State of California
Department of Fish and Wildlife

Memorandum

Date: 21 May 2026

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

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

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Subject: 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: 2018–2025 summary.**

Sierra Nevada Yellow-legged Frog (*Rana sierrae*) basking at the edge of Highland Lake. (CDFW)

SUMMARY

The Highland Lake drainage is an area from which California Department of Fish and Wildlife (CDFW) staff removed Rainbow Trout (*Oncorhynchus mykiss*, RT) from 2012–2015 to benefit Sierra Nevada Yellow-legged Frogs (*Rana sierrae*, SNYLF). Amphibian monitoring data from 2003 through 2025 indicate that the Highland Lake drainage supports one of the largest known SNYLF populations in the northern Sierra Nevada.

Since at least 2015, annual visual encounter surveys (VES) have revealed that the Highland Lake drainage contains a large enough SNYLF population to provide a source for translocating adults to nearby suitable fishless habitats. 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. In 2016, CDFW applied for 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 translocate SNYLF from the Highland Lake drainage to 4-Q Lakes, a nearby fishless drainage, where VES conducted by CDFW in 2003, 2015, and 2018 suggested SNYLF were not present. The grant was awarded by the USFWS in November 2016 (Award #F17AP00001) and allowed staff from CDFW and Eldorado National Forest (ENF) to undertake two translocations from Highland Lake to 4-Q Lakes, one in July 2018 (60 adult frogs) and another in August 2019 (40 adult frogs).

After initial success of the first two translocations—as evidenced by many adults surviving overwinter, rapid growth of recaptured adults, and observations of early life stage SNYLF at 4-Q Lakes in June 2020—CDFW applied for another round of funding through Section 6 to conduct two additional translocations in 2021 and 2022. USFWS awarded the grant in January 2021 (Award #F21AP00483). Therefore, in July 2021 and 2022, CDFW and ENF staff biologists translocated 51 and 26 adults, respectively. As part of current Section 6 funding for long-term monitoring of Ranid frogs in the northern Sierra Nevada (Award #F25AP00356), CDFW staff conducted one additional translocation of 36 adults in early July 2025. In total, CDFW and ENF staff have translocated 213 adult SNYLF (116 females and 97 males) from the Highland Lake drainage to 4-Q Lakes.

Each year from 2018–2025, CDFW field staff revisited 4-Q Lakes two or three times per summer to monitor the SNYLF population. During these visits, CDFW has recaptured 104 of the 213 translocated SNYLF (49%) at least once since release. From 2020–2024, CDFW staff observed occasional egg masses, tadpoles, subadults, and new young adults (individuals unmarked with passive integrated transponder (PIT) tags and, therefore, born at 4-Q Lakes). In 2025, CDFW staff observed 32 adult SNYLF born at 4-Q Lakes, 24 of which were newly tagged in 2025. All recaptured SNYLF originally translocated to 4-Q Lakes from Highland Lake appeared healthy, and many had grown noticeably (some translocated frogs are now close to their maximum size and, therefore, growth has slowed). CDFW plans to continue monitoring in the Highland Lake drainage and 4-Q Lakes basin during summer 2026 and beyond.

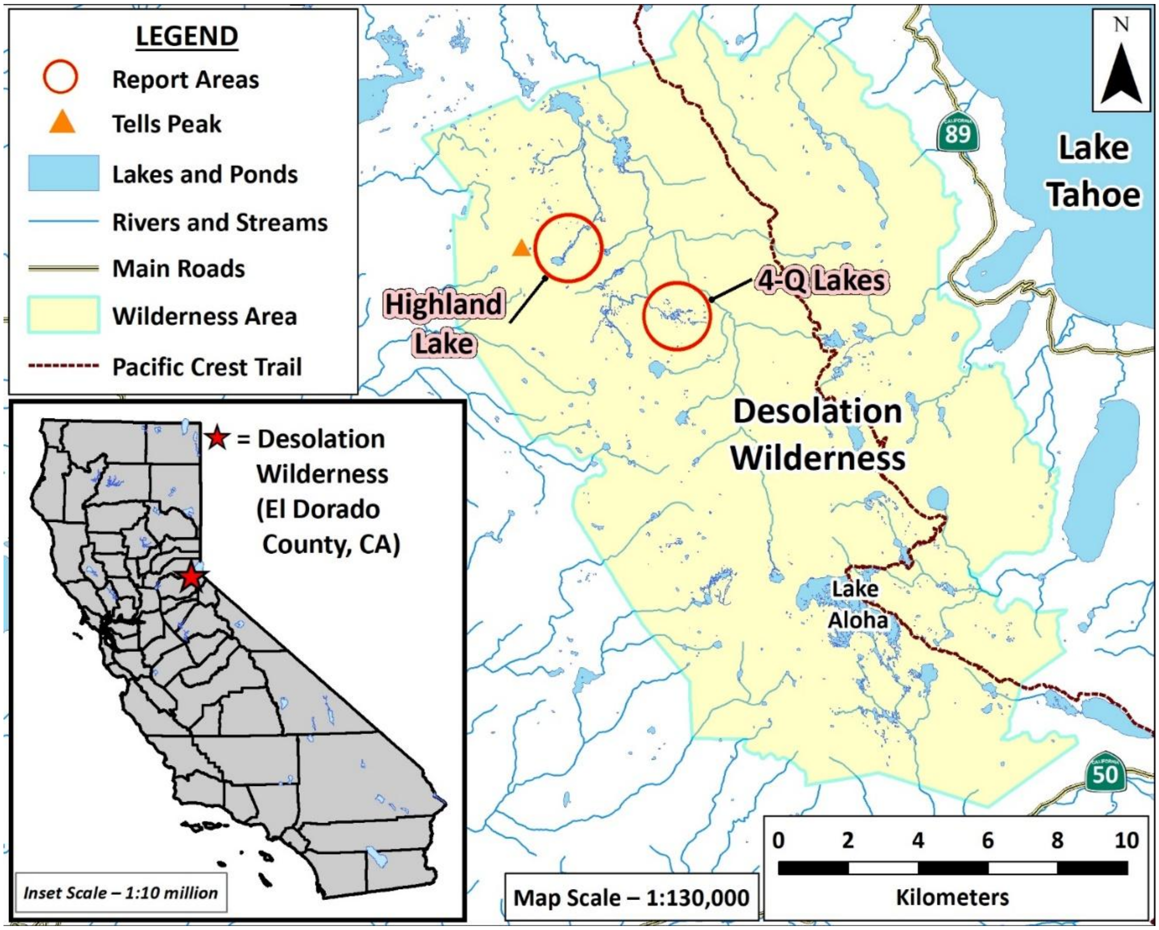


Figure 1. Desolation Wilderness, El Dorado County, CA. The areas discussed in this memorandum are circled.

ENVIRONMENTAL SETTING

Highland Lake and 4-Q Lakes are in 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. 4-Q Lakes sit in a granite basin at approximately 7,500 feet in elevation and drain 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**) and the surrounding habitat, 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; **Figure 3**) for SNYLF (**Figure 4**).

Figure 2. Highland Lake, Desolation Wilderness (El Dorado County) on 14 July 2025, looking east from the saddle south of Tells Peak. Ponded areas along the Highland Lake outlet stream are visible toward upper left, just behind the tallest foreground conifer. The furthest ridgeline visible is the Carson Range. (CDFW)

