An Assessment of the Reintroduction of the Foothill Yellow-Legged Frog (*Rana boylii)* in the Tuolumne Watershed, California

Tyler Robert Goodearly

Introduction

California, complete with the Sierra Nevada Mountain Range, coastal redwoods, and the Mojave Desert, and coupled with its Mediterranean climate, offers unique and dynamic habitats for its native species. In particular, California's rivers are an essential home for many wildlife species, including the Foothill Yellow-Legged Frog (*Rana boylii*). Historically these frogs occupied a tremendous range from the Cascade Mountains in Oregon down through Los Angeles County to Baja California and from sea level to about 2,000 meters in elevation (Lind et al. 1996; Morey 2010). By transcending the aquatic-terrestrial barrier, they served an important ecological role providing food for snakes, fish, and mammals (Morey 2000). Unfortunately, these once numerous frogs are now federally listed as a species of special concern (Lind et al. 1996).

R. boylii has a reproductive cycle that is intimately correlated with the natural flow regime of California's Mediterranean climate—they lay their eggs during the Spring when river flows are low and the young emerge as froglets in the Fall (Bondi et al. 2013). Consequently, their population numbers continue to fall most notably due to the disrupting effects of dams on the hydrological regime (Lind et al. 1996; Bondi et al. 2013), but also due to invasive species, changes in macroinvertebrate assemblages, changes in water temperatures, pollution, and increased sedimentation due to fires (Lind et al. 1996). One study found that out of

213 known locations of *R. boylii* only 30 had populations with at least 20 adult frogs (Lannoo 2005). Because of these declines, it is imperative that conservation efforts be met to ensure the survival, persistence, and success of this species.

Reintroduction is one tool to consider to meet these goals. The IUCN defines reintroduction as the "intentional movement and release of an organism inside its indigenous range from which it has disappeared," with the goal "to re-establish a viable population," (IUCN 2013). However, for reintroductions to be successful it is essential to understand the physical habitat requirements of a species and whether or not these will still be met despite an altered habitat. Bondi et al. (2013) constructed a habitat suitability criteria for *R. boylii,* in which they address the physical requirements for this species. They found that for reproduction to be successful, the corresponding habitat must be relatively shallow (>0.9 m for eggs and >1.5 m for tadpoles), have slow mid-column water velocities (> 0.3 m/s for eggs and > 0.5 m/s for tadpoles), and have a substrate of cobble (64 – 256 mm in diameter) or boulders (>256 mm in diameter) (Bondi et al. 2013).

Our team of scientists from the University of California, Davis travelled along the Tuolumne River watershed recording stream data from seven different sites. During the nine days we spent along the river there were no sightings of *R. boylii*, despite passing through some of the frog's historic range. The data we collected will be used in conjunction with the habitat suitability criteria for *R. boylii* in order to determine the best location for their reintroduction.

Methods and Materials?

Sites - We wanted to illustrate a comprehensive idea of how the river's water quality and wildlife assemblages change throughout the watershed. Therefore, our sites were chosen based on three criteria:

1. The location of the site within the watershed and whether it will add to our comprehensive understanding of its changes.
2. The accessibility of the site.
3. The presence of all three major hydraulic units (run, riffle, and pool).

Sediment - Sediment analyses were conducted by blindly selecting at least 100 rocks and measuring each rock along its second largest axis using a gravelometer. This was repeated at each site. A habitat was considered to have good suitability if more than 75 percent of the sediment was composed of cobble and boulder, intermediate if in between 25 and 75 percent was composed of cobble and boulder, and bad if less than 25 percent was composed of cobble and boulder.

Water Velocity – A transect was erected at each site within the run and measured at regular intervals across the transect (at least 10) at 60 percent depth using a wading rod and a Marsh-McBirney flow meter. A habitat was considered to have good suitability if it fit within the margins of *R. boylii's* habitat suitability criteria. Each interval of suitable habitat within the cross-section was added together to get a total width of suitable habitat within each site.

Water Depth – Water depths were collected in two ways:

1. Within pools, a stadia rod and an auto-level were used to measure water depth and channel morphology.
2. Within runs, water depth was collected using the wading rod.

A habitat was considered to have good suitability if it fit within the margins of *R. boylii's* habitat suitability criteria. Each interval of suitable habitat within the cross-section was added together to get a total width of suitable habitat within each site.

Results

Of the seven sites from which we collected data, only five are within the historic range of *R. boylii:* two sites below Preston Falls, two sites above Merals Pool, and one site above Turlock Lake.

Location	Total Amount of Suitable Habitat (Water Depth and Velocity)	Total Amount of Suitable Sediment Composition	Overall Rating
Preston Falls A	4 meters wide	14 percent	Bad
Preston Falls B	2 meters wide	67 percent	Intermediate
Merals Pool A	10 meters wide	42 percent	Intermediate
Merals Pool B	3.85 meters wide	82 percent	Good
Turlock Lake	2 meters wide	7 percent	Bad

Table 1: This table includes the location, total amount of suitable water depth and velocity, total amount of suitable sediment composition, and the overall rating of each study site within the range of *R. boylii.*

Discussion

While seductive in concept, reintroductions prove to be difficult because they require the removal of the cause of the organism's decline—in this case, large and expensive hydraulic dams. One study found that out of 74 reintroduction projects,

only four were considered successful after five years (Seddon 1999). Of the sites we collected data from that are within the historic range of *R. boylii,* none of them are suitable for successful reintroduction. The habitat suitability criteria presented for *R. boylii* are representative of undammed rivers during the Spring. However, the dammed Tuolumne River has a variable stream velocity and depth throughout a 24-hour period due to the hydropeaking that is used to generate power and provide flows for fish. These high flows are not just unsuitable breeding habitat for *R. boylii*, but they will also scour away egg masses and push tadpoles out of their ideal rearing habitats (Bondi et al. 2013). Consequently, for the reintroduction of *R. boylii* to be successful, hydropeaking must cease and natural flows must remain constant and low during their reproductive window from late Spring to early Fall (Bondi et al. 2013). This will give adults the chance to reproduce and the eggs the chance develop without being scoured; therefore, the population will be able to survive and persist.

Acknowledgements

This research was funded and supported by the Center for Watershed Sciences at the University of California, Davis. I would like to thank Dr. Peter Moyle, Dr. Sarah Yarnell, Carson Jeffres, and Ryan Peak for their guidance, assistance, and leadership. I would also like to thank all of my fellow undergraduate researchers who helped collect this data.

References

Bondi, C. A., Lind, A. J., and Yarnell, S. M. 2013. Habitat Suitability Criteria for *Rana boylii* in the Sierra Nevada, California. Herpetological Conservation and Biology 8(1): 88-103.

IUCN/SSC. 2013. *Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0*. Gland, Switzerland: IUCN Species Survival Commission, viiii + 57 pp.

Lannoo, M. 2005. *Amphibian Declines: The Conservation Status of United States Species*. University of California Press. London, England.

Lind, A. J., Welsh Jr., H. H., and Wilson, R. A. 1996. The Effects of a Dam on Breeding Habitat and Egg Survival of the Foothill Yellow-Legged Frog (*Rana boylii)* in Northwestern California. Herpetological Review 27(2): 62-67.

Morey, S. 2000. Foothill Yellow-Legged Frog. California Wildlife Habitat Relationships System, California Department of Fish and Wildlife. LHA: A043.

Seddon, P. J. 1999. Persistence without Intervention: Assessing Success in Wildlife Reintroductions. TREE 14(12): 503.