Homework 13 – Local adaptation in ʻŌhiʻa lehua

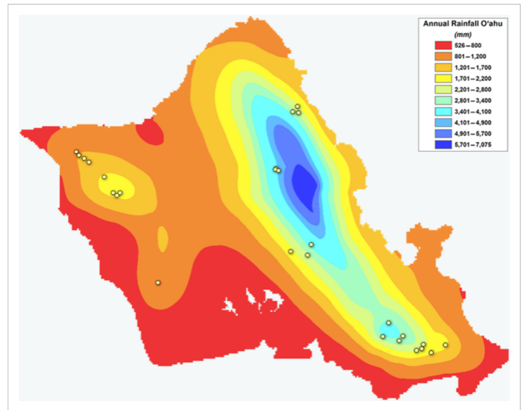

Figure 2 Open in figure viewer | PowerPoint

Map of Oahu showing mean annual rainfall (Giambelluca et al., 2013) and the 27 field sites marked with yellow circles

ʻŌhiʻa lehua (*Metrosideros polymorpha*) is the most widespread and abundant tree in Hawaiʻi. It occurs across broad gradients of rainfall, and plays a major ecological role in forest ecosystems. ʻŌhiʻa is phenotypically diverse, and there is evidence for substantial genetic diversity among populations, as well as local adaptation. Barton et al. (2020) investigated local adaptation in drought tolerance across a broad rainfall gradient on Oahu. Drought is likely to be ecologically relevant for local adaptation, considering the many microclimates in which ʻŌhiʻa occurs, and climate change is predicted to increase the frequency of drought in the future. The researchers focused on the response of seedlings to drought in field and greenhouse experiments, using seeds collected from 27 field sites varying greatly in average rainfall (circles on the plot above).

We will focus on data from the greenhouse experiment. Seedlings were planted in germination trays and watered normally for four weeks. After four weeks seedlings were placed into one of two treatments: a control treatment with normal daily watering, or a 'press drought' treatment in which seedlings were watered every other day, to 80% capacity. After six weeks of the press drought half of the seedlings (randomly chosen at the start of the experiment) were harvested for phenotypic measurements (if they survived), while the remaining seedlings (from both treatments) were placed into terminal drought (no more watering).

The attached file contains data on each seedling in the experiment. The column definitions are as follows:

ID Seedling experimental identification number.
BLOCK Experimental block, due to variation in germination timing.
POPULATION Source of seeds, collected on Oahu Island.
DROUGHT Experimental water treatment: control (watered every other day to 100% field capacity) and drought (watered every other day to 80% field capacity).
FATE Harvested after press drought treatment, or subjected to terminal drought with no water until the seedling died.
DEAD Binary mortality (1 = dead; 0 = alive).
HEIGHT Seedling height at harvest (cm).
SHOOT Dry shoot biomass at harvest (g).

ROOT Dry root biomass at harvest (g).
LONGEVITY Number of days in terminal drought with no water before dying.
TERMINAL_GWC Soil gravimetric water content (% field capacity) at the time of mortality in terminal drought.
MAR Historical mean annual rainfall at the site from which the seeds were collected (cm)
MET Historical mean annual evapotranspiration at the site from which the seeds were collected (mm)

1. Using the seedlings that were harvested after the press drought treatment, analyze how seedling height varies among treatments and populations. Specifically, set up models to test whether populations differ in height, whether the press drought treatment affects height, and whether populations differ in how press drought affects height. Next, set up models to test whether historical rainfall at a site predicts the height of seedlings, and whether historical rainfall at a site predicts the effect of press drought on height. Finally, set up models to test whether historical evapotranspiration at a site predicts the height of seedlings, and whether historical evapotranspiration at a site predicts the effect of press drought on height. Be sure to include Block in your models, and think about which terms in the model should be random effects, which should be fixed effects, which should be fixed:random interactions, and which should be fixed:fixed interactions (you will need all four). Make appropriate plots of model results and describe the magnitude of any apparent relationships. How do you interpret the results?

2. Using the seedlings that were fated to be harvested after the press drought treatment, analyze how survival during the press drought is affected by the various potential predictors. Specifically, set up models to test whether populations vary in probability of mortality (i.e., the response column DEAD), whether the press drought treatment affects mean mortality, and whether populations vary in how mortality is affected by the press drought treatment. Next, set up models to test whether historical rainfall at a site predicts mortality, and whether historical rainfall at a site predicts the effect of press drought on mortality. Finally, set up models to test whether historical evapotranspiration at a site predicts mortality, and whether historical evapotranspiration at a site predicts the effect of press drought on mortality. Be sure to think about what the appropriate probability distribution is for the response variable. How do you interpret the results?

3. Using the seedlings that were fated for the terminal drought experiment (i.e., the seedlings that were not harvested), analyze how longevity during terminal drought is affected by the various potential predictors. Specifically, set up models to test whether populations vary in longevity, whether the press drought treatment affects longevity, and whether populations vary in how longevity is affected by the press drought treatment. Next, set up models to test whether historical rainfall at a site predicts longevity, and whether historical rainfall at a site predicts the effect of press drought on longevity. Finally, set up models to test whether historical evapotranspiration at a site predicts longevity, and whether historical evapotranspiration at a site predicts the effect of press drought on longevity. How do you interpret the results?