State of California

Memorandum

Date: 2/8/2019

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Subject: Native amphibian restoration and monitoring in Desolation Wilderness.

- **Highland Lake *Rana sierrae* monitoring.**
- ***Rana sierrae* translocation from Highland Lake to 4-Q Lakes.**

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 2018 suggest a large, healthy, and growing SNYLF population. The Highland Lake drainage SNYLF population has a sufficiently abundant adult population 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"; USFWS 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 will duplicate these translocation efforts during summer 2019. Additionally, CDFW will continue yearly amphibian monitoring to document SNYLF population status at both donor and recipient sites.

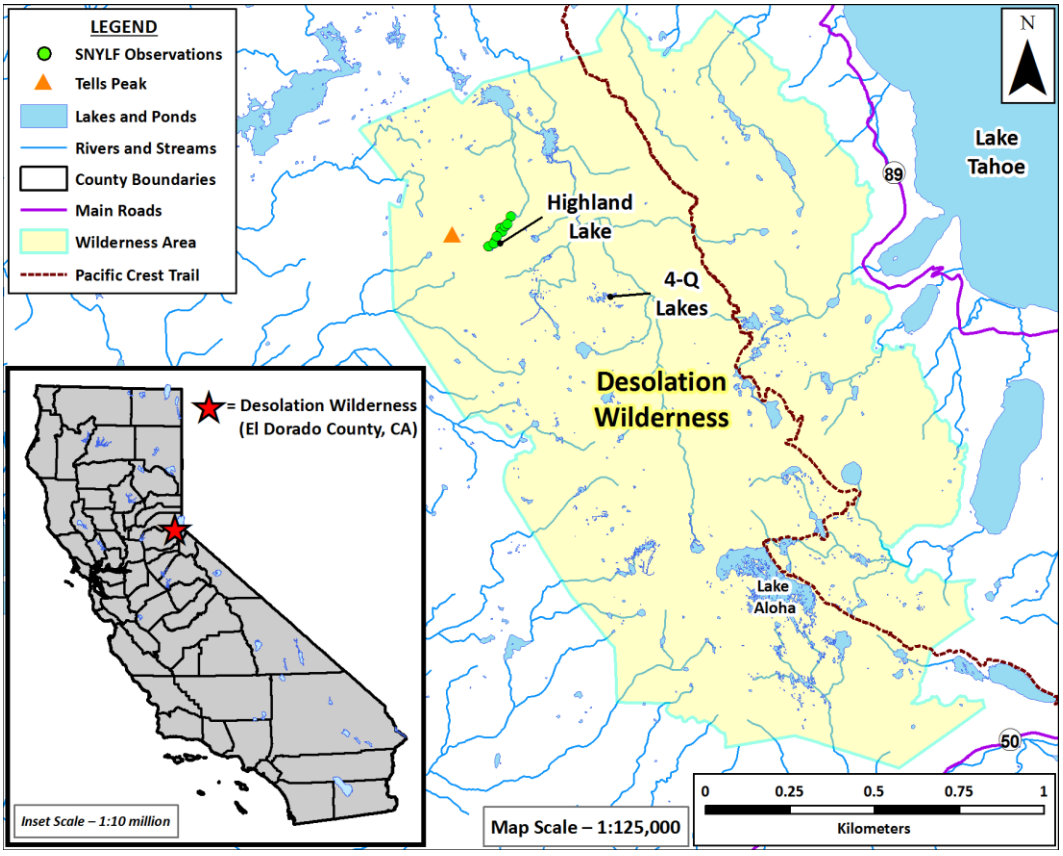


Figure 1: Desolation Wilderness, El Dorado County, CA. Green dots show *Rana sierrae* (SNYLF) sites with positive detections by CDFW staff during recent visual encounter surveys (VES).

