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Connections between gross nitrogen cycling and exoenzyme activity across soil depths in three northern hardwood forests

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Despite the enormous size of the organic nitrogen (N) pool contained in mineral subsoils, and its potential importance in supplying N in response to plant and microbial demand, rates of N cycling and soil exoenzyme activities are rarely measured in soils below 10 or 20 cm depth. Furthermore, assumed relationships between measurements of N mineralization and the activities of various decomposition exoenzymes are poorly characterized. We measured rates of gross and net N mineralization and nitrification as well as the activities of hydrolytic and oxidative enzymes at five soil depths (forest floor to 50 cm) in Spodosols at three hardwood forests of varying age (45 and 100 years post-harvest and old growth) at and near the Hubbard Brook Experimental Forest in New Hampshire, USA. As expected, all rates of N cycling and enzyme activities per gram soil correlated strongly with soil carbon (C) concentration, which decreased exponentially with increasing soil depth. Normalized per gram soil C, N cycling rates and specific enzyme activities generally decreased little with depth within the mineral soil. Gross N mineralization rate correlated with specific activities of those enzymes that hydrolyze cellulose (β-glucosidase, cellobiohydrolase) and N-rich glucosamine polymers (N-acetylglucosaminidase), but not those that enzymes that degrade protein or more complex C compounds, leading us to suggest that these N cycling measurements largely capture the N released during microbial N recycling rather than from decomposition of soil organic matter. The rapid speed of measured N cycling rates support this inference. Few differences occurred across the three sites, but the youngest site had a lower ratio of C- to N-acquiring enzyme activities, consistent with expectations of greater N demand in younger than older stands. For all three stands, soil below 10 cm contributed 30-53% of all gross and net N cycling (kg N ha-1 d-1) to 50 cm. Overall, even though microbial N cycling and enzyme activities per gram soil decreased with depth, microbial processes in subsoils contributed substantially to ecosystem-scale N fluxes because of the sustained microbial activity per gram soil C at depth and the large size of the mineral soil pool.