From Frog to Forest Stewardship:
Building Climate Resilience into Conservation

Incorporating climate change considerations into land management and species conservation remains challenging for natural resource managers, because other stressors such as drought or invasive species currently have a larger impact. Thus, it is often difficult to prioritize long-term goals when resources for the immediate needs of species are already difficult to secure. This project aims to combine the latest decision science with climate change refugia modeling to create a novel decision-framework that emphasizes a collaborative approach to complex management issues, which aims to bridge the gap between managing for current priorities and long-term climate change adaptation. In doing so, this framework will be used to give foresight to current management actions, preventing maladaptive strategies and increasing climate change resilience, specifically with a focus on species persistence in the foothills in and around Yosemite NP.

With the intention to eventually increase the scale of the project to multiple species across the landscape, the project will begin using the foothill yellow-legged frog as our focal species. The foothill yellow-legged frog has experienced significant population declines across the Southern extent of its historic range mostly due to threats such as land use changes, changes in hydrology, competition and/or predation from introduced species, and disease [1;2]. While these threats already pose challenges to species conservation, climate change will exasperate the risk to species' persistence in this geography. To address both the current and future stressors to the foothill yellow-legged frog populations, specifically in the Sierra Nevada, this project aims to identify near term conservation strategies in the Southern Sierra Nevada that simultaneously lead to increased adaptive capacity to climate change impacts.

Ecology and Threats

The decline of amphibian species across North America is an indication of aquatic ecosystems in peril – in the Western US caused largely due to altered streamflow as a result of reservoir operations and increasing severity of droughts. The foothill yellow-legged frog (FYLF), *Rana boylii*, had historically occurred throughout most of California and western Oregon but is now considered near local extinction in its most southern clade, as well as across two thirds of its range within the Sierra Nevada [1]. As a stream dwelling and obligate stream-breeding species, altered flow regimes from land use changes such as dams and water diversions have been identified as its primary threat [1]. Other threats include competition and predation from invasive species, like the American Bullfrog, Crayfish, and Smallmouth and Largemouth Bass, as well as disease like *Batrachochytrium dendrobatidis* (Bd), which is known to have caused significant declines in the Coastal clade [2]. Climate stressors, such as increased temperatures and decreased snowpack are projected to cause additional stress to the population by further altering flows and water temperatures necessary for breeding.

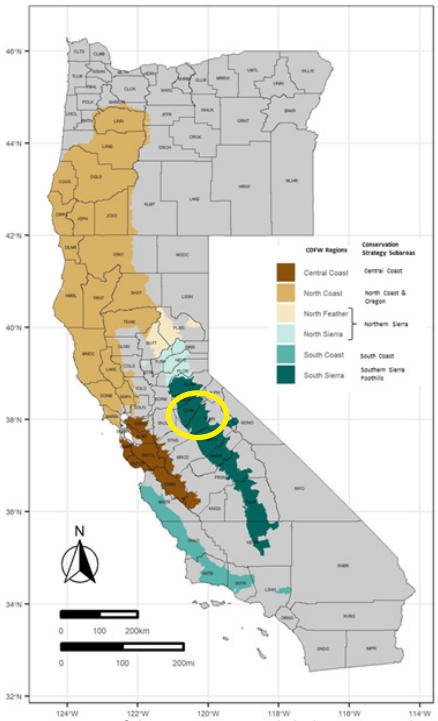

Figure 1: Map of the FYLF range and clades across California and Oregon. The Southern Sierra Nevada clade is in dark green, with the focal area circled in yellow. Image by USFWS.

Southern Sierra Nevada

The Sierra Nevada Range is one of California's most prominent geological features containing iconic peaks, high montane meadows, clear alpine lakes, and rushing rivers. It provides a variety of resources, including habitat for a broad range of wildlife and provides over 50 percent of all of California's water supply, primarily in the form of snow at its alpine environments [3]. Yet, climate change projections show that Sierra Nevada range will experience increased annual temperatures and a decrease in precipitation, with precipitation more likely to come in the form of rain instead of snow, even at higher elevations [4]. These changes will increase the Sierra Nevada's vulnerability to severe fire, drought, and decreased snowpack

[5], the effects of which will cause further disruption to aquatic species in the area, including the FYLF.

In addition to facing near local extinction in the area, protecting the endangered FYLF Southern Sierra clade is of high priority as the population contains high genetic variability, which may be necessary for the species survival against disease and climate change (Figure 1)[6]. In addition, the Southern Sierra Nevada offers a unique opportunity for conservation as a majority of the FYLF habitat is on public lands such as the Stanislaus NF and Yosemite NP, with flows managed by a public utility (the San Francisco Public Utility District). Given the public land ownership, this geography offers opportunities for collaborations that can help leverage resources for expertise, funding, and monitoring that will be necessary to understand whether the conservation actions increase the adaptive capacity of these populations.

Study Goals

In the short-term, the project aims to incorporate long-term climate considerations into near-term conservation planning for FYLF and co-occurring aquatic species; and thus, overcome the frequently described knowledge-to-action barrier and start implementing climate adaptation actions immediately. Potential actions range from species to landscape scale options including in-situ head-starting, captive rearing, translocation of current populations to climate refugia, and habitat restoration. While many of these conservation actions have been used for other frog populations, they are not always observed and monitored for the long-term and their efficacy to increase climate resilience is unknown [7]. Therefore, the project aims to create an adaptive climate adaptation management plan with clearly defined management milestones that will be monitored and revisited.

Once the framework for FYLF conservation and monitoring has been developed, the project aims to broaden the decision-framework's application to benefit other at-risk resources of interest to land managers in the vicinity. For example, Western Pond Turtles are likely to benefit from invasive species removal and habitat restoration. Other possible actions, like riparian or meadow restoration could also optimize the storage of water and help buffer the effects of decreased snowpack on the forest ecosystem [3;8], which would be beneficial for protecting one of California's most important resources: water. Ultimately, managing forested ecosystems to increase species habitat, water retention, and carbon retention will maximize its resilience to climate change and its benefits to California's economy and human communities.

Acknowledgements:

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