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 clearly marked 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 two associated ponds (Site IDs 13903 and 13896) 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 2018 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 over a thousand adults, hundreds of subadults, and over a thousand tadpoles during 2018 visual encounter surveys (VES). The large SNYLF population allows for removing a subset of 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) 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 on 26 June 2018, looking west. (CDFW)

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

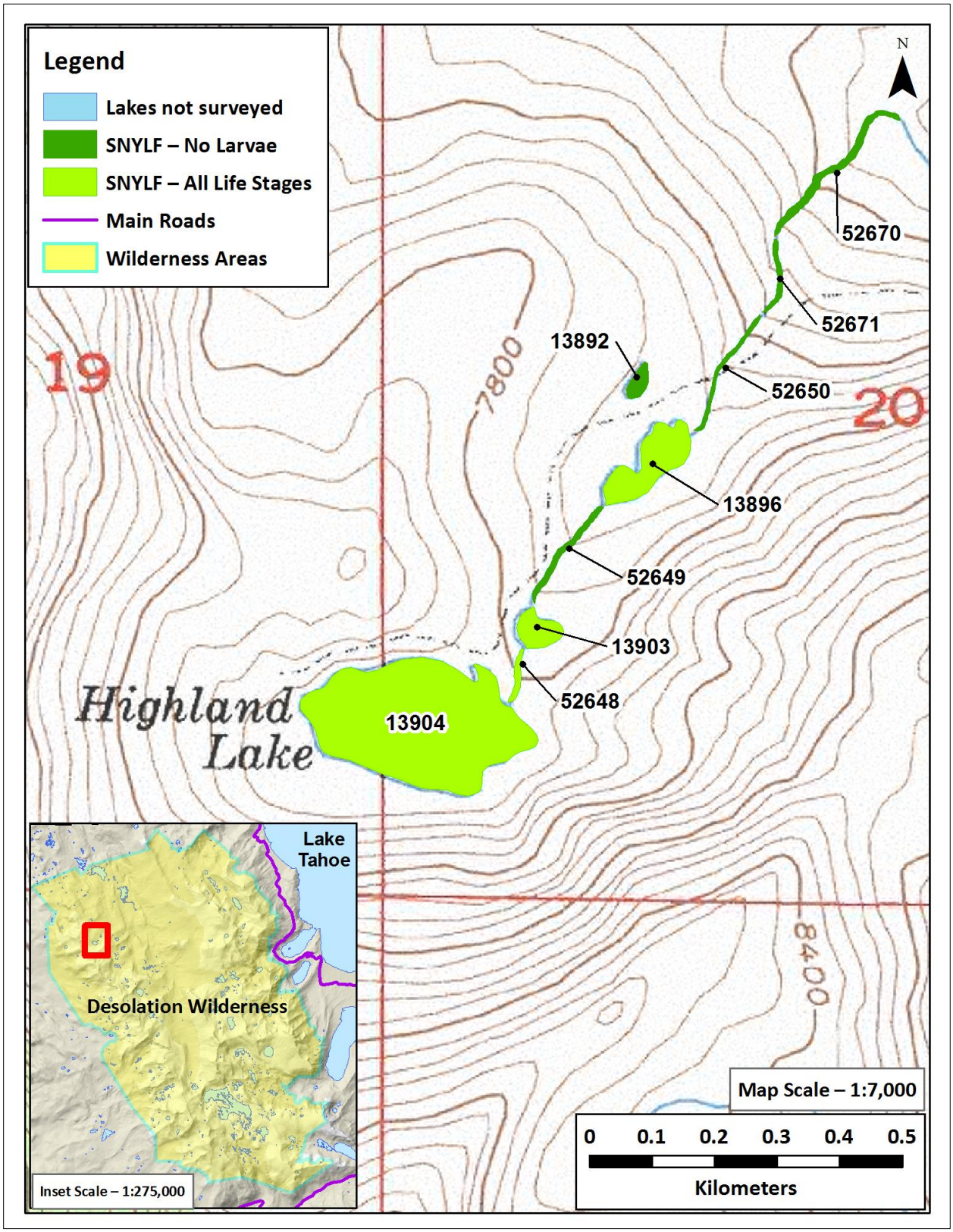


Figure 4: Highland Lake Native Species Reserve (NSR). CDFW staff have observed Sierra Nevada yellow-legged frogs (*Rana sierrae*; SNYLF) throughout the drainage. During VES in June 2018, all SNYLF larvae observed by field staff were located in Highland Lake and the stream widening ponds. However, field staff do occasionally observe SNYLF larvae in the stream segments. 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.

