

State of California  
Department of Fish and Wildlife

# Memorandum

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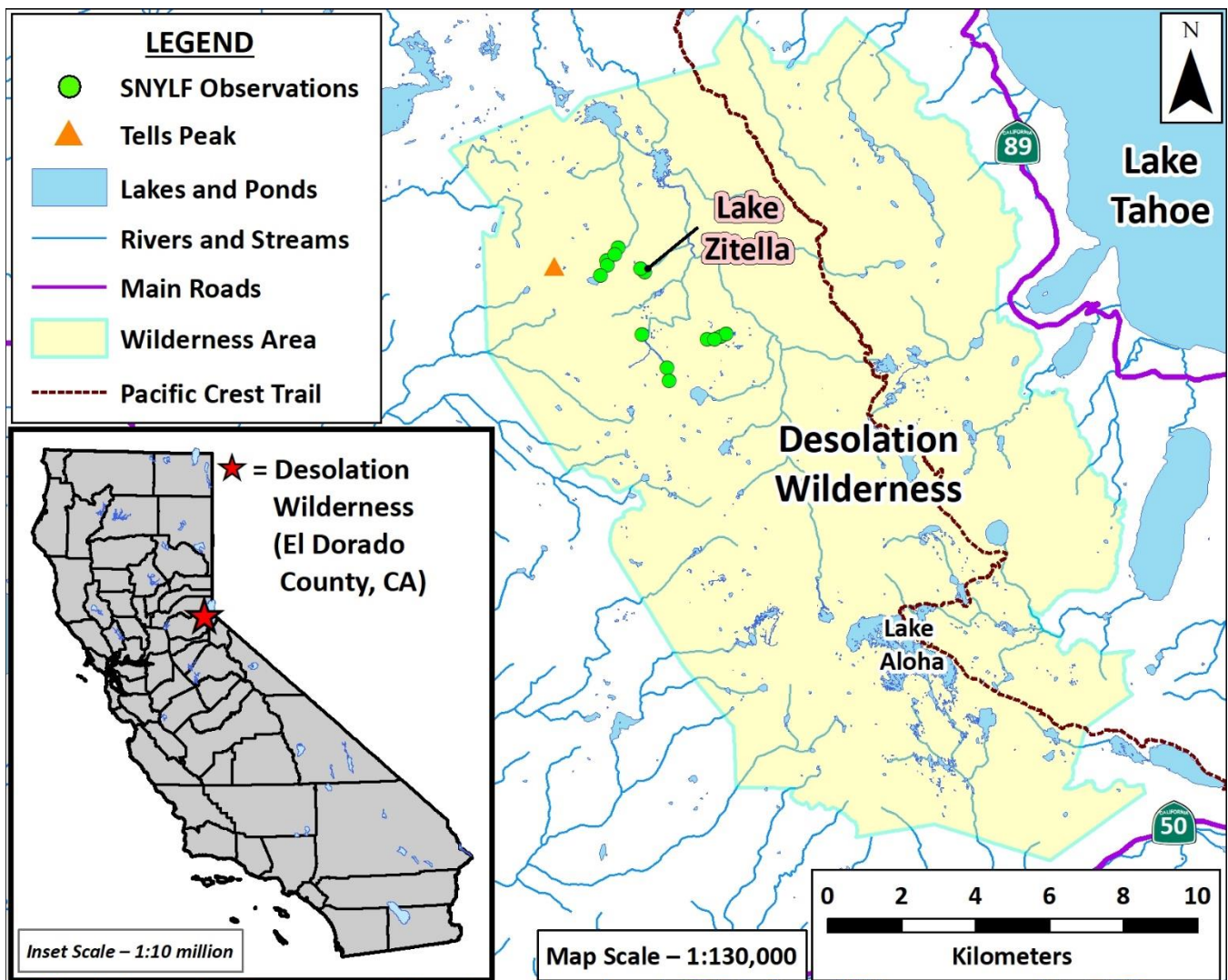
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**Subject: Native amphibian monitoring in Desolation Wilderness; *Rana sierrae* monitoring at Lake Zitella.**