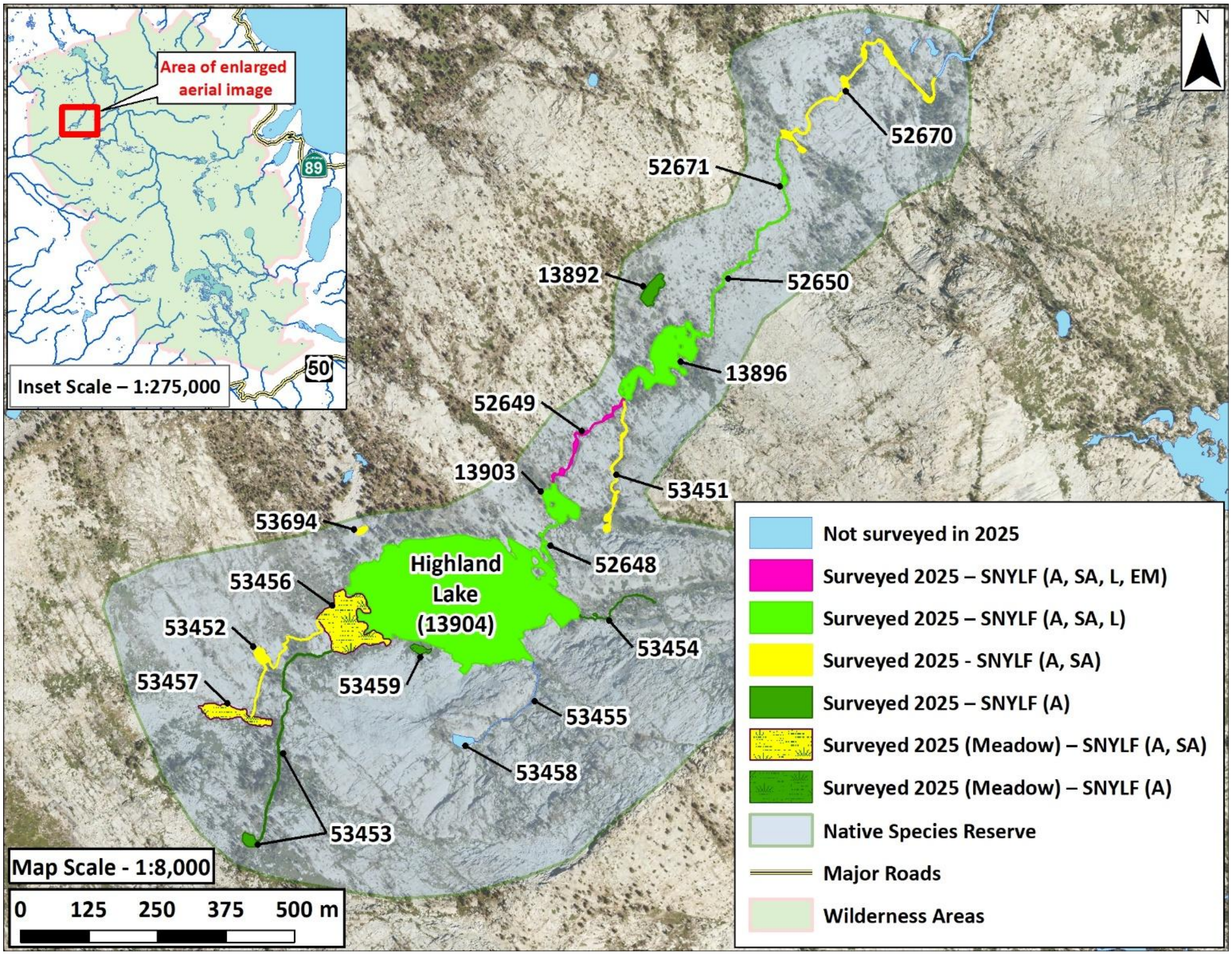


Figure 3. Highland Lake Native Species Reserve (NSR). California Department of Fish and Wildlife (CDFW) staff have observed Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) throughout the drainage. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent 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.

Figure 4. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*), *in situ*, basking along the northern shore of Highland Lake in July 2025. (CDFW)

CDFW stocked Highland Lake with RT from 1935 until 2000. The lake contains limited spawning habitat and 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 NSR to benefit SNYLF. In 2017, CDFW and ENF determined that the NSR was fishless, 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 memorandum (**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 459 adults, 261 subadults, and 985 larvae detected per survey during VES from 2014 to 2025 (**Figures 6 and 7**). 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 and the lakes were fishless.

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.

THREATS

Disease

All known SNYLF populations sampled 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, the disease caused by *Bd*).

Recently, the topic of wearing disposable nitrile gloves as a biosecurity measure when handling amphibians has received more widespread emphasis in the herpetological research and management community (see Gray et al. 2017, Thomas et al. 2020, Bletz et al. 2023, and Noelker et al. 2024 for some related biosecurity and decontamination discussions), although research on this topic has been ongoing (Mendez et al. 2008, Greer et al. 2009). As a general rule, these recommendations are prudent and highly warranted, given concerns about amphibian declines (Stuart et al. 2004) and the presence of often virulent pathogens, which are variously:

1) endemic (in the case of *Bd* throughout much of the Sierra Nevada; Briggs et al. 2010),
2) emerging (e.g., *Bd*'s first arrival into *R. muscosa* and *R. sierrae* populations naïve to the disease, which has been occurring most recently in parts of the southern Sierra Nevada; Vredenburg et al. 2010),
3) potential (e.g., *B. salamandrivorans*, *Bsal*; the chytrid fungal pathogen first identified in Europe that has not yet been detected in wild amphibian populations in the United States; Martel et al. 2013, Gray et al. 2023), and
4) largely unknown (Bienentreu and Lesbarrères 2020; e.g., ranaviruses, particularly in their distribution and impact to amphibians in the Sierra Nevada, but see Smith et al. 2017).

In particular, the use of nitrile gloves may be especially important for handling amphibians in areas with high species diversity, greater risk of exposure to multiple pathogens, and/or high likelihood of invasion and devastating outcomes from novel pathogens (e.g., in the case of one recent analysis of *Bsal*, northern California [i.e., Cascades Range and north] and the Pacific Northwest had high environmental suitability and invasion potential for *Bsal*; also, notably, several California genera had high infection risk, including *Taricha* and *Ensatina*; Gray et al. 2023). However, many locations in the United States have high risk potential associated with hypothetical *Bsal* invasion (Connelly et al. 2023, Gray et al. 2023). High elevation habitats of the Sierra Nevada in which Highland and 4-Q Lakes are located—with more limited amphibian species diversity and fewer known susceptible species—are arguably at lower risk for *Bsal* emergence than other areas with more susceptible species, higher species diversity, and more potential exposure pathways. However, *Bsal* has the potential to be pestilential for amphibians no matter where it may emerge in North America.

In isolated, geographically limited work areas, using a new pair of disposable gloves to handle each individual may be unnecessary, given known *Bd* presence, persistence of the population in the presence of disease, animal behavior, and logistical concerns. For example, in the case of Highland Lake, which supplied the original source of all frogs present at 4-Q Lakes (see details in the SNYLF TRANSLOCATION section below), SNYLF are relatively abundant, particularly when compared with other populations in the northern Sierra Nevada. SNYLF are regularly found in congregations, with individuals pressed directly together—and sometimes on top of—one another (**Figure 5**), behavior that provides ready opportunity for pathogen spread. Due in part to these behaviors (although many other factors are involved in *Bd* disease dynamics; see Wilber et al. 2022), *Bd* prevalence tends to be high in populations that are persisting despite continued presence of the pathogen (Briggs et al. 2010), while infection intensities in *Bd* persistent populations tend to be low. However, *Bd*-induced mortality still plays a role in population dynamics, especially among recently metamorphosed frogs, which are particularly susceptible to chytridiomycosis (Rachowicz et al. 2006).

Figure 5. Examples of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) congregations at Highland Lake. These tight clusters of frogs can be seen occasionally at the site, and this clustering behavior is common, especially in higher density SNYLF populations. (CDFW)

During processing for capture-mark-recapture (CMR) surveys at 4-Q Lakes, adult SNYLF are handled briefly to insert PIT tags (or scan for tags already in place) and collect morphological measurements. This process is made more difficult and time consuming while wearing nitrile gloves, especially when surveyors are solo, which is a common occurrence during these surveys. There is a loss of dexterity, which is particularly important during the PIT tag insertion process. Therefore, in this instance, with long-term population persistence at relatively high abundances in the presence of *Bd*, and increased efficiency and decreased processing time without disposable gloves, staff handle frogs bare-handed at this population.

However, several important caveats should be noted: first, staff ensure their hands are free of sunscreen, bug spray, lotions, soap residue, or any other topical substance that could harm frogs by being readily absorbed through their highly permeable skin. In addition, staff vigorously rinse off their hands in lake water and lake substrate (e.g., sand, gravel, and organic matter at the lakeshore) at the beginning of surveys, and also rinse their hands and dip nets between each frog handled. These measures help ensure no unnatural materials are being introduced to the frogs' skin, and any transfer of human skin oils would be limited. Additionally, given relatively low frog densities at 4-Q Lakes, there is often several minutes, or more, between each frog that is handled. Often, staff note their hands have sufficient time to dry completely between processing frogs, and bare hands that have dried completely would be less likely to spread *Bd* (Mendez et al. 2008; although, note that the authors specifically state, "*These experiments show that single use of disposable gloves is the only handling technique providing 100% confidence that* Batrachochytrium dendrobatidis *will not be transmitted between amphibians.*") However, in these experiments, which were conducted in a sterile lab environment, participants were specifically prevented from drying their hands, given that drying can kill *Bd* (Johnson et al. 2003), and thus confound their experiments (Mendez et al. 2008, pg. 99).

Additionally, an important aspect of biosecurity and mitigating the spread of disease involves decontamination of footwear, nets, and other equipment that has come in direct contact with aquatic substrate and amphibians. CDFW has protocols for decontaminating equipment between individual lake basins (e.g., **CDFW 2022a**), which staff have followed rigorously for over 20 years to prevent the spread of aquatic pathogens between field sites. The only exceptions involve specific circumstances, such as when staff directly translocate frogs between nearby lake basins (e.g., Highland Lake to 4-Q Lakes), so decontaminating equipment would be nonsensical in those instances.

All these considerations and caveats stated, CDFW staff plan to incorporate the use of nitrile gloves at other SNYLF populations when amphibians need to be handled, since less is known about disease dynamics at some other populations where CDFW has recently initiated CMR surveys. SNYLF populations in these other CMR locations tend to be small and more widely distributed on the landscape, reducing the chances that frogs regularly encounter as many conspecifics, when compared with a site like Highland Lake (at least outside of overwintering periods, during which frogs may aggregate at preferred overwintering locations; Wilber et al. 2022). Therefore, gloves may help mitigate the risks of moving pathogens that would otherwise not be transferred as readily within a low density population.

