

State of California
Department of Fish and Wildlife

Memorandum

Date: 1 August 2023

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

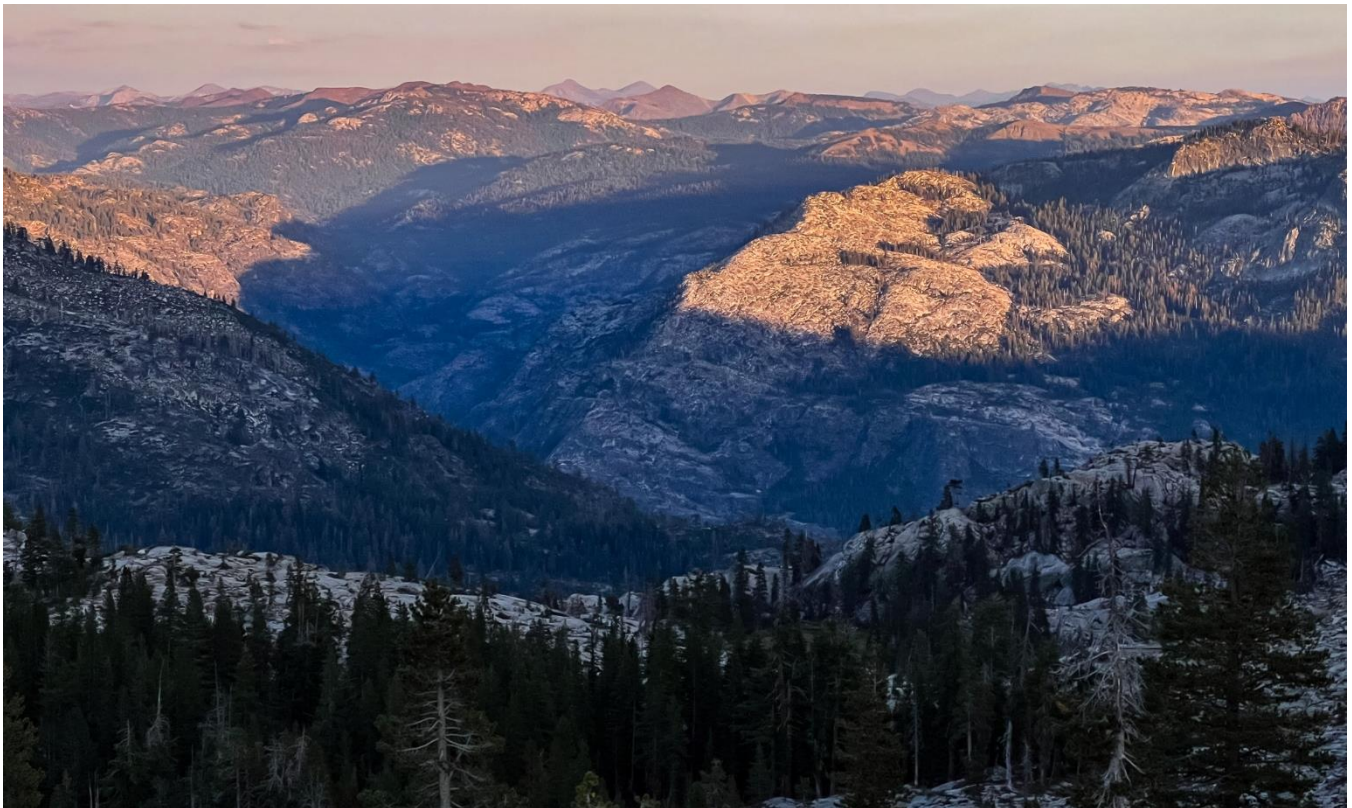
From: Isaac Chellman, Environmental Scientist;
High Mountain Lakes;
North Central Region Fisheries

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Subject: Native amphibian restoration and monitoring in Mokelumne Wilderness;

- Beebe Lakes drainage *Rana sierrae* monitoring
- Updates on non-native fish removal in the Beebe Lakes drainage



View into North Fork Mokelumne River Canyon from the Beebe Lake area, August 2022.
(CDFW)

SUMMARY

Beebe Lakes drainage is an area from which California Department of Fish and Wildlife (CDFW) and Eldorado National Forest (ENF) staff had worked to remove introduced Brook Trout (*Salvelinus fontinalis*; BK) to restore habitat for the state threatened Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF). Those interested in learning more about the previous Beebe Lakes drainage BK removal work may consult the [2017 Beebe Lakes area survey memorandum](#) (CDFW 2018).

In late June 2020, CDFW staff visited the Beebe Lakes drainage to conduct visual encounter surveys (VES) for native amphibians. During the visit, CDFW staff observed small fish in the littoral zone of Beebe Lake (**Figure 1**). These observations triggered follow-up visits in 2020, during which CDFW used monofilament gill nets and backpack electrofishing units to capture 172 BK in Beebe Lake and Beebe Meadow (CDFW 2021). Staff continued fish removal efforts throughout 2021, during which CDFW caught 34 BK from gill nets set overwinter (2020–2021).

At some point between 23 June and 14 July 2021, an individual or group illegally removed 14 gill nets from Beebe Lake and Beebe Meadow. Given the net confiscation, CDFW does not know whether any fish had been captured in early summer 2021. After discovering the net theft, CDFW staff placed a new suite of gill nets into Beebe Lake and Beebe Meadow. Since resetting gill nets in summer 2021, CDFW has maintained gill net sets in Beebe Lake continuously, and staff have set several gill nets into Beebe Meadow during summer and early fall of 2021 and 2022. However, staff remove nets from the meadow during winter, since spring and early summer flows in the meadow can severely damage and/or bury gill nets in sediment. Since summer 2021, staff have not captured BK in the Beebe Lake area.

Currently, CDFW has four overwinter monitoring gill nets set in Beebe Lake. CDFW plans to check these gill nets once the site is accessible in summer 2023. CDFW plans to continue monitoring for BK in the Beebe Lakes area through summer and fall gill net sets. Additionally, staff may employ backpack electrofishing and angling surveys to monitor for any trout presence in Beebe Meadow or the associated stream segments. If necessary, CDFW will continue these restoration efforts beyond 2023, particularly if staff detect any sign of BK, or if additional sabotage occurs.

Amphibian monitoring data from 2012 through 2022 suggest a small SNYLF population that appears to be stable. Population trends can be difficult to determine in small SNYLF populations. However, to help better determine SNYLF population status in the Beebe Lake area, CDFW staff began capture-mark-recapture (CMR) monitoring of SNYLF in the Beebe Lake area in summer 2022. CMR involves marking adult SNYLF with a passive integrated transponder (PIT) tag, which allows individual identification of adult frogs. PIT-tagging frogs allows more accurate estimation of abundance and allows CDFW the ability to track SNYLF growth, movement, and longevity over time. This newly implemented CMR effort is part of a State Wildlife Grant for long term SNYLF monitoring (federal grant # F22AF01541).



Figure 1. Beebe Lake on 29 June 2020, looking north. (CDFW)

ENVIRONMENTAL SETTING

Beebe Lakes drainage is located in the Mokelumne Wilderness, just east of the Alpine County line (**Figure 2**). The basin is on the western slope of the Sierra Nevada, between 2,408 and 2,591 meters (m; or 7,900 and 8,500 feet [ft]) in elevation. Eldorado National Forest manages the land and issues grazing permits in the area. The site is accessed by four-wheel drive roads from the Silver Lake area off State Route 88, then by hiking trail east into the Mokelumne Wilderness, past an old trading post, and through Ladeux Meadow before reaching Beebe Lakes basin. CDFW staff conducted baseline surveys in 2001 and 2002, during which staff captured BK in Beebe Lake during an overnight gill net survey. Staff also observed SNYLF at four sites in the area. All SNYLF populations in the area are small and isolated. CDFW and ENF determined that eradicating BK from Beebe Lake and Beebe Meadow area using gill nets and backpack electrofishing units would be feasible and provide SNYLF with more deep-water habitat.

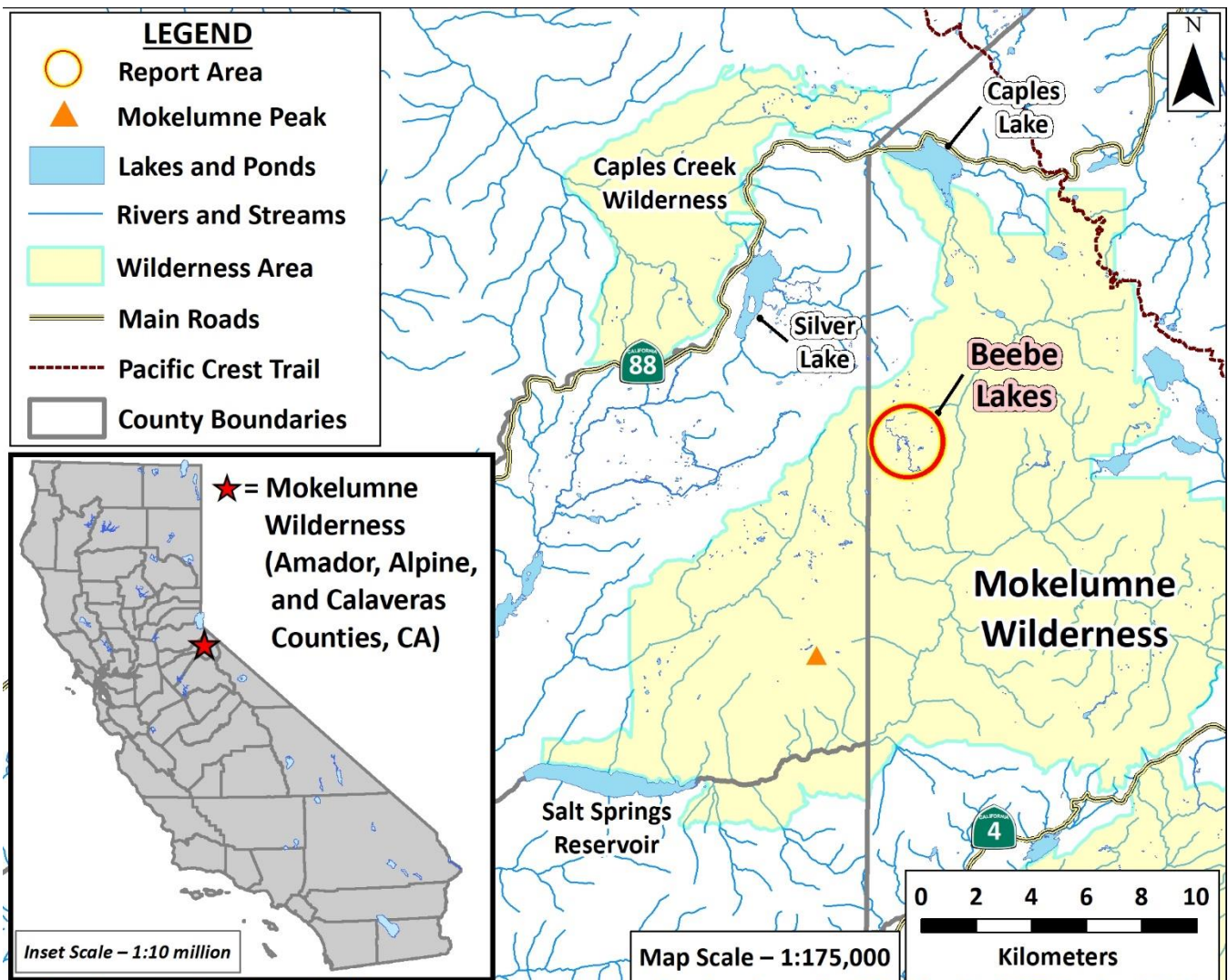


Figure 2. Mokelumne Wilderness, Amador, Alpine, and Calaveras Counties, CA. The area discussed in this memorandum is circled.

INTRODUCTION

The Aquatic Biodiversity Management Plan for the Upper Mokelumne Management Unit (CDFW 2016) identifies Beebe Lake (Site ID 14797; **Figure 1**), Lower Beebe Lake (Site ID 2694; which is filling in with sediment and is no longer a lake, but rather an occasionally flooded meadow with stream channels), Beebe Meadow (Site IDs 14791, 14795, and 14799), approximately 1.5 kilometers (km) of stream (Site IDs 52651, 52707, and 52783), three small ponds with consistent SNYLF observations (Site IDs 14774 [**Figure 3**], 14802, and 14829), and several other small ponds in the basin as a Native Species Reserve (NSR; **Figure 4**) for SNYLF. Thus far, CDFW staff have not observed SNYLF in Beebe Lake, which is the deepest wetted habitat in the basin, with a maximum depth of about four meters. Additionally, Beebe Lake is located approximately halfway between Site IDs 14774 and 14802. Therefore, removing BK from Beebe Lake, Beebe Meadow, and the adjoining stream is required to create a series of interconnected fishless aquatic habitats for SNYLF.

