State of California

Memorandum

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To: Sarah Mussulman
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 monitoring at Lake Zitella, Desolation Wilderness.

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). California Department of Fish and Wildlife (CDFW) formerly stocked Lake Zitella 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 2002 through 2018 suggest a healthy and growing SNYLF population. CDFW will continue amphibian monitoring at Lake Zitella at least biennially to document SNYLF population status.

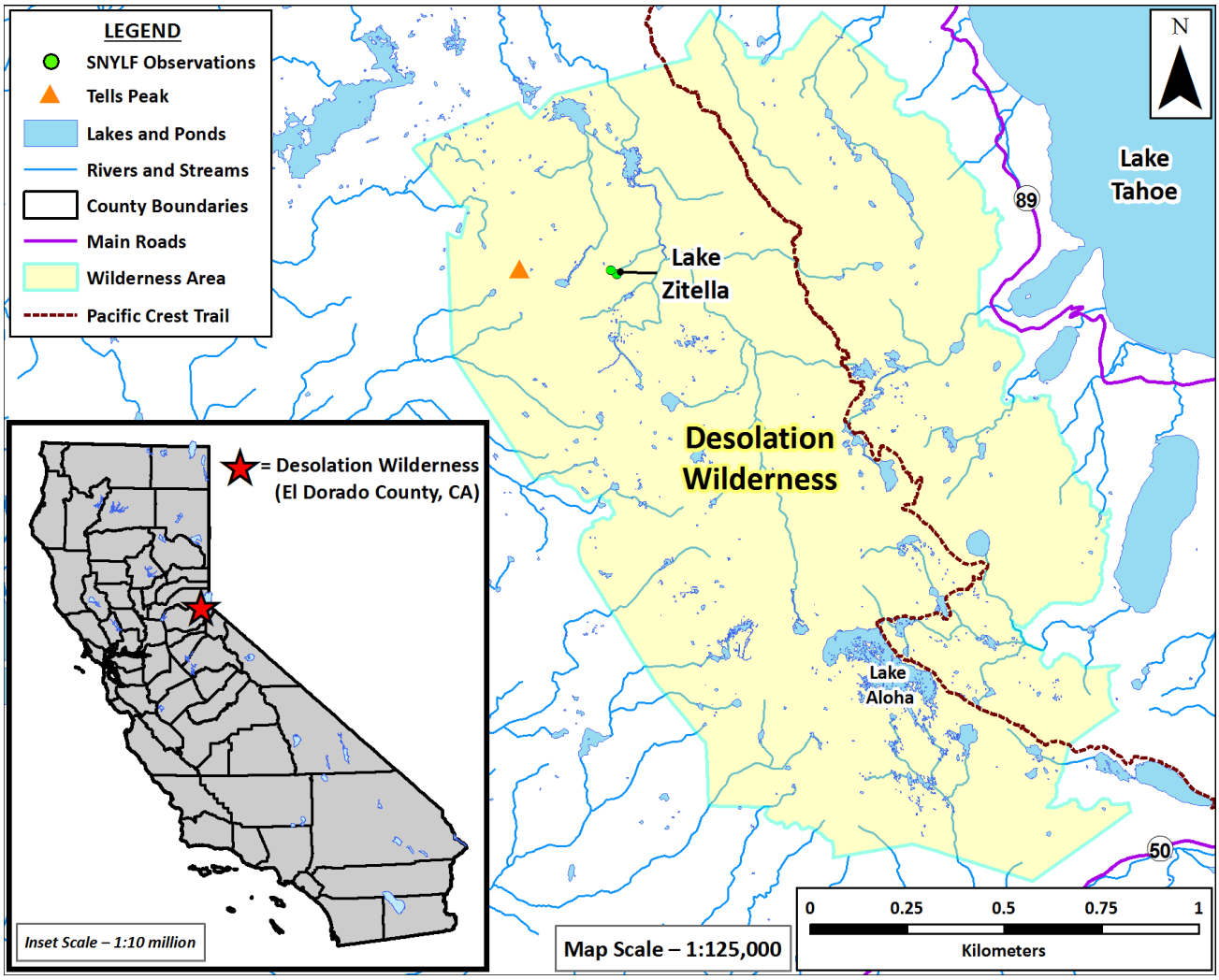


Figure 1: Desolation Wilderness, El Dorado County, CA. Green dots show *Rana sierrae* (SNYLF) sites with positive detections by CDFW staff during recent visual encounter surveys (VES).