Loss of Genetic Diversity

VES data suggest that the Highland Lake drainage SNYLF population was very small and only recently expanded. 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 level of inbreeding, effective population size, and 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 immigrate from in the near term, but the other populations are close enough to allow for rare instances of gene flow. This arrangement contrasts with 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 barriers, 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.

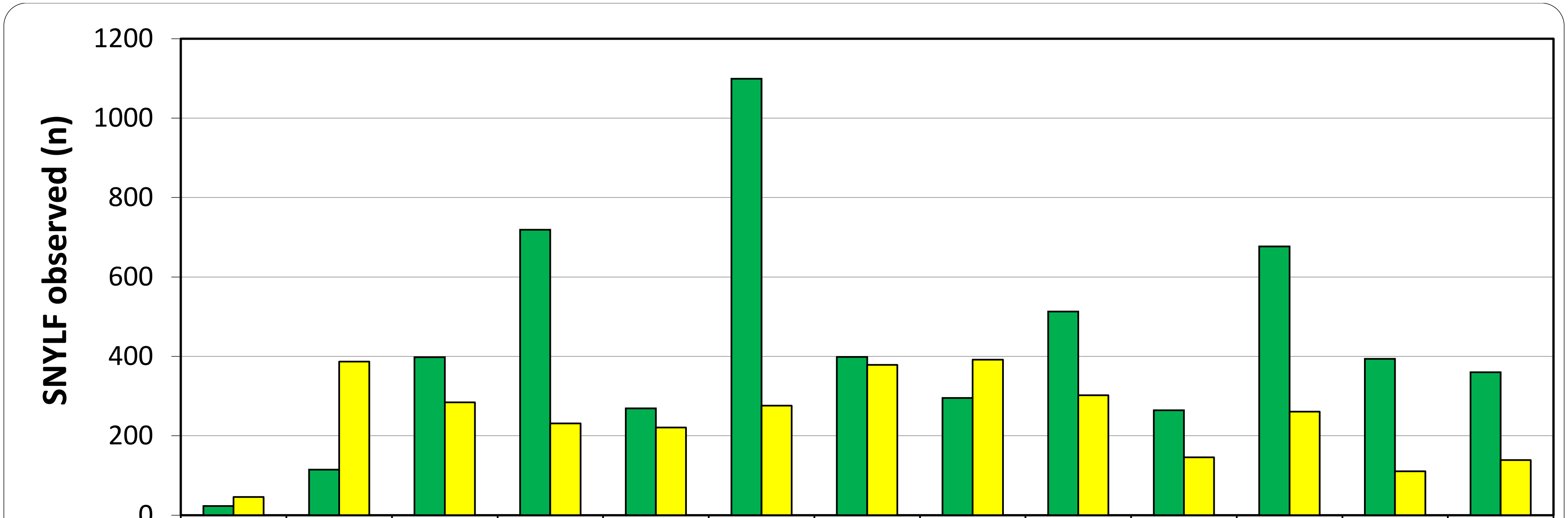
HIGHLAND LAKE DRAINAGE SNYLF POPULATION STATUS: RESULTS

Although CDFW did not detect SNYLF in the Highland Lake drainage prior to 2008, ENF staff have been monitoring this population since 1993 (USFS 1993). VES data between 2013 and 2025 confirm that the population has increased dramatically when compared with survey results prior to 2014 (**Figures 6 and 7**; to see VES results from 2003–2013, see earlier survey memos, the most recent of which is **CDFW 2025**). 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 had begun to successfully utilize additional breeding habitats.

What follows is a brief recap of past results, followed by more detailed discussion of survey results in 2025.

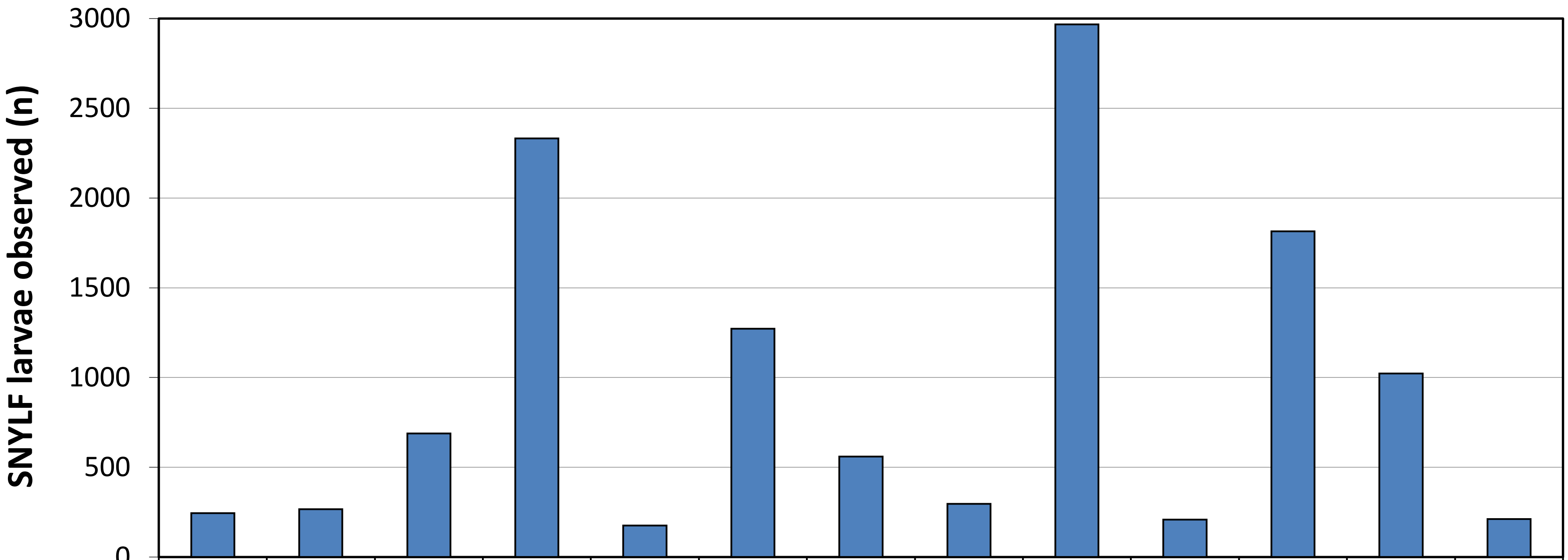
Each summer from 2014 to 2025, CDFW staff surveyed the Highland Lake drainage at least once per season, including Highland Lake, inlets to the main lake, the Highland Lake outlet stream (which includes two stream-widening ponds), and adjacent wetted habitat (**Figure 3**). The only minor exceptions to survey coverage occurred in 2017, when staff did not survey Site ID 13892; 2019, when staff did not survey the furthest downstream section of the Highland Lake outlet within the NSR (Site IDs 52670 and 52671; **Figure 3**); and 2023, when staff did not survey the stream segments below Site ID 13896; **Figure 3**). During the period 2014–2025, post-metamorphic SNYLF detections have varied, but staff have detected at least several hundred post-metamorphic SNYLF each season (**Figure 6**). During the same period, larval SNYLF observations have been more variable, with staff detecting anywhere from approximately 200 to nearly 3,000 tadpoles (**Figure 7**).

CDFW will continue long-term monitoring of the core NSR to maintain up-to-date knowledge on the status of the Highland Lake drainage SNYLF population. During the next several years, CDFW will monitor the Highland Lake drainage at least once each summer. CDFW staff will also survey 4-Q Lakes, the translocation recipient site, to monitor the status of the translocated SNYLF population.



Year	2013‡	2014	2015	2016	2017Δ	2018	2019††	2020	2021	2022Δ	2023◊	2024	2025
Adult	23	115	398	719	269	1099	399	295	513	264	677	394	360
Subadult	46	387	284	231	221	276	379	392	302	146	261	111	139

Figure 6. 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 2013 and 2024. In 2014–2018, 2020–2022, and 2024, surveys occurred throughout the entire drainage, including Highland Lake, the outlet stream, and the two downstream ponds.
‡Surveys in 2013 only included Highland Lake and the two downstream ponds.
†† CDFW did not survey Site IDs 52670 and 52671 in 2019.
ΔIn 2017 and 2022, weather conditions were cold and windy in the Highland Lake drainage. See CDFW (2023) for details.
◊In 2023, due to time constraints and weather conditions, CDFW did not survey the Site IDs downstream of 13896 (Site IDs 52650, 52670, and 52671).



Year	2013‡	2014	2015	2016	2017Δ	2018	2019††	2020	2021	2022Δ	2023◊	2024	2025
Larva	244	267	689	2333	176	1272	560	297	2967	209	1814	1022	211

Figure 7. Number of larval Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) in the Highland Lake drainage between 2013 and 2024. (See **Figure 6** for caveats about surveys and symbol meanings.) Steady winds and occasional strong gusts during the Highland Lake survey on 10 September 2017, 7 August 2019, 11 August 2020, 6 July 2022, and 15 July 2025 made visibility into the lake difficult, which may account for the low larval SNYLF observations when compared with other recent survey years.

