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Note

Occurrence of the California Red-legged Frog in Reservoirs Despite Habitat Alterations and Non-native Predatory Fish

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***Abstract.*—Losses of declining species can be confounding. Determining the origins of these losses can come from direct observation, literature review, or may be information passed along from biologist to biologist. A frequently cited literature source related to the natural history of California Red-legged Frog (*Rana draytonii*) may have painted a picture that was not only inaccurate but also has led to the dismissal of numerous opportunities to survey for and document the presence of this threatened species. Our observations from three municipal reservoirs in northern California suggest that California Red-legged Frogs occupy this habitat despite the putative acceptance of the absence of this species in reservoirs and downstream areas where predatory fish are sympatric. This conclusion is supported by a previous report for a reservoir in southern California. We found California Red-legged Frogs syntopic with predatory fishes, both native and non-native, and their downstream habitat. We do not suggest that reservoir construction has no effect on California Red-legged Frogs. Rather, we contend that it is important to survey reservoirs and associated upstream and downstream habitat for this species when presence/absence surveys are considered.**

Key Words.—downstream; persistence; occupy, predatory fishes; *Rana draytonii*; recolonization; syntopic

The decline of the California Red-legged Frog (*Rana draytonii*; Fig. 1), a federally listed Threatened species throughout its range in California (U.S. Fish and Wildlife Service [USFWS] 1996), has been associated with introduced non-native species, habitat modification or destruction, water-quality degradation, and other factors (Moyle 1973; Jennings and Hayes 1994; USFWS 1996; Gilliland 2010; Thomson et al. 2016). Among contributing factors associated with the decline of the species are impoundment structures and water management projects (USFWS 1996). Although few dams have been constructed within the range of the species since 1994, water management projects and their associated habitat modifications routinely occur and are widely believed to be hindering the recovery of this threatened frog (Jennings and Hayes 1994).

Previous work on this species suggested that municipal reservoirs with concomitant habitat alteration and associated exotic species may have confounding negative effects on California Red-legged Frog populations and population persistence (Hayes and Jennings 1986). It has also been reported that upstream and downstream dispersal of exotic species can disrupt the community dynamics of California Red-legged Frogs (USFWS 2002). We assembled observations of California Red-legged Frog conducted during unrelated surveys from widely disparate areas over a 25-y period and examined those observations *post hoc* to determine the use of reservoirs by this species.

The dam on the Los Vaqueros Reservoir of the Contra Costa Water District located in Contra Costa County, California, was constructed in 1998 to improve domestic water quality and reliability for residents of central and eastern Contra Costa County (Fig. 2). Inundation of 566.6 ha of the upper Kellogg Creek watershed was complete by 1999 (https://www.ccwater.com/435/Los-Vaqueros-Project-History). The area of inundation included portions of Kellogg and Adobe Creeks, and approximately five minor tributaries and drainages. The reservoir was inundated from waters pumped through a

Figure 1. California Red-legged Frog (*Rana draytonii*), Wragg Ridge Preserve, Napa County, California. (Photographed by Jeff A. Alvarez).