ENVIRONMENTAL SETTING

Lake Zitella (Figure 2) 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 a small SNYLF population in the area. 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, from only a handful of post-metamorphic frog detections in 1993 (USFS 1993), to several hundred post-metamorphic frogs observed during VES in 2018 (Figure 4). CDFW will continue to visit Lake Zitella at least every other year to monitor the status of the SNYLF population.

Figure 2: Lake Zitella on 30 July 2015, looking west. (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 could indicate *Bd*-induced mortality, but a definitive cause of death cannot be determined.

- ***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 self-sustain in Lake Zitella.

Figure 3. A large adult female Sierra Nevada yellow-legged frog (*Rana sierrae*) at Lake Zitella on 22 July 2018. (S. Serson).

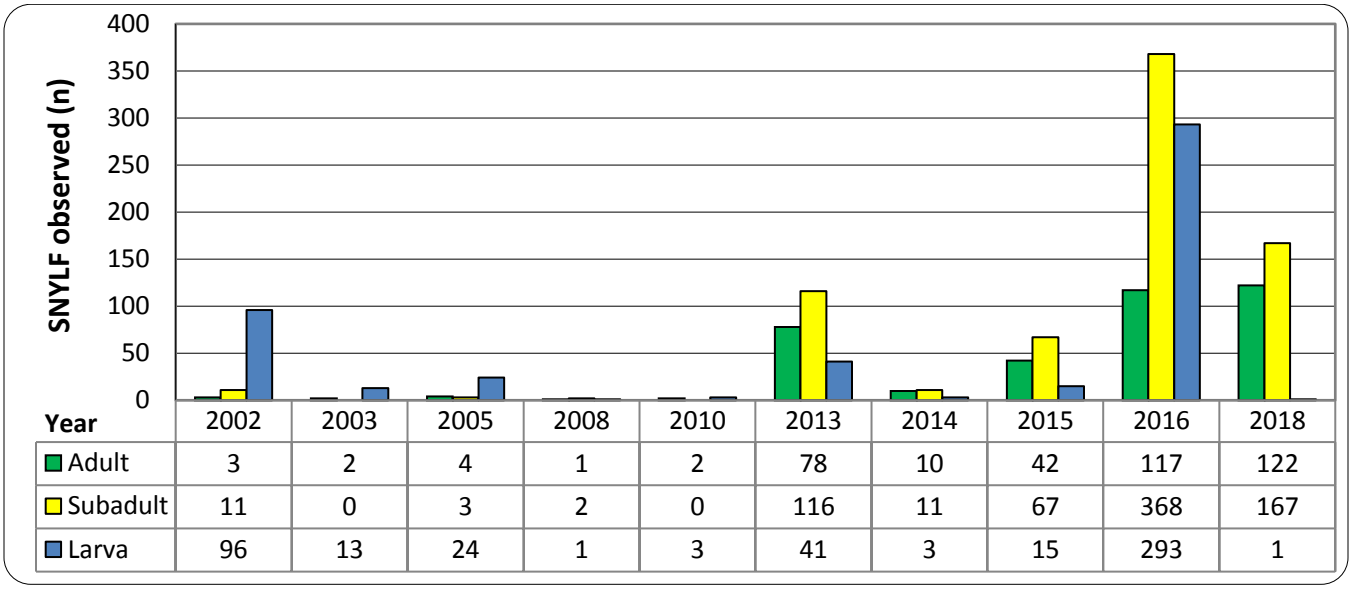
POPULATION STATUS

SNYLF (Figure 3) 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 since 2013 have been 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 (i.e., temperatures were warmer during surveys in 2013, 2015, 2016, and 2018). 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 appears 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 past several years. However, CDFW field staff have 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).



Year	2002	2003	2005	2008	2010	2013	2014	2015	2016	2018
Adult	3	2	4	1	2	78	10	42	117	122
Subadult	11	0	3	2	0	116	11	67	368	167
Larva	96	13	24	1	3	41	3	15	293	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 2018. 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 increases include increased temperatures and food availability during the 2012–2015 drought, and adaptive resistance to the amphibian fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*; Knapp et al. 2016).

