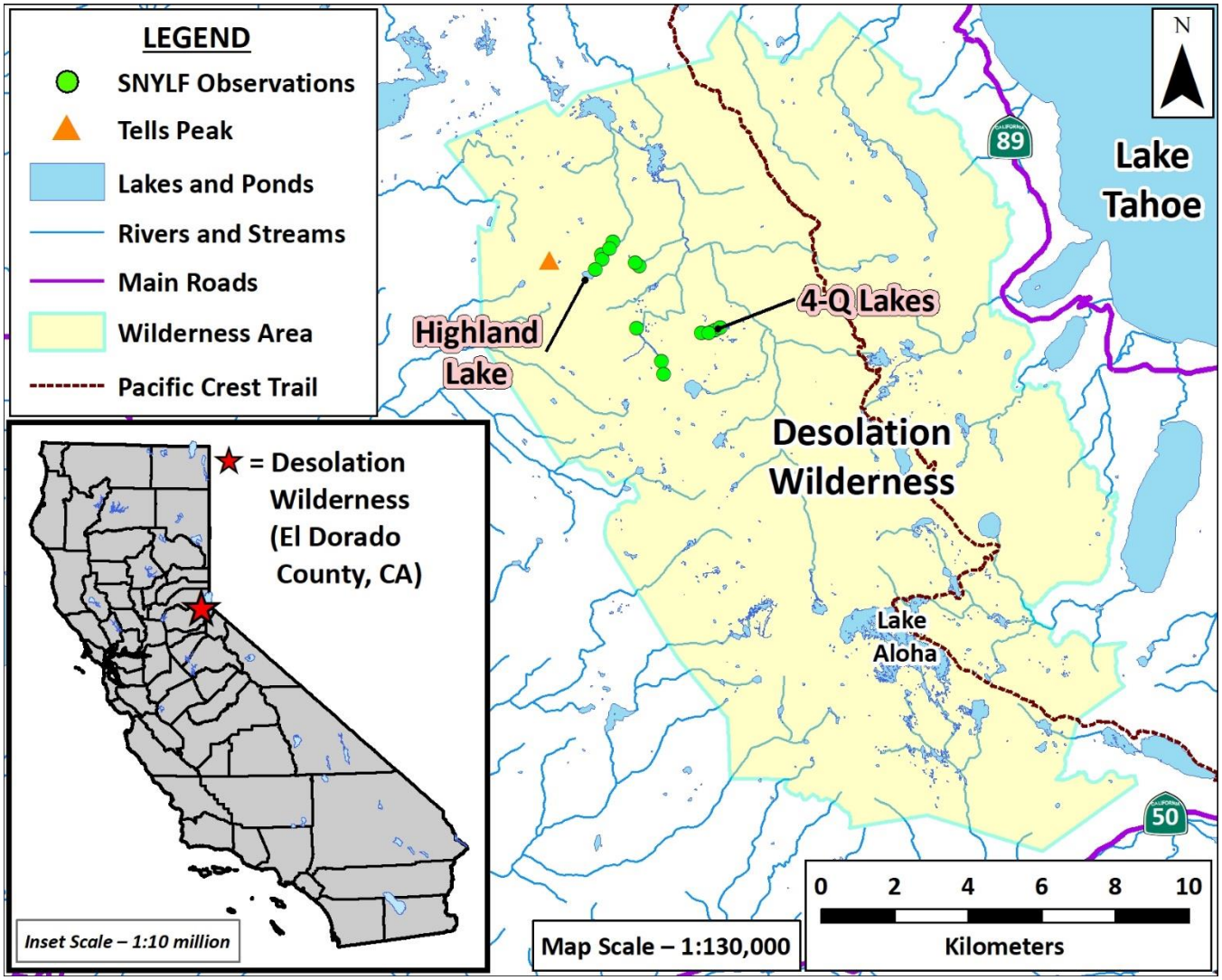


Figure 1. Desolation Wilderness, El Dorado County, CA. Green dots show sites in nearby watersheds with positive Sierra Nevada Yellow-legged Frog (*Rana sierrae*) detections during recent visual encounter surveys (VES).

ENVIRONMENTAL SETTING

Highland Lake is located in the Desolation Wilderness, northeast El Dorado County (**Figure 1**). The lake sits in a granite cirque at approximately 7,800 feet in elevation and drains northeast into Rockbound Lake (**Figure 2**). ENF manages this section of Desolation Wilderness and the surrounding land. 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. 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. 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. Now fishless, CDFW manages Highland Lake, the outlet stream, and associated ponds as SNYLF breeding habitat (**Figure 3**).

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 12892, 13896, and 13903) as a Native Species Reserve (NSR) for SNYLF (**Figure 4**).

Highland Lake was stocked 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. Gill net surveys in 2003 and 2010 indicated that RT were persisting at low density in the absence of stocking. As a result, CDFW decided to eradicate the remaining fish in the lake and manage the site for SNYLF.

Beginning 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 500 adult observations, 296 subadult observations, and 883 larvae observations during visual encounter surveys (VES) each year from 2014 to 2019 (**Figures 5 and 6**). The large SNYLF population allows for removing a subset of adult frogs for use in translocation efforts to establish new SNYLF populations in the surrounding area. The Desolation Wilderness ABMP identifies 4-Q Lakes (located a few km to the east; **Figure 7**) 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.