Beebe Lake was stocked with BK from 1930 until 2000. Gill net sampling conducted by CDFW staff in 2001 and 2010 revealed that the BK population in Beebe Lake was self-sustaining. Beginning in 2011, CDFW, with assistance from ENF personnel, began removing BK from Beebe Lake and the surrounding area to benefit SNYLF. As of 2018, after three years of monitoring without detecting BK, CDFW had determined the basin was fishless. Prior to 2020, the most recent BK capture was in 2015. However, in 2020, CDFW discovered that BK had reemerged in the basin. Therefore, CDFW reinstated fish removal efforts. Additionally, staff will continue to regularly survey the Beebe Lakes basin SNYLF population and increase monitoring for presence of any latent BK.



Figure 3. Site ID 14774 in June 2021, looking northeast. This spring-fed meadow pool is one of the locations in Beebe Lakes basin where California Department of Fish and Wildlife staff (CDFW) have observed evidence of Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) breeding, including egg masses and tadpoles. (CDFW)

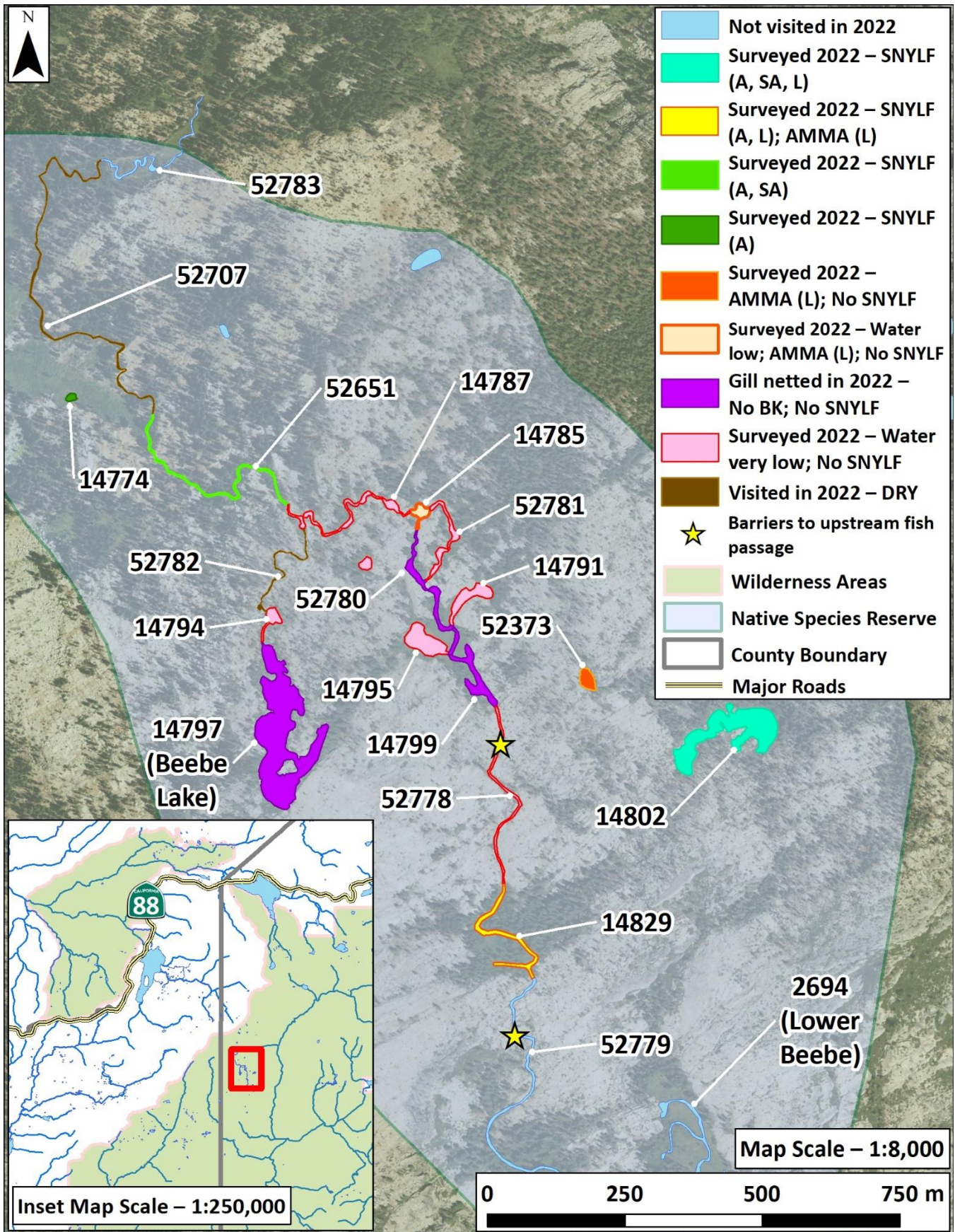


Figure 4. [See figure caption at the beginning of the next page.]

Figure 4 (continued). Sierra Nevada Yellow-legged Frog (*Rana sierrae*; SNYLF) detections, gillnetting locations, and surface water status at sites in the Beebe Lakes Native Species Reserve (NSR) in 2022. California Department of Fish and Wildlife (CDFW) did not capture any trout in Beebe Lake or Beebe Meadow in 2022. On 30 September 2022, CDFW staff removed gill nets from Beebe Meadow and left four gill nets in Beebe Lake for the winter. Staff will check the overwinter gill nets when the site is accessible following snowmelt. Areas shown as “DRY” are those that no longer contained visible surface water in late August 2022. All flowing waters in the basin drain south, then east into Summit City Creek, and eventually into the North Fork Mokelumne River. In prior surveys, CDFW staff have observed SNYLF at multiple additional locations in the Beebe Lakes drainage, including Site IDs 14785, 14799, 52707, 52778, and 52781.

