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Comparing Leaf Properties of Inland and Coastal Malosma laurina in the Santa Monica Mountains

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Comparing Leaf Properties of Inland and Coastal *Malosma laurina* in the Santa Monica Mountains

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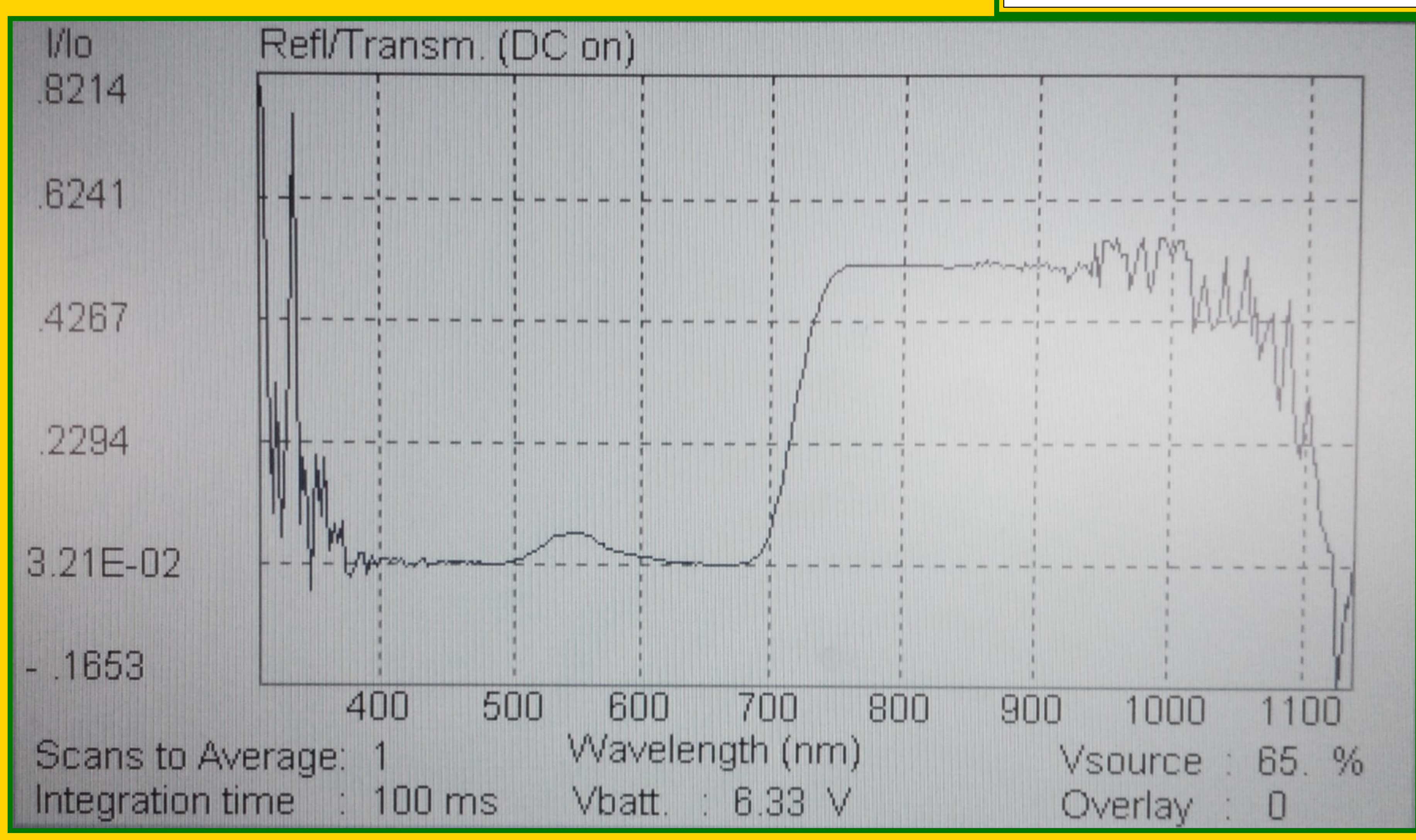
Abstract

Our group chose *Malosma laurina*, commonly known as Laurel Sumac, to observe and test. We hypothesized that there would be difference in photosynthetic trade-offs and capabilities between coastal and inland populations, specifically with respect to leaves. This was based on the low freezing tolerance in *Malosma laurina* (Pratt *et al.* 2005), and hypothesized that based on this stress, resources would be allocated differently in inland leaves than in coastal leaves. This hypothesis was tested using the indices of Normalized Difference Vegetation Index (NDVI), the Photochemical Reflectance Index (PRI), the ratio of green to red reflectance, and Leaf Specific Area (LSA). The first three indices were tested using a Unispec Spectral Analysis system, and the LSA was tested using a simple Leaf Area Meter and balance. We collected two leaves fifteen from the tip of the branchlet off of eight coastal individuals and eight inland individuals to test. We found a statistically significant difference in NDVI, indicating that coastal individuals had higher chlorophyll amounts and higher photosynthetic efficiency as compared to inland individuals. We also found that the green to red ratios were statistically significant, indicating that inland individuals are more highly light stressed than coastal individuals. Based on these significant differences, we concluded that our hypothesis was correct and there was indeed a difference in the photosynthetic abilities between coastal and inland populations.

