Predicting effects of climate change: Ecosystem drivers in the tropical subalpine shrubland

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Current global warming projections forecast that extant climatic zones are changing and “novel” climates are anticipated at high latitudes and altitudes including tropical mountains. Changes in Hawaiian high elevation plant communities are expected as climate change shifts the trade wind inversion belt downslope resulting in drier conditions. Simultaneously, non-native plant invasions are predicted to increase upslope with rising temperatures. To manage for native plant assemblages within these novel communities, we need to understand how current plant communities respond to environmental (precipitation, elevation, substrate age, type) and anthropogenic (disturbance) gradients.

The goal of this project is to characterize Hawaiian subalpine vegetation (Figure 1) within Hawai‘i Volcanoes National Park on Hawaii Island and Haleakalā National Park on Maui Island and determine the relative strength of various environmental and anthropogenic factors. Based on this plant community analysis, we will then parameterize models with forecasted climatic changes to aid in predicting future vegetation changes.

Baseline data regarding relationships between plant communities and abiotic and biotic factors in this unique endemic plant community are critical for detecting changes in the future. In order to prioritize natural lands for management in these shifting landscapes, land managers need baseline data and scientifically rigorous predictions at appropriate local and regional scales. Additionally, national parks may be considered reference lands for detecting climatic changes relative to more urban areas.

Interestingly, preliminary analysis of subalpine shrublands shows a much stronger correlation with mean annual rainfall than temperature, which is contrary to findings at higher latitudes (Figure 2). We are now investigating the importance of seasonality and finer-scale abiotic factors on this plant community. Additionally, by building a functional trait matrix for shrubland species, we will be able to assess whether patterns differ between phylogenetic and ecological or functional groups. The next steps will be to incorporate data from the adjacent wet forests to assess the potential for treelines to shift on these tropical mountains.

To date, preliminary results were shared in 2013 with land managers (Pacific Island Inventory & Monitoring Network quarterly newsletter no.33 and Hawaii Conservation Conference poster presentation) and the scientific/academic community (Vitousek and PICCC/PICSC meetings). This work is possible, thanks to support from the Pacific Island Climate Science Center and multiple partners within the National Park Service (Inventory & Monitoring Program, Hawai‘i Volcanoes National Park, and Haleakalā National Park) and the University of Hawai‘i at Mānoa (Botany and Meteorology).
Figure 1. The subalpine shrubland communities of Haleakalā NP (above) and Hawai‘i Volcanoes NP, some of the most intact native dominated plant communities remaining in the Hawaiian Islands, and increasingly threatened by climatic changes and non-native species invasion.

Figure 2. Mean annual rainfall ($r=0.56$) is more important than temperature ($r=0.12$; not pictured) in explaining variation in community composition based on non-metric multidimensional scaling ordination. Sample plots (0.1ha; $n=55$) from Hawai‘i Volcanoes NP (red triangles) and Haleakalā NP (blue triangles) are distributed across the rainfall gradient (1000-2200mm). Plots (triangles) closer in ordination space represent more similar vegetation than those further apart. The fact that vegetation does not clearly separate between the islands suggests that rainfall is also more important than biogeographical factors in explaining overall composition in these subalpine shrublands.