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Community Structure and Differential Mortality of Chaparral during Extreme Drought

Keb Doak, Allison Hubbard, Alawna Jamison

Abstract

We have set out to find, in extreme drought, which species of chaparral are dominant and why they are dominating. We thought that the indicator species of chaparral, *Adenostoma fasciculatum,* would have highest relative density, relative frequency, and dominance in our research area. Additionally, plants with higher water potential values would have lower percentages of mortality. Chaparral with stronger ability to fluoresce (higher Fv/Fm value) would have lower mortality percentages due to their ability to dissipate excess energy, and therefore reduce water loss. By analyzing our vegetation area using point-quarter sampling system, we were able to record data that show the chaparral shrub with the highest relative density was *A. fasciculatum.* The chaparral shrub with the highest relative dominance was *Adenostoma sparsifolium*. The chaparral shrub with the highest relative frequency was *Ceanothus cuneatus.* Midday water potential values were taken using the Scholander-Hammel Pressure Chamber from the sample site and plotted against the other plants. *Arctostaphylos glauca* had the lowest water potential (-13.6 MPa) while *Malosma laurina* had the highest water potential (-3.7MPa). Except for the outlier, *Ceanothus spinosus*, midday water potentials corresponded negatively to mortality. Fluorescence values and water potential values were positively correlated (R^2= 0.7466). Water potential values are positively correlated with chaparral shrub mortality (R^2=0.566). Fluorescence also links with chaparral shrub mortality (R^2= 0.845).

Introduction

Chaparral plants are efficient in drought tolerance. During heat spells, some plants are known to have a water potential as low as -9MPa during the day, which for most plants can cause severe embolism (Kolb and Davis, 1994). Oliver et. al reported in 2010 that majority of plants die at water potentials of -5MPa to -10MPa. In 2012 a major drought started in California. The U.S. Drought Monitor reported in 2012 that about 80% of California land is in a severe drought. Due to these factors, plant water potentials are being tested to the extreme. Our research shows that native Cold Creek/Green Valley Preserve chaparral now have recorded water potentials of up to -13.6 MPa. We have set out to find, in extreme drought, which species of chaparral are dominant and why they are dominating. We believe that the indicator species of chaparral, *Adenostoma fasciculatum,* will have highest relative density, relative frequency, and dominance in our research area. Additionally, plants with higher water potential values will have lower percentages of mortality. Chaparral with stronger ability to fluoresce (higher Fv/Fm value) values should have lower mortality percentages due to their ability to dissipate excess energy, and therefore reduce water loss. By analyzing our vegetation area using point-quarter sampling system, we are able to record data on chaparral structure, and qualify them as either alive or dead.

Description of Study Site

The group visited lower Cold Creek, Green Valley Preserve in Malibu, CA, and recorded data from a segment off of Stunt Road. The unit sampling area was 7830.5 m^2. All data were recorded from early to midday.

Methods

Data were taken off Stunt Road in the sample area was done by a point-quarter technique. We started by obtaining a rock and throwing it behind one's shoulder to avoid a biased sampling point. Once the rock was located, a meter stick was laid at the location where the rock landed and oriented magnetic North with the help of a compass. A second meter stick was laid perpendicular to transect this point. The result is four equal quadrants for sampling. Facing magnetic North, the quadrants were numbered as 1 being the top right, 2 being the top left, 3 being the bottom left, and 4 being the bottom right. In each quadrant, the chaparral shrub that was closest to the origin was selected for measurements. We recorded the species of the chaparral shrub and then measured with a measuring tape in meters the point-to-point distance of the chaparral from the transect. We also used the measuring tape and meter sticks to measure the basal diameter, height, and crown size of the chaparral. All of this information was recorded in a table while in the field and it was furthermore indicated whether the chaparral was dead or alive. This description of life/death was based on elasticity and pigmentation of the leaves. When this process was completed in all four quadrants, the rock was thrown again to determine the next sampling point. In order to calculate the overall sampling area, Google Maps was used to determine the area (m^2) where data were collected.

Leaves were collected from the field and placed into air-tight bags and put on ice. The water potential and fluorescence were measured in the lab using the Scholander-Hammel Pressure Chamber and the OS1-FL Modulated Fluorometer, respectively.

The species of chaparral found during sampling include: *Malosma laurina* (Ml); *Rhus ovata* (Ro); *Quercas berberidifolia* (Qb); *Adenostoma sparsifolium* (As); *Heteromeles arbutifolia* (Ha); *Ceanothus spinosus* (Cs); *Rhus integrifolia* (Ri); *Adenostoma fasciculatum* (Af); *Ceanothus cuneatus* (Cc)*; Arctostaphylos glauca* (Ag).

Results

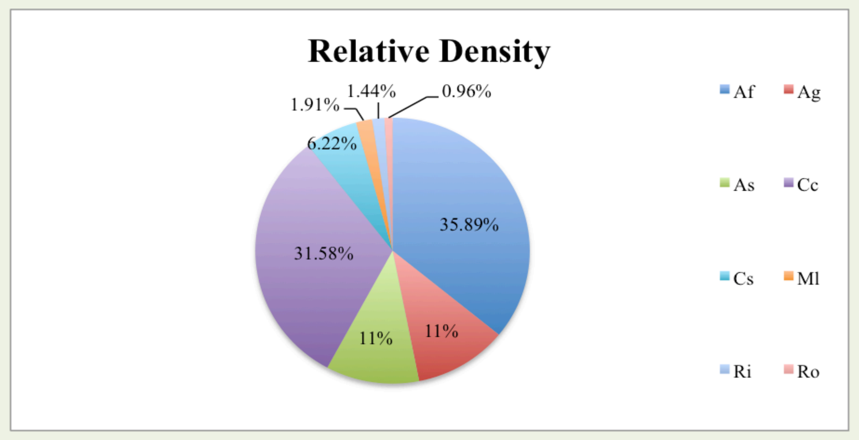

Figure 1: Relative density of chaparral

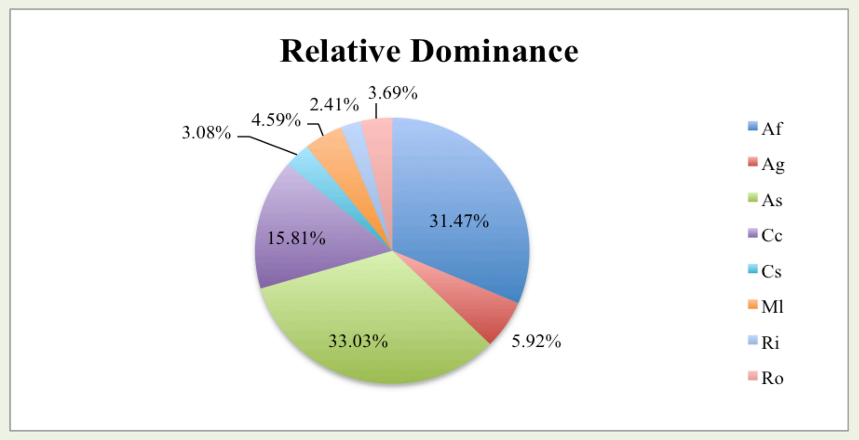

Figure 2: Relative dominance of chaparral

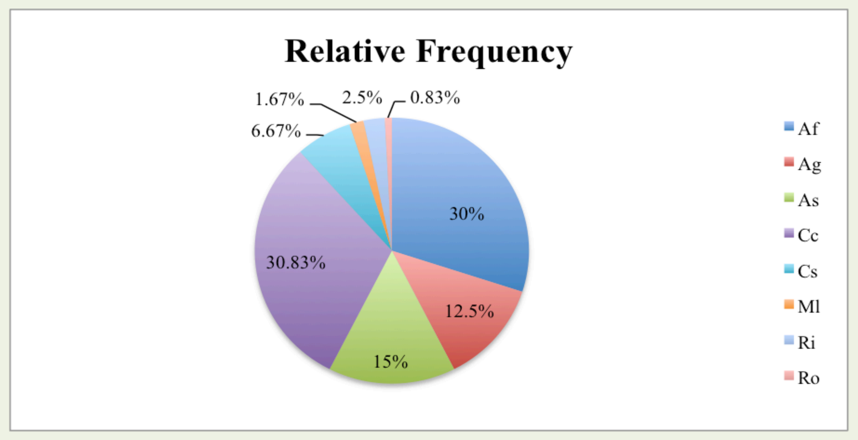

Figure 3: Relative frequency of chaparral

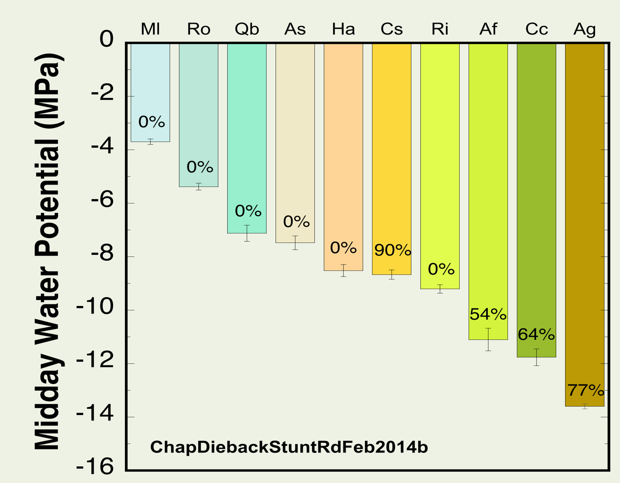

Figure 4: Midday Water Potential for the ten chaparral shrubs

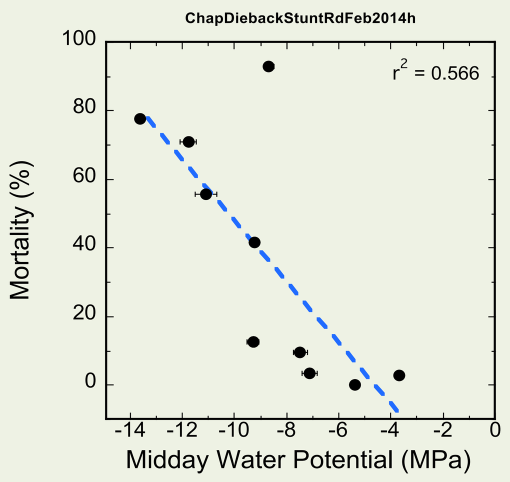

Figure 6: Relative mortality and midday water potential of chaparral shrubs

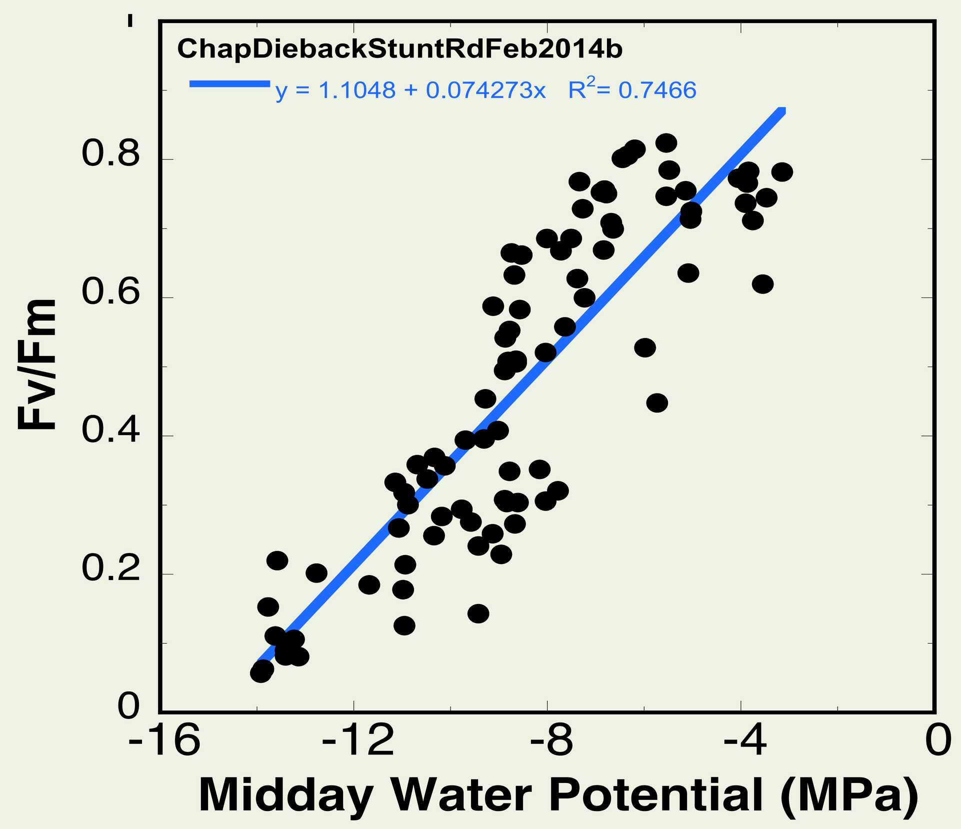

Figure 8: Fluorescence and midday water potential

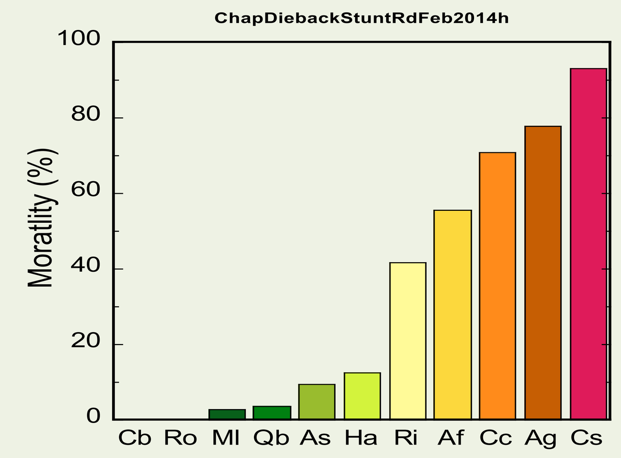

Figure 5: Relative mortality in chaparral shrubs

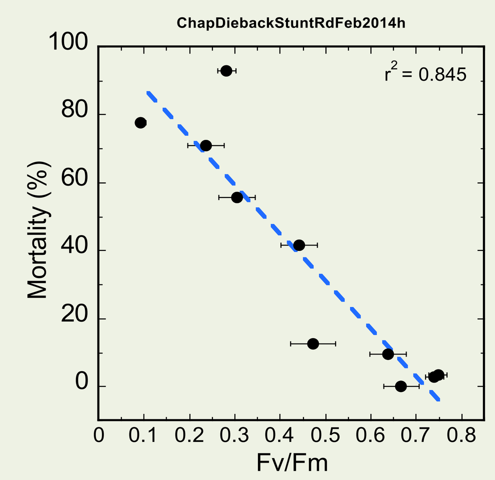

Figure 7: Relative mortality and fluorescence of chaparral shrubs

Discussion

After sampling 208 quadrants, we found that the chaparral shrub with the highest relative density was *A. fasciculatum* (chemise) (*Figure 1*). The chaparral shrub with the highest relative dominance was *A. sparsifolium* (redshank) (*Figure 2*). The chaparral shrub with the highest relative frequency was *C. cuneatus* (*Figure 3*). Chemise is an indicator species of chaparral; therefore, we expected *A. fasciculatum* to be the most dense. This could be due to the ability of chemise to survive in drought, to spread their seeds and to germinate. In the water potential data, *A. fasciculatum* had negative water potential values near -12MPa. Since some of these plants were still living, this shows that some chemise have high