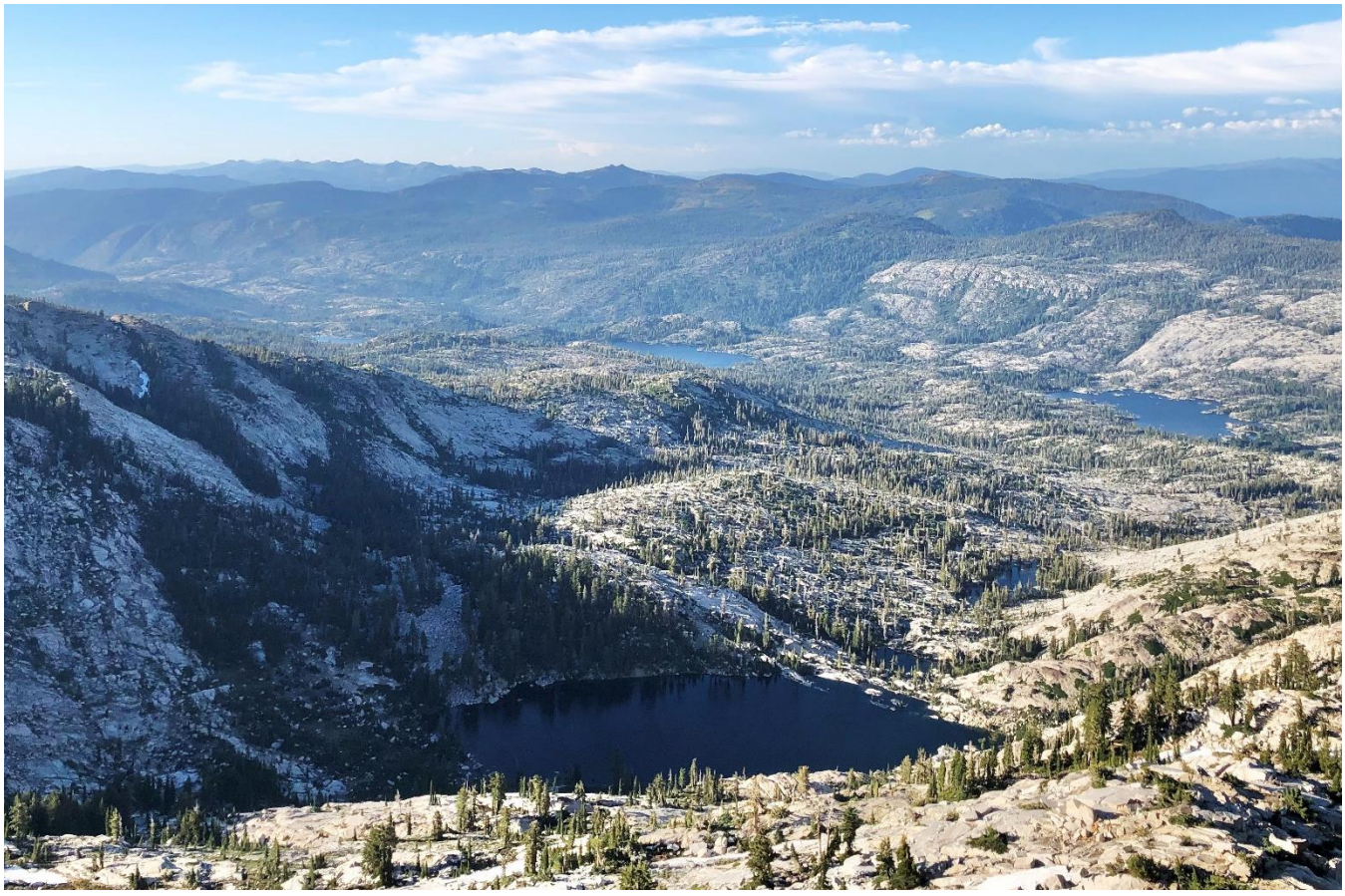


Figure 2. Highland Lake (foreground) and Rockbound Lake (background, center) on 7 August 2019, looking northeast. (CDFW)

