



## N-15 tracing helps explaining N leaching losses from contrasting forest ecosystems

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Despite chronically enhanced nitrogen (N) deposition to forest ecosystems in Europe and NE America, considerable N retention by forests has been observed, reducing N leaching losses. Organic and mineral soil layers typically immobilize more N than the aboveground biomass, but it is unclear which factors determine N retention in forest ecosystems. However, this knowledge is crucial to assess the impact of changing anthropogenic N emissions on future N cycling and N loss of forests. For coniferous and deciduous forest stands at comparable sites, it is known that both N deposition onto the forest floor as well as N loss by leaching below the rooting zone are significantly higher in coniferous stands. In addition, the N loss in coniferous stands is often more enhanced than can be explained by the higher N input only. This suggests lower N retention by coniferous stands, and may be related to differences in litter and soil characteristics, microbial activity, and N uptake by plant roots.

To test this hypothesis, we studied the effect of forest type on N retention using  $^{15}\text{N}$  tracing techniques: a field tracer experiment and a combination of *in situ* isotope pool dilution and a tracing model. The N dynamics were examined for two adjacent forest stands (pedunculate oak (*Quercus robur* L.) and Scots pine (*Pinus sylvestris* L.)) on a well-drained sandy soil and with a similar stand history, located in a region with high N deposition (Belgium). Input-output N budgets were established by quantifying atmospheric deposition and leaching below the rooting zone, and confirmed the above finding of higher N deposition and disproportionately higher N loss for the pine stand compared to the oak stand. First, the fate of inorganic N within the ecosystems was studied by spraying three pulses of dissolved  $^{15}\text{N}$ , either as ammonium or as nitrate, onto the forest floor in 12 plots of 25 m<sup>2</sup>. The organic and mineral soil layers, tree roots, soil water percolate, ferns, and tree foliage were sampled and analyzed for total N and  $^{15}\text{N}$  four times in the year after  $^{15}\text{N}$  application. Here we present results of the  $^{15}\text{N}$  recovery four months after the first application, and compare the recovery between the two forest stands and the two N treatments.

Second, gross N transformation rates in the undisturbed mineral forest soils were determined via  $^{15}\text{N}$  pool dilution and advanced trace modelling. Using five spatial replicates per stand, three  $^{15}\text{N}$  treatments were applied in the field to 'virtual' soil cores (0-10 cm) that were disturbed only at sampling. Each treatment solution contained ammonium, nitrate, and nitrite, with one of the N forms labelled with  $^{15}\text{N}$  at 99% at. excess. Intact soil cores were sampled at six time intervals over a 12-day period, and analyzed for N and  $^{15}\text{N}$  content in different mineral and organic pools. The parameters of different simultaneously occurring process rates were optimized using a Markov Chain Monte Carlo algorithm. In both stands, heterotrophic nitrification of the organic soil pool was more important than autotrophic nitrification of ammonium. Significantly different process rates between the two forest stands were found for mineralization, heterotrophic and autotrophic nitrification, and ammonium and nitrate immobilization. Gross mineralization and ammonium immobilization rates were higher in the oak soil than in the pine soil. Gross nitrate production, in contrast, was faster in the pine soil, while nitrate immobilization was slower. These different soil nitrate dynamics likely contribute to the observed higher nitrate leaching loss in the pine than oak stand. In addition to the faster nitrate immobilization in the oak soil, our results strongly suggested the occurrence of a second N-conserving process under oak, i.e. dissimilatory nitrate reduction to ammonium (DNRA). This is unexpected for a temperate forest soil under enhanced N deposition, as this process has mainly been described for unpolluted soils.