THREATS

Disease

All known SNYLF populations in the Mokelumne Wilderness are positive for chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*). In 2008 and 2010, CDFW collected epithelial swabs from SNYLF in the Beebe Lake NSR and had the samples screened for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. Staff collected 11 swabs from sites 14774, 14802, and 14829, and results from both years detected very light to moderate zoospore loads.

Marginal Habitats

SNYLF populations in the surrounding area are persisting at small, isolated ponds and their seasonally flowing tributaries. Any disturbance, natural or otherwise, that threatens overwintering habitats presents a potential extirpation risk. Potential risks include severe winter conditions, extended drought, or anthropogenic habitat disturbances.

Introduced Fish

Those interested in a detailed accounting of previous Beebe Lakes drainage BK removal may consult the [2017 Beebe Lakes area survey memorandum](#) (CDFW 2018) and the [2021 Beebe Lakes area survey memorandum](#) (CDFW 2022). CDFW provides a summary of information from previous fish removal work and updates from 2022 below in the [BROOK TROUT REMOVAL](#) section of this report.

Trout prey on SNYLF and are a potential source of competition for food (e.g., benthic macroinvertebrates). Self-sustaining BK were limiting successful SNYLF breeding and recruitment in Beebe Lake and Beebe Meadow, which supply most deep-water habitat in the basin. Barriers to upstream fish movement prevent resident BK in Lower Beebe from moving into Beebe Meadow or Beebe Lake (**Figure 4**). However, there is risk of people illegally moving trout into Beebe Lake, Beebe Meadow, and other NSR ponds and stream segments containing SNYLF, particularly in light of illegal activities that have occurred ([see below](#)). However, CDFW continues to mitigate the immediate threat from trout predation through fish removal efforts.

Cattle Grazing

Studies investigating direct interactions between cattle and SNYLF populations have not been conducted. However, the U.S. Forest Service (USFS) acknowledges potential cattle impacts to SNYLF in an environmental assessment for the Bear River grazing allotment, which is adjacent to the Pardoe grazing allotment on which the Beebe Lake NSR is located (USFS 2018, pgs. 26 and 27). Additionally, potential negative effects of livestock grazing on SNYLF habitat are discussed in the U.S. Fish and Wildlife Service (USFWS) final rule for listing SNYLF as a federally endangered species (USFWS 2014, pg. 24628–24630). USFWS concluded: “*Current livestock grazing activities may present an ongoing, localized threat to individual populations in locations where the populations occur in stream riparian zones and in small waters within meadow systems, where active grazing co-occurs with extant frog populations.*”

The USFWS also concluded that, “*Livestock grazing that complies with forest standards and guidelines is not expected to negatively affect mountain yellow-legged frog populations in most cases, although limited exceptions could occur, especially where extant habitat is limited.*” (USFWS 2014, pgs. 24269–24270).

One of these limited exceptions appears to be Site ID 14774 (**Figure 5**), which is a known SNYLF breeding site that can receive heavy use by cattle.

Additionally, CDFW field staff consistently observe cattle in many locations within the Beebe Lake NSR. In summer 2022, CDFW observed numerous cattle in the meadow surrounding Site ID 14774. Staff also observed abundant evidence of cattle use throughout the NSR, in the form of tracks all around waterbodies and abundant manure, including at Beebe Lake, Beebe Meadow, the meadow surrounding Site ID 14774, and Site ID 14829 (**Figure 4**).

CDFW is in discussion with ENF aquatic biologists to consider fencing off Site ID 14774 (including a portion of the small, braided meadow stream channels which flow into the pond) to prevent direct cattle access, trampling around the pond perimeter, and eutrophication and bacterial growth caused by cattle feces (**Figure 5**). Under current conditions, cattle appear to be negatively affecting SNYLF breeding at this location. These poor water quality conditions may be particularly acute during dry water years or late in the summer, when cattle are more often congregating at the fewer remaining water sources. Similar cattle exclusion efforts to benefit SNYLF have been conducted for many years in a large portion of Ladeux Meadow, which is in the adjacent drainage, west of the Beebe Lake NSR.



Figure 5. Site ID 14774 on 30 August 2022 (compare with **Figure 3**, during June 2021). This small pond, which is the main water source in the upper meadow north of Beebe Lake, receives regular visitation from cattle. During surveys in late summer 2022, CDFW staff observed cattle in the area, numerous cattle prints around this pond, and abundant manure at the pond margin and in the adjacent meadow. The pond contained thick algal growth, a phenomenon staff had not previously observed in this pond, which is one of only a few spots known to currently provide SNYLF breeding habitat in the Beebe Lake area. In past surveys, CDFW has observed numerous SNYLF tadpoles in this pond. However, during the survey when staff took this photo, no SNYLF tadpoles were available for detection. The lack of detections may have been due to limited visibility from thick algal growth. CDFW suspects that algal growth may be facilitated by eutrophication caused by cattle manure. As noted by the USFWS (2014, pg. 24268), *“Livestock can increase nutrient-loading in water bodies due to urination and defecation in or near the water, and can cause elevated bacteria levels in areas where cattle are concentrated.”* Without intervention, these conditions may result in this pond becoming unsuitable for SNYLF breeding.

Loss of Genetic Diversity

Like many SNYLF populations in the northern Sierra Nevada, the population in Beebe Lakes is small and isolated. Although there are small populations in relatively close proximity (e.g., Ladeux Meadow, Devils Hole Lake, Bear River, and Deadwood Canyon; CDFW 2016), the rugged landscape of the Upper Mokelumne results in the Ladeux population being the only realistic source for gene flow from a source outside Beebe Lakes. The nearest location with fairly widespread SNYLF occupancy is the Jeff Davis Creek area, which is about 14 km east of Beebe Lakes (CDFW 2014). In addition to the threats presented by stochastic environmental events (e.g., drought or especially harsh winter), genetic isolation can lead to factors such as inbreeding depression, genetic drift, fixation of deleterious alleles, and loss of genetic diversity, all of which are population genetic factors exacerbated in small populations like those in Beebe Lakes (Frankham et al. 2009).

