Introduction:
Among the currently expected outcomes of human-induced climate change are increased frequency of extreme drought, and increased frequency, intensity, and duration of extreme heat waves (National Research Council, 2007; Franco et al, 2014). An important component in preparing for the effects of these events is to understand how (and to what extent) organisms in natural communities will change in response to them, and what portions of landscapes will be vulnerable to species loss and land cover change. My dissertation research focuses on the impacts of extreme drought on a classically drought tolerant chaparral species *Arctostaphylos glauca* (big berry Manzanita) that is a dominant component of mid-to high-elevation chaparral where it provides important structure and food for wildlife.

Significant dieback of *A. glauca* was first observed in the Santa Ynez mountain range in Santa Barbara, California in late summer, 2013 (personal observation). I hypothesize that this was due to extreme drought. Preliminary observations revealed patterns of dieback occurring along an elevational gradient, with canopy dieback being most pronounced at lower elevations. I also observed that dieback was prevalent in stands located on steep, exposed southerly-facing slopes. Based on these observations, I developed the following questions:

- How has canopy dieback of *A. glauca* developed across the landscape during the current drought, and
- What environmental and landscape-scale factors are most strongly correlated with dieback?

I hypothesize that there has been quantifiable dieback of *A. glauca* in the study region since the beginning of the drought, and that portions of the landscape most prone to drought (south facing slopes, lower elevations, exposed ridges, etc.) will show the greatest dieback because these are areas associated with plant water stress.

To assess the changes in *A. glauca* stand health resulting from the current drought, I plan to using remote sensing technology to compare current and pre-drought images and measure the changes over time. The use of remote sensing to detect dieback is based on the principle that unhealthy, diseased, and dead leaves and canopies have differing spectral properties from healthy ones, and that these differences are measurable through various remote sensing techniques (Roberts et al, 1993; Ustin et al, 1998; Jones and Vaughan 2010; Lee et al, 2010). I will be using aerial images of the Santa Barbara front range from Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) missions to quantify dieback of *A. glauca* and measure changes over time. Previous researchers have attempted to map *Arctostaphylos* spp. using remote sensing in California (Dennison and Roberts, 2003; Roberts et al, 2003; Roberts et al, 2015; Roth et al, 2012). While there is variability in the outcome of these efforts, it does appear possible to detect and map this genus because of its unique spectral signature (Claudio et al, 2006; Meentemeyer and Moody, 2000; Roberts et al, 2015; Roth et al, 2015). To date, however, there have been no in-depth efforts to separate *Arctostaphylos* species from one another, or to track the impacts of the recent drought on *A. glauca* using remote sensing techniques. Significant complications of these tasks include difficulties in distinguishing the spectral signatures of the two species of...
Arctostaphylos found in this region, A. glauca and A. glandulosa, and the natural heterogeneity of the landscape, which makes finding pure stands for training classifications challenging. The research conducted during the summer of 2017 was aimed at solving these problems. To successfully quantify the amount of A. glauca dieback that has occurred across this landscape, one must (1) identify and ground-truth large (>10m²) stands of A. glauca, (2) map these areas using ArcGIS from ESRI, and (3) use these regions of interests to train and create a highly resolved and detailed map of species distribution. The ERI Fellowship allowed me to complete parts (1) and (2) of this process.

**Methods and Preliminary Results**

In the summer of 2017, ground-truthing of healthy and unhealthy stands of *Arctostaphylos glauca* was completed, as well as mapping of A. glauca and A. glandulosa stands. The study area covers approximately 20km of road running east of Highway 154 and south of East Camino Cielo in Santa Barbara County (Figure 1). The range of *Arctostaphylos* extends from a lower boundary of approx. 400m to 1200m at the top of the highest point in the range, La Cumbre Peak. Due to the steep slopes and often-impenetrable vegetation that is characteristic of the study region, the location and identification of stands was limited to what was visible from main roads and trails. Stands were located and confirmed using a combination of binoculars and a spotting scope (or plain eyesight where stands were close to the road). Distances and sizes of stands were estimated using a Nikon laser rangefinder. Coordinates were found using a handheld GPS device and then located on images from the National Agricultural Imagery Program (NAIP) that were loaded into ArcGIS. Polygons were then drawn in ArcGIS of pure stands of A. glauca and A. glandulosa.

In all, nearly 20 pure stands of A. glauca and 10 stands of A. glandulosa large enough to be used for classification training were located and mapped. This is the largest number of pure stands of these species that has been recorded for mapping purposes in the region. These data yield promising potential for mapping *Arctostaphylos* on a larger scale, and quantifying changes in canopy health over time.

*Figure 1: Map of Study Region (area highlighted in yellow)*
Future Work:

Sources of change in spectral signatures due to drought and disease include changes in leaf color, reductions in photosynthetic activity, leaf water content, and fluorescence, and defoliation. Hyperspectral imaging across the combined visible, near infrared, and short wave infrared spectral regions (VSWIR; 350-2500nm) can be extremely useful in detecting these changes (Coates et al, 2015; Zhang et al, 2003; Apan et al, 2004; Franke and Menze 2007). Therefore, hyperspectral data will be used to compare the 2014 (drought) AVIRIS image with a georeferenced pre-drought image from 2011.

I am collaborating with the Visualization and Image Processing for Environmental Research (VIPER) lab at UCSB and using a combination of Multiple Endmember Spectral Mixture Analysis (MESMA) and vegetation indices to determine how well unhealthy A. glauca can be differentiated from green, healthy stands. This will enable me to identify healthy, greener stands in the pre-drought images that have progressed to diseased/defoliated stands in the 2014 image, and thus quantify the onset and progression of drought-related canopy disease. In addition, I will use a digital elevation model (DEM) to correlate elevation, slope, and aspect of mapped stands of A. glauca, and identify the variables that best explain the distribution of severely altered stands as compared to stands that have remained healthy throughout the drought.

Summary

Ground-truthing and recording the location of pure stands Arctostaphylos are important parts of the mapping process, and therefore were the focus of my summer 2017 research. The ERI Summer Fellowship provided me with the support and resources necessary to accomplish these important steps. It can be concluded that the number, size, and diverse locations of these stands will provide sufficient data with which to create an accurate map of Arctostaphylos across the study region. Once completed, this map will not only enable to me to carry out the analyses required to answer my research questions, but will be a valuable resource to others as the most complete and highly resolved map of species distribution in the Santa Barbara front range to date.
References:


