Evaluating plasticity in *Machaeranthera canescens* and its adaptive significance: a glimpse at its relationship with water, light and nutrients

Jennet Chang[1], Taran Lichtenberger[2*], Andrea Kramer[2]
[1]University of Hawai'i at Hilo, HI, 96720, [2]Chicago Botanic Garden, Glencoe, IL, 60022

Introduction

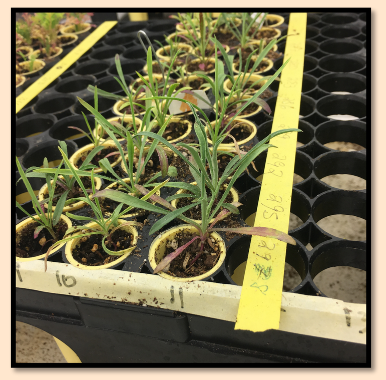
Climate change plays an increasingly larger role in changing the environment. The rapid change of temperature, sunlight, rain, and other factors can lead to high plant mortality. Plants are able to adjust to conditions through phenotypic plasticity. Phenotypic plasticity is the ability of a single genotype to express numerous phenotypes that show physical change in its environment[1]. Studies have shown that plants respond to their abiotic environments plastically[2] through the modification of their morphology in response to various abiotic factors such as light, water, and others[3]. In particular, this leads to many questions about whether locally sourced seeds are appropriate options for restoration[5]. However, plasticity data is rarely available, particularly for the species that are commonly used in shrubland restoration efforts.
This study looks at the plasticity of functional traits for *Machaeranthera canescens,* a native Colorado Plateau species, under differing environmental conditions.

Hypothesis

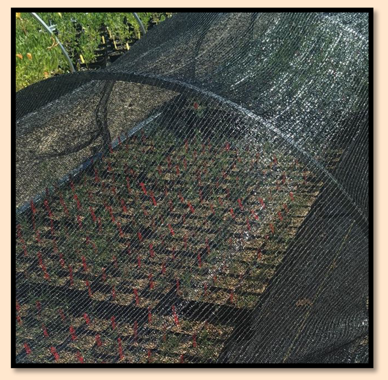
- Functional traits will differ by treatment

1. Below ground traits will show higher plasticity in drought treatment
2. Above ground traits will show higher plasticity in shade treatment

Methods



Transplanted 240 individual seedlings into 4 inch SVD pots



Acclimated all pots outside in the cold frame under a 40% shade cloth for 1 week

Assigned 60 pots to each of the 4 treatments: control, drought, shade, and nutrient-deficiency

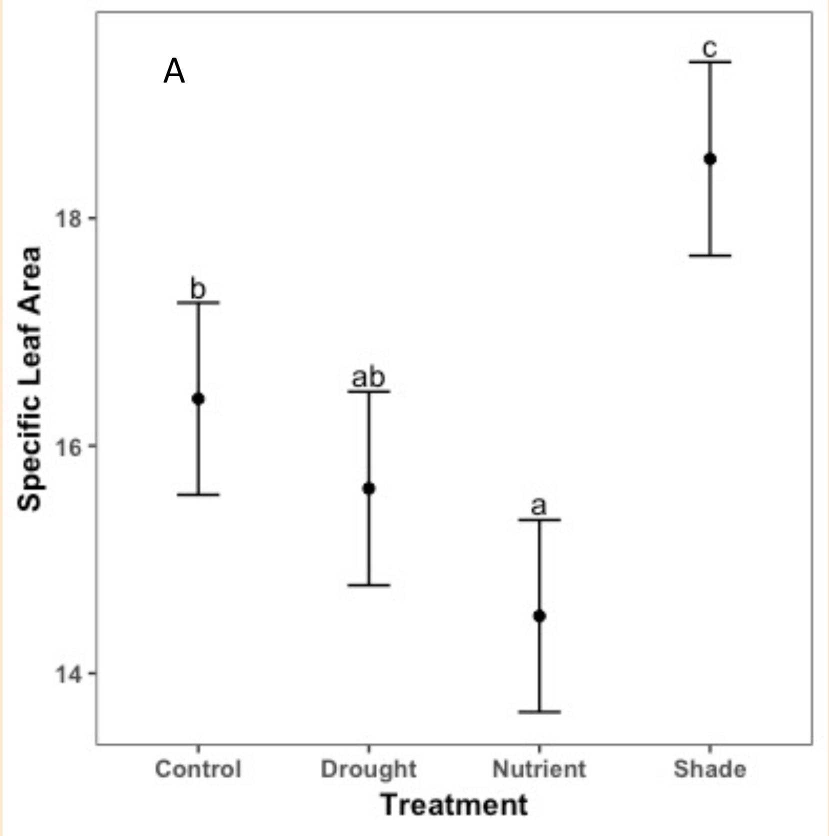
Harvested plants and conducted analysis of variance (ANOVA) and Tukey post hoc tests to determine significant differences