***Rana sierrae* POPULATION STATUS: RESULTS**

In the past, the sites in which a majority of SNYLF have been observed during VES in the Beebe Lakes drainage are Site IDs 14774, 14802, and 14829 (**Figure 4**). During backpack electrofishing on 26 September 2018, CDFW staff observed two adult and three subadult SNYLF in the Beebe Lake meadow inlet stream (Site ID 52651; **Figure 4**). CDFW field staff did not conduct any additional VES during summer 2018. CDFW returned to Beebe Lake in late September 2019, during which staff detected very few SNYLF. However, CDFW conducted the surveys late in the summer and conditions were atypically cold during VES. In late June 2020, CDFW field staff returned to VES the Beebe Lake area. Conditions during these survey efforts were more ideal than those staff experienced in late summer 2019. In 2020, staff surveyed 16 Site IDs in the NSR, during which staff observed 12 adults, two subadults, and 132 tadpoles. Staff detected nearly all larvae in the perennial meadow pool (Site ID 14774; **Figures 3 and 5**). This is the highest larval SNYLF count observed so far by CDFW in the Beebe Lakes area. In 2021, staff focused on [non-native fish removal](#), but site access was also limited for much of the summer due to the [Caldor Fire](#), so CDFW did not conduct SNYLF surveys in the Beebe Lake area.

In 2022, CDFW began PIT-tagging adult SNYLF (**Figure 6**) in the Beebe Lake area to track frogs using CMR methods (Williams et al. 2001). This newly initiated work is part of a State Wildlife Grant for long term SNYLF monitoring (federal grant # F22AF01541). With this new monitoring effort, CDFW seeks to PIT tag all newly captured (untagged) adults in the Beebe Lake NSR. PIT-tagging will provide the opportunity to gain a better understanding of SNYLF abundance, growth, movement, longevity, and other population demographic factors.

Briefly, the PIT-tagging methods are as follows: once a frog is large enough (~40 mm snout-to-urostyle length [SUL]), CDFW staff insert a PIT tag beneath the dorsal skin of each frog (using methods recommended by McAllister et al. 2004). PIT tags are an 8 x 1.4 mm, glass-coated chip that biologists can scan using a handheld PIT tag reader, which displays a unique identifying code for each PIT tag. Therefore, all PIT-tagged frogs can be individually identified.

In late August 2022, staff conducted full survey efforts at eight Site IDs in the NSR (**Figure 4**). Additionally, staff performed more rapid, incidental surveys in Beebe Meadow and dry (or mostly dry) stream segments. In total, staff observed 14 SNYLF adults, 10 of which staff were able to capture and mark with PIT tags. Staff also observed eight SNYLF subadults and 75 larvae (**Figure 7**). The number of post-metamorphic SNYLF that staff observed in 2022 is very similar to counts during the past decade, although subadult SNYLF counts have occasionally been notably higher (e.g., 2008, 2012, and 2014; **Figure 8**). However, the high subadult counts in some years is likely an artifact of survey timing, since observed subadults are often frogs that metamorphosed later in the summer and early fall.



Figure 6. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) hiding in a pool beneath a deeply undercut bank within Site ID 14829 in late August 2022. (CDFW)



Figure 7. Sierra Nevada Yellow-legged Frog (*Rana sierrae*) tadpoles (plus two Southern Long-toed Salamander [*Ambystoma macrodactylum sigillatum*] larvae at the far left side of the photograph) in a pool within Site ID 14829 in late August 2022. (CDFW)

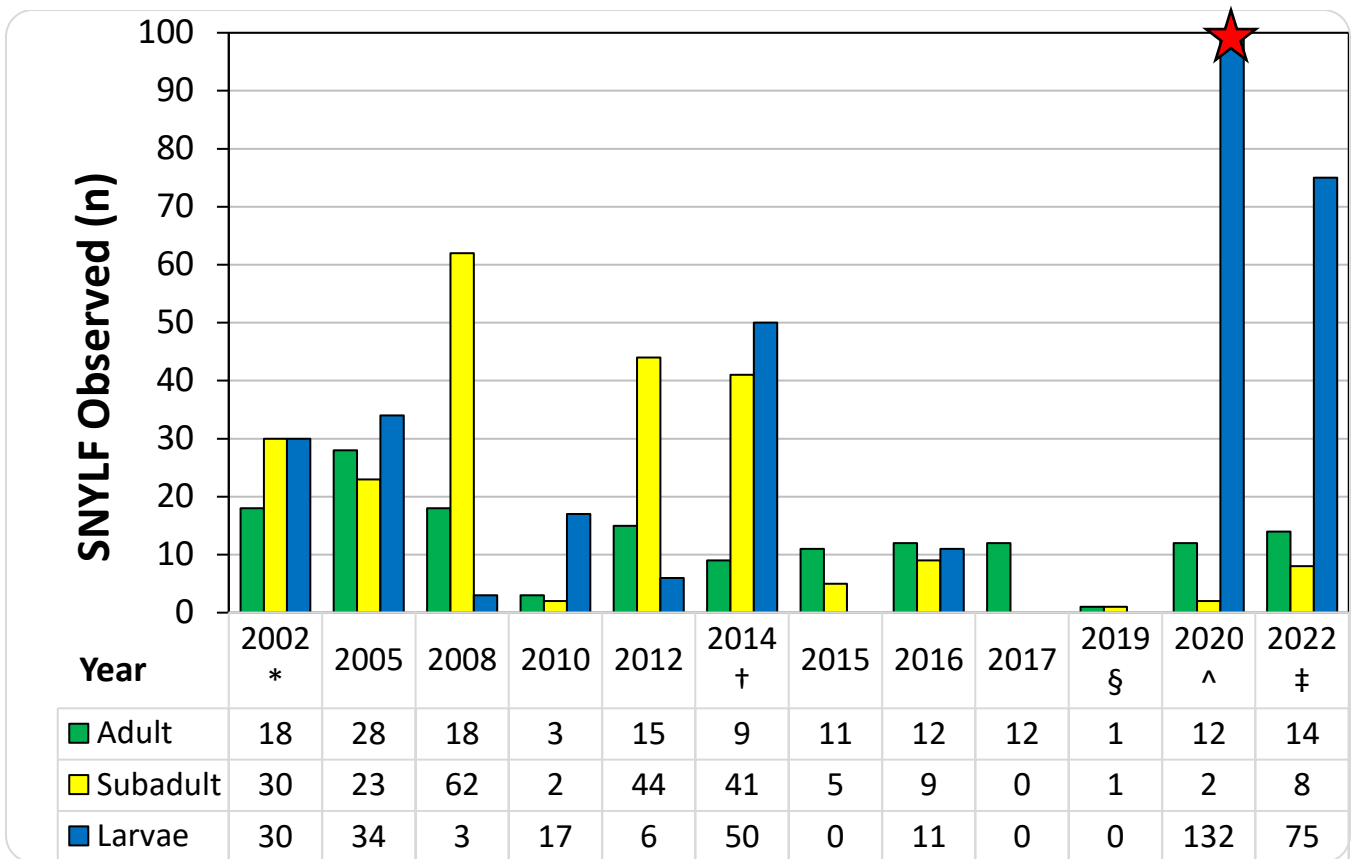


Figure 8. Total number of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) of each life stage observed in the Beebe Lakes area by California Department of Fish and Wildlife (CDFW) staff between 2002 and 2020. Yearly totals primarily include observations from Site IDs 14774, 14802, and 14829. The chart also includes occasional SNYLF adult individuals seen Site IDs 14785, 14787, 14799, and 52707.

