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Adaptability in linkage of soil carbon nutrient cycles – the SEAM model

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In order to understand the coupling of carbon (C) and nitrogen (N) cycles, it is necessary to understand C and N-use efficiencies of microbial soil organic matter (SOM) decomposition. While important controls of those efficiencies by microbial community adaptations have been shown at the scale of a soil pore, an abstract simplified representation of community adaptations is needed at ecosystem scale.

Therefore we developed the soil enzyme allocation model (SEAM), which takes a holistic, partly optimality based approach to describe C and N dynamics at the spatial scale of an ecosystem and time-scales of years and longer. We explicitly modelled community adaptation strategies of resource allocation to extracellular enzymes and enzyme limitations on SOM decomposition. Using SEAM, we explored whether alternative strategy-hypotheses can have strong effects on SOM and inorganic N cycling.

Results from prototypical simulations and a calibration to observations of an intensive pasture site showed that the so-called revenue enzyme allocation strategy was most viable. This strategy accounts for microbial adaptations to both, stoichiometry and amount of different SOM resources, and supported the largest microbial biomass under a wide range of conditions. Predictions of the SEAM model were qualitatively similar to models explicitly representing competing microbial groups. With adaptive enzyme allocation under conditions of high C/N ratio of litter inputs, N in formerly locked in slowly degrading SOM pools was made accessible, whereas with high N inputs, N was sequestered in SOM and protected from leaching.

The finding that adaptation in enzyme allocation changes C and N-use efficiencies of SOM decomposition implies that concepts of C-nutrient cycle interactions should take account for the effects of such adaptations. This can be done using a holistic optimality approach.