## SUMMARY

Lake Zitella is a small, high mountain lake in the northwest corner of Desolation Wilderness (**Figure 1**). The lake and an adjacent pond contain a population of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*, SNYLF; **Figure 2**). California Department of Fish and Wildlife (CDFW) formerly stocked Lake Zitella (**Figure 3**) with trout, but stocking ceased in the early 1970's. Since 2002, CDFW staff have been conducting consistent visual encounter surveys (VES) for amphibians. Survey data from 2019 suggests a possible decline in SNYLF population, which in recent years had been growing (**Figure 4**). However, CDFW will need to continue monitoring the Lake Zitella SNYLF population to determine if the low detections in 2019 indicate real declines or a sampling anomaly. Therefore, CDFW will continue amphibian monitoring at Lake Zitella at least biennially to document SNYLF population status.



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

## ENVIRONMENTAL SETTING

Lake Zitella (**Figure 3**) is located in the Desolation Wilderness, northeast El Dorado County (**Figure 1**). The lake sits in a granitic basin at approximately 7,650 feet in elevation and drains northeast into Rockbound Lake. Eldorado National Forest (ENF) manages this section of Desolation Wilderness and the surrounding land. No maintained trails access Lake Zitella, but there is a visible use trail with old signage from nearby Horseshoe Lake.

## INTRODUCTION

In 1993, ENF field staff documented a small SNYLF population at Lake Zitella (USFS 1993). Beginning in 2002, CDFW High Mountain Lakes project crews confirmed the continued presence of SNYLF. The Aquatic Biodiversity Management Plan (ABMP) for the Desolation Wilderness Management Unit identifies Lake Zitella, Horseshoe Lake, McConnell Lake, Leland Lakes, and 4-Q Lakes as a Native Species Reserve (NSR) for SNYLF (CDFG 2012).

Lake Zitella was stocked with Rainbow Trout (*Oncorhynchus mykiss*; RT) until 1966 and Brook Trout (*Salvelinus fontinalis*; BK) until 1973. The lake is fairly shallow, contains limited spawning habitat, and was suspected to be subject to winter fish kill during the period stocking occurred (CDFG 2012). For several decades, CDFW has not detected BK or RT in Lake Zitella, via both visual observations and multiple overnight gill net sets (CDFG 2012).

During the past 25 years, VES have revealed that the Lake Zitella SNYLF population has grown substantially, but may currently be in decline, from only a handful of post-metamorphic frog detections in 1993 (USFS 1993), to several hundred post-metamorphic frogs observed during VES in 2016 and 2018, to less than 50 post-metamorphic frogs observed in 2019 (**Figure 4**). CDFW will visit Lake Zitella in summer 2020 to monitor the status of the SNYLF population.



**Figure 2.** An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Lake Zitella on 22 July 2018. (CDFW)



**Figure 3.** Lake Zitella on 22 July 2018, looking south. (CDFW)

## **THREATS**

### ***Disease***

All SNYLF populations in El Dorado County are positive for chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*). CDFW collected epithelial swabs in 2008 (n = 3) and 2010 (n = 1) from SNYLF at Lake Zitella, and screened for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. Results from both years did not detect *Bd*. However, the low sample size and presence of *Bd* in the immediately surrounding drainages (e.g., Highland Lake and Lower Leland Lake) suggests that *Bd* is likely present in the population, albeit at low levels. Additionally, field staff have occasionally observed SNYLF mortalities at the site, including an unknown age class mortality in 2014 and three dead adults in 2016. These anecdotal observations may indicate *Bd*-induced mortality, but a definitive cause of death cannot be determined. In 2019, CDFW staff collected 23 epithelial swabs from SNYLF at Lake Zitella (n = 18) and Site ID 51075 (n = 5). CDFW plans to have the swabs analyzed for the presence of *Bd* DNA in spring 2020.

### ***Loss of Genetic Diversity***

VES data suggest that the Lake Zitella SNYLF population was very small and only recently underwent expansion. This potential population bottleneck may have resulted in negative genetic consequences for the population, including loss of genetic diversity, inbreeding depression, and fixation of deleterious alleles (Frankham et al. 2009). However, the true size of the Lake Zitella population during the time-period when it was smallest is unknown. Population genetic analyses are necessary to estimate the degree of genetic bottlenecks, 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 Lake Zitella population is not completely isolated. There are a few SNYLF populations relatively close to Lake Zitella; including the Highland Lake drainage, McConnell Lake area, and Leland Lakes. The Highland Lake SNYLF population is the only location from which SNYLF could conceivably immigrate in the near term, but the other populations are close enough to allow for rare instances of gene flow.