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

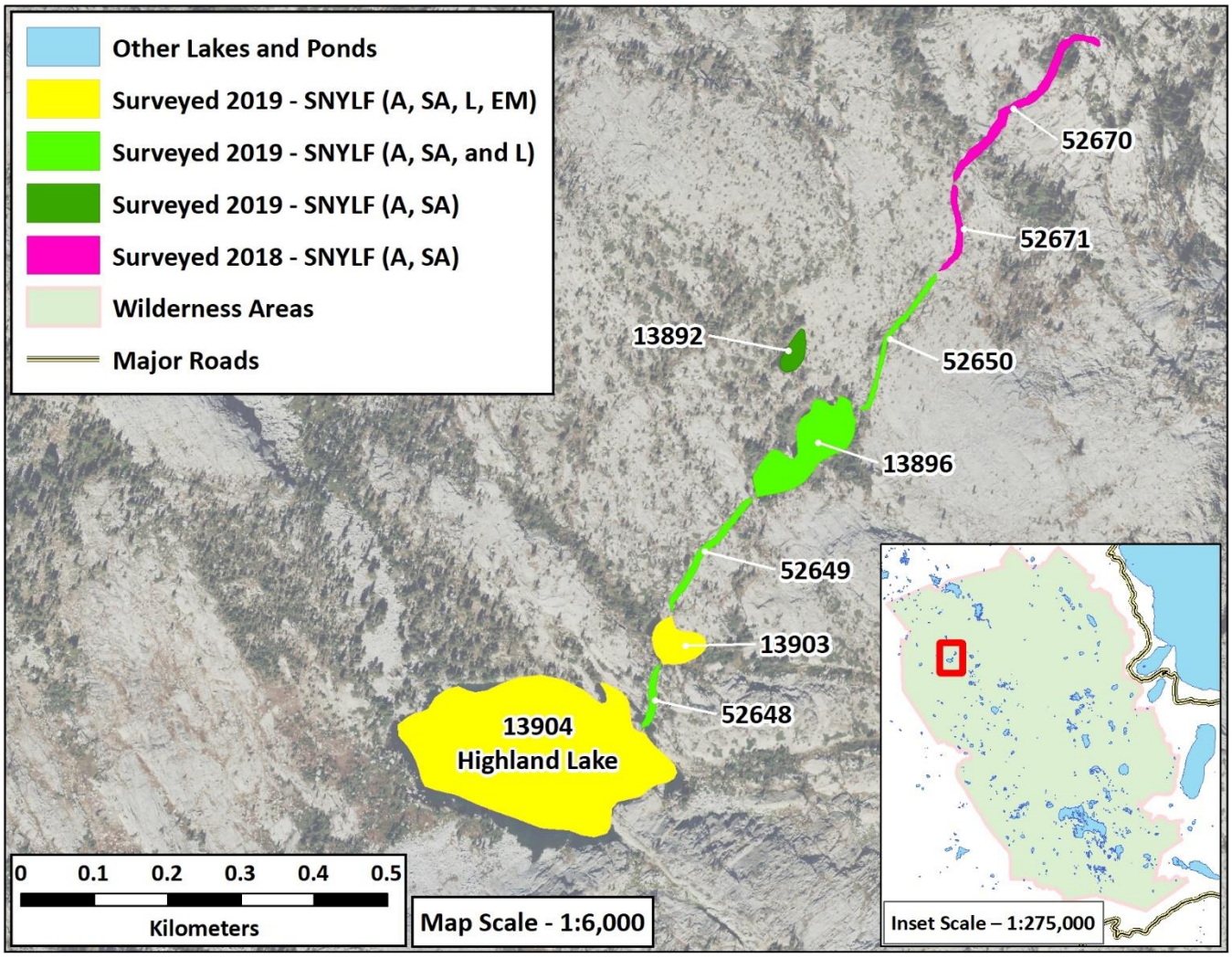


Figure 4. Highland Lake Native Species Reserve (NSR). CDFW staff have observed Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) throughout the drainage. During VES in August 2019, SNYLF were observed in all sites surveyed. In 2019, CDFW field crews did not survey the areas where 2018 survey results are displayed (i.e., this map shows the most recent SNYLF observations for each site). SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: "A" = adults, "SA" = subadults, "L" = larvae, and "EM" = egg masses. 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. CDFW plans to have these swabs analyzed in 2020 to determine more current *Bd* status of the Highland Lake drainage SNYLF population.

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 from which SNYLF could conceivably immigrate in the near term, but the other populations are close enough to allow for rare instances of gene flow. This situation is in contrast to 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. 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 2019 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.

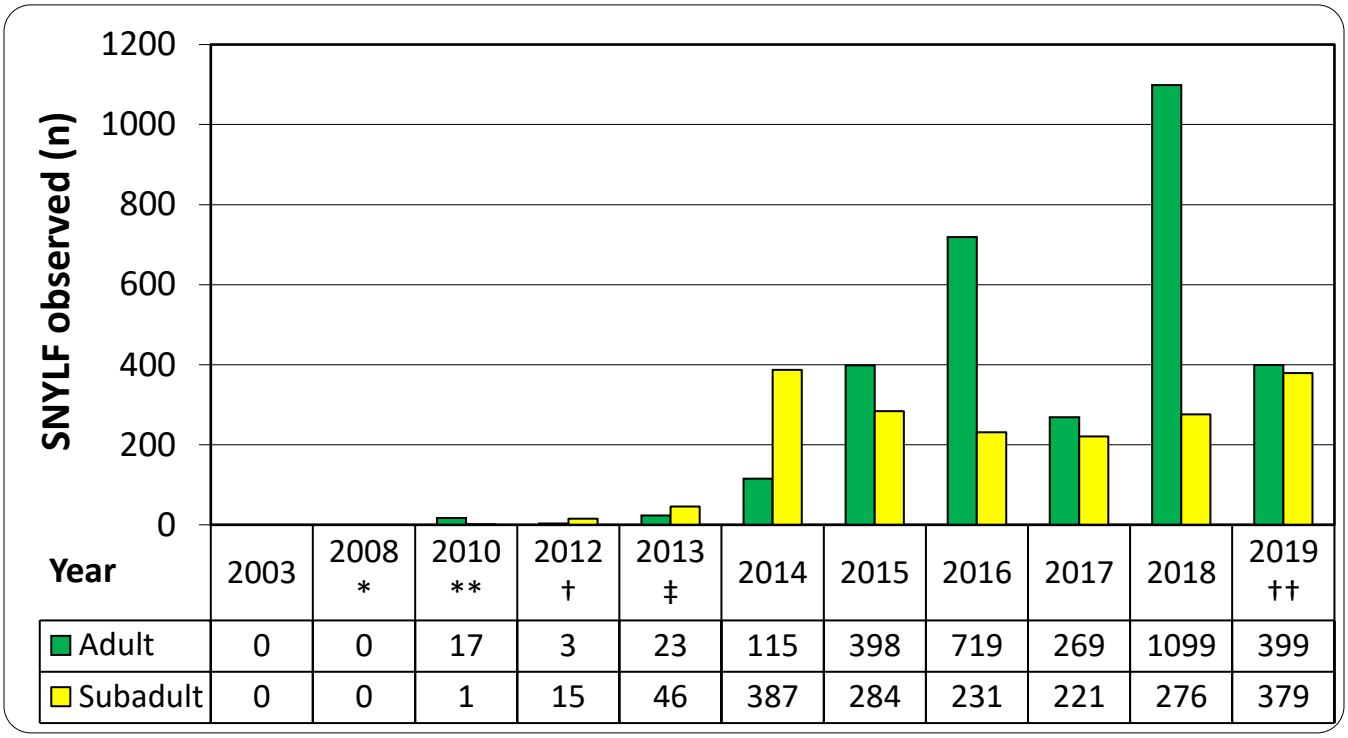
In October 2014 and July 2015, CDFW staff observed SNYLF at two shallow ponds in which crews had not previously observed frogs. Coincidentally, nearby Lake Zitella (2 km southeast of the Highland Lake drainage) experienced a similar increase in SNYLF observations (CDFW 2019b). On 30 July 2015, CDFW and 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 crews surveyed all sites in the NSR three times. In addition to observing another large increase in frogs, crews observed three egg masses in Highland Lake on 26 June 2016. Another single egg mass was observed in Highland Lake in 2019. Prior to fish removal, crews 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 crews surveyed all sites along the outlet stream, with the exception of 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 crews 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 2019a). Survey conditions were sunny and warm, but light wind obscured visibility into the water. Despite the wind, field crews observed hundreds of SNYLF.

