Title: Path analysis unravels complex interactions between the plant communities and the soil microbial communities

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Abstract

The interactions between the aboveground plant communities and the belowground microbial communities are complex and intertwined yet critical to understanding the consequences of biodiversity loss and global change factors. Path analysis offers the suitable tool to evaluate multiple hypothesized causal relationships at once. Here I applied path analysis to data from a biodiversity experiment that manipulate plant richness, plant phylogenetic diversity (PD thereafter), and water availability, to study (1) the effect of plant richness vs. PD on microbial diversity, (2) the direct effect of plant diversity (richness and PD) on plant productivity, and (3) the indirect effect of plant diversity on plant productivity via the change in soil fungal communities. The model consisted of 18 parameters estimated with 273 data points derived from sequencing and surveying. I found that the increase in plant PD directly increased (estimate=4.936, Z=2.436, p=0.015) plant productivity, measured in total plant cover. Plant richness, on the other hand, indirectly decreased plant productivity through decreasing soil moisture and the diversity of arbuscular mycorrhizal fungi (AMF), a group of mutualistic microbes. In particular, plant richness significantly decreased soil moisture (estimate= -6.524, Z=-2.472, p=0.013) potentially due to more efficient water use. The decrease in soil moisture then suppressed AMF Shannon diversity (positive correlation, estimate=0.002, Z=2.898, p=0.004). Eventually the decrease in AMF Shannon diversity decreased plant productivity (positive correlation, estimate=6.277, Z=4.241, $p<0.001$). These results reveal that different modes of plant diversity loss would lead to different downstream consequences in ecosystem productivity. They also highlight the complexity in above-below ground interactions and in their role in mediating biodiversity-ecosystem functioning relationships.