State of California
Department of Fish and Wildlife

Memorandum

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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. Beginning in 2013, observations of post metamorphic SNYLF greatly increased when compared to SNYLF detections during the previous decade. The higher SNYLF detections continued during surveys in 2015, 2016, and 2018. In 2019, CDFW field staff observed far fewer post-metamorphic SNYLF than seen during the previous three survey years. Fewer detections in 2019 caused CDFW concern about a potential decline in the Lake Zitella SNYLF population. However, in 2020, CDFW staff observed over twice as many post-metamorphic SNYLF when compared with survey results from 2019 (**Figure 4**). Overall, SNYLF detections in recent years have been modest when compared with the peak in detections observed by staff in 2016. CDFW will need to continue monitoring the Lake Zitella SNYLF population to determine population trends. Therefore, CDFW will continue amphibian monitoring at Lake Zitella at least biennially to document SNYLF population status.

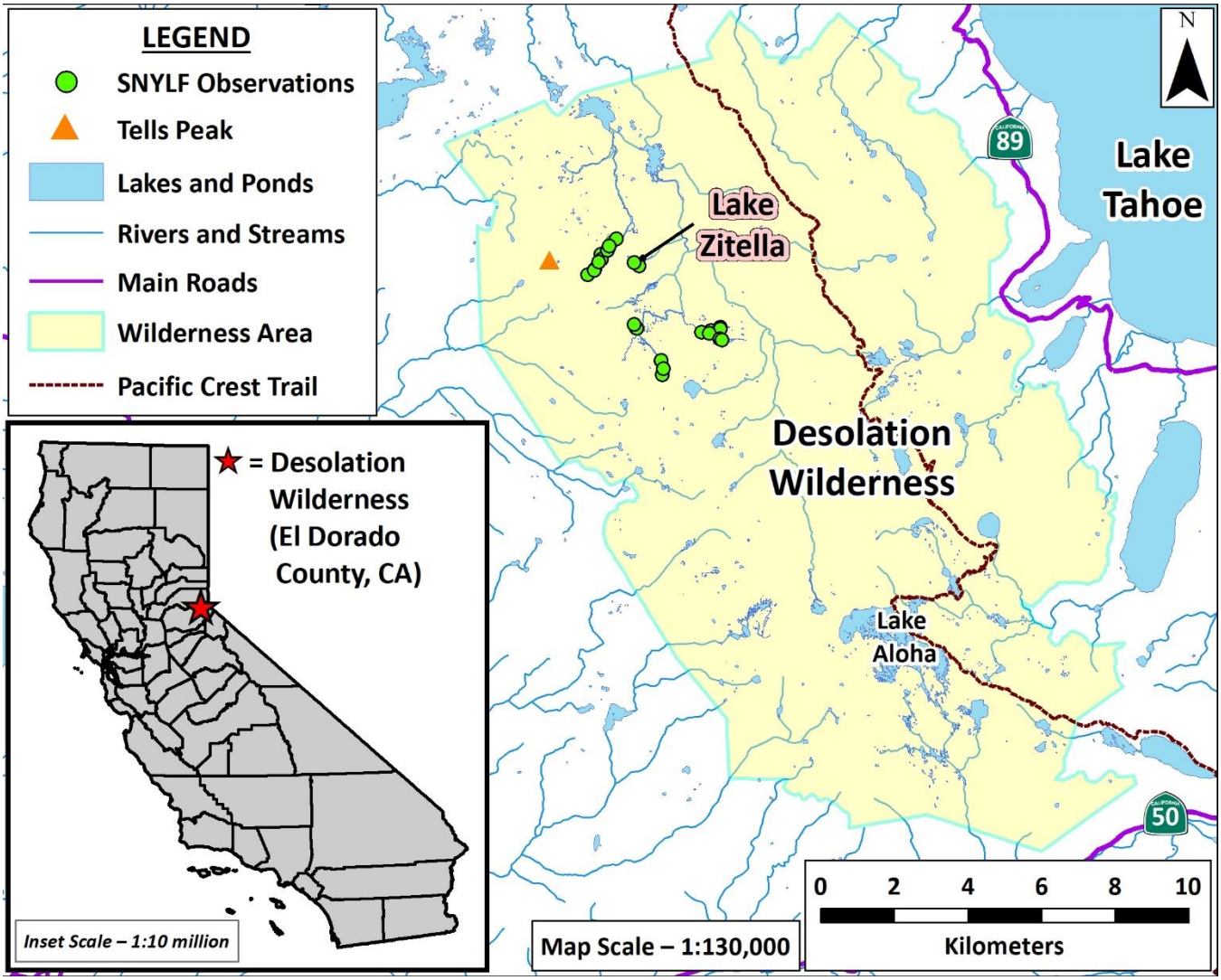


Figure 1. Desolation Wilderness, El Dorado County, CA. Green dots show *Rana sierrae* (SNYLF) sites with positive detections by CDFW staff during recent visual encounter surveys (VES).

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. Post-metamorphic SNYLF detections have varied from only a handful in 1993 (USFS 1993), up to several hundred in 2016 and 2018, down to less than 50 in 2019, and a modest increase back to 140 in 2020 (**Figure 4**). These changes may be a sampling anomaly or caused by other factors discussed below. CDFW field staff plan to visit Lake Zitella again in summer 2021 to monitor the status of the SNYLF population.

Figure 2. An adult Sierra Nevada Yellow-legged Frog (*Rana sierrae*) at Lake Zitella on 11 August 2020. (CDFW)

Figure 3. Lake Zitella on 11 August 2020, looking northwest. (CDFW)

THREATS

Disease

All SNYLF populations in El Dorado County are positive for chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*). Additionally, field staff have occasionally observed SNYLF mortalities at Lake Zitella, including an unknown age class mortality in 2014 and three dead adults in 2016. These anecdotal observations and a drop in SNYLF detections after 2016 may indicate *Bd*-induced mortality, but a definitive cause of death cannot be determined. CDFW collected epithelial swabs from SNYLF at Lake Zitella in 2008 (n = 3), 2010 (n = 1), and 2019 (n = 18). During swab collection in 2019, staff also swabbed post-metamorphic SNYLF at Site ID 51075 (n = 5). Swabs collected in 2008 and 2010 were screened for the presence of *Bd* DNA using real-time quantitative polymerase chain reaction (qPCR) analysis. In fall 2020, partner scientists at the Sierra Nevada Aquatic Research Laboratory (SNARL) screened the swabs collected in 2019 for presence of *Bd* DNA using similar methods (Knapp and Lindauer 2020). Results from 2008 and 2010 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) suggested that *Bd* was likely present in the population at that time, albeit at low levels. Results from 2019 detected *Bd* in seventeen of the twenty-three samples. Most loads were very light to light, with one moderate load. The larger sample size in 2019 likely provides a more accurate picture of *Bd* levels in the Lake Zitella population.

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 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 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 persist 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**).