### ***Introduced Fish***

Trout prey on SNYLF and are a potential source of competition for food (e.g., benthic macroinvertebrates). Although CDFW formerly stocked trout in Lake Zitella, field staff have not seen or captured any fish at the site for decades. Trout are still present in the Rubicon River, below the natural barrier to upstream fish movement along the outlet stream of Lake Zitella. Illegal movement of trout into Lake Zitella presents a very low extirpation risk for SNYLF. Past observations strongly suggest introduced trout are unable to self-sustain in Lake Zitella.



## POPULATION STATUS

SNYLF were observed at Lake Zitella in 1993 by ENF, and CDFW has been monitoring the population since 2002 (**Figure 4**). CDFW field staff have also been surveying an unnamed pond directly adjacent to Zitella (Site ID 51075; **Figure 5**). Between 2002 and 2010, CDFW observed very few post-metamorphic SNYLF (**Figure 4**). Given the simplicity of habitat at Lake Zitella and the site's isolation at the top of a small watershed, the SNYLF population was likely very small. In 2013, field staff discovered that far more SNYLF were present than seen during previous surveys (**Figure 4**).

Apart from 2014, post-metamorphic SNYLF detections from 2013 to 2018 were encouraging. CDFW does not know why there were low SNYLF detections in 2014. However, there are a few possible explanations. One is observer bias: many factors, especially experience, can affect a person's ability to detect SNYLF effectively (Mazerolle et al. 2007). Another possibility is survey conditions. Air and water temperatures during the 2014 survey were cooler than temperatures during surveys in the other recent years. In 2014, field crews went to Lake Zitella twice, because survey conditions during the first attempt in August were poor (i.e., very windy and unseasonably cold). Although conditions were better during the second attempt in early September, the weather was still not ideal. Subsequent surveys in 2015 VES were more similar, albeit lower, compared with 2013 (**Figure 4**).

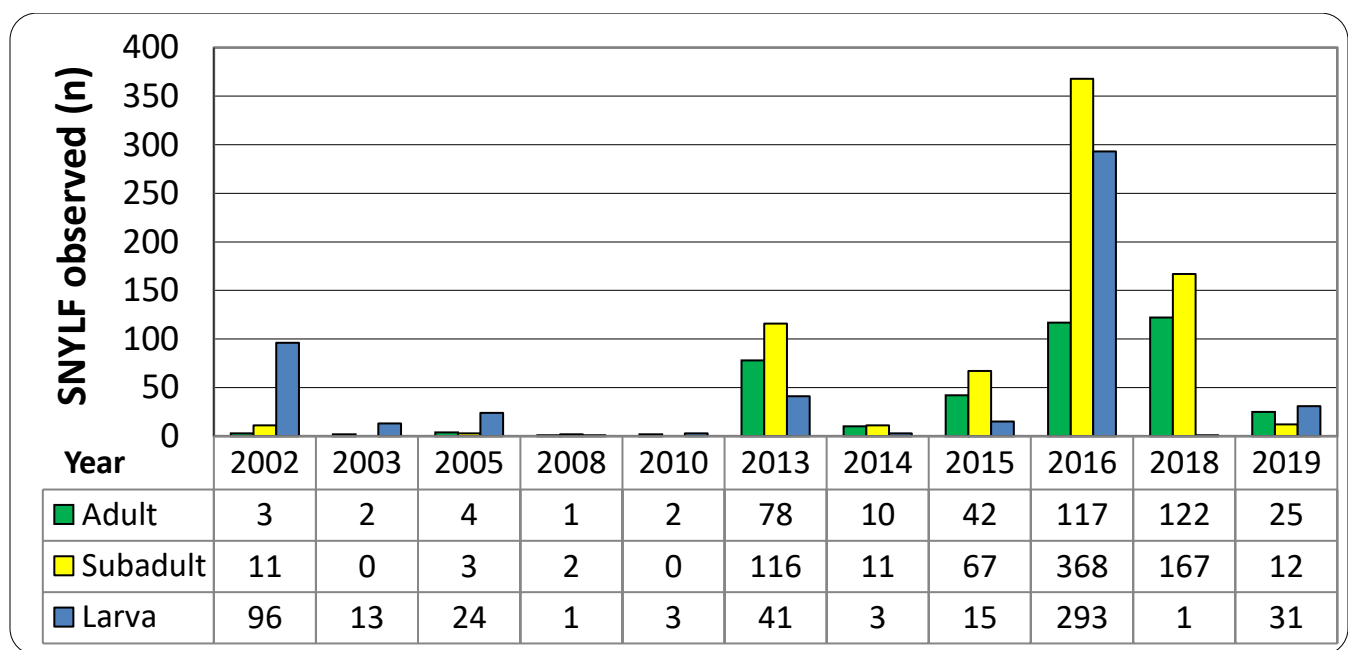
In 2016, the SNYLF population appeared to have grown substantially, and field staff observed a dramatic increase in detections of all life stages. Although the number of SNYLF observed in 2018 was lower than 2016 (especially the number of larvae), the population still appeared to be thriving. There are many possible explanations for the lack of larvae observed during VES in 2018, including observer bias, tadpoles remaining in deeper water on the day of surveying, time of year, and low reproductive output following a harsh winter in 2016–2017.

