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Vertical patterns of ecoenzyme activities in forest soils after 20 years of simulated nitrogen deposition

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The below-ground part of terrestrial carbon (C), nitrogen (N) and phosphorus (P) cycles are controlled by soil microorganisms. In order to meet their energy and nutrient requirements, soil microbes produce enzymes which catalyze the release of smaller molecules from decomposing organic matter. Recent work has shown that the potential activities of commonly measured enzymes for C-, N-, and P-acquisition can be related to microbial demand of these elements and link stoichiometry of soil microbes and their resources. Regulation of enzyme production might therefore be an important mechanism for microbes to adapt to different resource regimes.

To investigate links between ecoenzyme activities, soil depth and N availability we make use of two long-term experiments where N has been added to two temperate forest stands for over 20 years. At both sites Norway spruce is the dominating tree whereas other site characteristics like soil type, climate, parent material and morphology differ. Increased N deposition was simulated by regularly applying $NH4NO_3$ in the range of 35 kg N ha-1 y-1 (Klosterhede, Denmark; since 1992) and 25 kg N ha-1 y-1 (Alptal, Switzerland; since 1995), respectively.

We hypothesize that ecoenzyme activities will decline exponentially with depth reflecting well-established similar trends in organic matter and microbial biomass. However, when normalized to microbial biomass we further hypothesize that activities will not change or even increase down the soil profile. Concerning microbial nutrient limitation, we expect to see a shift from N- to C-limitation with depth which should be reflected in increasing ratios of C- to N-acquiring enzymes.

Preliminary results suggest that activity of hydrolytic enzymes generally decreases with depth, although this drop in activity is not so pronounced when normalized to microbial biomass. Oxidative enzymes, on the other hand, do not follow this pattern, often showing increased activities with depth.

We further see site- and horizon-specific responses of ecoenzymes to N additions. At Klosterhede, enzymes involved in N-cycling increase with N in organic horizons whether C-enyzmes generally did not respond. Interestingly, N addition increased phosphatase activities over the whole soil profile, probably indicating a shift towards P limitation of soil microbes. At Alptal, N addition generally had less effect on hydrolytic enzymes.

Taken together, this first results suggest a response of microbial function to long-term N addition that goes beyond simple stoichiometry. In this context, please note the contribution of Kloss et al. ("Long-term effects of chronic N deposition on soil organic matter quality in two temperate forests", Session 6.5) which presents data on SOM chemistry from the same sites.