HIGHLAND LAKE DRAINAGE SNYLF 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 had 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 aquatic 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 and 2020–2022 drought periods. Regardless, monitoring efforts over a >20-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.

In 2024, CDFW observed typical post-metamorphic and larval SNYLF counts when compared with the average 2014–2024 survey record (394 adults, 111 subadults, and 1022 tadpoles; **Figures 6 and 7**; see page 7 for a summary of average counts). Overall, survey conditions were excellent during the three-day survey period (29–31 July 2024). Winds were mostly light, with clear skies and air temperatures during surveys averaging approximately 21°C (70°F).

Survey conditions may be one of the most important factors explaining differences in SNYLF detections in the Highland Lake drainage. Similar to some other high alpine sites in the Sierra Nevada, numerous visits by CDFW over the past approximately 20 years suggest that Highland Lake basin is prone to periods of strong winds. These windy conditions greatly limit visibility through the water for observing tadpoles or detecting post-metamorphic frogs resting on lake and stream bottoms. Additionally, high winds and frequent gusts appear to reduce basking behavior of post-metamorphic SNYLF (**Figure 8**), when compared with calmer conditions (I. Chellman, pers. obs.; M. Lockhart, pers. comm.). Frogs may be more likely to seek refuge underwater and beneath lakeside cover objects during cooler and windier periods. Winds were stronger during VES in 2017, 2019, 2020, and 2022, all years during which CDFW staff detected fewer SNYLF tadpoles. By comparison, less wind occurred during CDFW surveys at Highland Lake in 2016, 2018, 2021, 2023, and 2024; all years during which staff detected more tadpoles.

Figure 8. Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) basking on granite at the edge of Highland Lake in late July 2024. (CDFW)

In discussing past results, CDFW brought up the topic of harsh winter conditions and the effect those conditions may occasionally have on SNYLF populations (**CDFW 2023**), since poor SNYLF survivorship can occur during long, harsh winters (Bradford 1983). Thankfully, the above average northern Sierra Nevada snowpack in winter 2022–2023 (when the April 1^{st} northern Sierra Nevada snow water content reached approximately 200% of the 30-year average; CDEC 2024) did not appear to significantly impact the SNYLF population in the Highland Lake drainage, at least in terms of detection rates during surveys in August 2023.

Overall, VES results can be difficult to compare, due to numerous factors, including weather conditions, time of year, and observer bias (Mazerolle et al. 2007; **Figure 9**). 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). 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).


Figure 9. Low cloud ceiling above the Highland Lake cirque during an atypically cool summer day in July 2022. (CDFW)

SNYLF TRANSLOCATION

For complete details about the translocations of SNYLF from Highland Lake to 4-Q Lakes (**Figure 10**) in 2018 and 2019, including background on the translocation recipient site, consult the survey memo for the 2019 Highland-4-Q Lakes VES and translocation (**CDFW 2020**). Additionally, details on the 2021 and 2022 translocations, including methods and photographs, were included in the 2021 update for Highland and 4-Q Lakes (**CDFW 2022b**) and the 2022 update (**CDFW 2023**). Below is a brief summary of the previous translocation efforts, followed by detailed discussion of follow-up surveys at 4-Q Lakes in 2024.

Figure 10. View east from the southwestern shore of Upper 4-Q Lake (Site ID 13922) on 16 July 2025. (CDFW)

Translocation Summary

CDFW has conducted five translocations of adult SNYLF (**Figure 11**) from Highland Lake to 4-Q Lakes (**Figure 12**). The first, in July 2018, involved moving 60 adults (26 males and 34 females); the second, in August 2019, involved moving 40 adults (18 males and 22 females); the third, in July 2021, involved moving 51 adults (28 females and 23 males); the fourth, in July 2022, involved moving 26 adults (14 females and 12 males); and the fifth, in July 2025, involved moving 36 adults (18 females and 18 males). In total, CDFW and ENF staff have translocated 213 adult SNYLF (116 females and 97 males) from the Highland Lake drainage to 4-Q Lakes. During most translocations, staff intentionally collected a female-biased sample to attempt increasing the odds of successful reproduction at the recipient site. All translocated adults received a PIT tag at the time of collection at Highland Lake to uniquely mark each individual.

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 HIGHLAND LAKE DRAINAGE SNYLF 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 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 per translocation action.

Figure 11. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) being handled for scanning with a passive integrated transponder (PIT) tag reader and collection of morphological measurements. *Note*: amphibian chytrid fungus (*Bd*) is present at Highland and 4-Q Lakes, and all other northern Sierra Nevada populations sampled by CDFW staff from 2008–present (see detailed discussion in the *Disease* section above). Therefore, staff do not typically wear nitrile gloves when briefly processing frogs for capture-mark-recapture in known persistent *Bd*-positive populations, especially those where frogs are present at high densities in some locations, like Highland Lake, and consistently exposed to the pathogen. Ungloved hands also provide better dexterity and faster processing, which decreases handling time for the frogs. (CDFW)

Translocation Methods

After VES on 15 July 2025 confirmed that the SNYLF population remained robust enough to support removal of 36 adult SNYLF (**Figure 11**), CDFW staff mobilized for translocation efforts. On 16 July 2025, field crews began collecting adult SNYLF (individuals >40 millimeters snout-to-urostyle length [SUL]). Field staff collected adults via hand capture or dip nets, identified sex, implanted a PIT tag to provide a unique identifier for each individual (**Figures 13a** and **13b**), measured SUL (**Figure 14a**), and recorded weight (**Figure 14b**). In total, staff collected 36 adult SNYLF (approximately 10% of the adult population observed the previous day). For the translocation, staff collected individuals between 47 and 68 mm SUL, with an average length of 51 mm SUL for males and 57 mm SUL for females. Staff collected adults from the northern shore of Highland Lake, Site ID 52648, Site ID 53454, and the southern shore of Site ID 13903 (**Figure 3**). The 36 adult SNYLF were comprised of 18 females and 18 males.

Staff placed each frog into its own plastic container with multiple holes for ventilation (**Figure 15**) and stored the containers on snow in the shade to prevent frogs from overheating (**Figure 16**). Once staff had completed the collection, they 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 12 and 17**). 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 18 and 19**). All frogs appeared healthy upon release.

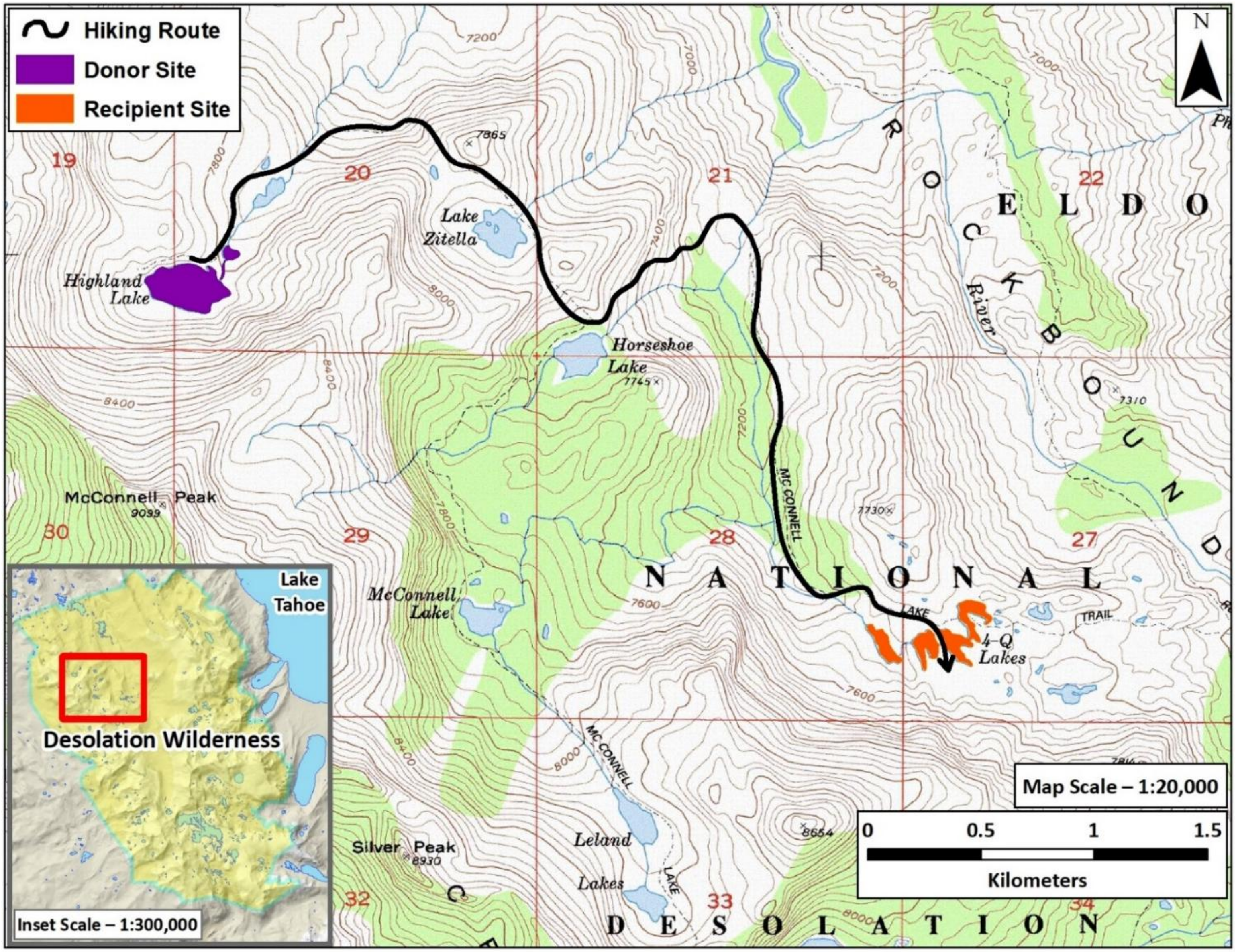


Figure 12. Path of travel for the Sierra Nevada Yellow-legged Frog (*Rana sierrae*) translocations from Highland Lake (donor site) to 4-Q Lakes (recipient site). Travel distance between the two sites via the route shown is approximately 6 kilometers (3.7 miles). The hike takes about two hours to complete.