- ***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

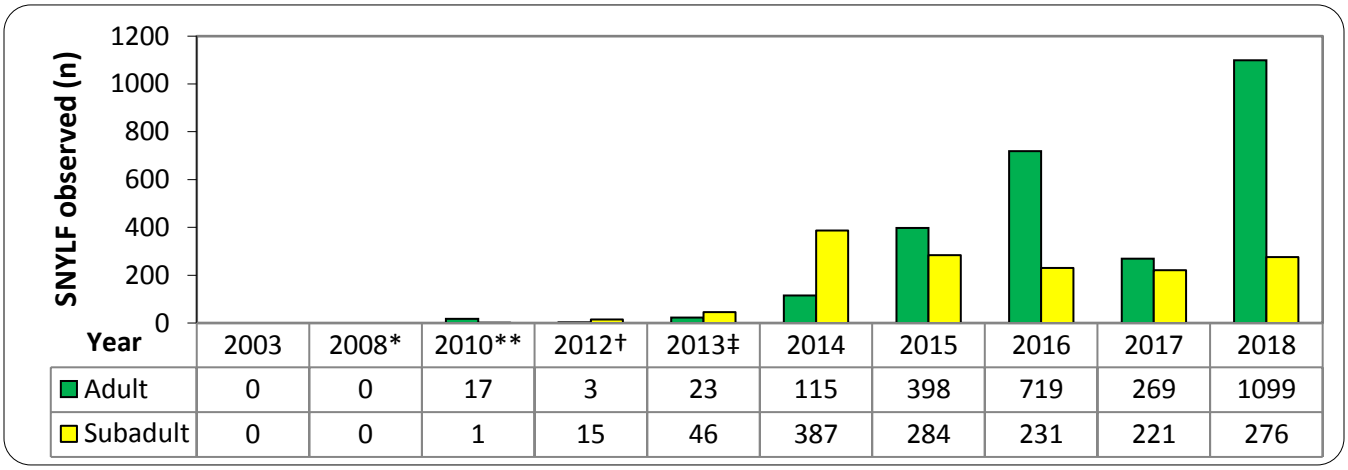
Although CDFW did not detect SNYLF in the watershed prior to 2008, ENF staff have been monitoring this population since 1993 (USFS 1993). VES data between 2013 and 2018 confirm that the population has increased dramatically (Figures 5 and 6). As the RT population declined, CDFW staff observed SNYLF moving 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. 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. Prior to fish removal, crews only observed egg masses in the outlet ponds, where the likelihood of 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 Pond 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.

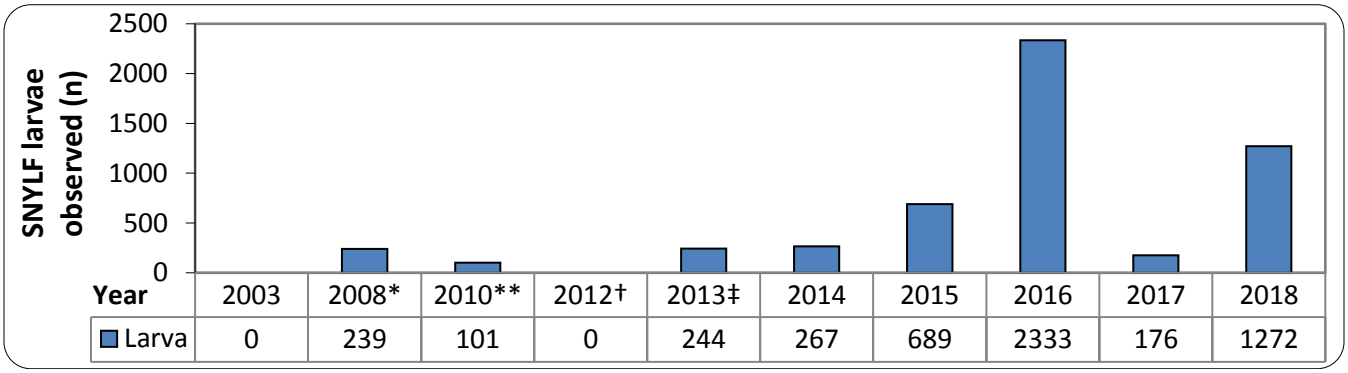
On 26 June 2018, CDFW crews surveyed the entire NSR (Figure 4). The goals of the VES were to determine the current population status and to estimate the number of adult SNYLF available for translocation to 4-Q Lakes the following week (see "SNYLF Translocation" section below). Survey conditions were sunny and warm, but light wind obscured visibility into the water. Steady wind, which is common at Highland Lake, often limits visibility, making it especially difficult to see tadpoles in deeper water, and can reduce basking of post-metamorphic frogs. Despite the wind, field crews observed hundreds of SNYLF.