resistance to cavitation and embolism at such a low water potential. The relative dominance of any chaparral shrub is representative of the average basal area or areal coverage of a species. *A. sparsifolium* has the highest average basal area and therefore is the most dominant in our sample. The majority of the redshank sampled were in groups of two to three large sprouts per individual shrub. This combination led to a large basal diameter and therefore a higher dominance value. The percent mortality of redshank was 8.7% (2 out of 23 sampled). We believe that *A. sparsifolium* has adapted a larger basal diameter to combat drought stresses by strengthening the base near the roots to make water extraction more efficient. *C. cuneatus* was found to have the highest relative frequency. A possible explanation is that this chaparral plant survives with extremely low water potential (~-12MPa) and can survive in a wide variety of soil moisture levels, allowing for a high frequency of sampling.

Midday water potential values were taken from the sample site and plotted against the other plants. In *Figure 4* we see that *Arctostaphylos glauca* had the lowest water potential (-13.6 MPa) while *Malosma laurina* (laurel sumac) had the highest water potential (-3.7MPa). We know that laurel sumac is a phreatophyte allowing for extraction of water deep in soil. Its ability to obtain and retain water is the reason for its high water potential. The rest of the ten species fell somewhere in-between -3.7MPa and -13.6MPa. Except for the outlier, *Ceanothus spinosus*, midday water potentials corresponded negatively to mortality (*Figure 5).*

Water potential values are negatively correlated with chaparral shrub mortality (R^2=0.566) (*Figure 6*). Those with higher fluorescence and therefore higher water potential were seen to have a lower percent mortality. Fluorescence is negatively correlated with chaparral shrub mortality (R^2= 0.845) (*Figure 7*). Those with higher Fv/Fm values allow the maximum amount of the light energy to take the fluorescence pathway, dissipating excess energy, and therefore conserving water loss. Fluorescence values and water potential values were positively correlated (R^2= 0.7466) (*Figure 8*). Excess solar radiation affects the plants negatively, causing dehydration, lowering water potential of the plant. In order to minimize this water loss, some chaparral maximize the use of fluorescence to conserve water. These plants therefore have a higher water potential and are able to survive this extreme drought.

Conclusions

- *A. fasciculatum* had the highest relative density observed.
- *A. sparsifolium* had the highest relative dominance observed.
- *C. cuneatus* had the highest relative frequency observed.
- Percent mortality and midday water potential were negatively correlated (R^2=0.566).
- Percent mortality and Fv/Fm were negatively correlated (R^2=0.78).
- Fv/Fm and water potential were positively correlated (R^2=0.7466).

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