Given the likely presence of *Bd* in this SNYLF population, CDFW did not expect such a large increase in abundance during the 2013 to 2018 period. However, CDFW field staff observed an even larger increase simultaneously in the adjacent Highland Lake drainage SNYLF population. Apart from trout removal at Highland Lake, other possible reasons for these recent population increases include increased temperatures and food availability during the 2012–2015 drought, and adaptive resistance to *Bd* (Knapp et al. 2016).

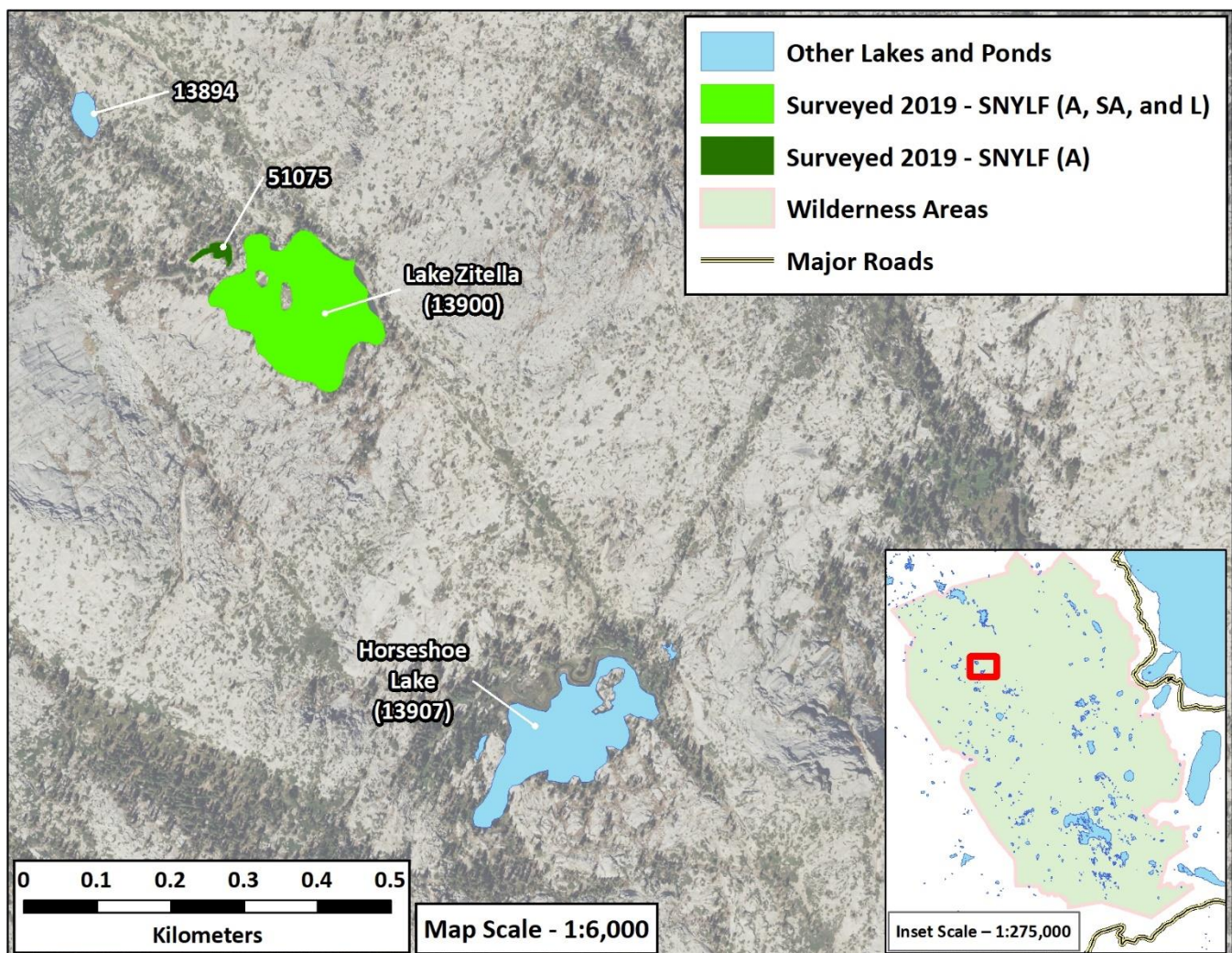
In 2019, CDFW staff noted a marked decrease in SNYLF observations when compared with the previous two survey years. This potential decline may be cause for concern. However, confounding factors preclude making any definitive assessments based on a single survey. For example, moderate winds during the survey may account for a portion of the decrease in observations. Additionally, snow water content and precipitation during winter 2018–2019 were well above average (CDWR 2019a, CDWR 2019b), and the Lake Zitella SNYLF population may have experienced substantial overwinter mortality (Bradford 1983). There is less evidence for overwinter mortality during the same timeframe in the Highland Lake drainage SNYLF population, which is located directly west of Lake Zitella. However, Highland Lake is much larger