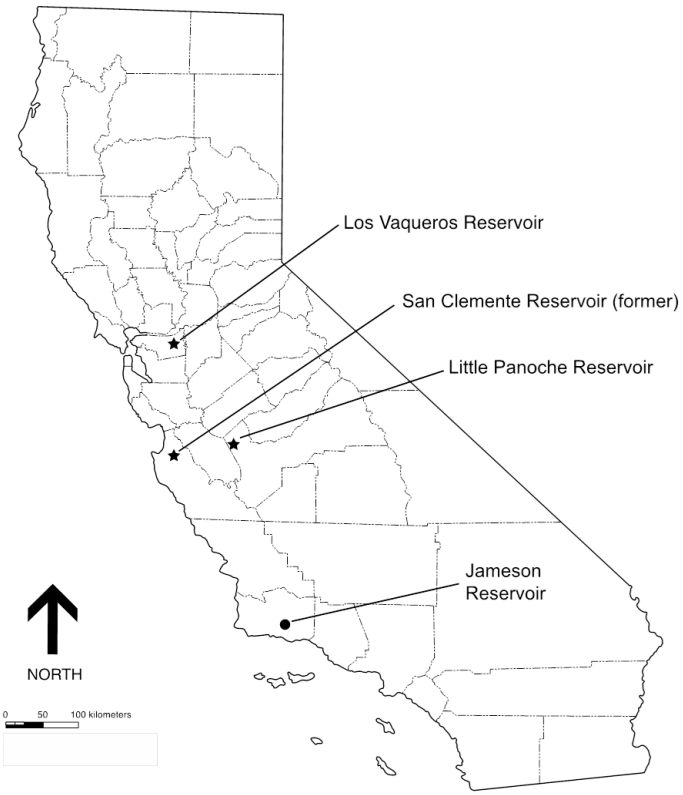

Figure 2. Locations of three reservoirs (star) that support California Red-legged Frogs (*Rana draytonii*) and predatory fishes in California. The location of the Jameson Reservoir (dot) included for reference.

pipeline connected to the Sacramento-San Joaquin River Delta (https://www.ccwater.com/435/Los-Vaqueros-Project-History). Shortly (one to two months) after pumping began, maintenance on the pumping station removed fish screens and allowed fish to freely enter the pipeline, which, thereafter, began to establish in the reservoir (pers. obs.). Among the many predatory species observed in the reservoir were Largemouth Bass (*Micropterus salmoides*) that exceed 4.5 kg and Striped Bass (*Morone saxattilis*) that exceed 18.1 kg, as well as Channel Catfish (*Ictularus punctatus*), White Catfish (*Ameiurus catus*), Brown Bullhead (*A. nebulosus*), Bluegill (*Lepomis macrochirus*), Green Sunfish (*L. cyanellus*), and numerous smaller, so-called bait fish (i.e., Mosquitofish, *Gambusia affinnis*, Inland Silverside, *Menidia beryllina*, Sacramento Blackfish, *Orthodon microlepidontus*, Threadfin Shad, *Dorosoma petenense*, Golden Shiner, *Notemigonus crysoleucus*, and Goldfish, *Carassius auratus*; Robert Nuzum, unpubl. report).

Following inundation, focused surveys for American Bullfrogs (*Lithobates catesbieanus*) and other non-native species were initiated by us. These surveys included both daytime and nighttime surveys during the late spring and summer months and included fish monitoring for the management of recreational fishing. Our surveys along the reservoir shoreline were expected to continue for the life of the reservoir, and occurred twice annually, offering numerous opportunities to examine habitat around the reservoir.

Additionally, in October, November, and December 2023, we visited the Little Panoche Reservoir located in western Fresno County, California, which is a 16.6 ha reservoir that impounds water from the Little Panoche Creek drainage (Fig. 2). The reservoir was constructed in 1966 for the purpose of providing flood protection and agricultural and domestic water uses associated with the San Luis Canal, Delta-Mendota Canal, and other downstream developments (https://damsoftheworld.com/usa/california/little-panoche-detention-dam/). We conducted three nighttime Visual Encounter Surveys from both the shoreline and from kayaks on most of the shoreline edge.

We also conducted surveys at the San Clemente Reservoir, Carmel Valley, California. The dam at the San Clemente Reservoir was constructed in 1921 to supply water to the residents of western Monterey County and created a 576.1 ha reservoir (https://www.sanclementedamremoval.org/faqs). We conducted surveys for the presence of California Red-legged Frogs, including a 1,000 m downstream section of the Carmel River, in the summer of 1996 (Fig. 2). Surveyors walked the shoreline and conducted snorkel surveys (slowly moving along the shoreline edge and river channel) through all available habitats. We also included

observations reported by the USFWS (2002) from the Jameson Reservoir in Santa Barbara County. The Juncal Dam at this site was completed in 1930, creating a 55.8 ha reservoir, which provides drinking water to regional residents (https://montecitowater.com/our-water/water-sources-supply/surface-supplies/).

