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

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Research questions

(1) Does increased nitrogen deposition alters greenhouse gas fluxes (CO_2, N_2O, CH_4) from a forest soil ?
(2) How do greenhouse gas fluxes respond to a bark beetle infestation (tree girdling experiment) ?
(3) How does the felling of bark beetle infested trees alters greenhouse gas fluxes ?


Location of the Alptal site

Material & methods

Experimental site Alptal

- located in the foothills of the Alps at 1200 m a.s.l.
- subalpine Norway spruce forest (*Picea abies*)
- precipitation 2300 mm a^{-1} (30% as snow)
- mean air temperature: 6°C
- bulk N deposition: 12 kg $ha^{-1}a^{-1}$ (half NH_4^+, half NO_3^-)


Experimental setup at Alptal

Long-term low-dose N addition

- since April 1995 N addition with sprinklers during rain events as NH_4NO_3
- two plots (each 1500 m^2):
  1) control: rainwater only (12 kg N $ha^{-1}a^{-1}$)
  2) N-fertilized: addition (+25 kg N $ha^{-1}a^{-1}$)

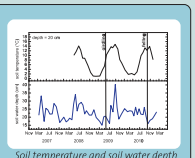

Sprinkler distributing NH_4NO_3

Soil properties

- soil/parent rock: Gelysol/Flysch
- different humus types depending on micro-topography:
  ⇨ mounds : mor (raw humus)
  ⇨ depressions: anmoor humus
- low permeability due to high clay (~47%) and silt (~48%) content
- the water table is usually close to the surface
- anoxic conditions in depressions : mean redox potential = 259 ± 15 mV


Schematic of mounds and depressions


Soil profile at Alptal


Soil temperature and soil water depth

Greenhouse gas flux measurements

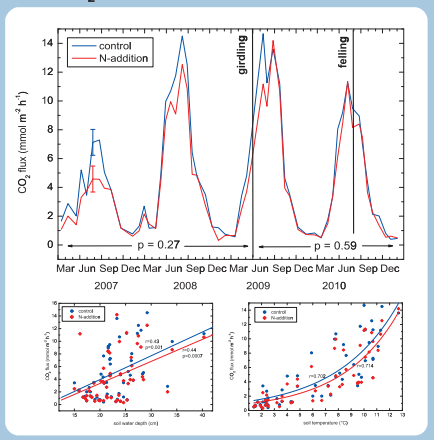
- CO_2, N_2O and CH_4 measured using the static chamber technique
- 12 plots in a replicated plot design (6 x 2 N levels)
- gas samples taken by a syringe, 0, 30, 60 minutes after closure
- sampling intervals of approx. 3 weeks
- samples analyzed by gas chromatography

Tree girdling as a best possible bark beetle simulation

- climate warming will increase bark beetle damage
- tree girdling: removing a 30 cm strip of bark and phloem around the trunk
- half of the trees (15) per plot were girdled
- after 14 month, trees had to be felled due to a real bark beetle infestation

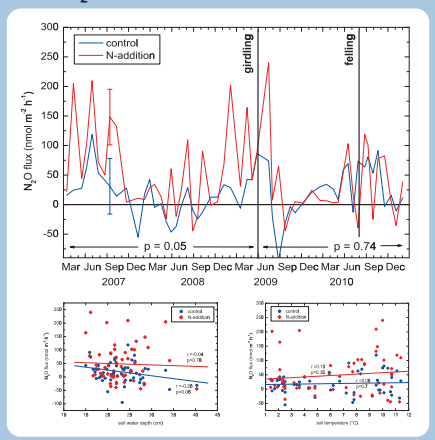
Results

CO_2



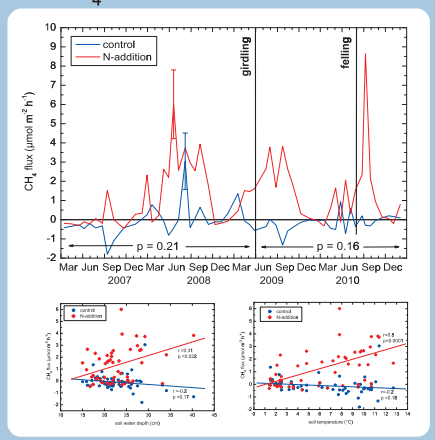
Control: CO_2: 1851 g m^{-2} a^{-1}
N-fertilized: CO_2: 1556 g m^{-2} a^{-1}

N_2O



Control: N_2O: 0.11 mmol m^{-2} a^{-1}
N-fertilized: N_2O: 0.5 mmol m^{-2} a^{-1}

CH_4



Control: CH_4: -1,2 mmol m^{-2} a^{-1}
N-fertilized: CH_4: 10 mmol m^{-2} a^{-1}

Conclusions

- only N_2O fluxes changed significantly due to N-addition
- over 99% of the carbon dioxide equivalency emissions from the soil are in form of CO_2 itself
- after tree girdling, the significant N-fertilization effect on N_2O fluxes dissapeared
- results from the felling of the trees as a management option after bark beetle infestation are expected in the current vegetation season

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