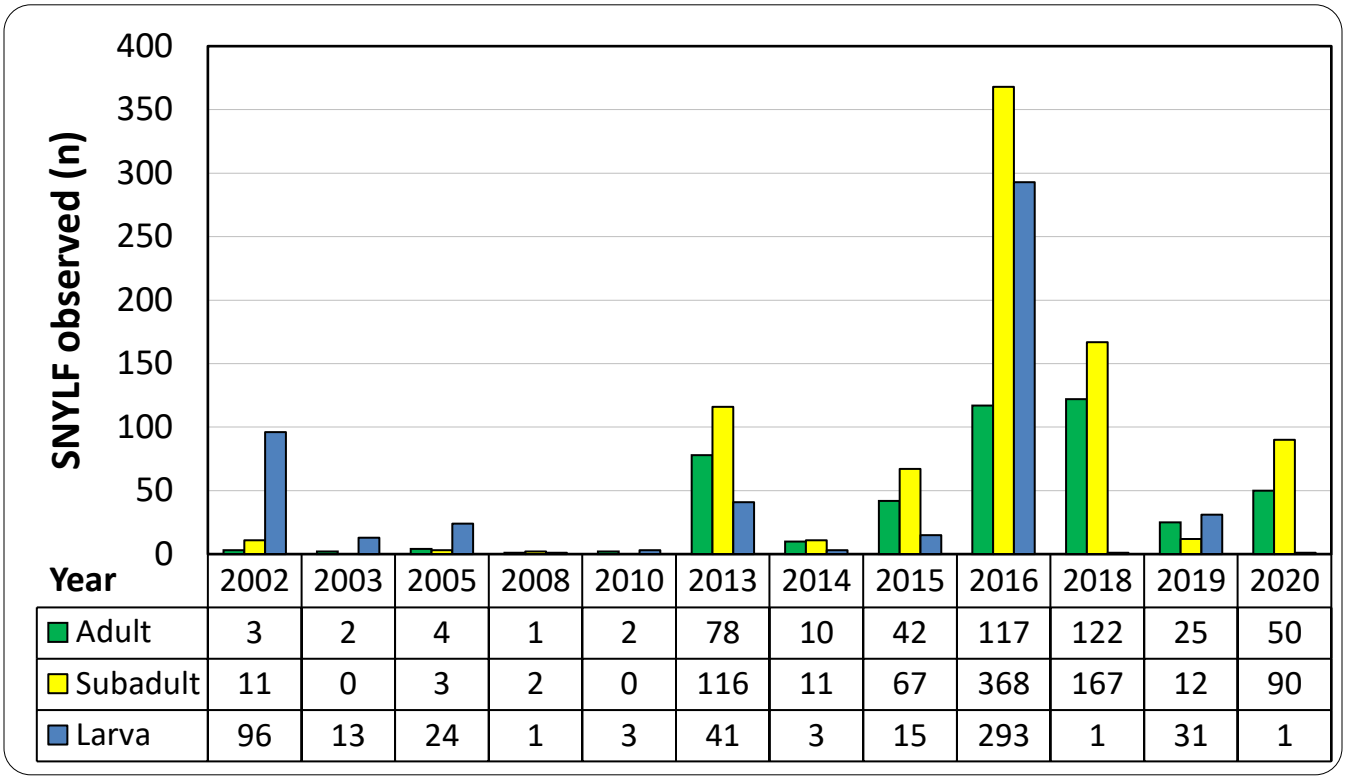
In 2016, the SNYLF population appeared to have grown substantially, and field staff observed a dramatic increase in detections of all life stages. Although the number of SNYLF observed in 2018 was lower than 2016 (especially the number of larvae), the population still appeared to be thriving. There are many possible explanations for the lack of larvae observed during VES in 2018, including obscured visibility into the water from wind, 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 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 was a possible 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 (CDEC 2020a, CDEC 2020b), 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 when compared with Highland Lake (Bradford 1983).

Another possible explanation for the sharp decline in SNYLF observations in 2019 is *Bd*-induced mortality. However, results from skin swabs collected in 2019 suggest that an outbreak of chytridiomycosis may be unlikely. *Bd* loads detected in the samples were well below levels typically associated with severe chytridiomycosis and increased frog mortality (Knapp and Lindauer 2020). Additionally, the known presence of *Bd* in immediately adjacent basins, for at least the past decade, is more evidence against a recent *Bd*-induced population crash at Lake Zitella. The widespread presence of *Bd* in the surrounding area, along with results from studies of other SNYLF populations in the Sierra Nevada, suggest that the initial wave of *Bd* likely passed through the Lake Zitella population many years ago (e.g., in the early 2000s or earlier, when SNYLF detections were consistently low in Lake Zitella, but non-native fish were absent; Briggs et al. 2010, Knapp et al. 2016).

Post-metamorphic SNYLF observations in 2020 were only slightly lower than the average number of observations made by CDFW staff between 2013 and 2019. This result is encouraging and suggests that the population may not be in sharp decline. While observations in 2020 were not as high as those in 2016 or 2018, staff observed enough frogs to suggest that the population is still doing well. Limited number of SNYLF larvae staff observed in 2020 is likely due to moderate winds on the survey day. During most of the survey, wind disturbance on the surface prevented visibility into the water.



Year	2002	2003	2005	2008	2010	2013	2014	2015	2016	2018	2019	2020
Adult	3	2	4	1	2	78	10	42	117	122	25	50
Subadult	11	0	3	2	0	116	11	67	368	167	12	90
Larva	96	13	24	1	3	41	3	15	293	1	31	1

Figure 4. Number of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) detected during visual encounter surveys (VES) at Lake Zitella between 2002 and 2020. 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 in 2019, 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.