*CDFW did not survey Site ID 14829 in 2002.

†CDFW began surveying Site ID 52651 in 2014. Until 2020, staff had only observed post-metamorphic SNYLF in Site ID 52651 (one in 2014, one in 2015, five in 2016, one in 2017, and five in 2018). However, CDFW observed one subadult and one tadpole in late June 2020.

§CDFW staff began surveying Site ID 52707 in 2019.

^In 2020, CDFW staff surveyed farther up the Beebe Meadow inlet stream (Site ID 52707) than during previous surveys. Staff also surveyed the entire stream reach between Lower Beebe and Beebe Meadow (Site IDs 52779, 14829, and 52778).

‡In 2022, CDFW began capture-mark-recapture of SNYLF adults in the Beebe Lakes Native Species Reserve (NSR). Staff marked 10 of 14 adults detected with PIT tags (i.e., four adult frogs evaded capture before they could be marked).

★ [Red star] Indicates a larval SNYLF count above the scale range of the histogram (n = 132).

***Rana sierrae* POPULATION STATUS: DISCUSSION**

Twenty-one years of monitoring data suggest the Beebe Lakes SNYLF population is remaining relatively stable (albeit at a small population size; **Figure 8**). However, observer bias, variation in survey conditions, and relatively low number of detections all make deriving trends difficult. Additionally, SNYLF have been forced to contend with introduced predators (BK) for many decades. Although BK were nearly absent from the NSR by 2016, observations in 2020 prove that there was only a brief window—of at most three years—during which SNYLF were not functionally overlapping with BK in at least some locations in the Beebe Lakes area. As of summer 2021, BK may once again be extirpated from Beebe Lake and Beebe Meadow. However, brazen sabotage of fish removal efforts in 2014 and 2021 ([see below](#)), plus unknown provenance of BK reemergence, means that CDFW will need to remain vigilant in this drainage to prevent additional BK infiltration and allow SNYLF the opportunity to regain a foothold in their native habitat.

Another confounding factor in interpreting long term SNYLF population trends is recent drastic changes in water years. For example, since 2012, winter precipitation in the northern Sierra Nevada has repeatedly swung between far below average (2012–2015, 2018, and 2020–2022) and far above average (2017, 2019, and 2023), with very little in between (2016) (CDEC 2023b). SNYLF mortality can increase during long winters with deep snowpack (Bradford 1983). Contrarily, drought conditions can dry up many areas normally occupied by SNYLF, especially in places like the Beebe Lake NSR, where much of the available aquatic habitat is small, shallow ponds and ephemeral streams. A mitigating factor to exceptionally dry water years is that sections of the meadow west of Site ID 52707 appear to be perennial, and this spring-fed water source prevents the largest pool in the meadow (Site ID 14774; **Figures 3 and 5**) and the Beebe Meadow inlet stream from drying entirely during poor water years. Clearly, this water source provides a refuge for SNYLF, in part indicated by the consistent reproduction observed in Site ID 14774 (although see the [Cattle Grazing](#) section above, and caption for **Figure 5**).

Two other important environmental considerations are survey timing and weather during the survey. CDFW amphibian VES at Beebe Lakes in 2017 and 2019 occurred during the first and second weeks of September, respectively. Although these dates are within the window of time that survey conditions are generally favorable for SNYLF detectability, weather becomes less predictable during September, and cooler evening temperatures become more common. The Beebe Lake area is one of the higher elevation SNYLF sites in the northern Sierra Nevada (2,560 m [\sim 8,400 ft]), so temperatures at Beebe Lakes during any given time tend to be cooler when compared with many other SNYLF sites in the northern Sierra Nevada.

During both survey occasions in 2017 and 2019, weather conditions were less than ideal. For example, in 2017, VES followed an afternoon of heavy thunderstorms and cool temperatures. Weather conditions were overcast and relatively cool (\sim 17° C [62° F] for a mid-day high) during the survey. In 2019, it was even cooler on the day of surveying, with a mid-day high air

temperature of 14° C [57° C] in the NSR. During both years, CDFW surveyed several sites in the morning, during which air temperatures were even cooler ($\leq 10^{\circ}$ C [$\leq 50^{\circ}$ F]). SNYLF activity in both years may have been reduced during these relatively cold late summer temperatures.

The habitat composition of Beebe Lakes drainage is another reason that estimating SNYLF abundance is difficult. Available habitat consists of Beebe Lake, numerous small ponds darkly stained with tannins, multiple springs, a long stream channel, and a large meadow complex with dozens of isolated depressions that occasionally hold water. Dense vegetation surrounds many of these aquatic areas. This habitat variety is likely beneficial for SNYLF. However, the habitat complexity and thick vegetation also reduces visibility and maneuverability for surveyors. Therefore, SNYLF detectability during VES in the Beebe Lakes drainage is likely very limited.

Despite these challenges, CDFW will continue to monitor the Beebe Lake SNYLF population regularly to assess the population status over time. Long-term monitoring will be required to derive population trends and quantify the SNYLF population in the Beebe Lakes area, particularly following the reemergence of BK in the NSR. In 2023, CDFW will be visiting the area to check gill nets and potentially conduct backpack electrofishing in stream channels. Additionally, CDFW plans to visit the Beebe Lakes area for at least one visit focusing specifically on continued SNYLF CMR in 2023. Over time, PIT-tagging SNYLF in this manner will allow more accurate estimation of population size, especially for a relatively small population occupying habitat that is challenging to survey (Mazerolle et al. 2007).