Figure 13a. A CDFW staff member inserting a passive integrated transponder (PIT) tag into an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake on 7 July 2022. (CDFW)

Figure 13b. A CDFW staff member scanning the recently inserted PIT tag of an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake on 7 July 2022. (CDFW)

Figure 14a. A CDFW staff member preparing to measure the snout-to-urostyle (SUL) length of an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake on 16 July 2025. (CDFW)

Figure 14b. A CDFW staff member weighing an adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Highland Lake on 6 July 2021. (CDFW)

Figure 15. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) inside its individual transport container, soon before making its way into new habitat at 4-Q Lakes in July 2025. For the translocation, 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. In this photograph, staff have removed the lid from the frog’s container so it can hop out into its new home. (CDFW)

Figure 16. 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 17. California Department of Fish and Wildlife (CDFW) staff carrying Sierra Nevada Yellow-legged Frog (*Rana sierrae*) adults (housed individually inside bear canisters, inside backpacks) into 4-Q Lakes on 16 July 2025. (CDFW)

Figure 18. California Department of Fish and Wildlife (CDFW) staff releasing adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) at 4-Q lakes on 16 July 2025. (CDFW)

Figure 19. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) soon after being released at 4-Q Lakes on 16 July 2025.

Follow-up Surveys

In addition to the translocations, CDFW revisited 4-Q Lakes two or three times during each year, 2018–2025 (**Table 1**). During initial post-translocation surveys (2018–2019), CDFW conducted follow-up surveys at 4-Q Lakes to assess if the translocated frogs: 1) moved from the original release sites, 2) appeared in good health, 3) were behaving normally, and 4) had successfully reproduced. Now that CDFW staff have consistently observed SNYLF reproduction at 4-Q Lakes (e.g., early life stages observed each year and new adults being recruited into the population; see **CDFW 2022b**, **2023**, **2024**, **2025** and additional results below), staff return annually to continue CMR surveys, including documenting early life stage observations and PIT tagging new adults being recruited into the population.

In 2025, two CDFW staff surveyed 4-Q Lakes basin on 25–27 August, and three staff surveyed 4-Q Lakes basin on 22–24 September. During each visit, staff surveyed the main 4-Q Lakes, an assortment of nearby ponds that retained water, and portions of the outlet stream (see **Figure 20** for specific survey locations).

In late August, CDFW staff observed 34 adult SNYLF individuals. In late September, CDFW staff observed 42 adult SNYLF individuals. Of the 34 SNYLF adults captured and handled in late August, 24 were recaptured in late September. Among all adult SNYLF captures in 2025, 24 individuals were adults originally born at 4-Q Lakes that staff newly captured and PIT tagged (14 tagged in late August, and 10 tagged in late September). Combining both surveys in 2025, CDFW observed 52 SNYLF individuals (25 females and 27 males).

CDFW observed 20 of the 213 translocated SNYLF in 2024 (~9%; **Table 1**). Of the 20 translocated adult recaptures, two were translocated to 4-Q in 2018, four were translocated to 4-Q in 2019, one was translocated to 4-Q in 2021, one was translocated to 4-Q in 2022, and 12 were translocated to 4-Q in mid-July 2025. When combining data for all follow-up surveys at 4-Q Lakes from 2018–2025, CDFW has observed 104 of the 213 released adult SNYLF individuals at least once (49%; **Table 1**).

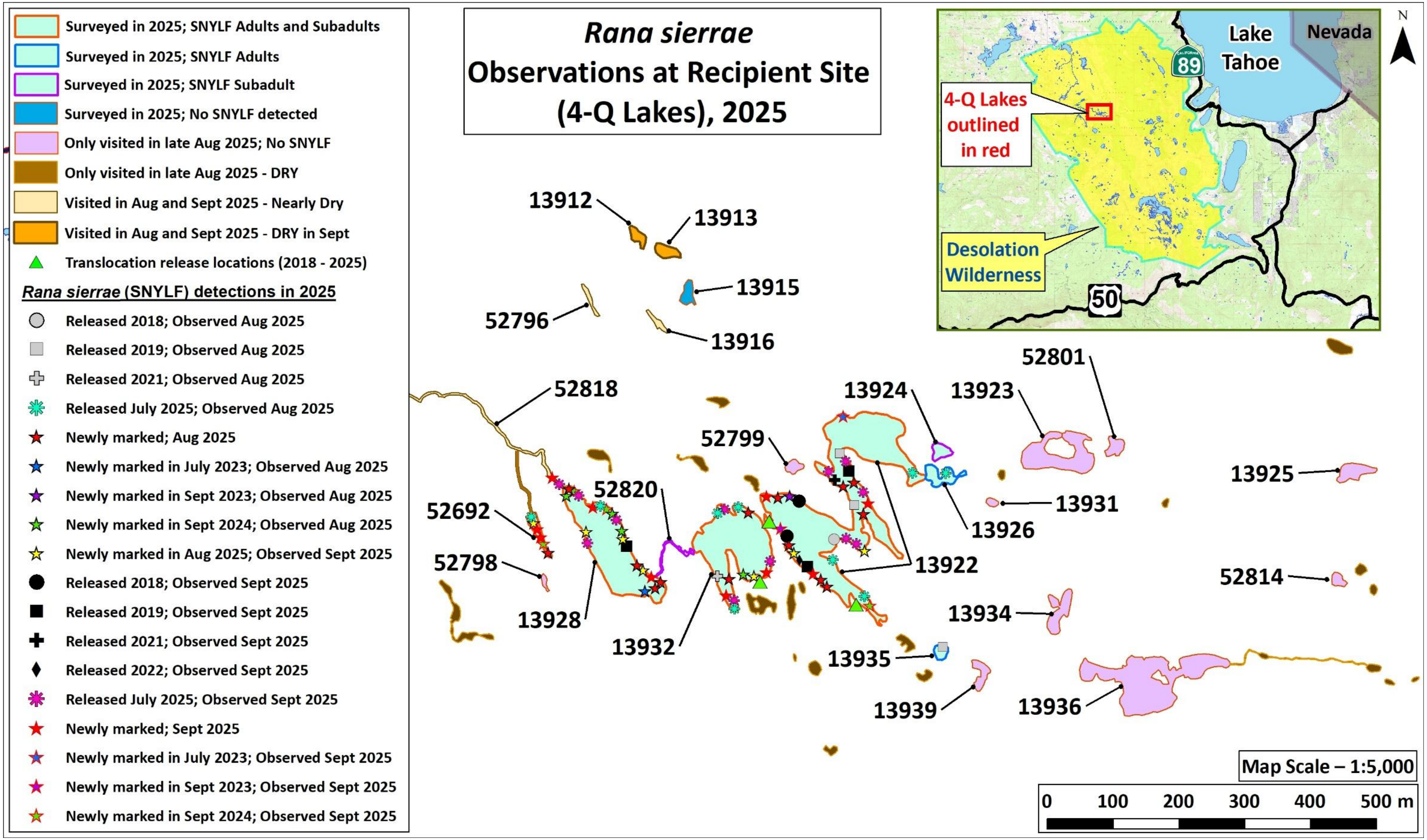


Figure 20. [See figure caption on the next page.]

Figure 20 (continued). Map showing locations of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) individuals detected by California Department of Fish and Wildlife (CDFW) field staff during capture-mark-recapture (CMR) surveys at 4-Q Lakes in 2025. Number labels shown are unique aquatic site identification codes used by CDFW. The map also shows green triangles depicting locations where adult SNYLF translocated from Highland Lake were released in 2018 (n = 60; 26 males, 34 females), 2019 (n = 40; 18 males, 22 females), 2021 (n = 51; 23 males, 28 females), 2022 (n = 26; 12 males, 14 females), and 2025 (n = 36; 18 males, 18 females).

In 2025, CDFW conducted surveys at 4-Q Lakes on 25–27 August, and 22–24 September. During both surveys, staff visited all ponds shown in light blue. All ponds shown in dark brown were completely dry by late August and, therefore, most were not revisited in late September. Additionally, all sites in light purple with orange outlines were only surveyed in August due to lack of previous SNYLF detections at these locations. In August and September, staff surveyed the entire outlet stream, from Lower 4-Q Lake (Site ID 13928) down to the confluence with the ephemeral McConnell Lake outlet (just outside the extent of the map, to the west).