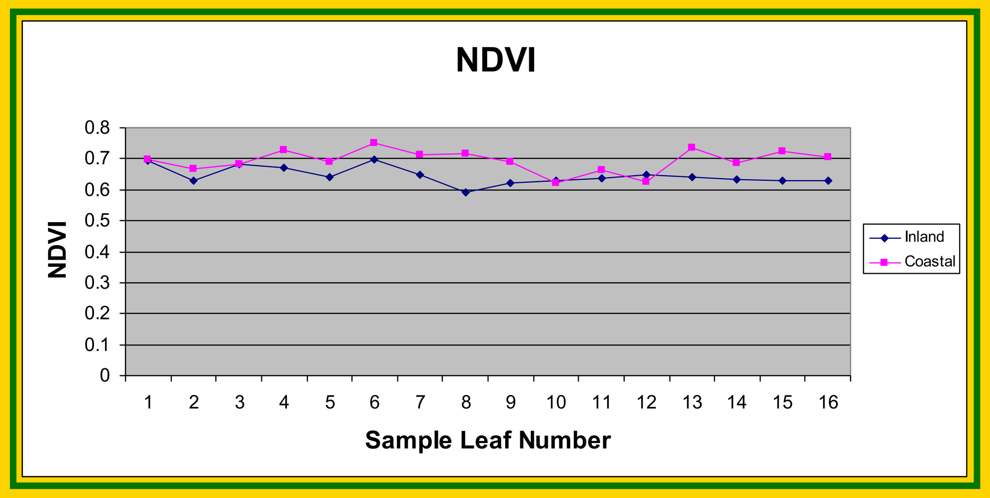
Introduction

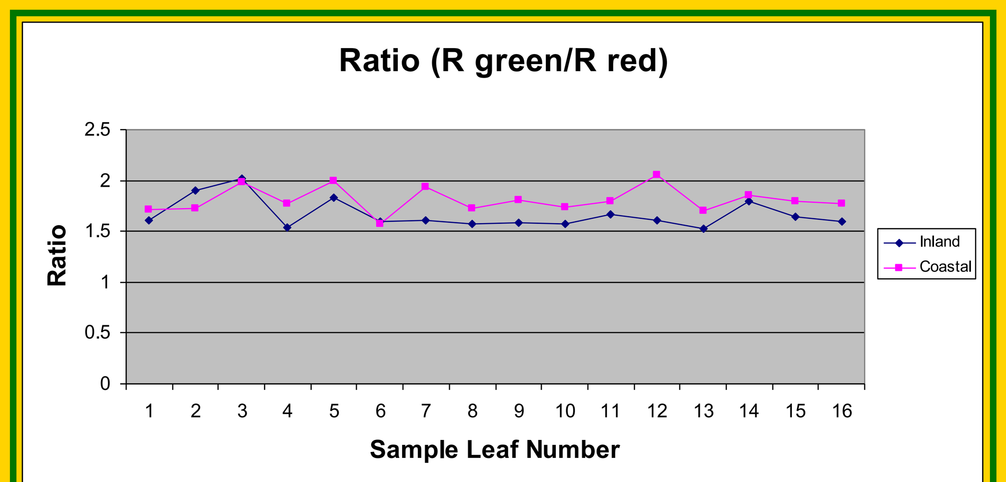
An important aspect of plant ecology is the distribution of plants based on various environmental factors such as water resources, solar exposure, and freezing temperatures (Davis SD *et al.* 2007). Based on this focus of research, our project aimed to determine the difference of certain plant characteristics based on location. Common study sites for previous research have compared coastal and inland species. We built on previous studies and researched coastal and inland species of the chaparral shrub *Malosma laurina*. Since these locations experience varying temperature highs and lows as well as different levels of sun exposure and resources we compared many traits that hint at the stress of the individuals. We hoped to gain insight to the trade offs present in each location along with the differing allocations of resources in response to stress. Because plants at each site experience stresses of their own, we hypothesized that there would be a difference in the Normalized Difference Vegetation Index (NDVI), the Photochemical Reflectance Index (PRI), a green reflectance to red reflectance ratio and the leaf specific area (cm2/g) between the two locations but not in one specific direction. Each of these helps determine health and stress of the leaves. Leaves were collected, a UniSpec spectrometer was used for data collection and many two-tailed Student's t tests were performed in order to compare the species in the two different locations.