BROOK TROUT REMOVAL:

Background

CDFW and ENF staff originally began removing introduced BK from Beebe Lake in 2011. Before 2020, the last BK captures in Beebe Lake occurred during summer 2012. Subsequent gill net sets from fall 2012 until early summer 2015 yielded no BK captures. Therefore, CDFW removed gill nets from Beebe Lake in July 2015, after more than two years of constant gill net sets with no BK captured. One notable event during the latter period of fish removal occurred in summer 2014, during which one or more people removed most of the nets from the lake. The looters damaged several nets, including somehow stringing several into the canopies of dead trees adjacent to Beebe Lake (**Figure 9**). Between July 2015 and August 2020, CDFW set no gill nets in Beebe Lake. Those interested in a detailed accounting of Beebe Lakes drainage BK removal from 2011–2017 may consult the [2017 Beebe Lakes area survey memorandum](#) (CDFW 2018).



Figure 9. Gill net sabotage at Beebe Lake in September 2014. (CDFW)

CDFW also used gill nets and backpack electrofishing units to remove BK from Beebe Meadow (Site IDs 14785, 14787, 14791, 14795, 14799, 52780, and 52781; **Figure 4**) and the inlet stream (i.e., Site IDs 52707 and 52651; **Figure 4**). Staff had gill nets set in the meadow pools from July 2014 to August 2017. Late September 2015 was the last time CDFW or ENF captured any BK in Beebe Meadow or the inlet stream. The final confirmation rounds of electrofishing for the BK removal project occurred in late September 2018, during which CDFW staff completed three full passes of the Beebe Meadow inlet stream with no BK detected. In all, between 2016 and 2018, CDFW and ENF staff completed 14 electrofishing passes of the Beebe Meadow inlet stream (areas holding water in Site IDs 52707 and 52651; **Figure 4**) with no BK detected. In 2018, after eight consecutive years of fish removal efforts, CDFW declared Beebe Lake and Beebe Meadow area fishless.

Following fish removal efforts, CDFW staff have returned to the Beebe Lake drainage annually to conduct VES for native amphibians. During VES in late June 2020, CDFW staff observed small fish in the littoral zone of Beebe Lake. These observations triggered a follow-up visit in mid-September, during which CDFW set two gill nets in Beebe Lake to attempt capturing and identifying the fish present. The gill nets captured 63 BK during a two-week set. CDFW staff returned to the site from 30 September to 1 October 2020 and deployed twelve 30-m (100-ft) monofilament gill nets into Beebe Lake and three gill nets in Beebe Meadow. Additionally, staff used a backpack electrofishing unit to capture fish in areas with shallow water in Beebe Meadow, nearby connected ponds, and the wetted stream segments (**Figure 4**). During these efforts, staff removed 172 BK from the Beebe Lake NSR. Before leaving the site on 20 October, CDFW staff removed all gill nets from the meadow (in which nets tend to get damaged and/or buried by early season high flows) and half the gill nets from Beebe Lake, leaving six gill nets to capture fish overwinter. For further details on these fish removal efforts, please consult the memorandum "[Native amphibian restoration and monitoring in Mokelumne Wilderness; Beebe Lakes *Rana sierrae* monitoring and updates on non-native fish removal](#)" (CDFW 2021).

When Beebe Lakes drainage became accessible in early summer 2021, CDFW staff returned to check overwinter gill nets in Beebe Lake. On 22 June, staff removed approximately 34 trout from the overwinter gill nets. All overwinter fish captures were likely BK, but staff could not definitively identify many captures to species due to decomposition of the carcasses. On 23 June, staff reset Beebe Lake with 10 summer gill nets. Additionally, staff set five gill nets into Beebe Meadow (**Figure 4**, area shown in purple).

Staff next visited Beebe Lake on 14 July 2021. Upon arriving at the site, staff discovered that an individual or group had stolen all gill nets from Beebe Lake and most gill nets from Beebe Meadow. In the Beebe Meadow area, one net had been removed from the water, crumpled up, and stashed inside a downed tree hollow (**Figure 10**). Only one net was found undisturbed in Beebe Meadow. Staff cleaned and reset this single gill net. After discovering the sabotage, staff searched around the meadow and the lake extensively, and were unable to locate any other nets or net fragments.



Figure 10. A gill net, as found by California Department of Fish and Wildlife (CDFW) staff on 14 July 2021. Individual(s) had illegally removed the net from Beebe Meadow. (CDFW)

In response to the net theft, CDFW returned to Beebe Lakes drainage on 3 August 2021 and reset new nets into the same areas. Staff returned to the Beebe Lakes area one more time that summer, but were then prevented from accessing the site until October due to the [Caldor Fire](#). After the wildfire, CDFW staff returned to the Beebe Lakes area on 19 October for the final visit of the season. During this visit, staff checked all gill nets, removed the gill nets from Beebe Meadow, and removed four of the 10 gill nets from Beebe Lake. Staff left six nets in Beebe Lake to capture fish overwinter. Additional details on work in the Beebe Lake NSR in 2021 can be found in the [2021 Beebe Lakes are survey memorandum](#) (CDFW 2022).

2022 Updates

CDFW staff returned to check the six overwinter gill nets in Beebe Lake on 22 July 2022. Staff observed no fish in any of the overwinter gill nets (**Table 1**). Following net checks, staff replaced damaged gill nets and reset seven summer gill nets into Beebe Lake. Staff next visited Beebe Lake on 30 August 2022 to check all gill nets, none of which contained fish. Additionally, staff set three gill nets into Beebe Meadow (**Figure 4**, area shown in purple). CDFW staff returned to the Beebe Lakes area on 30 September 2022 for the final visit of the season. During this visit, staff checked all gill nets, removed the gill nets from Beebe Meadow, and removed three of the seven gill nets from Beebe Lake. Staff left four overwinter nets in Beebe Lake. CDFW plans to check these overwinter gill nets in summer 2023, when the site becomes accessible.

CDFW did not detect any fish in Beebe Lake or Beebe Meadow in 2022. Due to many additional grant-funded SNYLF survey priorities, and no current dedicated funding for this non-native fish removal effort, CDFW staff did not undertake any electrofishing in the Beebe Lake area in 2022. However, staff plan to undertake backpack electrofishing in Beebe Meadow and the Beebe Meadow inlet stream during late summer and fall 2023. These efforts may be particularly important if any latent BK are still present in Beebe Meadow. If so, there is a chance those fish may have been able to move into areas upstream (e.g., Site IDs 52651, 52782, 14794, and Beebe Lake) during high flows as record-breaking snowpack from winter 2022–2023 melted (CDEC 2023b).

