Roots stimulate carbon cycling while mycorrhizae stimulate nitrogen cycling in a boreal upland forest

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Plant roots, their associated mycorrhizal community, and the free-living microbial community interact to regulate the movement of carbon from soil to the atmosphere, one of the most important and least understood fluxes of terrestrial carbon. Our understanding of how plant-microbial interactions alter soil carbon decomposition is lacking, leading to poor model predictions of terrestrial carbon feedbacks to the atmosphere. I tested how roots, mycorrhizal fungi, and the free-living microbial community alter soil carbon decomposition and predicted roots and mycorrhizal fungi would additively increase microbial activity. I manipulated the access of roots and mycorrhizal fungi to bulk soils *in situ* in a boreal upland forest (Marcell Experimental Forest, MN, USA). I added ^{13}C-labelled substrate to trace carbon through respiration and measured microbial extracellular enzyme activity.

I used a structural equation modelling approach to determine how direct and indirect effects of roots and mycorrhizae alter soil microbial decomposition activity and carbon fluxes. The model with the best fit to my field data included a direct effect of roots on carbon-degrading enzyme activity, which was stronger than their indirect effect mediated by microbial biomass. Similarly, I found that the direct effect of mycorrhizal fungi on nitrogen-acquiring enzyme activity was stronger than their indirect effect mediated by microbial biomass. Soil respiration and metabolism of a ^{13}C-labelled substrate was positively correlated with activity of nutrient acquiring enzymes but negatively correlated with carbon-degrading enzymes. Overall, this study demonstrates differences in root and mycorrhizal effects on ecosystem processes. These results provide empirical support for next-generation ecosystem models that describe decomposition rates as a function of roots and mycorrhizal fungi.