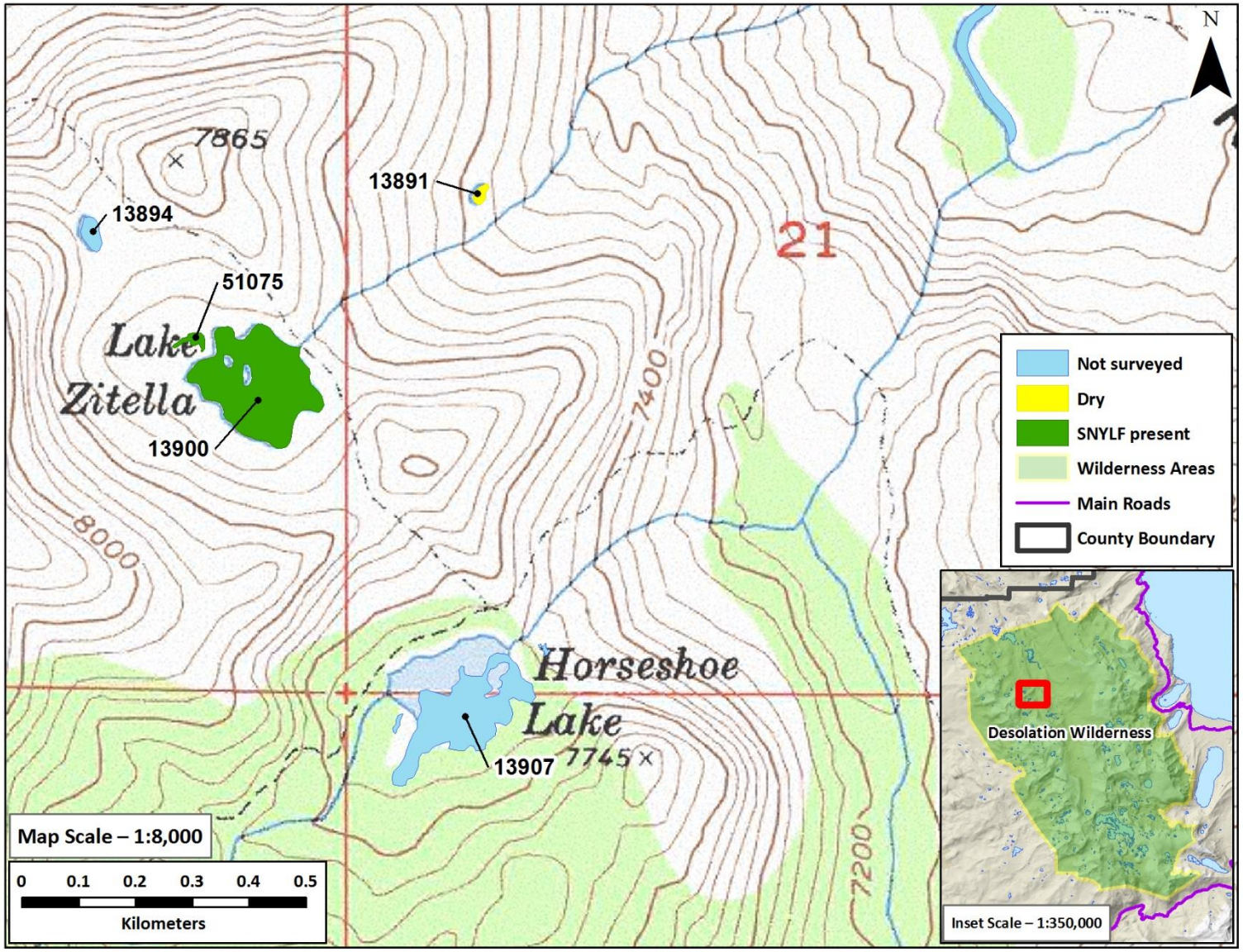


Figure 5: Lake Zitella (site ID 13900) area. CDFW staff have consistently observed Sierra Nevada yellow-legged frogs (*Rana sierrae*; SNYLF) in the main lake, outlet stream, and adjacent Pond 51075. Horseshoe Lake and Pond 13894 are shown for reference. Water flowing out of Lake Zitella enters the Rubicon River, which flows into Rubicon Lake (not shown).

LITERATURE CITED

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