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 survey 4-Q Lakes, the translocation recipient site, multiple times each summer to monitor the status of the translocated SNYLF population.



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

Figure 5: Number of adult and subadult SNYLF detected during visual encounter surveys (VES) in the Highland Lake drainage between 2003 and 2018. *2008 surveys only included Highland Lake and the larger downstream pond (13896). **Surveys in 2010 only included the two stream ponds (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. From 2014 onward, surveys include the entire drainage, including Highland Lake, the outlet stream, and the two downstream ponds.



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

Figure 6: Number of larval SNYLF detected during visual encounter surveys (VES) in the Highland Lake drainage between 2003 and 2018. (See Figure 5 for caveats about surveys between 2008 and 2013.) Steady winds and occasional strong gusts during the Highland Lake survey on September 10, 2017 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. 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, sixteen years of data suggest 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.

VES during the 2018 season resulted in the highest number of SNYLF observations of all life stages since ENF biologists began SNYLF surveys in the 1990's. These results emphasize the extent to which survey conditions can affect the results of VES. In 2017, high winds were occurring during the VES at Highland Lake, and hundreds fewer adults were observed than during surveys with less wind and less than one year later. Although winter 2016–2017 resulted in deeper snow pack for a longer duration (CDWR 2017a and 2017b) than winter 2017–2018, the large discrepancy in adult SNYLF observed between the two years is very likely the result of survey conditions, time of year, and observer bias, rather than poor survivorship during a long winter (Bradford 1983). If harsh winter conditions were responsible for the low number of SNYLF observed in 2017, then far fewer adult SNYLF would have been available for detection in early summer 2018.

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). 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, 13 larvae; and 130 frogs, 1 larvae; respectively) when compared with results from the September 2017 VES of Highland Lake (102 frogs, 32 larvae). However, the August 2016 survey of Highland Lake resulted in dramatically higher SNYLF detections (693 frogs, 2008 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).

SNYLF TRANSLOCATION

Planning

The Strategy highlights translocations as one of the primary actions to restore SNYLF populations (USFWS 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 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

In addition to the VES in the Highland Lake drainage on 26 June 2018 (detailed in the previous section), CDFW also surveyed the entire 4-Q Lakes basin to check for current occupancy by fish, SNYLF, or other special status herpetofauna. On 27 June 2018, four CDFW field staff surveyed all waterbodies in the 4-Q Lakes basin and located no sign of SNYLF or fish.

VES conducted by CDFW in 2003 and 2015 also resulted in no SNYLF observations, although field staff did observe other amphibian and reptile species. Therefore, CDFW and ENF personnel have not observed SNYLF in 4-Q Lakes basin during any surveys prior to the translocation. Given the habitat composition and relatively close proximity to extant populations, SNYLF likely occupied 4-Q Lakes before fish stocking began in 1931 (or earlier). However, CDFW is not aware of any museum or survey records that exist to prove former SNYLF occupancy in 4-Q Lakes basin.

CDFW regularly stocked the three largest 4-Q Lakes with Brook Trout (*Salvelinus fontinalis*; BK) from at least 1931 until 2000. In 2003, CDFW field staff sampled six BK in the basin with overnight gill net surveys. However, subsequent gill net surveys at Lakes 13922, 13928, and 13932 in 2010 (one-night net set) and 2016 (one-month net set) returned zero fish, confirming that BK were not self-sustaining.

