The Evolution and Implications of the Range Limits of a Sierra Nevada Foothill Endemic, *Mimulus glaucescens*

Ava Biscoe, California State University, Chico, Department of Biology, Dr. Ivey Lab

Introduction:

It is unknown how endemic plant species will respond to climate change in the future. Endemic plants are native to a geographically restricted region and are found nowhere else on the planet. They provide unique opportunities to research the evolution and drivers of range limits in native plants. *Mimulus glaucescens* is a regionally endemic monkeyflower that can serve as a model organism to investigate the evolution of range limits in native plants, which can help predict if they may respond to climate change through shifting their range or adapting in place (figure 1).

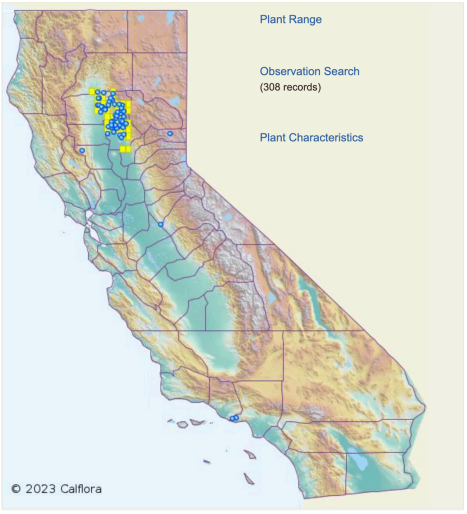

Figure 1: CalFlora.org map showing the restricted range of *Mimulus glaucescens.*

Study System:

Mimulus glaucescens, the shield-bracted monkeyflower, is an annual plant endemic to the Sierra Nevada foothills, where it occurs in wetland habitats, including seeps [1]. *Mimulus glaucescens* currently has a California Native Plant Society rare plant ranking of 4.3, meaning it is on a watch list due to its limited distribution [2]. *Mimulus glaucescens* occurs on and off serpentine soils, which means it is a soil generalist as well as a serpentine tolerator. Serpentine is a harsh environment due to low nutrients, low Ca to high Mg ratio, low water holding ability, and high levels of heavy metals [3].

Study Aims:

My study aims to predict if *Mimulus glaucescens* will be more likely to shift its limited range or adapt in place in response to climate change. This will be achieved by collecting field data of various fitness measures to compare the average fitness of populations at the range center versus the range margin of its current distribution.

In California, many climate models predict that the future will be drier, with rainfall occurring in fewer, but larger storms [3]. Additionally, many species distributions are expected to shift to higher latitudes and altitudes in response to climate change [4]. The soil generalist habit of *M. glaucescens* indicates potential ability to colonize a variety of habitat types, which can be adaptive for range shifts.

Alternatively, *M. glaucescens* may be able to adapt in place to future conditions, since serpentine tolerators have evolved to withstand drought and stress conditions.

Research Questions:

Range boundaries can be defined as where, on average, the probability of population extinction exceeds the probability of persistence [4]. It is often assumed population density and fitness decreases farther from the range center because range margins are believed to be aligned with ecological margins, beyond which the species' is maladapted to the environment. Despite this theory, it is necessary to test this in the field since spatiotemporal environmental variation, such as seed dispersal limitations or animal herbivory rates can generate unexpected results. My field study will test the following hypothesis and prediction:

Hypothesis: Central populations of *Mimulus glaucescens* will have higher mean fitness than marginal populations.

Prediction: If true, then the average plant height, number of flowers per plant, number of seeds produced per plant, and aboveground biomass will be greater in central than marginal populations.

Methods:

Over spring and summer 2024, I'll collect field data to compare mean fitness measures of central populations to low elevation western marginal populations and high elevation eastern marginal populations in Butte County (figure 2).

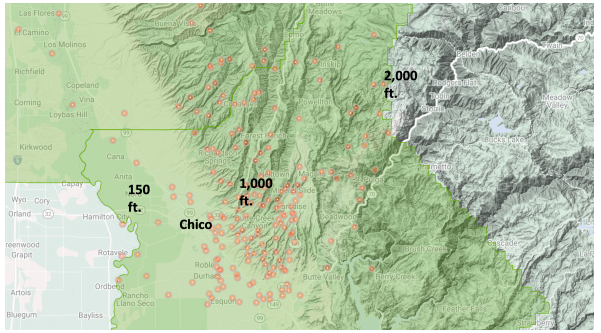

Figure 2: iNaturalist map showing observations for *M. glaucescens* spanning an elevation gradient from the valley in the west to the Sierra foothills in the east.

I'll survey 3 western, 4 central, and 3 eastern populations toward the end of the growing season for each population. I'll use a linear transect to systematically survey 30-50 plants per population to gather data on population mean number of flowers per plant, size of flowers, total seeds produced per plant, plant height, and aboveground biomass.

To determine effects of spatiotemporal environmental variation on population fitness I'll measure rates and type of herbivore damage at each field site.

Interpretation of Results:

If the central populations of *Mimulus glaucescens* have higher average fitness than the marginal populations, this supports the prediction to be more likely to adapt in place to climate change. Alternatively, marginal populations with higher average fitness than central populations would support the prediction to potentially undergo range shifts in response to climate change.

If the marginal eastern foothill populations have the highest fitness of all the populations, this may be due to warming trends of climate change and *M. glaucescens* fitness tracking higher elevations with optimal temperatures. If the western valley population has the highest fitness it may represent a sink population with entering downstream migrants that can bring adaptive alleles and rescue the population.

References:

1. Ivey, C.T., Habecker, N.M., Bergmann, J.P., Ewald, J., Frayer, M.E., Coughlan, J.M. 2023. Weak reproductive isolation and extensive gene flow between *Mimulus glaucescens* and *M. guttatus* in northern California. Evolution, 77(5), 1245-1261.
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3. Anacker, B.L. 2014. The nature of serpentine endemism. American Journal of Botany, 101(2), 219-224.
4. Angert, A.L. 2006. Demography of central and marginal populations of monkeyflowers (*Mimulus cardinalis* and *M. lewisii). Ecology,* 87(8), 2014-2025.