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Challenging the hypothesis that fungal-to-bacterial dominance characterizes turnover of soil organic matter and nutrients

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It is widely held that distinguishing the microbial decomposer groups fungi and bacteria can capture relevant differences in life-history strategies – associating fungi with a K-selected strategy and bacteria with an r-selected strategy for resource-use. Via food-web models, these differences between groups have been extended and have resulted in the expectation that the fungal-to-bacterial dominance of the decomposer food-web will determine the biogeochemistry of the ecosystem. The bacterial energy channel is thought to form the basis for high turnover rates of easily available soil organic matter (SOM) resources, while the fungal energy channel is thought to be the foundation of the slower turnover of more complex fractions of the SOM.

We used two field sites where Detrital Input and Removal Treatment (DIRT) experiments had been used during c. 20 years to change the SOM quality of forest soils. In these, litter and root inputs (control, no litter, double litter, or no tree roots) had been manipulated, generating differences in soil C quality. The Harvard Forest DIRT, was established on a glacial till deposited on acid bedrocks including granite and gneiss, with a mixed hardwood forest stand of red oak, red maple and paper birch dominating the canopy, resulting acid soil (pH 3.7-4.5). In the HJ Andrews DIRT, soils were developed from basaltic parent material in Douglas-fir and western hemlock stands, resulting in only mildly acidic soil (pH 5.0-5.8). We hypothesized (1) that ∂13C enrichment would decrease with higher soil C quality and that a higher C quality would favour bacterial decomposers, (2) that the C mineralized in fungal-dominated treatments would be of lower quality and also enriched in ∂13C relative to bacterial-dominated high-quality soil C treatments, and (3) that higher C mineralization along with higher gross N mineralization rates would occur in bacterial dominated treatments compared with more fungal-dominated treatments. We also expected that (4) the positive relationship between bacterial dominance and higher SOM quality would grow stronger at higher soil pH.

The DIRT-treatments strongly impacted the soil C quality, generating c. 5-fold differences between respiration per soil C in Harvard forest and c. 10-fold differences in HJ Andrews. In contrast with our expectations, higher quality of soil C benefited fungi, and the effect was stronger in the less acidic soil. The ∂13C signal in CO_2 produced in treatments with a relative dominance of bacteria was indistinguishable from that respired in fungal-dominated treatments. This selective microbial use of ∂13C-depleted soil C (presumably plant material) probably drove the ∂13C-enrichment (presumably due to microbial processing) of soil C observed in DIRT treatments that reduced the soil C quality. Our results show no support for the widely held hypothesis for the biogeochemical implications of the balance between bacterial and fungal food web energy channels. Instead, we find an association between fungal dominance and a high-quality soil C that is quickly transformed into mineral C and N. This calls for a revision of our basic understanding for how microbial communities regulate biogeochemistry.