Location	NDVI	PRI	Ratio $R_{(GREEN)}/R_{(RED)}$	LSA (cm^2/g)
Inland	0.6455 ± 0.0008	0.0087 ± 0.0002	1.6654 ± 0.0203	47.8718 ± 372.483
Coastal	0.6938 ± 0.0013	0.0142 ± $9.23x10^{-5}$	1.8084 ± 0.0160	58.5136 ± 184.102
p-value (two-tail)	0.000234	0.257076	0.005381	0.082351

Table 1. Measurements relating inland and coastal *Malosma laurina* demonstrating the varying results of all variables measured. Coastal *Malosma laurina* are found to have greater chlorophyll content based on NDVI and green:red ratio data. (R = reflectance in the Ratio data)





Materials And Methods

Malosma laurina, commonly known as Laurel Sumac, was our chosen species of chaparral for study. Our study site for coastal collections was the southern Pepperdine University guard house, where all eight individuals tested were found. For our inland individuals, Piuma Road, the Forestry Services, and the David Gonzales Camp just off of Malibu Canyon Road were needed to locate eight individuals, due to their scarcity within the canyon. We chose to test the Normalized Difference Vegetation Index (NDVI), the Photochemical Reflectance Index (PRI), the ratio of green to red reflectance, and Leaf Specific Area (LSA) of the leaves collected.

In order to fully test our hypothesis, we needed multiple measurements to show if there was a difference between inland and coastal leaves. We decided on four indices that measured different aspects of leaves, to give us the broadest perspective possible. We chose to test NDVI because it compares near infrared and red reflectance of a leaf surface, is particularly sensitive to the green vegetation and correlates to photosynthetic ability (Abdullah *et al.* 2002). PRI was used because it indicates photosynthetic efficiency by its sensitivity to measuring the xanthophyll cycling and de-epoxidation state (L. Suárez *et al.* 2007). Low PRI is associated with increasing stress and rations of carotenoid/chlorophyll ratios, and decreasing photosynthetic efficiency (Sims and Gamon 2002). Green to Red ratios indicate the light stress that a plant is undergoing based on its reflectance. Our last chosen index was LSA, because in Mediterranean type climates, LSA is important in the context of nutrient availability, water availability and herbivory. Low LSA indicates low photosynthetic rates, low leaf nutrient concentrations, long leaf life span, and low growth rates (Ackerly 2004).

Each leaf collected and tested was counted fifteen leaves down from the first leaf of a branchlet, and all leaves collected were placed in one of two plastic bags, depending on if they were coastal or inland. Once these leaves were collected and brought back to the student laboratory, they were measured for NDVI, PRI and green to red ratios using the Unispec Spectral Analysis System (for protocol for the Unispec, see Pepperdine Laboratory Manual). Placing the leaf face-down, the light reflectance was measured and our indices calculated and recorded by specifying the wavebands and calculation types. The leaves were then labeled "C" for coastal and "I" for inland, and given a corresponding number. The leaf areas were then measured with a Leaf Area Meter while still "fresh", then placed in small, individually labeled manila envelopes. The envelopes were placed in a drying oven for 24-48 hours, and then the mass of the leaves was measured. With the mass and the area, we were able to calculate the LSA and record the last of our indices.

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Discussion

The purpose of our experiment was simply to observe if there was a difference in various aspects of health and stress of leaves. To determine if the differences observed were significant, a p value from a two-tailed t test was obtained and compared to the alpha value of 0.05. If the p value was less than 0.05 then this indicated there was enough of a difference between the data to say that the populations are different. If the p value was greater than 0.05 then the data had to be accepted as not significant and the null hypothesis, that there is no difference between two populations regarding what is being measured, was not rejected. Our results regarding the four factors we measured indicate significant differences for NDVI and the green to red reflectance ratio.

Because NDVI confirmed significant difference, the hypothesis that there is a difference between costal and inland leaf health and stress can be applied regarding chlorophyll content and photosynthetic ability. The green to red reflectance ratio also showed a significant difference, again confirming the hypothesis. The larger number seen in the coastal populations represents less light stress. This is due to a higher amount of chlorophyll compared to the amount of anthocyanin, which is the pigment produced in response to light stress. The coastal plants in this case demonstrated higher affability for photosynthetic ability less for the volume of light stress.

While the values for PRI and LSA were not the same, their t test comparison did not yield low enough p values to indicate significance.

No previous literature was found regarding NDVI, PRI, green reflectance to red reflectance ratio, or LSA with consideration to minor climate difference in a specific species. However, differences in freeze and drought tolerance between inland and coastal species, including *Malosma laurina*, had been researched and published. In that circumstance, there was a significant difference in what was being measured for the inland and coastal species (Davis, SD *et.al.* 2007).

Conclusion

- Our research shows that there is a difference in photosynthetic trade-offs and capabilities between coastal and inland populations of *Malosma Laurina*.
- Significant difference in NDVI is evidence that there are greater amounts of chlorophyll and a greater ability to undergo photosynthesis in coastal populations compared to inland populations.
- Significant difference in the green reflectance to red reflectance ratio is evidence that light stress is lesser in coastal plants compared to inland plants.
- Because of the aforementioned, coastal *Malosma laurina* is more successful at undergoing photosynthesis when compared to inland populations of the same species.
- Further research could be done testing more samples of this species and others for differences in what was measured in this experiment, including PRI and LSA, in order to draw more informative conclusions about photosynthetic capability between populations. This research could aid in discovering what trade offs different climates require of plants of the same species.