On 7 August 2019, CDFW crews, 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 (see SNYLF TRANSLOCATION section below). 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, more subadults were observed in 2019 than in any prior year except 2014, during which CDFW staff observed comparable numbers of SNYLF subadults.

Continued monitoring is required 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. Although no translocation is planned for summer 2020, CDFW crews plan to visit 4-Q lakes at least twice for VES.



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

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 2019. From 2014 to 2018, surveys included 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.

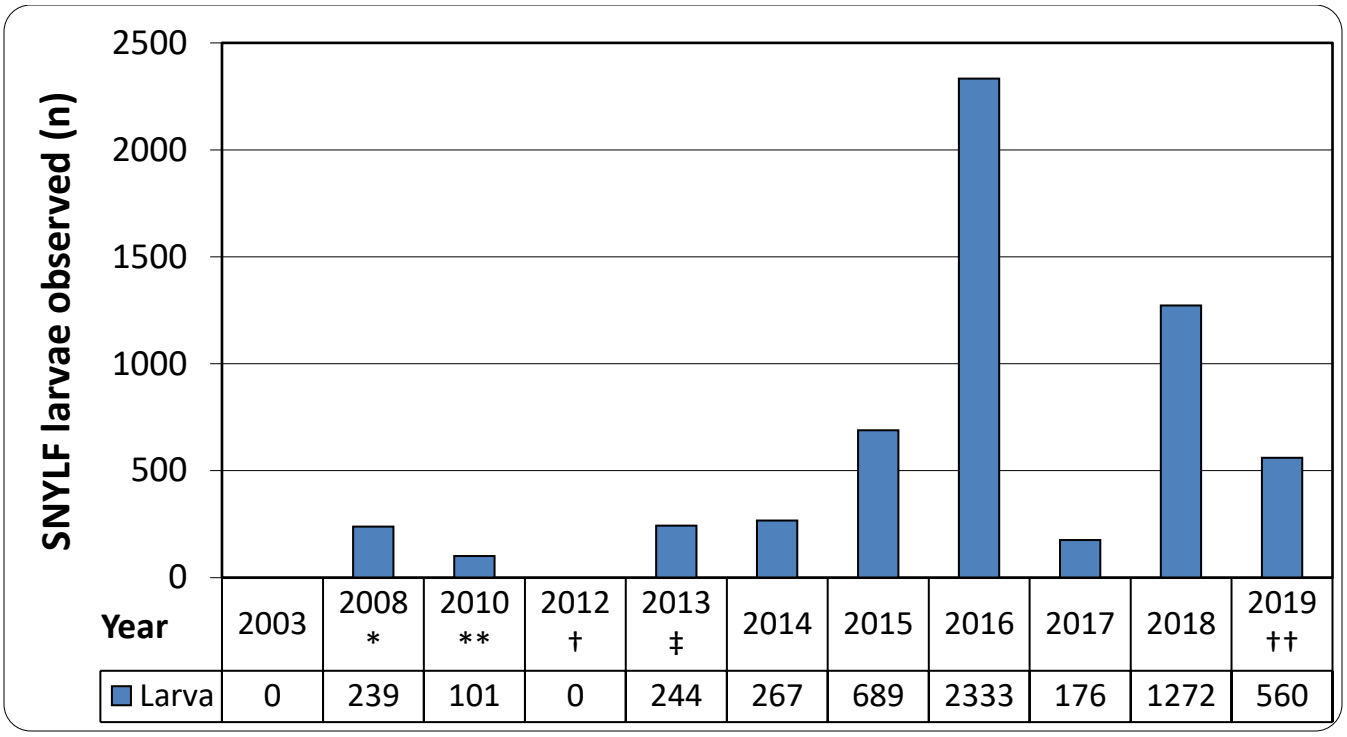


Figure 6. Number of larval Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) in the Highland Lake drainage between 2003 and 2019. (See **Figure 5** for caveats about surveys between 2008 and 2019.) Steady winds and occasional strong gusts during the Highland Lake survey on September 10, 2017 and August 7, 2019 made visibility into the lake difficult, which may largely 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 large SNYLF population increase observed in recent years occurred in tandem with the RT decline in the watershed. Part of the SNYLF population increase may be 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 likely 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 a sixteen-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 2019 were fewer than those in the previous year, and slightly below the average number of observations during VES from 2014 to 2018. Survey conditions may be an important factor explaining the lower SNYLF detections in 2019. Skies were clear and air temperatures were warm, but moderate winds with occasional 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 were 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).