During average water years, most of the small ponds shown in this map dry by late summer, and this trend continued in 2025, when most small ponds in the basin that staff visited were completely dry (and the others had low water) by the first follow-up surveys in August.

CDFW staff observed 34 SNYLF individuals in late August. Grey circles indicate frogs released in 2018, grey squares indicate frogs released in 2019, grey crosses indicate frogs released in 2021, and stars of varying colors with black outlines indicate frogs born at 4-Q Lakes captured in August and newly marked at the site during follow-up surveys (see the legend for details on the meanings of different colored star icons).

In late September, staff observed 42 SNYLF individuals. Black circles indicate frogs released in 2018, black squares indicate frogs released in 2019, black crosses indicate frogs released in 2021, black diamonds indicate frogs released in 2022, and stars of varying colors with red outlines indicate frogs born at 4-Q Lakes captured in September and newly marked at the site during follow-up surveys (see the legend for details on the meanings of different colored star icons).

Note: some frog location icons are not shown at the exact capture location. A few capture records for Site ID 13922 were added to the electronic data file (Survey123 form) when crew members were back at camp (between Site IDs 13932 and 13922), so the original capture location for those individuals is not known precisely. Those few misplaced icons have been placed at the margin of Site ID 13922, closest to camp (i.e., the southwest shore of Lake ID 13922). Most icons shown are in the correct capture locations. Icons that were packed together or stacked atop one another were separated a small distance to allow clearer differentiation between colors and shapes.

[***End of figure caption***.]

Table 1 (see next page). Dates of adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) translocations and follow-up surveys at 4-Q Lakes, Desolation Wilderness, between 2018 and 2025; and number of SNYLF translocated, recaptured, or newly captured during each site visit. SNYLF numbers shown in each row (females, males, and total) are the number of unique individuals recaptured or newly marked during that site visit (i.e., not capture events, since some SNYLF individuals were caught more than once during each visit). The total rows at the bottom of the table display the following: **1)** the sum of SNYLF individuals originally translocated from the Highland Lake drainage that have been recaptured at least once since the first follow-up survey in July 2018 (in yellow). In total, CDFW has moved 213 adult SNYLF from the Highland Lake drainage to 4-Q Lakes (all between 2018 and 2025). Of those 213 translocated frogs, CDFW has recaptured at least* 104 individuals (49% of all translocated adults) at least once during post-translocation follow-up surveys at 4-Q Lakes. **2)** The sum of all unique adult SNYLF individuals that have been observed at 4-Q Lakes at least once since 2018, including frogs translocated from the Highland Lake drainage and new adults that were born at 4-Q Lakes (in pink).

(**See below for why the total number of recaptured individuals is not known precisely, given a few recaptured frogs with passive integrated transponder [PIT] tag issues.*)

†For tallies showing the original year of translocation (in grey), CDFW does not know the release year of three SNYLF individuals. There is a chance that two of these unknown individuals are the same frog. Staff captured the first SNYLF with an unknown release year in August 2020. This frog had a PIT tag, but the tag was unreadable (i.e., the Biomark 601 PIT tag reader displayed "AVID tag detected," although no AVID brand tags have been inserted into frogs during this project). The frog was a male with snout-to-urostyle (SUL) length of 57 mm and a weight of 22 g. Staff captured the second SNYLF with an unknown release year in June 2022. This frog contained a PIT tag, but the tag would not read (staff could clearly see a PIT tag underneath the skin above the frog's urostyle, but the Biomark HPR Lite PIT tag reader did not detect the tag and nothing was displayed on the reader). Therefore, staff retagged the frog with a new PIT tag that was readable. The frog was a male with 59 mm SUL and a weight of 26 g. Given the PIT tag malfunctions and sizes of these two male frogs, there is a chance that the frog with an unreadable tag caught in August 2020 is the same individual as the frog caught in June 2022. However, since that possibility cannot be known definitively, the tallies below record these two frogs as separate individuals. Staff captured the third SNYLF with an unknown release year in August 2022. Staff found this frog dead and highly decomposed, so they could not determine the frog's sex. Additionally, staff did not detect a PIT tag in this dead SNYLF. Given this dead individual's large size, the frog had likely been translocated from Highland Lake. However, since staff did not detect a PIT tag in this individual, CDFW was unable to determine the potential translocation year.

[***End of caption for Table 1***.]

Table 1. (see caption on previous page).

Year	Dates	Females	Males	Unk Sex	Total	Notes
2018	**3 July**	**34**	**26**	**0**	**60**	**Translocation #1**
2018	17–18 July	5	7	0	12	
2018	21 Aug	13	2	0	15	
2018		***14***	***8***	***0***	***22***	***Total individuals observed in 2018***
2019	6 Aug	5	4	0	9	
2019	**8 Aug**	**22**	**18**	**0**	**40**	**Translocation #2**
2019	4 Sept	10	9	0	19	
2019	*4 Sept*	*2*	*2*	*0*	*4*	*Frogs released in 2018; all 4 also seen on 6 Aug 2019*
		8	*7*	*0*	*15*	*Frogs released in 2019*
2019		***13***	***11***	***0***	***24***	***Total individuals observed in 2019***
2020	16–17 June	14	6	0	20	
2020	11–12 Aug	10	6	0	16	
2020	*Trips*	*4*	*2*	*0*	*6*	*Frogs released in 2018*
	Combined–	*16*	*7*	*0*	*23*	*Frogs released in 2019*
	Unique Individuals	*0*	*1*	*0*	*1*	*Frog with unknown release year; (see table heading on previous page)*
2020		***20***	***10***	***0***	***30***	***Total individuals observed in 2020***
2021	30 June	10	5	0	15	
2021	**6 July**	**28**	**23**	**0**	**51**	**Translocation #3**
2021	11 Aug	18	3	0	21	
2021	*Trips*	5	3	0	8	*Frogs released in 2018*
	Combined–	7	3	0	10	*Frogs released in 2019*
	Unique Individuals	*6	1	0	7	*Frogs released in 2021; *one of the females found being eaten by a gartersnake, which dropped the frog when staff approached. Likely that frog later died.*
		4	1	0	5	*Newly tagged at 4Q Lakes in 2021*
2021		***22***	***8***	***0***	***30***	***Total individuals observed in 2021***
2022	22–23 June	*4	†10	1	‡15	*One female SNYLF found dead. †One male SNYLF detected inside a Sierra Gartersnake (*Thamnophis couchii*). ‡One additional adult, which was not one of the other 14 individuals tallied, evaded capture.
2022	**7 July**	**14**	**12**	**0**	**26**	**Translocation #4**
2022	26–27 July	9	8	0	17	One dead adult anuran also found; not included in tally. (Species unknown due to decomposition—SNYLF or *Anaxyrus* [*Bufo*] *boreas*; no PIT tag detected.)
2022	30–31 Aug	12	12	1	*25	*One additional SNYLF found dead and included in total; (no PIT tag, sex unknown due to decomposition).
2022	*Trips*	*2	3	0	5	*Frogs released in 2018; *one of the females was found dead.*
	Combined–	2	7	0	9	*Frogs released in 2019*
	Unique	3	*4	0	7	*Frogs released in 2021; *one of the males was eaten by a gartersnake*
	Individuals	10	5	0	15	*Frogs released in 2022*
		0	1	1	*2	*Frogs w/ unknown release year (*Includes one adult SNYLF of unknown sex found dead with no PIT tag detected).*
		1	**1**	**1**	***3**	***Adult SNYLF mortalities seen in 2022 (*sex of one individual unknown).***
		4	3	0	7	*Newly tagged at 4Q Lakes in 2022*
2022		***21***	***23***	***1***	****45***	***Total individuals observed in 2022*** *(*Includes one adult SNYLF of unknown sex found dead with no PIT tag detected).*
2023	26 July	6	6	10	22	10 newly marked adults small enough that sex ID was not definitive.
2023	19–20 Sept	13	2	0	15	
2023	*Trips*	1	2	0	3	*Frogs released in 2018*
	Combined–	1	1	0	2	*Frogs released in 2019*
	Unique	2	1	0	3	*Frogs released in 2021*
	Individuals	1	0	0	1	*Frogs released in 2022*
		0	1	0	1	*Newly tagged at 4Q Lakes in 2022*
		10	3	7	20	*Newly tagged at 4Q Lakes in 2023*
2023		***15***	***8***	***7***	***30***	***Total individuals observed in 2023***
2024	3–4 Sept	13	8	*3	24	*The three frogs of unknown sex were adults that evaded capture.
2024	23–25 Sept	12	†14	*5	31	†Two of the males were >40 mm SUL, but too small to tag. *Of the frogs with unk. sex, four evaded capture, but were different individuals (based on survey timing and locations), and one was found dead. The dead frog was not scanned for a PIT tag.
2024	*Trips*	1	1	0	2	*Frogs released in 2018*
	Combined–	2	2	0	4	*Frogs released in 2019*
	Unique	0	1	0	1	*Frogs released in 2021*
	Individuals	3	0	0	3	*Frogs released in 2022*
		0	1	0	1	*Newly tagged at 4Q Lakes in 2022*
		6	1	0	7	*Newly tagged at 4Q Lakes in 2023*
		7	*10	0	17	*Newly tagged at 4Q Lakes in 2024. *Two more males not tagged (too small).*
2024		***19***	***†18***	****5***	***42***	***Total individuals observed in 2024*** *(†Two not tagged due to small size, despite being a little >40 mm SUL. *Includes one adult SNYLF of unknown sex found dead that was not scanned for a PIT tag. Remaining four were all escapees.)*
2025	**16 July**	**18**	**18**	**0**	**36**	**Translocation #5**
2025	25–27 Aug	14	20	0	34	
2025	22–24 Sept	23	19	0	42	
2025	*Trips*	1	1	0	2	*Frogs released in 2018*
	Combined–	2	2	0	4	*Frogs released in 2019*
	Unique	0	1	0	1	*Frogs released in 2021*
	Individuals	1	0	0	1	*Frogs released in 2022*
		8	4	0	12	*Frogs released in 2025*
		0	0	0	0	*Newly tagged at 4Q Lakes in 2022*
		2	0	0	2	*Newly tagged at 4Q Lakes in 2023*
		3	3	0	6	*Newly tagged at 4Q Lakes in 2024*
		8	16	0	24	*Newly tagged at 4Q Lakes in 2025*
2025		***25***	***27***	***0***	***52***	***Total individuals observed in 2025***
		0	***2***	***1***	***†3***	***Total frogs with unknown release year;*** *(†see table heading on previous page).*
		116	***97***	***0***	***213***	***Total adult frogs translocated from Highland to 4-Q: 2018–2025***
		66	***38***	***0***	***104***	***Translocated individuals recaptured at 4-Q Lakes ≥ one time: 2018–2025***
		95	***72***	***5***	***†172***	***Total adult SNYLF individuals observed at 4-Q Lakes at least once during post-translocation surveys, 2018–2025.*** *(†see heading on previous page for details regarding SNYLF with unknown release year).*