Translocation Methods

Following the high SNYLF abundance observed on 26 June 2018, CDFW and ENF staff mobilized for translocation efforts. Field crews hiked out to the Highland Lake drainage on 2 July and began collecting adult SNYLF the morning of 3 July (Figure 8). For each frog, staff identified the 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). In total, staff collected 60 adult (>40 millimeters SUL) SNYLF from the northern shore of Highland Lake, stream segment 52648, and the southern shore of pond 13903 (approximately 5% of the adult population observed the previous week). The 60 adult SNYLF were comprised of 34 females and 26 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 (Figure 12). During transport, temperature readouts showed that the internal

temperature of all four bear containers remained at 10–12°C (50–54°F). Once at the site, staff released 60 frogs at three different release points (20 frogs per site) along the southern shore of the middle 4-Q Lakes (Lakes 13922 and 13932; Figures 13–15). All frogs appeared healthy upon release, and staff members observed several SNYLF feeding minutes after release.

Follow-up Surveys

During summer 2018, CDFW staff conducted two post-translocation surveys to assess the translocated frogs. The survey goals were to assess if: 1) the frogs have moved from the original release sites; 2) the frogs appear in good health; and 3) the frogs are behaving normally. The first follow-up survey occurred on 17 July 2018, two weeks after the translocation. During this visit, staff surveyed the main 4-Q Lakes, any nearby ponds (i.e., those within ~250 meters [m] of the main lakes) that retained water, and the outlet stream. In total, staff observed 12 individual SNYLF (five females and seven males). All frogs appeared to be healthy and behaving normally. Many frogs had spread out substantially from their original release points, and one adult was located in an isolated pool in the 4-Q Lakes outlet, over 500 m downstream of the nearest release site (Figure 15). Additionally, staff observed eight gartersnakes (three *Thamnophis couchii* and five *T. sirtalis*) during the survey. During this visit, the outlet stream immediately below 4-Q Lakes was not flowing. However, several hundred meters downstream, two ephemeral streams entering the 4-Q Lakes outlet provided enough water for the outlet to continue flowing.

The second follow-up survey occurred on 21 August 2018, seven weeks after the translocation. Field staff surveyed all remaining waterbodies in the drainage. Very little rain fell in the northern Sierra Nevada during all of summer 2018, so many small ponds in the basin were dry. Additionally, almost no water remained in the entire outlet stream. In total, staff observed 15 individual SNYLF (13 females and two males), five of which (four females and one male) were seen during surveys on 17 July 2018. All frogs appeared to be healthy and behaving normally. The frogs had continued to spread throughout the 4-Q Lakes area, including three females observed in Pond 52692, which was not hydrologically connected to the release sites (Figure 15). As of early July 2018, Pond 52692 was only accessible by overland movement of at least 60 m. When combining results from the two follow-up surveys, CDFW staff observed 22 out of 60 SNYLF released (approximately 37% of the original cohort).

Looking ahead: 2019

In summer 2019, CDFW and ENF staff plan to undertake a second translocation that duplicates the efforts described above. However, staff will first survey the entire Highland Lake drainage to ensure the SNYLF population is still robust and capable of sustaining an additional collection of 60 adult frogs. If a suitable number of adults are present (e.g., at least 200 adults seen during VES), staff will move forward with the translocation. In the event that field staff observe fewer SNYLF than expected during VES, CDFW will consult with the USFWS and researchers to determine the number of adults that may be collected. In general, the typical rule is 10% of the observed adult population (USFWS 2018). Therefore, in the event that only 200 adults are present during VES of the entire Highland Lake drainage, staff may collect a maximum of 20 adult SNYLF for the second translocation efforts. If staff observe fewer than 200 adults during initial VES in 2019, CDFW will reassess translocation plans.

Staff will continue closely monitoring the translocated SNYLF at 4-Q Lakes. CDFW plans to visit 4-Q Lakes at least four times during summer 2019: 1) VES prior to the second translocation, 2) second translocation, 3) first follow-up survey, and 4) second follow-up survey. If time and conditions allow, CDFW staff will visit 4-Q Lakes for a third translocation follow-up visit in late summer/early fall 2019. During each visit to 4-Q Lakes (except for the second translocation), 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/season for each individual). CDFW also plans to collect epithelial swabs from all translocated frogs to assess *Bd* status of the nascent SNYLF population at 4-Q Lakes.