Winter conditions may also partially account for the lower SNYLF observations in 2019. The northern Sierra Nevada experienced above average snow water content and total precipitation in 2018–2019 when compared with the previous winter. Precipitation levels in the northern Sierra Nevada reached approximately 136% of the historical average (CDWR 2019a) and snowpack reached approximately 150% of the historical April 1st average (CDWR 2019b). Conversely, the higher SNYLF observations in 2018 followed a winter during which precipitation and snow water content were well below average. Survey results from 2017 also provide some evidence for a correlation between summer SNYLF detections and conditions during the previous winter. Winter 2016–2017 resulted in even higher snow water content and greater

precipitation than winter 2018–2019 (CDWR 2017a and 2017b). CDFW surveys for SNYLF in summer 2017 were comparatively low, when compared with the years before and after.

Considering these observations, environmental conditions, in terms of both prior winter conditions and weather on the day of surveying, may be partly responsible for the fluctuations between years in the Highland Lake drainage SNYLF observations. 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. 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. Although another extended winter in 2018–2019 correlates with lower SNYLF detections during summer 2019, results from prior surveys suggest that weather conditions during VES may be the largest environmental influence on differences in detection between years, rather than overwinter mortality.

Visual encounter survey results can be difficult to compare due to numerous factors, including weather conditions, but also time of year and observer bias (Mazerolle et al. 2007). For example, in 2016, CDFW conducted three separate surveys of the Highland Lake drainage (in June, August, and September). The June and September 2016 surveys of Highland Lake resulted in similar detections (82 frogs and 13 larvae, then 130 frogs and 1 larva, respectively) when compared with results from the September 2017 VES of Highland Lake (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).

Finally, it is worth considering that lower SNYLF detections in 2019 (when compared with the previous year) may have been, in part, because CDFW staff did not survey Site IDs 52670 and 52671. SNYLF can move up and down drainages several hundred meters (m) or more, so there may have been more SNYLF present in these lower stream segment than anticipated (Brown et al. 2019, CDFW unpubl. data). However, VES during prior years resulted in relatively few detections in the lower portions of the stream. Since CDFW began surveying these two stream segments in 2016, staff have observed a combined average of nine adult, eight subadult, and three larval SNYLF each year. In 2020, CDFW will survey the entire Highland Lake drainage, including the lower stream segments. Additionally, CDFW may survey downstream of previously monitored portions of the Highland Lake outlet stream, to determine if there may be resident SNYLF occurring farther down the drainage.

SNYLF TRANSLOCATION

For details about the translocation of SNYLF from Highland Lake to 4-Q Lakes in 2018, including background on the translocation recipient site, consult the survey memo for the 2018 Highland-4Q Lakes VES and translocation (CDFW 2019a).

Planning

The Strategy highlights translocations as one of the primary actions to restore SNYLF populations (MYLF ITT 2018). CDFW first formally proposed the SNYLF translocation from Highland Lake drainage to 4-Q Lakes (**Figure 7**) in the Desolation Wilderness ABMP (CDFG 2012, pg. 121). In 2016, U.S. Fish and Wildlife Service (USFWS) awarded CDFW funds for this project through the endangered species recovery grant program (Section 6 of the U.S. Endangered Species Act of 1973; Federal Grant Award #F17AP00001). CDFW staff subsequently collaborated with ENF biologists to assist undertaking these translocations. In late 2017, CDFW applied for translocation approval under the new CDFW Conservation Translocation Policy (Department Bulletin 2017-05), which requires certain wildlife translocations to receive written approval from the local CDFW Regional Manager. In early February 2018, the CDFW Region 2 Regional Manager approved the translocations described below. Therefore, these translocation efforts represent a multi-agency collaborative effort to establish a new SNYLF population in the Upper Rubicon drainage of Desolation Wilderness.

Field Confirmation

CDFW conducted VES at 4-Q Lakes in early August, immediately before proceeding to the Highland Lake drainage. The goal of surveys at 4-Q Lakes was to find as many previously translocated SNYLF as possible. During surveys on 5 and 6 August 2019, CDFW observed and captured nine SNYLF (15% of the frogs released in 2018; five females and four males). Passive integrated transponder (PIT) tag scans confirmed that all frogs were individuals that CDFW translocated from the Highland Lake drainage in 2018. All individuals appeared to be in overall good condition and were behaving normally. One individual had some recent abrasions on its snout. CDFW staff also collected epithelial swabs from seven of the nine resighted frogs. CDFW plans to have these swabs analyzed in 2020 to assess *Bd* status of the nascent SNYLF population at 4-Q Lakes. After VES at 4-Q Lakes, CDFW staff hiked west early the morning of 7 August 2019 to meet up with other CDFW and ENF staff to complete VES in the Highland Lake drainage. Results of those surveys are presented above in the POPULATION STATUS: RESULTS section.

To undertake the translocation, CDFW needed to observe at least 200 adult SNYLF during VES of the Highland Lake drainage. 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 highly 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.

Translocation Methods

After VES on August 7, 2019 confirmed that the SNYLF population was robust enough to support removal of 40 adult SNYLF, CDFW and ENF staff mobilized for translocation efforts. Field crews began collecting adult SNYLF (**Figure 8**) the morning of August 8, 2019. For each frog, staff identified the sex, implanted a PIT tag to provide a unique identifier for each individual, measured snout-to-urostyle (SUL) length, and recorded weight (**Figure 9**). In total, staff collected 40 adult (>40 millimeters SUL) SNYLF from the northern shore of Highland Lake, Site ID 52648, and the southern shore of Site ID 13903 (approximately 10% of the adult population observed the previous day). The 40 adult SNYLF were comprised of 22 females and 18 males. Staff intentionally collected a female-biased sample to increase the odds of successful reproduction at the recipient site. Staff placed each frog into its own plastic container, which contained multiple holes for ventilation (**Figure 10**). Staff kept containers in the shade and on snow at all times to prevent frogs from overheating (**Figure 11**).

