

Project Title:

Unveiling patterns of climate adaptation in a widespread California scrub oak (*Quercus berberidifolia*)

Authors:

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Habitat transformation, landscape fragmentation, and climate warming are causing significant plant mortality and biodiversity loss^{1,7}. Native plants that are unable to adapt to changing environmental conditions or disperse to suitable habitats face an increased risk of local extinction¹. Long-lived woody plants are especially vulnerable to rapid environmental changes because they are unable to move, they reproduce slowly, and their seeds don't travel far¹. Even chaparral shrublands, characterized by dense, drought-tolerant shrubs, have experienced widespread plant mortality^{7,9}. The chaparral biome, which is one of California's most extensive native vegetation types, sustains the state's highest levels of biodiversity^{9,11}, and is dominated by the California scrub oak, *Quercus berberidifolia*^{10,11}. This native shrub oak ranges from Shasta to San Diego County¹⁰ and supports ecosystem function by providing habitat for numerous species, serving as a carbon sink, and influencing soil health and nutrient cycling^{5,11}. While chaparral may expand into some forested regions under climate warming⁹, other areas face an increasing risk of shrub loss and conversion to invasive annual grasslands⁷. The decline of *Q. berberidifolia* could lead to the substantial loss of California chaparral habitat. Thus, many chaparral shrubs will need to rely on the genetic diversity already present in their natural populations to adapt to new environmental conditions^{1,12}.

Q. berberidifolia is a great model for studying chaparral plants due to its widespread distribution. Complex environments can drive natural selection and local adaptation, where individuals perform best in their home environment¹². Landscape genomics is an approach that associates genetic gradients with environmental gradients across a landscape. By estimating the genetic change needed to adapt to future climates, we can identify shrub populations that may be at risk from climate change^{4,6} and those that may be more adapted to future climates, which can serve as climate-adaptive seed sources. This approach has primarily informed tree conservation planning. Additionally, genomic studies find that various tree species are maladapted to current climates³, or are predicted to be maladapted to future climates^{4,8}. However, shrubs remain underrepresented in landscape genomic research^{4,8}. This tree-focused bias creates a notable gap in understanding the extent of adaptedness² to current or future climates in shrub species. This project addresses that gap by investigating climate adaptation in the endemic California scrub oak to help guide conservation strategies that promote and protect chaparral biodiversity.

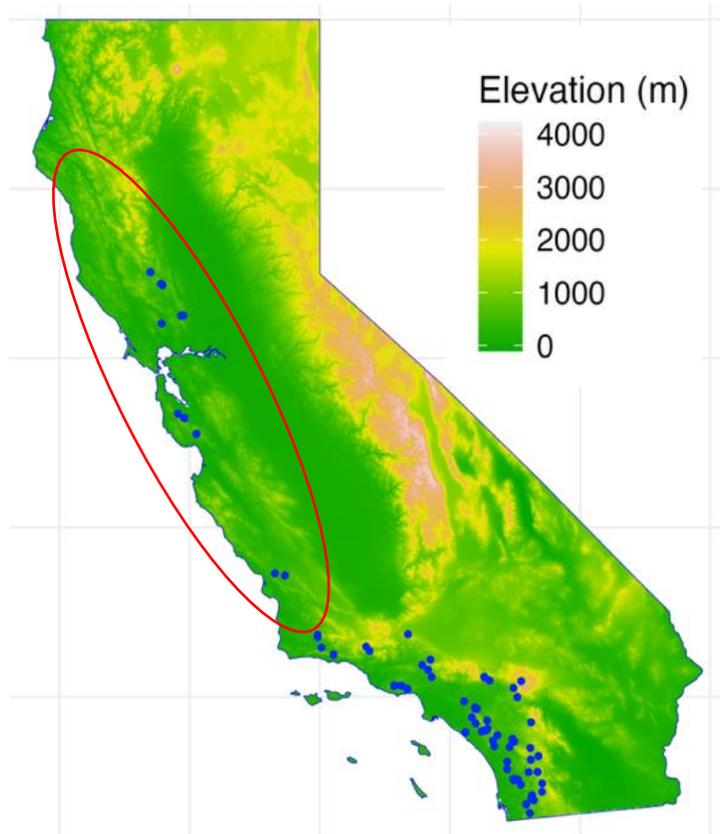
A previous Sork Lab graduate student collected and sequenced 120 *Q. berberidifolia* individuals as part of a project funded by the California Conservation Genomics Project (CCGP). My initial analyses of these data suggest that *Q. berberidifolia* populations differ across the landscape. However, there are sampling gaps in the central and northern regions, resulting in an incomplete representation of the California scrub oak's range (Figure 1). These gaps limit our ability to confidently identify which geographic areas are likely to survive (high adaptedness) or

be at risk (low adaptedness) under predicted future climates. To improve the accuracy of landscape genomic analyses for California scrub oak, we will sequence additional individuals from these underrepresented regions (Figure 1), with funding support from the La Kretz Center for California Conservation Science (LKCCS). We will complete range-wide sampling across both public and private lands, including the Placer Land Trust's Shutamul Bear River Preserve. The expanded dataset will enable comprehensive species-wide landscape genomic analyses to assess local adaptation and identify areas that will be more maladapted to climate change^{4,5}.

My key question is: Which geographic regions will contain shrubs with higher predicted levels of adaptedness to future climates and could potentially be used as climate-adaptive seed sources? This landscape genomics project, along with the expanded dataset, will be incorporated into an ongoing collaboration between the Sork Lab, The Nature Conservancy (TNC), and the LKCCS to analyze adaptedness across California oak species for conservation planning. This project will form a chapter of my Ph.D. dissertation and will be submitted for publication in a peer-reviewed journal. Once published, all data and products from this study will be publicly accessible to support climate-related management.

References: ¹Aitken et al. 2008. *Evol. App.* ²Allard. 1988. *J. Hered.* ³Browne et al. 2019. *PNAS*. ⁴Capblancq et al. 2020. *Ann. Rev. Ecol. Evol.* ⁵Cavender-Bares. 2018. *New Phyto.* ⁶Fitzpatrick & Keller. 2015. *Ecol. Lett.* ⁷Jacobsen & Pratt. 2018. *New Phyto.* ⁸Mead et al. 2024. *Evol. App.* ⁹Molinari et al. 2018. *Springer*. ¹⁰Nixon. 2002. *Gen. Tech. Rep.* ¹¹Safford et al. 2018. *Springer*. ¹²Savolainen et al. 2013. *Nat. Rev. Gen.*

Figure:



*Figure 1: Elevation map of California showing 95 existing samples of *Q. berberidifolia*. The red circle indicates gaps in geographic sampling, where additional samples will be added.*