

Progress

During this year, we continued experiments evaluating four topic areas within the context of the overall collaboration of the study of Common Mycorrhizal Networks (CMN). Our focal region is the southern end of the oak study, the coast live oak (*Quercus agrifolia*), and with linkages for synthesizing overall data with the UC Davis and southern Oregon University groups. The four areas are (1) assessing diversity of mycorrhizal fungi, (2) evaluating the spatial structure of mycorrhizal fungi, and (3) evaluating movement of resources between roots and mycorrhizal fungi through the CMN, and 4) synthesizing the complex array of results.

a) Diversity. We found that α diversity is very high. However, it is not infinite. In further analysis, we found that the species increment curve follows a broken stick model rather than a smooth curve. What this means is that in EM, β diversity continues to remain positive.

b) Vertical structure continues to be a focal point in understanding the spatial structure. We have now demonstrated that mycorrhizal fungal hyphae extend into the granite matrix below the thin soil layer. Oaks extend along the hillsides and hilltops as well as in the valley bottoms. Along the hillsides and higher elevations, we demonstrated that mycorrhizal root tips extend deep into granite materials using faults in the geologic bedrock (>4 m deep). Importantly, we have demonstrated that the fractures and granitic matrix have little of value to the plant nutritionally. However, we have determined that there is not enough water in the soil layers to maintain the evergreen oaks through the extended summer and autumn drought. However, there is an annual re-charge of water into the granite matrix. But, flow through this material is unsaturated, and therefore too slow to account for water use by the plant. However, mycorrhizal hyphae can transport water along depletion gradients. We are currently completing measurement of the soil moisture and nutrient gradients in this granite matrix, fractures, and in the soil. Our goal for the next year is to determine if mycorrhizal hyphae can account for additional use of the granite matrix water.

c) We have continued evaluation of the role of hydraulic lift in sustaining mycorrhizal activity. In greenhouse studies, we have demonstrated that water is transferred from fungus to plant during the daytime, when the driver is transpirational demand. During the night, horizontal gradients in the soil surface creates the demand and water moves from saturated deep roots through surface roots, into mycorrhizae and out the CMN. This water is used to aid in nutrient absorption by the fungi, and re-distribution through the CMN to the plants. In the valley bottoms where deep roots reach groundwater, surface mycorrhizae are comprised of a high diversity of fungal taxa and include many mesic species. These can be found active and hydrated, even into severe drought (<-5MPa). Isotopic signatures show that much of this water is derived from groundwater. Alternatively, in higher elevations where roots cannot reach the groundwater, drought tolerant fungi (*Glomus*, *Cenococcum*) predominate and the amounts of mycorrhizae are much lower than in areas where hydraulic lift can occur.

d) Synthesizing all of these data is one of the largest tasks of the program. We have initiated efforts linking variability among fungal species, and temporal dynamics of these interactions using a stoichiometric modeling framework. We are undertaking experiments and accumulated literature demonstrating a range in growth responses of plants to different fungal species and combinations of species. We have organized these into functional group categories. Subsequently, we recently started to model these using stoichiometric relationships to predict complex outcomes depending on the interactions. We will continue developing this approach to understanding the common mycorrhizal network.

Larger Society Implications

Our results are important to management of Conservation Reserves in California and elsewhere. While oaks and other trees are important to creating aboveground architecture for birds, reptiles and insects, their role as connectors of below-above ground linkages has not been integrated into conservation and restoration planning and management. As we have shown, individual species of these symbiotic fungi are not ubiquitous. They are diverse, with many different functions. The importance of microbial biodiversity has only recently been recognized and our work contributes to this effort.

The work has been highlighted in two recent instances. First, the work is one of the cornerstones of the diversity issues for reserve design in the western Riverside County Multiple Species Conservation plan. Second, our research plots are being further utilized in restoration studies linking belowground and insect diversity, and community structure. For this work, Allen received the Academic Leadership Award from the Inland Empire Section of the American Planning Association.

Secondly, we have supported undergraduate and graduate students as well as post-docs on this project. Many have gone on in both academia and in private industry. This includes several under-represented students and post-docs. A list is provided below.

Participants

Undergraduate students

New students

Completed or Continuing:

Andersen, Hally

Dang, Minh *

Despas, Frantz*

Dhillon, Amy

Fleming, Kathleen

Gaddis, LaQuasha*

Kamal, Nazia*

Lamb, Kelly

Lee, Moon*

Lepe Robert*

Olivares, Elaine*

Potter, Samantha
Tea, Vinh*

Graduate students

New

Rodrigo Vargas

Continuing

Bornyas, Margaret

Lansing, Jennifer

Completed

Lindahl, Amy

Post-doctoral

New

Swenson, William

Petra Prouzova-Kucerova

Completed

Treseder, Kathleen (NSF post-doctoral fellowship)

Querejeta, Jose' Ignacio (Fulbright Fellow, from Spain)

Snyder, Season

Egerton-Warburton, Louise

Staff

Veronique Rorive

Doljanin, Christina

Tennant, Tracy

Publications:

Updates:

Lindahl, A. 2002. Ecto- and arbuscular mycorrhizal fungi in transplanted oak seedlings in a southern California Oak (*Quercus agrifolia*: Fagaceae)-grassland ecosystem. M.S. Thesis, University of California.

Allen, M.F., W. Swenson, J.I. Querejeta, L.M. Egerton-Warburton, and K.K. Treseder. In press. Ecology of mycorrhizae: A conceptual framework for complex interactions among plants and fungi. *Annual Review of Phytopathology*.

Querejeta, J.I, J.M. Barea, M.F. Allen, F. Caravaca, and A. Roldan. In press. Differential response of $\delta^{13}\text{C}$ and water use efficiency to arbuscular mycorrhizal infection in two aridland woody plant species. *Oecologia*.

Crocker, T.L., R. L. Hendrick, R. Ruess, K. S. Pregitzer, A. J. Burton, M. F. Allen, J. Shan and L. A. Morris. In press. Substituting root numbers for length: Improving the use of minirhizotrons to study fine root dynamics. *Applied Soil Ecology*.

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Already entered

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