Results

Table 1: Results of ANOVA test that examines the differences in the response of traits to different treatments.

Traits	Degree of Freedom	F-statistic	P-Value
SLA	234	15.5	<0.0001
LDMC	232	12.92	<0.0001
Height	235	10.03	<0.0001
Circularity	Not significant		
RSR	235	16.97	<0.0001
Root length	Not significant		

- Four of the six traits were significant by treatment (Table 1).
- Plants in the shade treatment had a significantly higher SLA. Lower SLA was found in nutrient-deficient plants. No significant difference exists between control and drought treatments (Figure 1A).
- Plants in the nutrient-deficiency treatment showed higher RSR. There was no significant difference between control and the drought and shade treatments (Figure 1B)



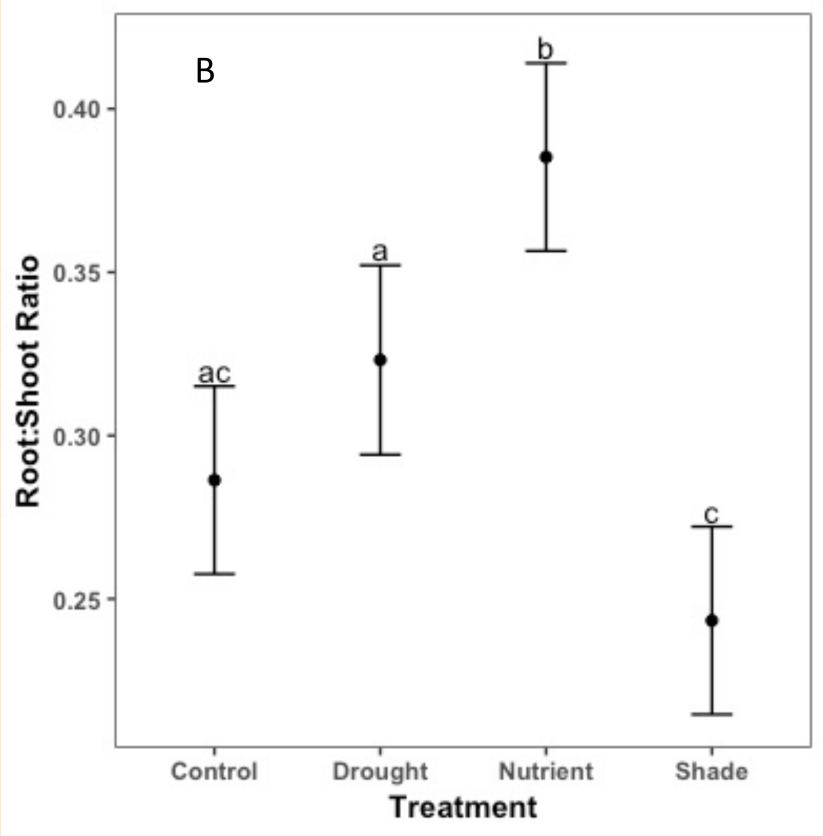
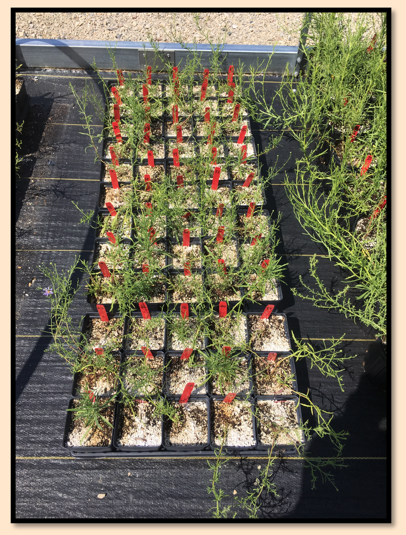
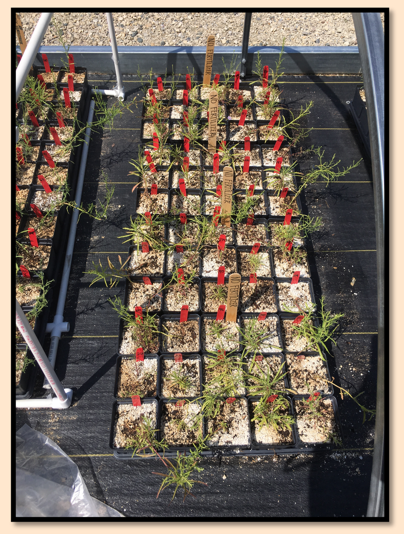


