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Nitrogen as a factor for enhanced carbon sequestration: Results from four NitroEurope-IP forest supersites

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Nitrogen (N) fertilization, both intended and unintended, interacts with carbon cycling in terrestrial ecosystems, because the major processes of carbon (C) turnover depend on enzymes and thus on N availability. Comparisons between annual carbon dioxide flux (CO_2) budgets and wet N deposition in forests showed a very strong linear increase of CO_2 sequestration with increased N deposition. After considering total rather than only wet N deposition the ratios between increased carbon uptake and atmospheric N input were closer to C/N that can be found in wood. This suggested that the observed ecosystems responses to enhanced N inputs were mainly driven by plant responses. Finally, looking at changes in soil organic matter changes indicated even lower sensitivities of carbon sequestration to N addition. The objective of this study is to describe the mechanisms of the responses and the fate of the N in the ecosystem based on results from intensively investigated forest sites.

Within the European NitroEuope-IP project the annual fluxes and pool sizes of C and N were estimated in four so-called forest supersites, including temperate coniferous forests in Southern Germany (Höglwald) and in the Netherlands (Speulderbos), one temperate beech forest close to Sorø on Zealand in Denmark and a boreal pine forest (Hyytiälä, Southern Finland). Due to differences in vegetation, bedrock and climate history, soils differed in acidity, organic matter content and biological activity; the levels of atmospheric N deposition varied from very low (Hyytiälä) to high (the other sites).

Comparisons of N and C budgets of plants and soils confirmed a simple and stoichiometric effect dC_{uptake}/dN_{dep} = constant and in the order of magnitude of $(C/N)_{wood}$ for plants but not for soils and thus not for the forest ecosystems as a whole. Differences in soil processes as indicated by the differing C/N of SOM, differing amounts of N stored in the soil and considerable differences in N leaching rates even at comparable N deposition levels, showed clearly that the diversity of soils play a large role in the N use for C sequestration and thus for the beneficial effects of additional N loads on climate change mitigation effects in forests. An important conclusion of the study for intended forest fertilization is to consider N leaching to the ground water, which might even enhance the greenhouse effect through increased N_2O emissions from streams, estuaries and coasts rather than mitigating it via increased CO_2 sequestration at the forest site.

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