Climate change vulnerability assessment of *Quercus tomentella*

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Credit: Denise Knapp

Background

Island oak

Quercus tomentella (QUTO; island oak) is a rare oak species endemic to six islands in the California Island Archipelago (CAIA), where it provides forest litter, protective habitat, and soil moisture through fog drip.[1]

Threats & Status

Historic ranching on the islands has degraded QUTO populations, and the species was listed as endangered by the IUCN in 2016.[2] While restoration and removal of historical threats are promoting species recovery, climate change may further reduce suitable habitat for QUTO across the islands.

Figure 1. Extent of QUTO range.


Figure 2. QUTO on Santa Rosa Island. Credit: Denise Knapp

Study Motivation

In collaboration with The Nature Conservancy and the Santa Barbara Botanic Garden, our study investigates how climate change may affect the future distribution of suitable habitat for QUTO and aims to inform adaptive management for climate change to increase the likelihood of species persistence.

Objectives

1. **Determine** current climate preferences of QUTO across islands
2. **Analyze** where current suitable habitat is located and how climate change might impact suitability
3. **Evaluate** the outlook of species persistence on each island, given uncertainty in climate scenarios

Recommendations

Future Research

Establish experimental plantings at a range of sites to explore QUTO's climate preferences and identify the degree of local adaptation.

Expand fog and climate monitoring to develop higher resolution climate models and more complete climate data coverage across the CAIA.

Explore historic human impacts to define their influence on the current spatial distribution of QUTO populations.

Management

Augment current QUTO groves since suitable habitat is expected to contract rather than shift as climate change progresses.

Restore habitat quality to mitigate water stress through fog nets, native species planting, erosion control, and soil restoration, especially for seedling establishment.

Develop assisted-migration procedures with an initial focus on intra-island translocation, further establishing procedures between islands if necessary.

Island-Specific

Santa Rosa
Focus management efforts on southern Santa Rosa near Soledad Peak, which remained suitable through all scenarios and therefore may be a climate refuge.

Santa Cruz
Complete a more comprehensive survey of QUTO on southern Santa Cruz to account for potential sampling bias towards oak points on the northern side.

Santa Catalina
Prioritize habitat restoration of current groves and protect seedlings from Santa Catalina's remaining non-native grazers.

Acknowledgments

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More information on our project can be found at https://oakology19.wixsite.com/oakology or by contacting gp-oakology@bren.ucsb.edu.

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Approach

We used MaxEnt, a presence-only species distribution model, to identify climate conditions in QUTO's current habitat and to predict areas of habitat occurrence through the end of the century.

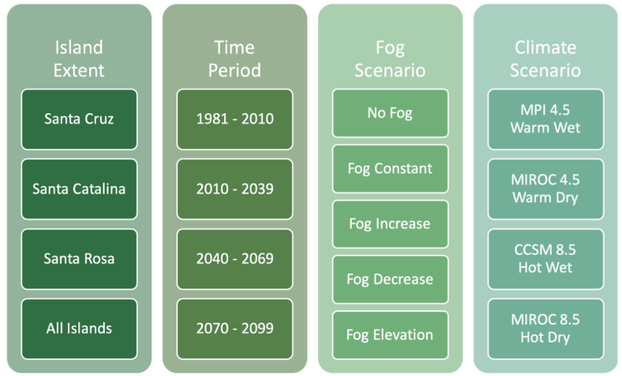

Figure 3. Extent, time period, and scenario options for MaxEnt input.

We performed the analysis for Santa Cruz, Santa Rosa, and Santa Catalina Islands using QUTO presence points and climate variables from the Basin Characterization Model (BCM).[3] For Santa Cruz and Santa Rosa Islands, we developed future fog scenarios to explore uncertainty in fog trends.[4]

Main Findings

1 Island Oak Climate Preferences

From the available BCM climate variables, we chose the 4 that were the most influential for QUTO probability of presence. QUTO's climate range was unique on each island (Figure 4).