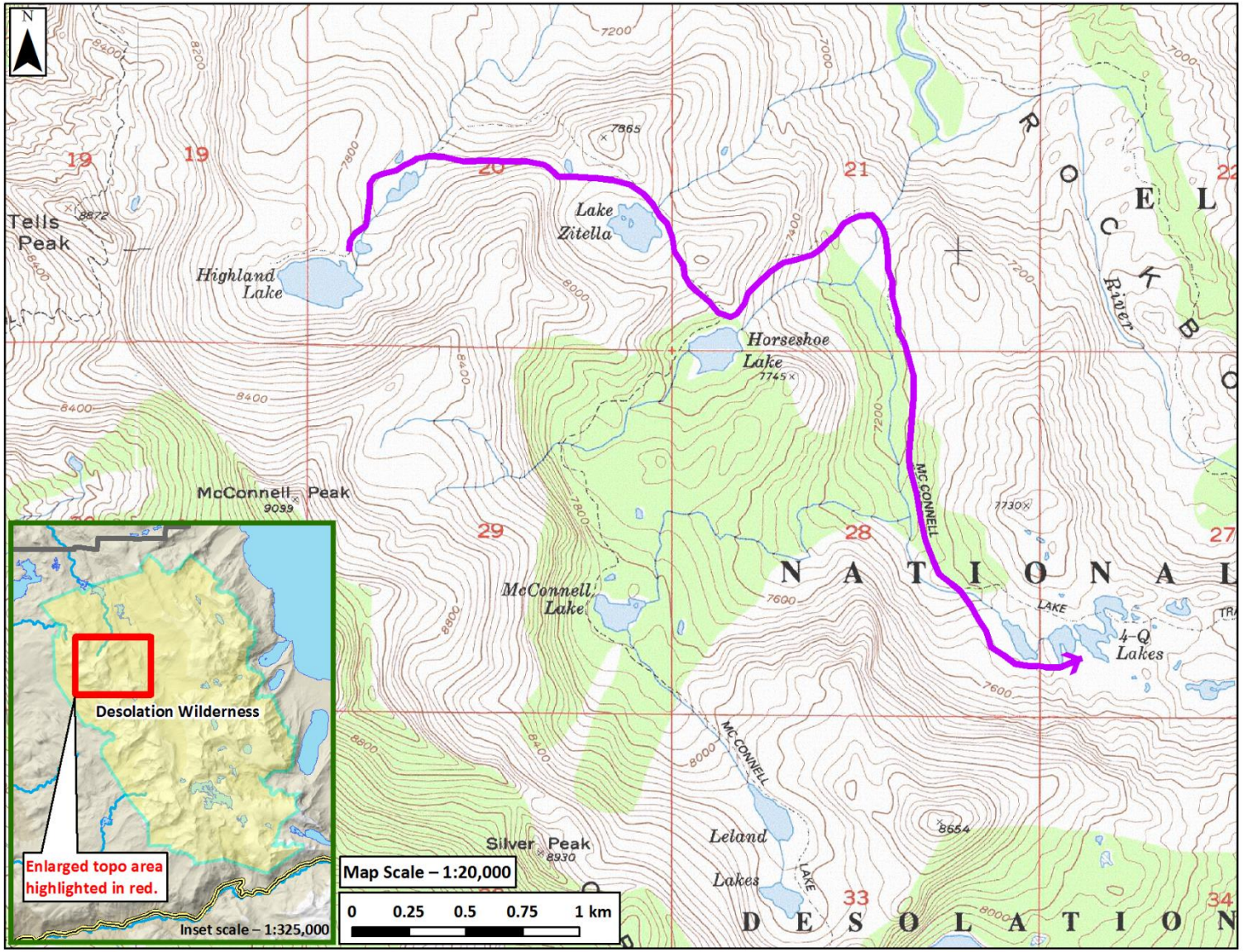


Figure 7. Path of travel for the *Rana sierrae* translocation from the Highland Lake drainage to 4-Q Lakes on 3 July 2018. The travel distance from the Highland Lake collection site to the 4-Q Lakes release site shown on the map is approximately 6 kilometers (3.7 miles). The hike between the two sites took about two hours to complete.