Once the collection was complete, staff packed the contained frogs into hard-sided plastic bear-proof containers. Staff then placed the containers into backpacks, along with bagged snow and foam insulating pads, to maintain cool temperatures for the frogs during transport. Crews also placed digital temperature loggers inside of the containers to provide constant temperature read-outs. Once securely packed, the field crew hiked the frogs for approximately 2 hours to 4-Q Lakes **(Figures 7 and 12**). During transport, temperature readouts showed that the internal temperature of all four bear containers remained at 9.5–12 °C (49–54 °F). Once at the site, staff released the 40 frogs at three different release points (13 or 14 frogs per site) along the southern shore of the middle 4-Q Lakes (Site IDs 13922 and 13932; **Figures 13–15**). All frogs appeared healthy upon release.

Follow-up Surveys

During summer 2019, CDFW staff conducted one post-translocation survey. The survey goal was to assess if the frogs: 1) had moved from the original release sites, 2) appeared in good health, and 3) were behaving normally. The follow-up survey occurred on 3 and 4 September 2019, four weeks after the translocation. During this visit, staff surveyed the main 4-Q Lakes, any nearby ponds that retained water (i.e., those within ~250 m of the main lakes), and the outlet stream. Staff observed 19 individual SNYLF (10 females and nine males). Fifteen of the 19 individuals were frogs released four weeks earlier (37.5% of frogs translocated in 2019), and the remaining four frogs had been released during the 2018 translocation. These four frogs from the 2018 cohort were also detected on 5 and 6 August, just before the second translocation (i.e., four of the nine frogs seen in August 2019 were also seen during surveys in September 2019).

Of the 100 total SNYLF released at 4-Q lakes, CDFW staff have observed 40 individuals at least once during follow-up surveys (16 females and 24 males; 40% of all released frogs). All frogs detected during follow-up surveys at 4-Q Lakes have appeared to be healthy and behaving

normally. Additionally, SNYLF have spread out from their original release points and now occupy many areas in 4-Q Lakes basin (**Figure 15**).

Looking ahead: 2020

CDFW staff plan to visit the Highland Lake drainage once in summer 2020. Given the conservation importance of this population, CDFW needs current information obtained by yearly monitoring. CDFW will not be conducting another SNYLF translocations from Highland Lake to 4-Q Lakes in 2020. However, CDFW staff will continue to closely monitor the translocated SNYLF at 4-Q Lakes. CDFW plans to visit 4-Q Lakes at least twice during summer 2020 to assess the movement, health, and behavior of translocated SNYLF. During each visit to 4-Q Lakes, staff will capture any SNYLF observed and record PIT tag, sex, location coordinates, and collect an initial set of weight and length measurements for each frog (only once per season for each individual).

CDFW staff will also focus on attempting to observe any evidence of SNYLF breeding at 4-Q Lakes (i.e., detecting egg masses or tadpoles). The earliest any translocated SNYLF would have been able to breed is early summer 2019, therefore, the earliest CDFW expects to observe any tadpoles large enough to detect easily will be in 2020. Additionally, CDFW does not expect to potentially observe any recently metamorphosed or subadult SNYLF at 4-Q Lakes until 2021, at the earliest. Previous projects have demonstrated that it may take many years before frog populations become established at translocation sites (e.g., Joseph and Knapp 2018). CDFW is submitting a grant for additional funding under the USFWS endangered species recovery grant program (Section 6 of the U.S. Endangered Species Act of 1973) to undertake two additional translocations in 2022 and 2023, using the same methods described in this memorandum. The ultimate goal is to help create a robust metapopulation of SNYLF in the Upper Rubicon watershed by establishing a self-sustaining breeding population at 4-Q Lakes.

