

Kearney Foundation Fellowship Final Report Summary

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Project Title: Mycorrhizal fungi in intact versus degraded coastal sage scrub

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Introduction:

The Coastal Sage Scrub (CSS) habitat of California is a threatened ecosystem and a biodiversity hotspot, with high levels of species diversity and endemism. Restoration of CSS is necessary for, grazed, farmed, fragmented, or non-native invaded areas. However, to achieve successful and efficient restoration, the ecology of the system must first be understood.

Over 70% of all plant families acquire scarce soil nutrients by associating with symbiotic mycorrhizal fungi (Newman and Reddell, 1987). Mycorrhizal fungi are “plant mutualists” that associate with plant roots and use plant carbon to construct hyphae that scavenge soil for nutrients. The fungi then return nutrients to their host plants in exchange for more plant carbon. Mycorrhizal hyphae can increase root surface area by up to 300-8000 m² m⁻¹ (Hogberg and Read, 2006), enabling plants to take up limited nutrients from soils more efficiently than relying on plant roots alone. In this dry and nutrient-limited region, mycorrhizal fungi associate with natives, thereby aiding in survivorship of native species. The two groups of mycorrhizal fungi that I observed in this study were Ectomycorrhizal (ECM) fungi and Arbuscular mycorrhizal fungi (AMF). AM fungi colonize roots internally, whereas ECM colonize roots externally. The goal of this project was to quantify these mycorrhizal associations in different soils that vary in plant success.

Field Sites:

I used two sites in the Newport Backbay Ecological Reserve of Orange County. The first site (149,737 m²), called “CSS site”, is a relatively unaltered and relatively non-disturbed, healthy CSS habitat. It is densely populated with native shrubs such as *Artemisia californica*, *Encelia californica*, *Rhus integrifolia*, and *Eriogonum fasciculatum*. This site is used as habitat for the endangered California Gnatcatcher; their call is often heard on site. The second site (232,165 m²), called BVS (Bayview Slope) site, is sparsely fragmented with natives, partly eroded, and invaded by non-native plant species during the growing season (winter and spring). The CA Coastal Commission has plans to eventually restore this site with native shrubs to enhance the native flora and fauna in the area. The dense CSS site represents successful CSS habitat and can be used as a benchmark for future restoration projects in the Newport Backbay and

other degraded CSS areas in southern California. I hypothesized that (1) there would be greater percent ECM colonization of roots in the CSS site along with greater AMF colonization of roots in the BVS site, and (2) *Encelia* would grow better in the site with more AMF, and *Eriogonum* would grow better in the site with more ECM fungi.

Experimental Design:

To test hypothesis 1, six 10 x 10 cm soil cores were taken from the sites (3 from each) to measure the percent colonization of roots by both types of mycorrhizal fungi. Percent colonization of ECM was measured by examination of extracted roots under 30x magnification (Brundrett 1991). Percent colonization of AMF was measured by Trypan blue staining of extracted fine roots (Koske and Gemma 1989, McGonigle et al. 1990). To test hypothesis 2, two CSS plants were grown in the greenhouse using soil from both sites. Six replicates of each plant species were grown in each of the two soil types from both sites, totaling 24 plants. The soil from each site was taken at random locations within each site and then homogenized as two groups to represent the soil of the two sites. Plant height was measured once every 5 days for 1 month. *Encelia californica* (Bush Sunflower), family Asteraceae, was chosen for the known arbuscular mycorrhizal fungi (AMF) associations in the Astreaceae family (Fontenla, 2001), and *Eriogonum fasciculatum* (California Buckwheat) was chosen for its known associations with Ectomycorrhizal fungi (ECM) (Egerton-Warburto, 2007). In this experiment, *Encelia* represents CSS plants that form AMF associations and *Eriogonum* represents CSS plants that form ECM associations.

Results:

A significant difference was found in ECM colonization of roots between the sites ($df= 4$, $t= -4.031$, $p= 0.016$), with more colonization in the CSS site. Although more AMF colonization was measured in the BVS soil, this difference was not significant ($df= 4$, $t= 2.043$, $p= 0.132$). The difference of growth of both plant species between the 2 soil types was marginally significant ($p= 0.10$), with both plant species growing more in the CSS soil.

Additionally, above ground community composition transects through the fragments of both sites yielded a positive regression between native plant species diversity and fragment size.

Discussion:

A likely explanation for more ECM in the CSS site is likely due to the relative non-disturbance of soil at that site. Conversely, the BVS site was farmed and possibly cow-grazed in the past, more than likely negatively impacting the mycorrhizal fungi at that site. These circumstances favor less ECM at the BVS site because succession of ECM takes much longer than AMF. ECM succession requires up to 15 years (Treseder, 2004).

The CSS site is densely populated with native shrubs and the BVS site is sparsely fragmented with natives. By comparing the growth of 2 species-specific mycorrhizal CSS species in both soils with the average percent colonization of mycorrhizal fungi in

these soils, a comparison between species-specific mycorrhizal associations was possible. AM colonization has been documented to colonize after 8 weeks (Puschel, 2007). Therefore, after 2 weeks of germinating and 4 weeks of plant growth, it is possible that it was premature for the roots to be colonized by AMF. If there was not ample time for colonization to occur, the difference in plant growth in the greenhouse is possibly a function of other soil characteristics, such as salinity, pH, water content, and nutrient contents such as N, K, and P. Further studies that determine any differences of these soil characteristics between the sites would be helpful in understanding the factors affecting plant growth at these two sites.

Additionally, further studies performed by the Treseder Lab will study the effects of mycorrhizal fungi on fragment size, including edge effects of fragments on these sites. The results from this study dovetail the fragment study. The combined information from these studies can be applied to restoration of CSS in the Newport Backbay and other areas in southern California.

References:

Brundrett, M. 1991. Mycorrhizas in natural ecosystems. *Advances in Ecological Research* **21**:171-313.

Egerton-Warburton, L.M., J.I. Querejeta, and M.F. Allen. 2007. Common mycorrhizal networks provide a potential pathway for the transfer of hydraulically lifted water between plants. *Journal of Experimental Botany* **58**: 1473- 1483.

Fontenla, S., J. Puntieri¹, and J.A. Ocampo. 2001. Mycorrhizal associations in the Patagonian steppe, Argentina. *Plant and Soil* **233**: 13–29, 2001.

Hogberg, P. and D.J. Read. 2006. Towards a more plant physiological perspective in soil ecology. *Trends in Ecology and Evolution*. **12**: 548-554.

Koske, R. E., and J. N. Gemma. 1989. A modified procedure for staining roots to detect VA mycorrhizas. *Mycological Research* **92**:486-505.

Newman, E. I., and P. Reddell. 1987. The distribution of mycorrhizas among families of vascular plants. *New Phytologist* **106**:745-751.

Puschel, D; Rydlova, J; Vosatka, M. 2007. The development of arbuscular mycorrhiza in two simulated stages of spoil-bank succession. *Applied Soil Ecology*. **35**(2):363-369.

Treseder, K. K., M. C. Mack, and A. Cross. 2004. Relationships among fires, fungi, and soil dynamics in Alaskan boreal forests. *Ecological Applications* **14**(6): 1826-1838.