Table 1. Locations (Site IDs), effort (number of gill nets and net check events), and total number of Brook Trout (*Salvelinus fontinalis*; BK) removed from the Beebe Lakes area by California Department of Fish and Wildlife (CDFW) staff in 2022. CDFW will check all overwinter nets in summer 2023. See **Figure 4** for locations of all Site IDs listed below.

Site ID	Name	Summer nets (n)	Date of first net check	Date of last net pull	Net check events	Trout total		Over-winter nets (n)
						Adults	Juveniles	
14797	Beebe Lake	7	22 July	30 Sept	3	0	0	4
52780	---	1	30 Aug	30 Sept	1	0	0	0
14799	---	2	30 Aug	30 Sept	1	0	0	0

Discussion

The reemergence of BK has been an unfortunate setback to SNYLF conservation in Beebe Lakes basin. CDFW cannot conclusively determine whether BK remained in the basin following eradicated work from 2011 to 2018, or if someone illegally replanted BK. Both scenarios are plausible. A small number of BK may have remained following initial fish removal efforts; the habitat in Beebe Meadow is complex, and low densities of BK may have remained undetected, despite gillnetting and electrofishing work that resulted in zero BK detections from 2015 to 2018. Alternatively, two known instances of project sabotage (2014 and 2021), and an incident in 2017 where a district fisheries biologist was told directly by a member of the public that they planned to reintroduce fish back into Beebe Lake, lend circumstantial evidence to illegal BK reintroduction. Lower Beebe and the connected stream (below barriers to upstream fish movement; **Figure 4**) contain BK and provide a potential source for illegal reintroduction into Beebe Lake. Whether failed initial eradication or illegal fish planting, CDFW's response—reinstating fish removal—is the same. However, the explanation for BK reemergence is important for long-term management and potential for project success. Detailed discussion of this topic is provided in the [2021 Beebe Lakes are survey memorandum](#) (CDFW 2022).

Irrespective of the true explanation for BK reemergence in the Beebe Lake area, these results provide an opportunity to adapt eradication techniques to focus more effort on fish removal in the meadow, including setting more nets in the main meadow channel and checking those nets more frequently. Due to other project priorities and wildfire, CDFW fish removal efforts in the Beebe Lake NSR were more limited in 2021 and 2022 than originally planned. However, CDFW plans to increase focus on gillnetting and backpack electrofishing in Beebe Meadow and connected stream channels, particularly in late summer and fall 2023. Additionally, CDFW will maintain gill nets in Beebe Lake, particularly following a record-breaking snowpack, when there may be risk of latent BK reinvading the lake from the meadow below during high flows.

Although BK may not yet be eradicated from Beebe Meadow and the connected streams, fish removal efforts from 2020–2022 demonstrate that the BK population, if still present, is very small, which will help expedite eradication efforts. Gillnetting in 2020–2022, all extremely low water years (CDEC 2023a and 2023b), likely helped prevent any additional BK spawning, which has improved the chances of restoring the Beebe Lakes area to its natural fishless condition. Years with dry conditions limit the available aquatic habitat for BK, reduce fall spawning potential, and consolidate fish into smaller areas for more targeted eradication.

The reemergence of BK in Beebe Lake basin emphasizes the importance for regular follow-up monitoring at fish removal sites. Periodic gill net sets will help detect any incipient non-native trout reinvasion. Catching these events early will likely make removing fish easier to achieve. Once BK are removed, SNYLF will finally have the chance to reclaim the larger, more perennial waterbodies in the basin. In summer and fall 2023, CDFW will continue *Rana sierrae* population monitoring and BK removal in the Beebe Lake NSR.

LITERATURE CITED

- 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>
- California Data Exchange Center (CDEC). Department of Water Resources. 2023a. Northern Sierra 8 station precipitation index – interactive water year plot. Accessed May 2023. Available from: <https://cdec.water.ca.gov/precipapp/get8SIPrecipIndex.action>
- CDEC. Department of Water Resources. 2023b. Daily regional snowpack plots from snow sensors – interactive plot. Accessed May 2023. Available from: <https://cdec.water.ca.gov/snowapp/swcchart.action>
- California Department of Fish and Wildlife (CDFW). 2014. Aquatic Biodiversity Management Plan for the Jeff Davis Creek Management Unit. Available from: <http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84128>
- CDFW. 2016. Aquatic Biodiversity Management Plan for the Upper Mokelumne Management Unit. Available from: <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=127574>
- CDFW. 2018. Native amphibian restoration and monitoring in Mokelumne Wilderness: Beebe Lakes fish removal and *Rana sierrae* monitoring. Available from: <http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=156671>
- CDFW. 2021. Native amphibian restoration and monitoring in Mokelumne Wilderness; Beebe Lakes *Rana sierrae* monitoring and updates on non-native fish removal. Available from: <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=186725>
- CDFW. 2022. Native amphibian restoration and monitoring in Mokelumne Wilderness; Updates on non-native fish removal in the Beebe Lakes drainage. Available from: <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=198871>
- Frankham, R., J.D. Ballou, and D.A. Briscoe. 2009. Introduction to Conservation Genetics. Cambridge University Press, New York, NY, USA.
- 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>
- McAllister, K.R., J.W. Watson, K. Risenhoover, and T. McBride. 2004. Marking and radiotelemetry of Oregon spotted frogs (*Rana pretiosa*). Northwestern Naturalist 85:20–25.
- U.S. Fish and Wildlife Service (USFWS). 2014. Endangered and threatened wildlife and plants; endangered species status for Sierra Nevada Yellow-legged Frog and northern distinct population segment of the mountain yellow-legged frog, and threatened species status for Yosemite toad. Federal Register 79:24256–24310. Available from: <https://www.govinfo.gov/content/pkg/FR-2014-04-29/pdf/2014-09488.pdf>

U.S. Forest Service (USFS). 2018. Bear River Grazing Allotment Management Project – Environmental Assessment. Available from: <https://usfs-public.app.box.com/v/PinyonPublic/file/933453481919>

Williams, B.K., J.D. Nichols, and M.J. Conroy. 2001. Analysis and management of animal populations. Academic Press, San Diego, CA, USA.