Figure 1: Differences of plant traits among treatments. Error bar shows 95% confidence intervals and letters are differences identified by post hoc test. **(A)** Specific Leaf Area. **(B)** Root:Shoot Ratio.

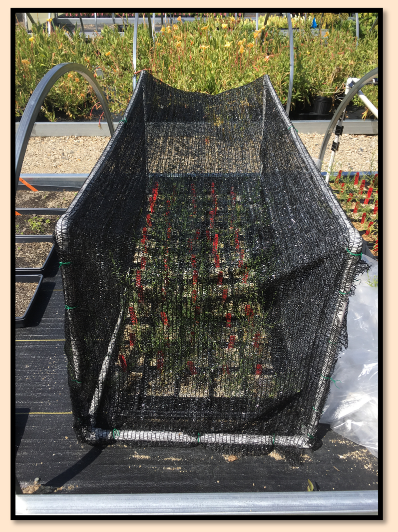


Control Treatment

Drought Treatment



Nutrient-Deficiency Treatment



Shade Treatment

Discussion & Conclusion

- The purpose of this project was to determine if plasticity existed when exposed to different environmental treatments.
- We found that leaf area was bigger in the shade treatment. This is most likely an allocation of plant energy in expanding leaves to capture more sunlight.
- Root:shoot ratio was higher in the nutrient deficient treatment. This energy allocation is most likely used to find nutrients deeper in soils the plants needed since there was lack of nutrients.
- The seeds of *M. canescens* were collected from the Colorado Plateau, and the results indicated that the shrubs not only adapt well to dry environments, but also tolerate low level sunlight locations.
- Within the communities, the differences of traits could be used to predict changes in ecosystems that experience drastic environmental changes[4]. The results may also inform the selection of seed sources for restorations.
- It is a great deal to understand how plant functional traits will respond to future environmental fluctuations of climate change to enhance restoration of degraded or affected regions around the world.

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References

1. Nicotra, A.B., O.K. Atkin, S.P. Bonser, A.M. Davidson, E.J. Finnegan, U. Mathesius, P. Poot, et al. 2010. "Plant Phenotypic Plasticity in a Changing Climate." *Trends in Plant Science* 15 (12): 684–92. https://doi.org/10.1016/j.tplants.2010.09.008.
2. Abakumova, Maria, Kristjan Zobel, Anu Lepik, and Marina Semchenko. 2016. "Plasticity in Plant Functional Traits Is Shaped by Variability in Neighbourhood Species Composition." *New Phytologist* 211 (2): 455–63. https://doi.org/10.1111/nph.13935.
3. Givnish, Thomas J. n.d. *Ecological Constraints on the Evolution of Plasticity in Plants. Evolutionary Ecology*.
4. Suding, Katharine N., and Leah J. Goldstein. 2008. "Testing the Holy Grail Framework: Using Functional Traits to Predict Ecosystem Change." *New Phytologist* 180 (3): 559–62. https://doi.org/10.1111/j.1469-8137.2008.02650.x.