and deeper than Lake Zitella, which has a maximum depth of five meters. Therefore, overwinter stress and oxygen deprivation among SNYLF may be more likely during harsh winters at Lake Zitella (Bradford 1983).

Another possible explanation for the sharp decline in SNYLF observations is *Bd*-induced mortality. However, this explanation remains speculative in the absence of more epithelial swab data. Additionally, the known presence of *Bd* in immediately adjacent basins, for at least the past decade, strongly suggests that a recent *Bd*-induced population crash in Lake Zitella is unlikely. Studies from other locations in the Sierra Nevada suggest that any *Bd* epizootic events that may have passed through the Lake Zitella population likely occurred many years ago (e.g., in the early 2000s, when SNYLF detections were consistently low in Lake Zitella, but non-native fish were absent; Briggs et al. 2010, Knapp et al. 2016).



**Figure 4.** Number of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) at Lake Zitella between 2002 and 2019. Surveys include both Lake Zitella and the adjacent pond (Site ID 51075). Observations in 2014 may have been lower due to observer bias and poor weather conditions. Possible reasons for the recent population increase include higher temperatures and food availability during the 2012–2015 drought, and adaptive resistance to the amphibian fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*; Knapp et al. 2016). The drastic drop in observations in 2019 could be caused by many factors, including observer bias, weather conditions on the survey day (e.g., gusty winds), overwinter mortality (winter 2018–2019 was harsh with above average snowpack), frogs spreading out into stream habitat (at the time of surveying, the inlet and outlet streams were flowing, whereas the Lake Zitella tributaries are often dry by mid-summer during average water years), and *Bd*-induced mortality. Additional monitoring will be needed to better determine the status of the Lake Zitella SNYLF population.



**Figure 5.** Lake Zitella (Site ID 13900) area. CDFW staff have consistently observed Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) in the main lake, outlet stream, and adjacent Pond 51075. Horseshoe Lake and Site ID 13894 are shown for reference. SNYLF letter codes in the legend, which indicate the life stages observed during the most recent survey, are as follows: “A” = adults, “SA” = subadults, and “L” = larvae. Number labels shown are unique site identification codes that CDFW uses for data collection. Water flowing out of Lake Zitella enters the Rubicon River, which flows into Rubicon Reservoir (not shown).

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