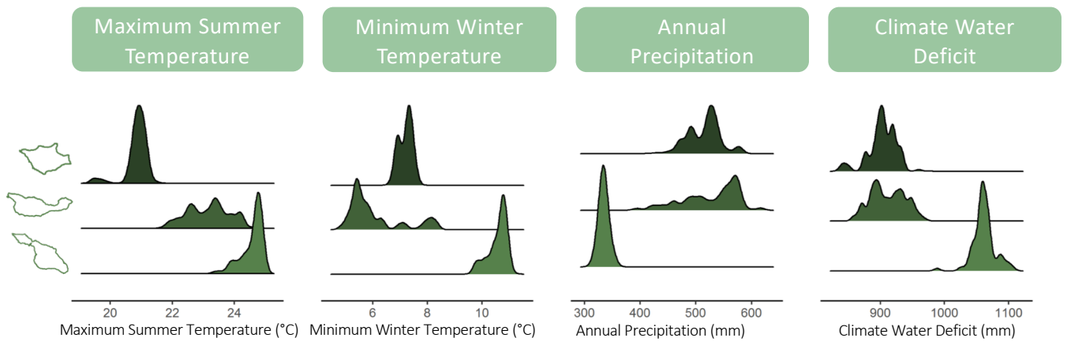

Figure 4. QUTO presence counts across climate conditions on each island, with x-axis as climate range and y-axis as count density.

QUTO occupies a wide range of climate conditions across the islands, and its climate preferences differ substantially by island. Do the distinct preferences indicate QUTO populations are adapted to island-specific climate ranges (local genetic adaptation) or island-wide ranges (environment-dependent physical adaption)?

2 Climate Suitability

Suitable habitat distribution differs when each island is run individually (Figure 5A), compared to when all islands are run together (Figure 5B).

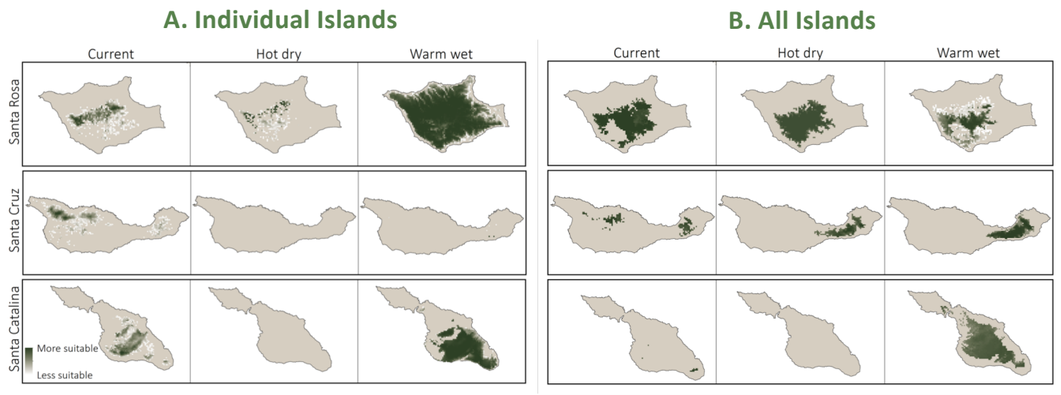

Figure 5. Probability of QUTO presence on Santa Rosa, Santa Cruz, and Santa Catalina Islands, with each island run individually (A) and all islands run together (B). Current climate conditions represent 1981 – 2010, and the two climate scenarios (hot dry and warm wet) represent 2070 – 2099.

Future suitability is largely dependent on whether the species' climate preferences are island-specific or island-wide. Additionally, suitable habitat is predicted to expand or contract around areas of current island oak suitability, rather than shift in elevation or latitude. Lastly, precipitation and fog are influential predictors of island oak presence on Santa Cruz and Santa Rosa, while temperature is most influential on Santa Catalina.

3 Integrated Outlook

The integrated outlook shows the climate suitability summed across all scenario combinations (Figure 6).

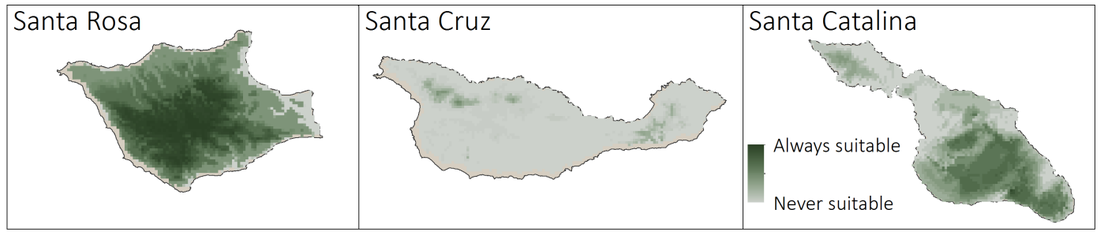

Figure 6. Integrated climate suitability for QUTO on Santa Rosa, Santa Cruz, and Santa Catalina Islands across all scenarios.

The distribution of predicted future suitable habitat varies by island and climate change scenario. Habitat on Santa Rosa is predicted to remain suitable across the highest number of potential future scenarios, followed by Santa Catalina. QUTO populations on Santa Cruz appear to face the highest risk from climate change due to low predicted suitability across scenarios.