Sex ratios among recaptures of translocated frogs during follow-up surveys have been dominated by females. During post-translocation surveys from 2018–2025, CDFW has recaptured 66 of the females and 38 of the males that were translocated. This ratio among translocated frog recaptures (1.72 females:1 male) is higher than the female-biased sex ratios of total released frogs (1.2 females:1 male). The reasons that staff have detected more translocated females than males during follow-up surveys are not known, but some possibilities include males migrating further than females (i.e., outside the regular survey area, such as far down the 4-Q Lakes outlet, or into more distant ponds), higher mortality rates among translocated males (e.g., increased movement may cause greater energetic costs and leave males more susceptible to predation), or translocated males having lower detectability than females. However, sex ratios among overall frog captures at 4-Q Lakes (both translocated frogs and frogs born on-site) for the past two seasons have been nearly even. For example, in 2025, staff observed 25 females and 27 males (**Table 1**).

Most frogs detected during follow-up surveys at 4-Q Lakes have appeared to be in good condition. All live recaptured SNYLF had grown substantially since their initial translocation, suggesting that the 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**). These trends in growth patterns between the sexes were consistent in individuals with data available for timespans between one month and three or more years between release and most recent capture (**Table 2**).

Looking at the longer periods of growth, female growth rates were strikingly higher than males. For example, CDFW collected data from nine females for which the most recent recapture event was three or more years following translocation or post-initial-marking at 4-Q Lakes (for individuals later born at the release site). Average growth for these nine females was 41 g and 25 mm SUL (**Table 2**). Meanwhile, average growth for 12 males most recently recaptured three or more years post-marking was 14 g and 12 mm SUL. See **Table 2** for growth summary statistics for other durations between translocation or initial marking at 4-Q Lakes and the most recent capture event. Like many explosive breeding anuran species, SNYLF females are on average much larger than males (Wells 2007, pg. 389), and the data presented in **Table 2** demonstrates that females can achieve these larger sizes in relatively short timeframes.

SNYLF released at 4-Q Lakes have continued to disperse from their original release points and now occupy many areas in 4-Q Lakes basin (**Figure 20**). In 2025, CDFW staff observed SNYLF occupying numerous areas in the basin, in all of which staff have previously detected SNYLF. Given the time of year and limited water availability outside of the main ponds during surveys in late summer 2025, staff observed most SNYLF in the largest lakes. However, at other times of year during past surveys, staff have detected SNYLF in a wider area, including within small, ephemeral ponds and stream channels (see previous memos; e.g., **CDFW 2023** and **2024**).

For further details on early life stage SNYLF detections, see the *Reproduction* section below.

Table 2. Average growth summary statistics—partitioned by timeframe† and sex (F = female, M = male)—for adult Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) translocated from Highland Lake to 4-Q Lakes, or born at 4-Q Lakes. Measurements displayed are original ("1st" = measurement on translocation day, or day of initial capture for frogs born at 4-Q Lakes) and most recent ("latest" = measurement from most recent recapture event) average snout-to-urostyle length (SUL, in millimeters [mm]) and average weight (mass, in grams [g]) of unique individuals recaptured from 2020–2025 for which California Department of Fish and Wildlife (CDFW) had original measurements*. Both SUL and mass have a column showing the average difference between the original and most recent measurements of each row ("diff."). The first column displays the number of individual SNYLF measurements incorporated into each average value within a row. In general—at intervals between original measurement and most recent capture events of one year or more—females grew ≥twice as much as males in both SUL and mass.

sex (years of growth†); sample size	SUL (1st)	SUL (latest)	SUL (+diff.)	Mass (1st)	Mass (latest)	Mass (+diff.)
F (3+); n = 9	**50 mm**	**75 mm**	**25 mm**	**17 g**	**58 g**	**41 g**
M (3+); n = 12	**52 mm**	**64 mm**	**12 mm**	**17 g**	**31 g**	**14 g**
F (2); n = 14 [†See below re: 2-yr males]	**53 mm**	**71 mm**	**18 mm**	**19 g**	**47 g**	**28 g**
F (1); n = 18	**52 mm**	**65 mm**	**13 mm**	**18 g**	**32 g**	**14 g**
M (1); n = 10	**51 mm**	**59 mm**	**8 mm**	**17 g**	**24 g**	**7 g**
F (2 months); n = 15	**55 mm**	**61 mm**	**6 mm**	**20 g**	**29 g**	**9 g**
M (2 months); n = 7	**50 mm**	**55 mm**	**5 mm**	**14 g**	**20 g**	**6 g**
F (1 month); n = 11	**54 mm**	**59 mm**	**5 mm**	**22 g**	**28 g**	**6 g**
M (1 month); n = 9	**53 mm**	**56 mm**	**3 mm**	**19 g**	**21 g**	**2 g**

†No statistics are shown for the two-year growth interval in males because only one recaptured male was two years removed from the original capture event, so the table omits that category.

*CDFW staff did not record morphological data during recapture trips at 4-Q Lakes in 2018 and 2019.

Reproduction

Establishing a self-sustaining SNYLF population at 4-Q Lakes has been the principal objective of this translocation project. CDFW staff observed the first signs of reproduction in June 2020 (a recently hatched egg mass and a tadpole). Later that same summer, staff observed more early life stage SNYLF, including tadpoles and subadults. In 2021, staff detected more subadults, followed by even higher numbers of early life stage SNYLF detections in 2022 (see **CDFW 2023** for details). In particular, the survey trip in August 2022 resulted in the largest number of early life stage SNYLF observed at 4-Q Lakes since the inception of translocations, during which staff detected at least 82 subadults.

Staff observed fewer subadult SNYLF in 4-Q Lakes in 2023. Staff did not detect young subadults in July and staff detected <10 subadults in September. However, these more limited detections were likely due to multiple factors that likely affected detection outcomes, including a short survey duration in July (one day), the timing of visits (given above-average snowpack during the preceding winter, the July survey was early enough that recent metamorphs had likely not yet emerged), observer bias, and weather. Staff encountered storms and hail during the visit in September 2023. The weather resulted in overall poorer survey conditions, and the need to pause surveys on several occasions. These conditions very likely affected detection probability of SNYLF in the basin. Despite the poorer survey conditions in September 2023, staff detected >100 SNYLF tadpoles at 4-Q Lakes, nearly all of which were at Site ID 13932 (see **Figure 20** for spatial reference). These observations, in combination with detecting 20 new young adults recently recruited into the population, were great signs that the newly established SNYLF population at 4-Q Lakes is doing well.

In September 2024, staff detected numerous subadult SNYLF (**Figure 21**), nearly all of which were in the main lakes (Site IDs 13922, 13928, and 13932) and Site ID 52692 (**Figure 20**). Given multiple passes of some lakes during each visit and subadults not being marked with unique identifiers, the exact number is unknown. However, considering only detections during a single pass at each site during the two trips, staff observed at least 49 subadults in early September, and at least 47 subadults in late September.