At the Los Vaqueros Reservoir, we made 40 survey visits that resulted in observations of 11–43 California Red-legged Frogs per survey. We found frogs in both adult and juvenile life stages in and around the reservoir every year during 20 y of surveys, 1998 to 2018. California Red-legged Frogs were typically observed within an extensive zone of interface between the remaining portions of Kellogg and Adobe Creeks, as well as in numerous other waterways that flow into the reservoir. As the waterways that flowed into the reservoir receded, we found California Red-legged Frogs occupying four of the five upstream reaches of drainages with fluctuating water levels, but where aquatic refuge habitat (i.e., upstream reaches of the arms of the reservoir) was maintained (e.g., shallow waters of the creek/reservoir delta). An incidental observation occurred in 2012 when we observed two California Red-legged Frogs in a small patch of partially inundated willow (*Salix* sp.) trees located approximately 12 m from shore and 300 m from the delta between the dry creek bed and reservoir inundation (i.e., well within the reservoir). We never observed California Red-legged Frogs in the waterways that flowed into the reservoir, which we also surveyed contemporaneously with reservoir surveys. This observation, in summer 2012 (14 y following inundation), was unanticipated, because the reservoir supported numerous predatory fish.

At the Little Panoche Reservoir, we found 182 juvenile and adult California Red-legged Frogs in the reservoir during the October 2023 surveys, and 56 juvenile and adult frogs in November and December 2023. Numerous predatory fish species were also present in the reservoir and upstream in Little Panoche Creek. These included non-native Black Bullhead (*Ameiurus melas*), Brown Bullhead, Channel Catfish, White Catfish, Largemouth Bass, Redear Sunfish (*L. microlophus*), Green Sunfish, Bluegill, Warmouth (*L. gulosus*), White Crappie (*Pomoxis annularis*), Black Crappie (*P. nigromaculatus*), as well as the native Sacramento Pikeminnow (*Ptychocheilus grandis*). In the downstream portions of the Little Panoche Reservoir, we also observed adult California Red-legged Frogs, and at least 47 juvenile frogs and one larva in downstream pools, 200 m downstream of the dam during a daytime Visual Encounter Survey, in July 2023.

At our third site, we found two adult California Red-legged Frogs among numerous adult and juvenile American Bullfrogs within emergent vegetation at the interface between San Clemente Creek and the San Clemente Reservoir. This observation coincided with predatory fish movements into the waterbody, as the native South/Central Coast Steelhead (*Oncorhynchus mykiss irideus*) annually moved up the creek into the reservoir (via a fish ladder) before migrating into the upper arms of the reservoir seeking spawning habitat (Moyle 2002; McGinnis 2006). The seasonal movement of steelhead into this coastal stream coincides with the spawning period of California Red-legged Frogs, which suggests that the two species are at least temporally sympatric (McGinnis 1984; Stebbins and McGinnis 2013). Subsequently, the San Clemente Dam was removed in 2015, which restored to conditions believed similar to pre-dam construction on the Carmel River (https://www.sanclementedamremoval.org). California Red-legged Frogs were present in the watershed and immediately recolonized the former reservoir area within the Carmel River (Gretchen Padgett-Flohr, pers. comm.). Even though we only surveyed this site in 1996, the observation of frogs first reported in 2015 suggests their persistence in the watershed. More recent observations of breeding California Red-legged Frogs in 2024 confirm occupation and population persistence at this site (Dawn Reis, unpubl. report). The USFWS (2002) also reported that California Red-legged Frogs were in Jameson Reservoir on the Santa Ynez River, Santa Barbara County, California. Fishes in the Jameson Reservoir include Largemouth Bass and native Rainbow Trout (*O. mykiss*), each of which is known or suspected of feeding upon California Red-legged Frogs (USFWS 1996).

We acknowledge that the surveys we conducted did not include monitoring of specific individual frogs. Therefore, we do not know if our repeated observations at a site (i.e., Los Vaqueros and Little Panoche Reservoirs) were transient individuals or the same individuals persisting in the habitat. Further, our surveys did not target and were not intended to detect egg masses or larvae. This would be important to investigate to determine if reproduction is occurring at the sites we surveyed, although reproduction must have been occurring at the Los Vaqueros Reservoir because we found frogs annually from 1998 to 2018.