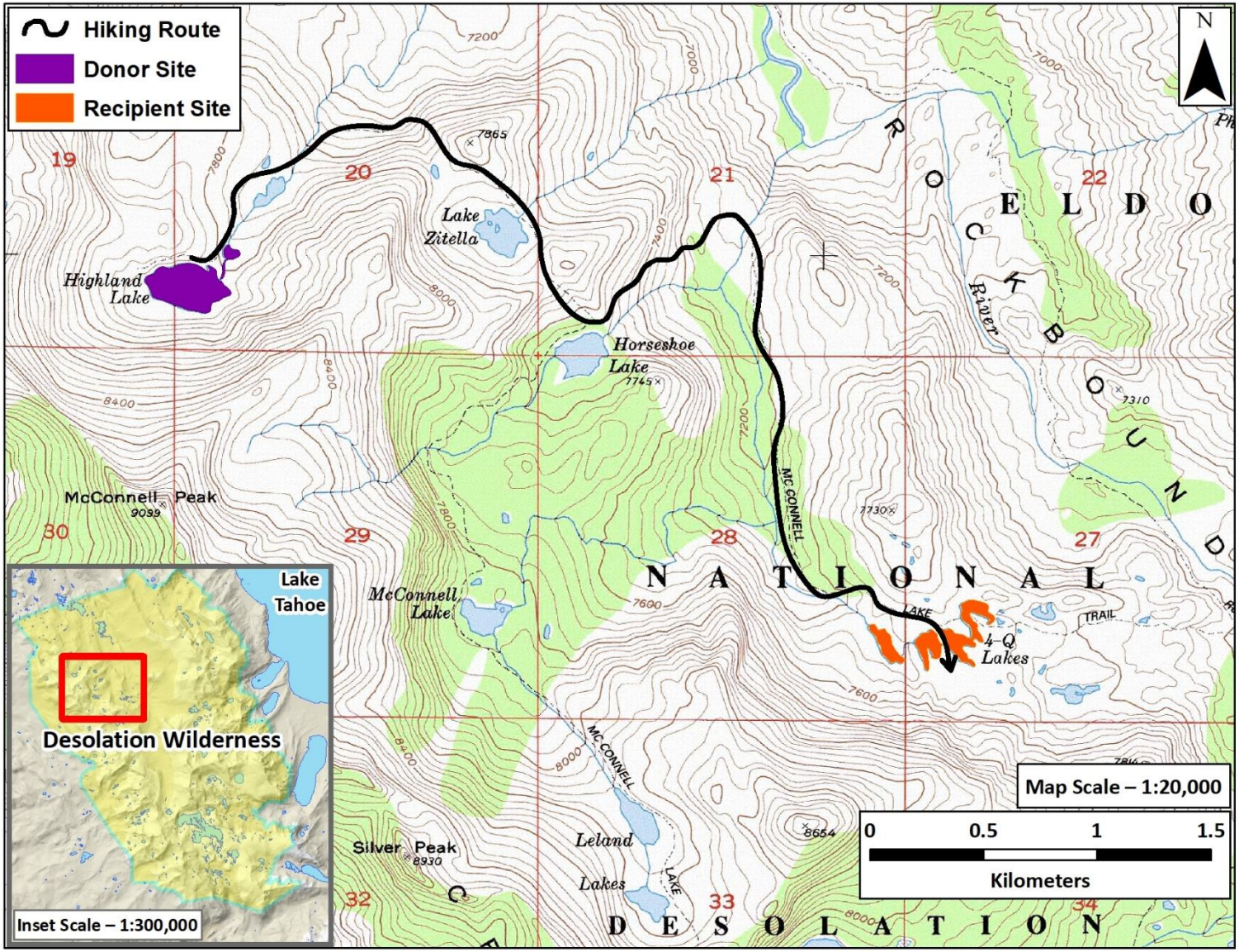


Figure 7. Path of travel for the Sierra Nevada Yellow-legged Frog (*Rana sierrae*) translocation from Highland Lake (donor site) to 4-Q Lakes (recipient site) on 8 August 2019. Travel distance between the two sites via the route shown is approximately 6 km (3.7 miles). The hike took about two hours to complete.

Figure 8. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake. (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, which contained 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 cans, 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 in plastic containers, inside bear bins, 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. Adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) being released at 4-Q Lakes on 8 August 2019.