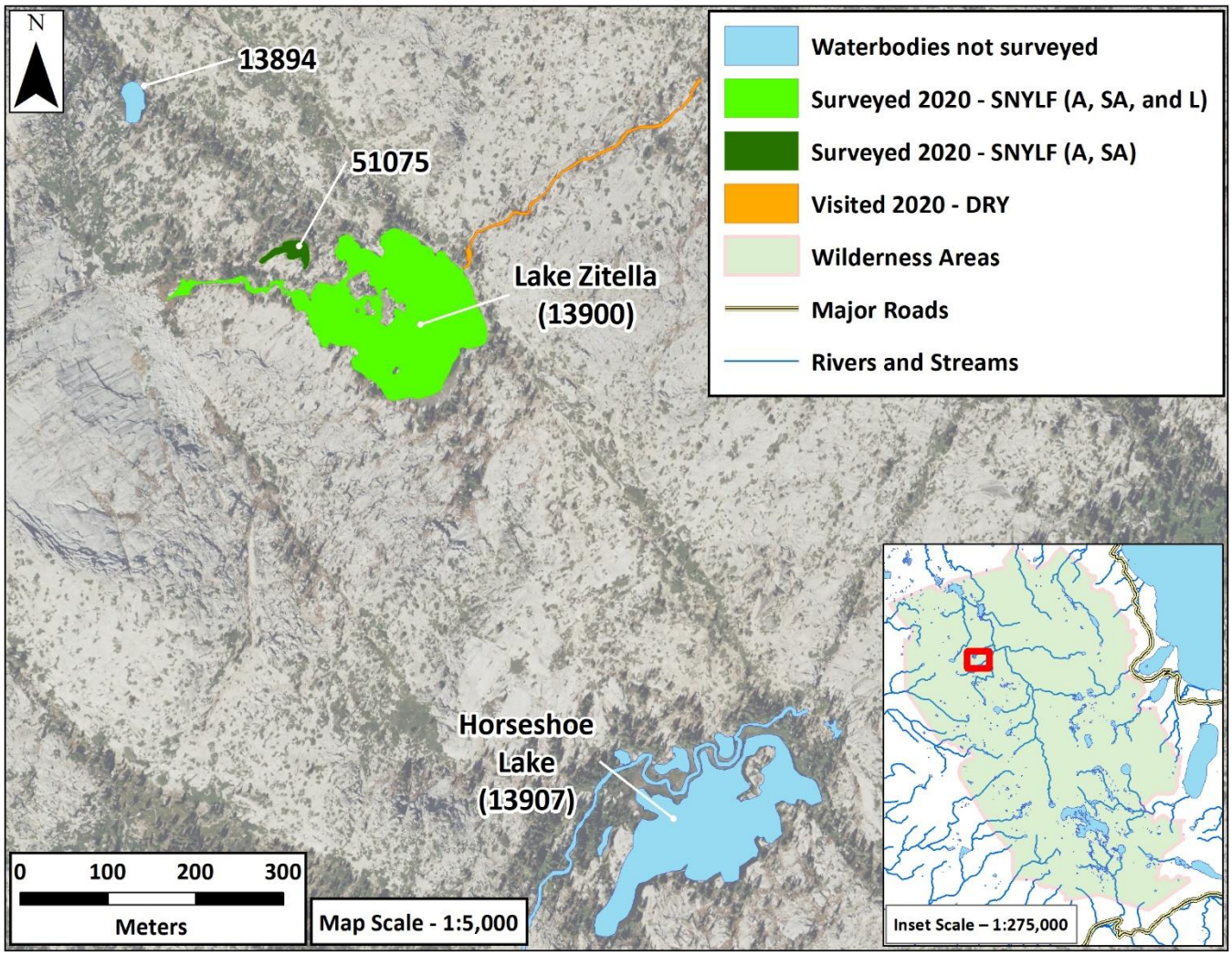


Figure 5. Lake Zitella (Site ID 13900) area. California Department of Fish and Wildlife (CDFW) staff have consistently observed Sierra Nevada Yellow-legged Frogs (*Rana sierrae*; SNYLF) in the main lake, outlet stream, and adjacent pond (Site ID 51075). Horseshoe Lake and Site ID 13894 are shown for reference. Since results reported in 2019, CDFW updated several existing GIS polygons to more accurately reflect the composition of the depicted waterbodies. 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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