In August and September 2025, subadult SNYLF detections were very similar to observations in 2024, both in terms of relative abundance and spatial extent. Staff observed at least 34 subadults in late August and at least 44 subadults in late September. Subadults were located primary at the main lakes (Site IDs 13922, 13928, and 13932). Staff also detected a small number of SNYLF subadults at Site IDs 13924, 52692, and 52820.

Figure 21. Young subadult (i.e., frogs that metamorphosed earlier in the same summer during which this image was taken) Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) near the shore of Middle 4-Q Lake (Site ID 13932) in early September 2024. (CDFW)

Looking ahead: 2026

In 2026, CDFW staff plan to visit Highland and 4-Q Lakes to maintain current demographic data on both SNYLF populations. CDFW has a Traditional Section 6 grant (Federal Grant Award #F25AP00356-00), which allows monitoring to continue at Highland and 4-Q Lakes through 2027.

For each adult captured during subsequent 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 for each individual per site visit). With consistent SNYLF recruitment occurring, CDFW will continue PIT-tagging any new adults observed at 4-Q Lakes. These data will be used for CMR analysis to determine abundance and survivorship in the SNYLF population more accurately (Mazerolle et al. 2007). Given the conservation importance of this population, CDFW needs current information obtained through annual monitoring.

LITERATURE CITED

Bienentreu, J.-F., and D. Lesbarrères. 2020. Amphibian disease ecology: are we just scratching the surface? Herpetologica 76:153–166. Available from: https://meridian.allenpress.com/herpetologica/article-pdf/76/2/153/2553611/0018-0831-76_2_153.pdf

Bletz, M.C., J. Palmisano, J.T. Julian, L. Shender, and D.H. Olson. 2023. Amping up biosecurity for herps: simple, stricter practices can help protect reptiles and amphibians from disease. The Wildlife Professional 17:46–49. Available from: https://research.fs.usda.gov/treesearch/download/67355.pdf

Bradford, D.F. 1983. Winterkill, oxygen relations, and energy metabolism of a submerged dormant amphibian, *Rana muscosa*. Ecology 64:1171–1183. Available from: https://www.jstor.org/stable/pdf/1937827.pdf

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. Available from: https://www.pnas.org/content/pnas/107/21/9695.full.pdf

CDEC. Department of Water Resources. 2024. Daily regional snowpack plots from snow sensors – interactive plot. Accessed January 2024. Available from: https://cdec.water.ca.gov/snowapp/swcchart.action

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. 2020. 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=177643

CDFW. 2022a. Aquatic Invasive Species Decontamination Protocol. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=43333

CDFW. 2022b. 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: 2018–2021 summary. Region 2 Survey Memo. California

Department of Fish and Wildlife, Rancho Cordova, CA. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=199108

CDFW. 2023. 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: 2018–2022 summary. Region 2 Survey Memo. California Department of Fish and Wildlife, Rancho Cordova, CA. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=210897

CDFW. 2024. 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: 2018–2023 summary. Region 2 Survey Memo. California Department of Fish and Wildlife, Rancho Cordova, CA. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=222206

CDFW. 2025. 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: 2018–2024 summary. Region 2 Survey Memo. California Department of Fish and Wildlife, Rancho Cordova, CA. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=233261

Connelly, P.J., N. Ross, O.C. Stringham, and E.A. Eskew. 2023. United States amphibian imports pose a disease risk to salamanders despite Lacey Act regulations. Communications Earth & Environment 4. Article 351. Available from: https://www.nature.com/articles/s43247-023-01004-z#Sec12

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

Gray, M.J., A.L.J. Duffus, K.H. Haman, R.N. Harris, M.C. Allender, T.A. Thompson, M.R. Christman, A. Sacerdote-Velat, L.A. Sprague, J.M. Williams, D.L. Miller. 2017. Pathogen surveillance in herpetofaunal populations: guidance on study design, sample collection, biosecurity, and intervention strategies. Herpetological Review 48:334–351. Available from: https://parcplace.org/wp-content/uploads/2017/08/Grayetal2017.pdf

Gray, M.J., E.D. Carter, J. Piovia-Scott, J.P.W. Cusaac, A.C. Peterson, R.D. Whetstone, A. Hertz, A.Y. Muniz-Torres, M.C. Bletz, D.C. Woodhams, J.M. Romansic, W.B. Sutton, W. Sheley, A. Pessier, C.D. McCusker, M.Q. Wilber, and D.L. Miller. 2023. Broad host susceptibility of North American amphibian species to *Batrachochytrium salamandrivorans* suggests high invasion potential and biodiversity risk. Nature Communications 14. Article 3270. Available from: https://www.nature.com/articles/s41467-023-38979-4.pdf

Greer, A.L., D.M. Schock, J.L. Brunner, R.A. Johnson, A.M. Picco, S.D. Cashins, R.A. Alford, L.F. Skerratt, and J.P. Collins. 2009. Guidelines for the safe use of disposable gloves with amphibian larvae in light of pathogens and possible toxic effects. Herpetological Review 40:145–147. Available from: http://public.wsu.edu/~jesse.brunner/pdfs/GreerEtAl2009_Gloves.pdf

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.

Johnson, M.L., L. Berger, L. Philips, and R. Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. Diseases of Aquatic Organisms 57:255–260. Available from: https://www.int-res.com/articles/dao2004/57/d057p255.pdf

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. Available from: https://www.pnas.org/content/pnas/113/42/11889.full.pdf

Knapp, R., and A. Lindauer. 2020. Collection and analysis of amphibian skin swabs for qPCR analysis and Bd load. Protocol available from: http://mountainlakesresearch.com/wp-content/uploads/Protocol_SkinSwabbing_forclients-1.pdf

Martel, A., A. Spitzen-van der Sluijs, M. Blooi, W. Bert, R. Ducatelle, M.C. Fisher, A. WOeltjes, W. Bosman, K. Chiers, F. Bossuyt, and F. Pasmans. 2013. *Batrachochytrium salamandrivorans* sp. nov. causes lethal chytridiomycosis in amphibians. Proceedings of the National Academy of Sciences 110:15325–15329. Available from: https://www.pnas.org/doi/pdf/10.1073/pnas.1307356110

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. Available from: https://www.jstor.org/stable/pdf/40060463.pdf

Mendez, D., R. Webb, L. Berger, and R. Speare. 2008. Survival of the amphibian chytrid fungus Batrachochytrium dendrobatidis on bare hands and gloves: hygiene implications for amphibian handling. Diseases of Aquatic Organisms 82:97–104. Available from: https://www.int-res.com/articles/dao2008/82/d082p097.pdf

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. Available from: fws.gov/sites/default/files/documents/Mountain-Yellow-Legged-Frog-Conservation-Strategy.pdf

Noelker, J.E., V.A. Ruozzi, H.M. Craig, J.P. Sckrabulis, and T.R. Raffel. 2024. Glove decontamination procedures to prevent pathogen and DNA cross-contamination among frogs. Diseases of Aquatic Organisms 158:173–178. Available from: https://www.int-res.com/articles/dao_oa/d158p173.pdf

Rachowicz, L.J., R.A. Knapp, J.A.T. Morgan, M.J. Stice, V.T. Vredenburg, J.M. Parker, and C.J. Briggs. 2006. Emerging infectious disease as a proximate cause of amphibian mass mortality. Ecology 87:1671–1683. Available from: https://esajournals.onlinelibrary.wiley.com/doi/epdf/10.1890/0012-9658%282006%2987%5B1671%3AEIDAAP%5D2.0.CO%3B2

Smith, T.C., A.M. Picco, and R. Knapp. 2017. Ranaviruses infect mountain yellow-legged frogs (*Rana muscosa* and *Rana sierrae*) threatened by *Batrachochytrium dendrobatidis.* Herpetological Conservation and Biology 12:149–159. Available from: https://www.herpconbio.org/Volume_12/Issue_1/Smith_etal_2017.pdf

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodriguez, D.L. Fischman, and R.W. Waller. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306:1783–1786. Available from: https://www.science.org/doi/pdf/10.1126/science.1103538

Thomas, V., P. Van Rooij, C. Meerpoel, G. Stegen, J. Wauters, L. Vanhaecke, A. Martel, and F. Pasmans. 2020. Instant killing of pathogenic chytrid fungi by disposable nitrile gloves prevents disease transmission between amphibians. PLoS ONE 15:e0241048. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0241048

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

Vredenburg, V.T., R.A. Knapp, T.S. Tunstall, and C.J Briggs. 2010. Dynamics of an emerging disease drive large-scale amphibian population extinctions. Proceedings of the National Academy of Sciences 107:9689–9694. Available from: https://www.pnas.org/doi/pdf/10.1073/pnas.0914111107

Wells, K.D. 2007. Chapter 8: Mating systems and sexual selection in anurans; Pg. 389 of subsection “Sexual dimorphism in body size” *In* The Ecology and Behavior of Amphibians. University of Chicago Press, Chicago, USA.

Wilber, M.Q., R.A. Knapp, T.C. Smith, and C.J. Briggs. 2022. Host density has limited effects on pathogen invasion, disease-induced declines and within-host infection dynamics across a landscape of disease. Journal of Animal Ecology 91:2451–2464. Available from: https://besjournals.onlinelibrary.wiley.com/doi/epdf/10.1111/1365-2656.13823