Geophysical Research Abstracts
Vol. 14, EGU2012-3723-1, 2012
EGU General Assembly 2012

Direct in situ measurement of Carbon Allocation to Mycorrhizal Fungi in a California Mixed-Conifer Forest

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Mycorrhizal fungi consume fixed C in ecosystems in exchange for soil resources. We used sensor and observation platforms belowground to quantify belowground dynamics in a California mixed-conifer ecosystem. We directly observed growth and mortality of mycorrhizal fungi *in situ* on a daily basis using an automated minirhizotron. We measured soil CO_2, T and soil moisture at 5-min intervals into the soil profile. These data are coupled with sensors measuring eddy flux of water and CO_2, sapflow for water fluxes and C fixation activity, and photographs for leaf phenology. We used DayCent modeling for net primary productivity (NPP) and measured NPP of rhizomorphs, and fungal hyphae. In an arbuscular mycorrhizal (AM) meadow, NPP was 141g/m2/y, with a productivity of fine root NPP of 76.5g C/m2/y, an estimated 10 percent of which is AM fungal C (7.7 g/m2/y). Extramatrical AM hyphal peak standing crop was 4.4g/m2, with a lifespan of 46 days, with active hyphae persisting for 240 days per year. The extramatrical AM fungal hyphal C was 22.9g/m2/y, for a total net allocation to AM fungi of 30.5 C/m2/y, or 22 percent of the estimated NPP. In the ectomycorrhizal (EM) forest, root standing crop (200g C/m2/y) and rhizomorph (2mg C/m2/y) was 33 percent of the NPP (600g C/m2/y). EM fungal hyphae standing crop was 18g/m2/y, with a 48day lifespan, persisting throughout the year, or 59 g C/m2/y. EM root tips and rhizomorph life spans were nearly a year. Assuming that EM fungi represent 40 percent of the fine root EM NPP (of 200g C/m2/y) or 80g C/m2/y, most of the rhizomorph (in the mineral soil) mass being EM (or 2mg C), and 57 percent of the soil fungal NPP or 80 g C/m2/y, then the EM NPP is 139 C/m2/y, or 23 percent of the estimated NPP (600g C/m2/y). As an independent check on the allocation of C, we applied the Hobbie and Hobbie isotopic fractionation d15N model to C allocation. Using d15N of Chantarellus sp. (10.6) and Rhizopogon sp. (9.1), with a leaf d15N of -4.9, we estimated that 35 percent of the plant N came from mycorrhizal fungi, with 16 percent of the NPP -C allocated to EM fungi. This may represent an underestimate, as many EM fungi present on site do not show a measurable d15N value from saprotrophic fungi. The next step is to incorporate hyphal dynamic events into the annual dynamics. We observed no correlation with soil temperature or moisture. In these forests, production of new hyphae occurs between T of 5C and 10C. During this T change, moisture ranges between 20 and 25 percent. Peak mortality occurs between T of 8C to 15C, with soil moisture of 15 to 20 percent. These correspond to the drying and wetting periods in these Mediterranean forests. Small shifts in soil T or soil moisture with global change could have major impacts on C allocation to mycorrhizal fungi which could feed back to plant species composition.