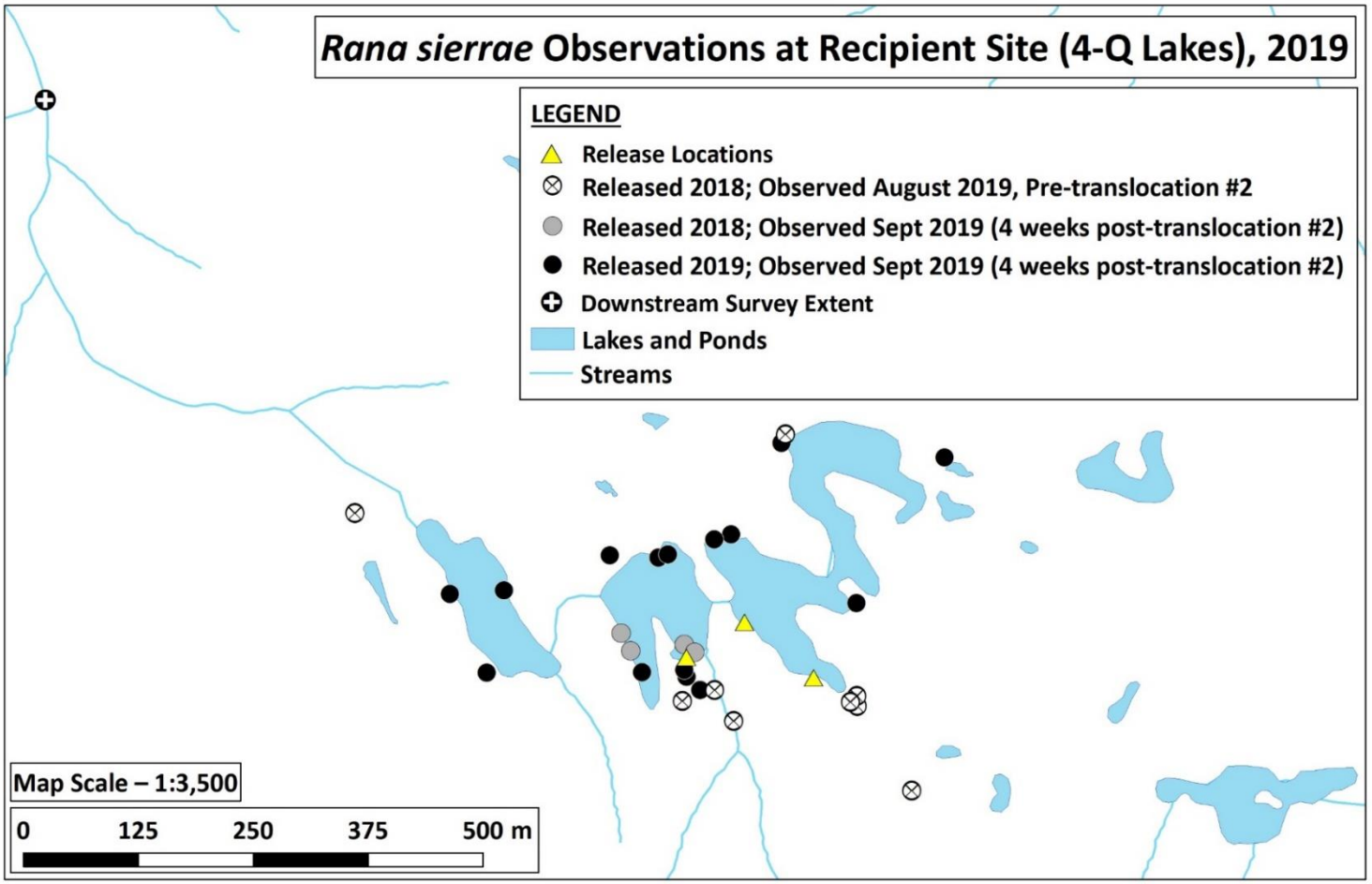


Figure 15. Map showing Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) release sites at 4-Q Lakes on 8 August 2019 (yellow triangles). The map also displays the locations of all SNYLF individuals seen during the pre-translocation visual encounter surveys (VES) on 5–6 August 2019 (white fill, X-marked circles) and the follow-up visual encounter survey (VES) on 3–4 September 2019 (solid fill black circles and solid fill gray circles). CDFW staff observed nine SNYLF individuals on 5–6 August 2019 and 19 SNYLF individuals on 3–4 September 2019. Of the SNYLF observed in September, four were also captured in August. Therefore, combining the pre-translocation survey and follow-up survey, CDFW observed 24 of the total 100 released SNYLF (24% of released frogs) in 2019. The white and black cross depicts the farthest downstream extent of VES surveys during both follow-up trips.

LITERATURE CITED

Bradford, D.F. 1983. Winterkill, oxygen relations, and energy metabolism of a submerged dormant amphibian, *Rana muscosa*. Ecology 64:1171–1183.

Briggs, C.J., R.A. Knapp, and V.T. Vredenburg. 2010. Enzootic and epizootic dynamics of the chytrid fungal pathogen of amphibians. Proceedings of the National Academy of Sciences, USA 107:9695–9700.

Brown, C., L.R. Wilkinson, K.K. Wilkinson, T. Tunstall, R. Foote, B.D. Todd, and V.T. Vredenburg. 2019. Demography, habitat, and movements of the Sierra Nevada Yellow-legged Frog (*Rana sierrae*) in streams. Copeia 107:661–675.

California Department of Fish and Game (CDFG). 1980. Status report on the stream flow maintenance dams in Eldorado National Forest. Prepared by R.W. Lassen. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=71305

CDFG. 2012. Aquatic Biodiversity Management Plan for the Desolation Wilderness Management Unit. California Department of Fish and Wildlife, Rancho Cordova, CA. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=59961

California Department of Fish and Wildlife (CDFW). 2018. Native amphibian restoration and monitoring in Desolation Wilderness: Highland Lake fish removal and *Rana sierrae* monitoring. Region 2 Survey Memo. California Department of Fish and Wildlife, Rancho Cordova, CA. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=156672

CDFW. 2019a. Highland Lake and 4-Q Lakes (Desolation Wilderness) *Rana sierrae* monitoring and translocation. Region 2 Survey Memo. California Department of Fish and Wildlife, Rancho Cordova, CA. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165313

CDFW. 2019b. Lake Zitella (Desolation Wilderness) *Rana sierrae* monitoring. Region 2 Survey Memo. California Department of Fish and Wildlife, Rancho Cordova, CA. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165321

California Department of Water Resources (CDWR). 2017a. Northern Sierra 8 station precipitation index water year plot. Available from: https://cdec.water.ca.gov/cgi-progs/products/PLOT_ESI.2017.pdf

CDWR. 2017b. Daily regional snowpack plots from snow sensors. Available from: https://cdec.water.ca.gov/cgi-progs/products/PLOT_SWC.2017.pdf

CDWR. 2019a. Northern Sierra 8 station precipitation index water year plot. Available from: http://cdec.water.ca.gov/reportapp/javareports?name=PLOT_ESI.pdf

CDWR. 2019b. Daily regional snowpack plots from snow sensors. Accessed by J. Imperato, CDFW. Available from: http://cdec.water.ca.gov/snowapp/swcchart.action

Frankham, R., J.D. Ballou, and D.A. Briscoe. 2009. Introduction to Conservation Genetics. Cambridge University Press, New York, NY, USA.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.-A.C. Hayek, and M.S. Foster (eds.). 1994. Measuring
and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Joseph, M.B., and R.A. Knapp. 2018. Disease and climate effects on individuals drive post-reintroduction population dynamics of an endangered amphibian. Ecosphere 9:e02499

Knapp, R.A., G.M. Fellers, P.M. Kleeman, D.A.W. Miller, V.T. Vredenburg, E.B. Rosenblum, and C.J. Briggs. 2016. Large-scale recovery of an endangered amphibian despite ongoing exposure to multiple stressors. Proceedings of the National Academy of Sciences 113:11889–11894.

Mazerolle, M.J., L.L. Bailey, W.L. Kendall, J.A. Royle, S.J. Converse, and J.D. Nichols. 2007. Making great leaps forward: accounting for detectability in herpetological field studies. Journal of Herpetology 41:672–689.

Mountain Yellow-legged Frog Interagency Technical Team (MYLF ITT). 2018. Interagency conservation strategy for mountain yellow-legged frogs in the Sierra Nevada (*Rana sierrae* and *Rana muscosa*). California Department of Fish and Wildlife, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service. Version 1.0.

U.S. Forest Service (USFS). 1955. Special use application for California Department of Fish and Game to construct a streamflow maintenance dam at Highland Lake. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=98652

USFS. 1993. Eldorado National Forest Amphibian Records. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=98669