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Comparative mycorrhizal fungal production and respiration of a neotropical rainforest versus a California mixed forest

Michael Allen[1,2], Michael Taggart[2], George Rothbart[2], and Thomas Harmon[3]
[1]University of California-Riverside, Center for Conservation Biology, Riverside, United States of America (michael.allen@ucr.edu)
[2]Rhizosystems LLC,Camas, United States of America (mike.taggart@RhizoSystems.com)
[3]University of California-Merced, Merced, United States of America (tharmon@ucmerced.edu)

Mycorrhizae are a symbiosis between fungi and plants. We have learned about the complexity of mechanisms of interaction and interactions between the mycorrhizae and the local environment from over a century of laboratory observations experiments. Point observations and laboratory studies identify processes, but cannot delineate activity. Our goal is to use an in situ system to study mycorrhizal roots and fungi during hot moments, daily shifts, and seasonal change.

We integrated continuous in situ observation-sensor measurements using our Soil Ecosystem Observatories. As turnover rate estimates are related to sample frequency, individual scans using manual minirhizotrons (Bartz and Rhizosystems) and Rhizosystems Automated Minirhizotrons (32,000-3.01mm x 2.26mm 307,200 pixel images). Automated scans were collected up to 4x daily. Manual scans across multiple tubes in campaigns provided spatial variation. Images were organized into mosaics using RootView software, and roots and hyphae identified and length, width and biovolume determined using RootDetector <http://www.rhizosystems.com/>. Individual roots and hyphae were tracked using RootFly <https://cecas.clemson.edu/~stb/rootfly/>. Lifespans were determined using Mark-Recapture modeling and turnover calculated. With each minirhizotron tube, sensors were placed at 3 or 4 depths for temperature, moisture, CO_2 and O_2 at 5minute intervals.

Mycorrhizal fungi (MF) explore soil for nutrients and requiring C. Most C to the hyphae is respired (with a ^{14}C signal of autotrophic respiration), with the remaining divided into decomposing (heterotrophic respiration) and sequestered C pools.

Our first site is a mature neotropical rainforest, the La Selva Biological Station, Costa Rica. Trees predominantly form arbuscular mycorrhizae (AM). AMF fungi comprise 50% of total fungal mass (PLFA). Aboveground NPP-C was 750g/m^2. Root standing crop C was 120g/m^2, average lifespan 60days, =6 generations/y, = root NPP of 720g/m^2/y. The AMF hyphal standing crop C was 12.5g/m^2, average lifespan of 25 days, =14.7 generations/y, = AMF NPP of 183g/m^2/y. With an NPP of 1,650g/m^2/y, then AMF comprises 11% of NPP.

Soil respiration provides CO_2, converting in water to HCO_3^-, altering soil pH (Henry's Law). AMF

respiration thereby increases P availability. If 10% of the AM fungal hyphae are live, then the hyphal respiration is 438g/m^2/y of C, =38% of total soil respiration and 16% of site respiration.

Our second site is a mature California mixed forest, USA. Ectomycorrhizal (EM) trees predominate. Annual NPP-C was 200g/m^2, and root NPP was 200g/m^2. EMF NPP was 162.6g/m^2, or 27% of the NPP. N, water, and temperature limit NPP. The seasonal signal was very high in this ecosystem. Peak standing crop of extramatrical EM hyphae was 19gC/m^2 in April. Total soil respiration in April was 0.26g/h, and extramatrical hyphae 0.029g/h, or 11% of the total soil respiration. Since P is less limiting, but N and water are, hyphae likely play a greater role in enzymatic activity and exploratory surface area.

In summary, different mycorrhizal fungi play different roles depending on ecosystem limiting factors. With global change, our challenge is to determine how an ecosystem will change and the extent and rapidity of mycorrhizal fungal change.