# Greenhouse gas exchanges of the soil in a mountain forest subjected to N addition and after girdling Norway spruce trees.

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## Overview

At Alptal, central Switzerland, a nitrogen addition experiment (+25 kg N / ha / a) is conducted since 16 years in a mountain *Picea abies* forest using a paired-catchment design. The N addition resulted in increased nitrate leaching and in the ecosystem moving towards N saturation. Greenhouse gas exchanges of the soil have been measured year-round approximately monthly for the last 4 years with static chambers in a replicated block design. The N saturated plots showed increased emissions of nitrous oxide and a tendency to reduced soil respiration. In June 2009, half of the large trees (age 100-250 years) were girdled by removing a 30-cm strip of bark and phloem at breast height. In August 2010, these trees had to be felled because they were infested by bark beetles. The girdling had practically no effect on the greenhouse gas exchanges, but effects are expected since the trees were felled.

## Methods/Approach

The Alptal site is characterised by a cool and wet climate (6°C in average, 2300 mm/a, of which 800 mm as snow). N deposition rates are moderate (bulk: 12 kg/ha/a, throughfall: 17 kg/ha/a).

In a paired catchment design, a low-dose N-addition experiment is conducted since April 1995. Therefore two small catchments (approx. 1500m$^2$) within a spruce forest were delimited by trenches. Due to the impermeable gleyic sub-soil, the water is believed not to infiltrate below the depth of the trenches (80 cm) and thus the water balance is approximately balanced (Schleppi et al., 1998). One catchment is subjected to an increased deposition of 25 kg N ha$^{-1}$ a$^{-1}$ as $NH_4^+NO_3^-$ added to rain water and sprinkled 1.5 m above ground, i.e under the tree canopy but over the ground vegetation (Schleppi et al., 1998). A second catchment is acting as a control receiving only rain water.

Since four years the exchanges of carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$) from the Gleysols of the Alptal site is measured. For that we installed chambers within 12 small plots set as 6 replicates of each one control and one N-treated plot. These chambers can be closed either to collect gas samples for analysis (by gas chromatography, GC) or to measure directly soil respiration by infrared gas analyses (IRGA).

In June 2009, half of the trees (15, age 100-250 years) per plot were girdled as a best possible simulation of a bark beetle infestation. At breast height, bark and phloem were removed in a 30 cm strip around the trunk. In August 2010, these trees had to be felled because they were really infested by bark beetles.

## Results

As expected, soil respiration shows a strong seasonality and is mainly driven by soil temperature. The water table has also a strong effect: when it is high, the respiration is always limited; when it is low, the respiration can be high, depending on the temperature. After two growing seasons and one winter, the experimental N addition shows a weak tendency to reduce soil respiration. Calculated over a year, the average C loss as soil respiration amounts to 450 g/m$^2$ in the control plots and 400 g/m$^2$ under N-addition.

$CH_4$ exchanges are generally low, partly positive (emissions), partly negative (consumption); they relate to the small-scale heterogeneity of the topography and of the soil, but not significantly to the long-term N addition. They also vary strongly over time. In an overall average, the annual production of $CH_4$-C is 80 mg/m$^2$.

$N_2O$ emissions are also low, in spite of the hydromorphic nature of the gley soil. In the control plots, they correspond to an N loss of 1.7 mg/m$^2$, with some negative measurements (apparent consumption) but relatively few variations over time. Under long-term N addition, however, some peaks of $N_2O$ emission occur, especially when the water table is not too high (20-25 cm below ground or deeper). The yearly production can be estimated to 7 mg/m$^2$ of N. In a previous study (Mohn et al., 2000), the production of $N_2$ by denitrification was estimated to be 170 mg/m$^2$ in the control (i.e. 100 times higher than $N_2O$-N), and 290 mg /m$^2$ under N addition. Under the prevailing wet conditions of the site, denitrification thus appears to go mostly towards $N_2$ as an end-product, and it stops at $N_2O$ only when the soil is not too wet.

From the girdling and the later felling of trees, we expect that fluxes of $CO_2$ are likely to decrease due to reduced root respiration. $CH_4$ emissions are expected to increase following more anoxic conditions in the soil because of decreased water uptake.

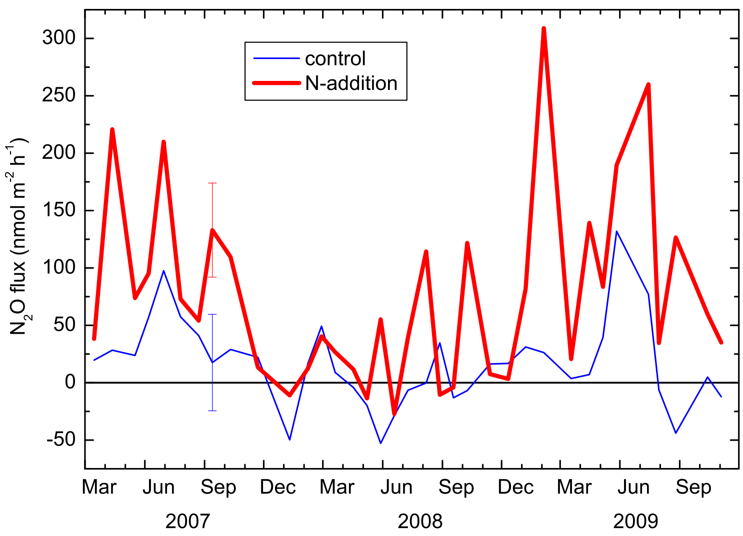


**Fig. 1.** Three years of nitrous oxide fluxes on the control and N-addition plot

## References

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