NITRATE LEACHING FROM AN ALPINE FOREST ECOSYSTEM WITH SIMULATED INCREASED NITROGEN DEPOSITION

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NITREX NITROGEN SATURATION EXPERIMENTS

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Nitrogen cycling in forested catchments

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Introduction

Natural alpine ecosystems tend to have a rather tight nitrogen cycle. This is because both the supply and demand of mineral nitrogen are limited by climate and soil conditions prevailing at higher altitudes. The relative impact of nitrogen deposition is therefore potentially stronger there than at lower altitudes.

Critical loads of N are exceeded in large parts of Swiss forests. Tree health, biodiversity and water quality may be detrimentally affected. Nitrate leaching into surface and ground water is a particular matter of concern.

A simulation of a higher deposition rate is being conducted as a paired-catchment experiment in a spruce forest at Alptal, Switzerland. Following questions are addressed:

- *Are present and future N deposition rates likely to induce N saturation and nitrate leaching ?*
- *Are N critical loads for alpine forests correct ?*

Material and methods

Site description

Geography: Alptal, central Swiss Prealps, 1200 m a.s.l.

Geology: Flysch (calcareous sandstones with clay-rich shists).

Soil: umbric gleysol, with mor (raw humus) on the mounds and anmoor in the depressions; very heavy, impermeable substratum.

Slope: ~ 20%, aspect west.

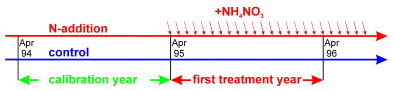
Climate: cool and wet (mean temperature 6°C and 2300 mm precipitation / year).

Vegetation: *Equiseto-Abieti-Picetum*, with *Picea abies* (up to 250-year-old) and 15% *Abies alba*; loose canopy structure (leaf area index = 2.5), well developped herb layer.

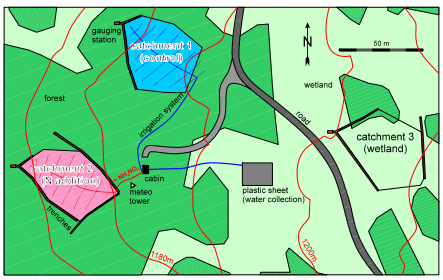
Active vegetation period: June - September.

Experimental catchments

Two forested catchments (~1500m²) have been delimited by trenches. Nitrogen is added to the rain water at times of precipitation as NH_4NO_3, and applied by sprinklers to catchment #2 at 30 kgN / ha / year. Catchment #1 is the control and receives only unchanged rain water. The addition experiment started after one year of calibration.



NITREX experimental setup at Alptal



a sprinkler

the Mythen from catchment 3

a V-notch weir

Sampling and analyses

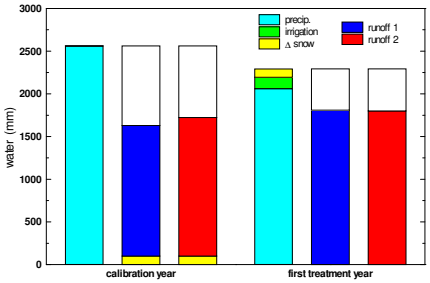
Bulk deposition and throughfall: collected weekly.
Water discharge: measured with V-notch weirs.
Runoff-proportional samples: bulked weekly.
Water analyses: electrical conductivity, pH, ICP-MS (cations+P), IC (anions), FIAS (ammonium).

Results and discussion

Water budget

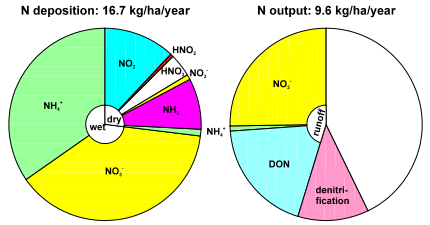
Water discharge was found to be less than precipitation by 500 - 900 mm. Differences between years are partly due to temporary water storage in the soil. Estimations of evapo-transpiration are 500 - 800 mm. The water fluxes of both catchments can thus be considered as balanced. This allows the calculation of element balances.

Water balance of the experimental catchments



Nitrogen budget

Under moderate deposition rate, the control catchment appears to retain 7 kg N / ha / year.

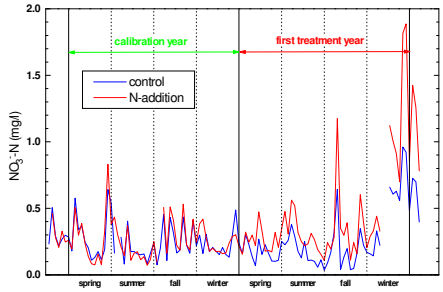


Nitrate leaching

Nitrate concentration in runoff is mostly below 0.5 mg N / l. In the control, higher concentrations occur either at low runoff or during snowmelt. During the calibration year, both catchments were very similar. The N-treatment induced a quick increase over the control. A statistical intervention analysis showed this effect to be significant.

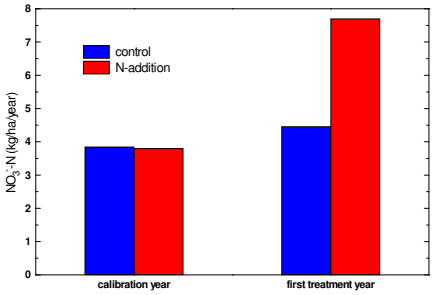
Over one year, the addition of 30 kg NH_4NO_3-N almost doubled the nitrate release.

Nitrate-N concentrations in runoff



Nitrate leaching is partly dependent on the flow regime of soil water. Preferential flow through macropores was shown to be important in the gleyic soils at Alptal. Water residence times and contact with soil matrix may then be sufficient for ammonium to be removed by cation exchange, while slower microbial immobilisation of nitrate remains incomplete. At present it is therefore not possible to tell if the release of nitrate is a sign of nitrogen saturation or merely a consequence of site characteristics.

Nitrate-N output in runoff



Conclusions

- *This alpine forest, which is subjected to moderate N deposition rates, exhibits nitrate leaching.*
- *Simulation of increased NH_4NO_3 inputs increases nitrate leaching, but most added N appears to be retained in the ecosystem.*
- *Nitrate leaching may be due to incomplete removal from precipitation or snowmelt water rather than to ecosystem N saturation.*
- *DON leaching is also an important output and has to be considered in the N budget.*
- *Reducing conditions in the gleyic soils lead to significant denitrification.*
- *Responses of mineralisation, nitrification and denitrification to the addition of NH_4NO_3 are currently being examined.*

Acknowledgements

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