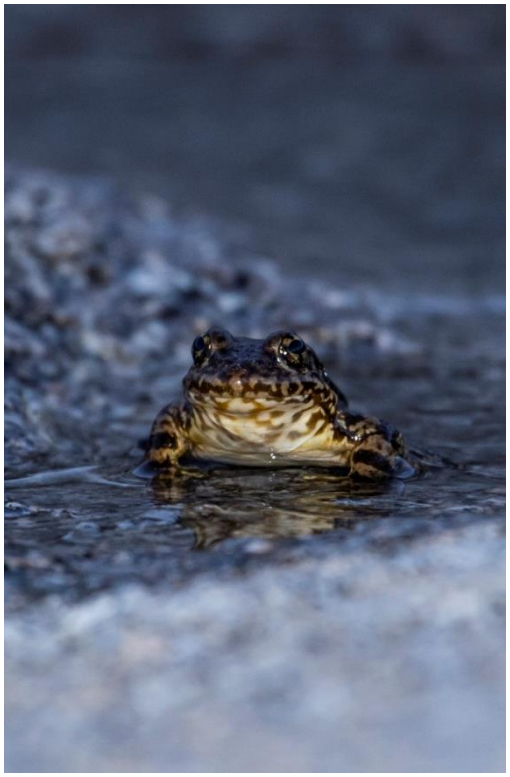


Figure 8. An adult Sierra Nevada yellow-legged frog (*Rana sierrae*; SNYLF) at Highland Lake. (CDFW)

Figure 9. CDFW field staff weighing an adult SNYLF at Highland Lake. (CDFW)

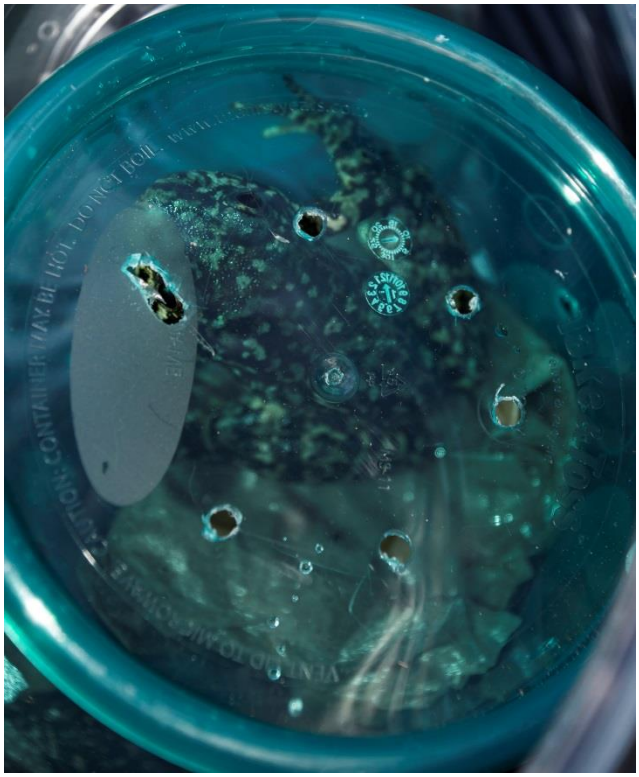


Figure 10. An adult SNYLF inside its individual transport container. Field staff housed each adult SNYLF inside one of these containers, which contained ventilation holes and a piece of wetted, unbleached paper towel to help retain moisture during transport. (CDFW)

Figure 11. Adult 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 *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. A CDFW staff member releasing an adult SNYLF at 4-Q Lakes on 3 July 2018. (CDFW)

Figure 14. Adult SNYLF being released from their containers at 4-Q Lakes on 3 July 2018. (CDFW)