Predatory fish are considered a significant threat to California Red-legged Frogs (USFWS 1996; Alvarez et al. 2002). Nonetheless, despite the presence of predatory fish that are known, believed, or likely to eat frogs, California Red-legged Frog have been found in these four reservoirs. Predatory fish-populated reservoirs that offer the appropriate microhabitat (i.e., high levels of habitat complexity) for refuge and dispersal seem to support California Red-legged Frog adults and juveniles over long periods.

It has been reported and widely cited that California Red-legged Frogs are generally extirpated from the drainages downstream of reservoirs within 1–5 y of impoundment (Hayes and Jennings 1988; Jennings and Hayes 1994; USFWS 2002). We, however, did not find this to be true at the sites we examined. For example, at the Los Vaqueros Reservoir, a large population of California Red-legged Frogs (approximately 7,000 to

10,000 individuals) have been extant within Kellogg Creek watershed for the 26-y life of the reservoir impoundment (USFWS 2002). It should be noted that a robust and effective control program for American Bullfrogs, as well as a high level of habitat complexity, may facilitate the persistence of this population in Kellogg Creek, downstream of the reservoir (Alvarez and Wilcox 2021; Alvarez and Wilcox, in press). We speculate that in the absence of American Bullfrog control (i.e., in the presence of bullfrogs), and presence of predatory fishes there might well have been a synergistic negative impact on the viability of California Red-legged Frogs in these drainages.

Our observations were similar in the downstream portions of the Little Panoche Reservoir where we recorded adult, juvenile, and larvae California Red-legged Frogs. These downstream observations of the presence of California Red-legged Frogs were in contrast to that reported by Jennings and Hayes (1994) and USFWS (2002). We also note that the decrease in numbers of observations from October to December at the Little Panoche Reservoir is likely due to the Allaback Effect (Allaback et al. 2010), whereby juveniles leave aquatic sites *en masse* during fall rain events, a commonly observed behavior for this species.

Our observations in the Los Vaqueros, Little Panoche, and San Clemente Reservoirs, and reports for the Jameson Reservoir (USFWS 2002) suggest that habitat use by California Red-legged Frogs, syntopic with predatory fishes over long periods of time (i.e., up to 26 y) is possible. Further, this may occur in the presence of certain anthropogenic structures, large-scale habitat modifications, continuous water-level fluctuations, as well as recreational fishing activity. We do not suggest that reservoir construction has no effect on California Red-legged Frog populations, or that this frog can routinely co-exist with, or reproduce, in the presence of predatory fishes and/or other significant habitat modification or degradation. Rather, we contend that reservoirs, and associated upstream and downstream habitat, even when predatory fish use these water bodies, should be considered viable dispersal and refuge habitat if California Red-legged Frogs are extant in the general area (Alvarez et al. 2002). All such habitats should be thoroughly surveyed to determine the potential presence of California Red-legged Frogs and how this declining species exploits various microhabitats within these types of reservoirs.

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Jeff A. Alvarez is a Herpetologist who has specialized in California reptiles and amphibians for over 35 y. He has worked with California Red-legged Frogs, California Tiger Salamanders (*Ambystoma californiense*), Southwestern and Northwestern pond turtles, (*Actinemys marmorata* and *pallida*), and Alameda Whipsnakes (*Masticophis lateralis euyxanthus*) for much of his career. His focus is on the conservation and natural history of herpetofauna, survey techniques development, and conducting peer-level special-status species workshops. (Photograph courtesy of CostaRicaRafting).

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Sarah M. Foster has been a Wildlife Biologist in California for 22 y. She specializes in the natural history of California Tiger Salamanders (*Ambystoma californiense*), California Red-legged Frogs, Sandhill Cranes (*Grus canadensis*), and secretive marsh birds. Her recent focus is on California Tiger Salamander population and movement ecology. (Photographed by Jeff A. Alvarez).