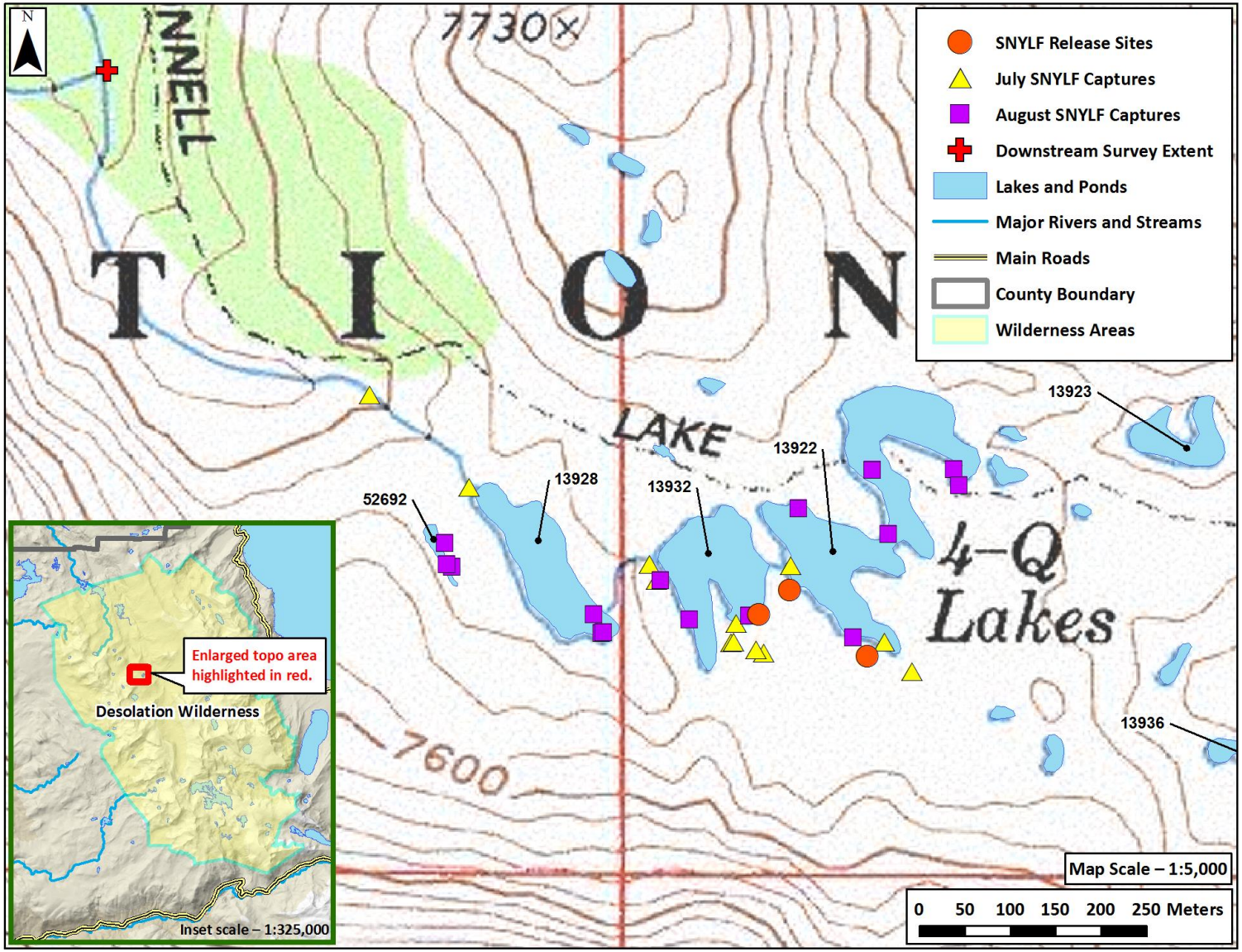


Figure 15. Map showing *Rana sierrae* (SNYLF) release sites at 4-Q Lakes on 3 July 2018 (orange circles). The map also displays the locations of all SNYLF individuals seen during follow-up visual encounter surveys (VES) on 17 July 2018 (yellow triangles) and 21 August 2018 (purple squares). CDFW staff observed 12 SNYLF individuals on 17 July 2018 and 15 SNYLF individuals on 21 August 2018. Of the SNYLF observed in August, five were also captured in mid-July. Therefore, combining the two follow-up surveys, CDFW observed 22 of the original 60 released SNYLF (37% of released frogs). The red cross depicts the farthest downstream extent of VES surveys during both follow-up trips.

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