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Carbon and nitrogen transformations under elevated temperature

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Introduction/Background

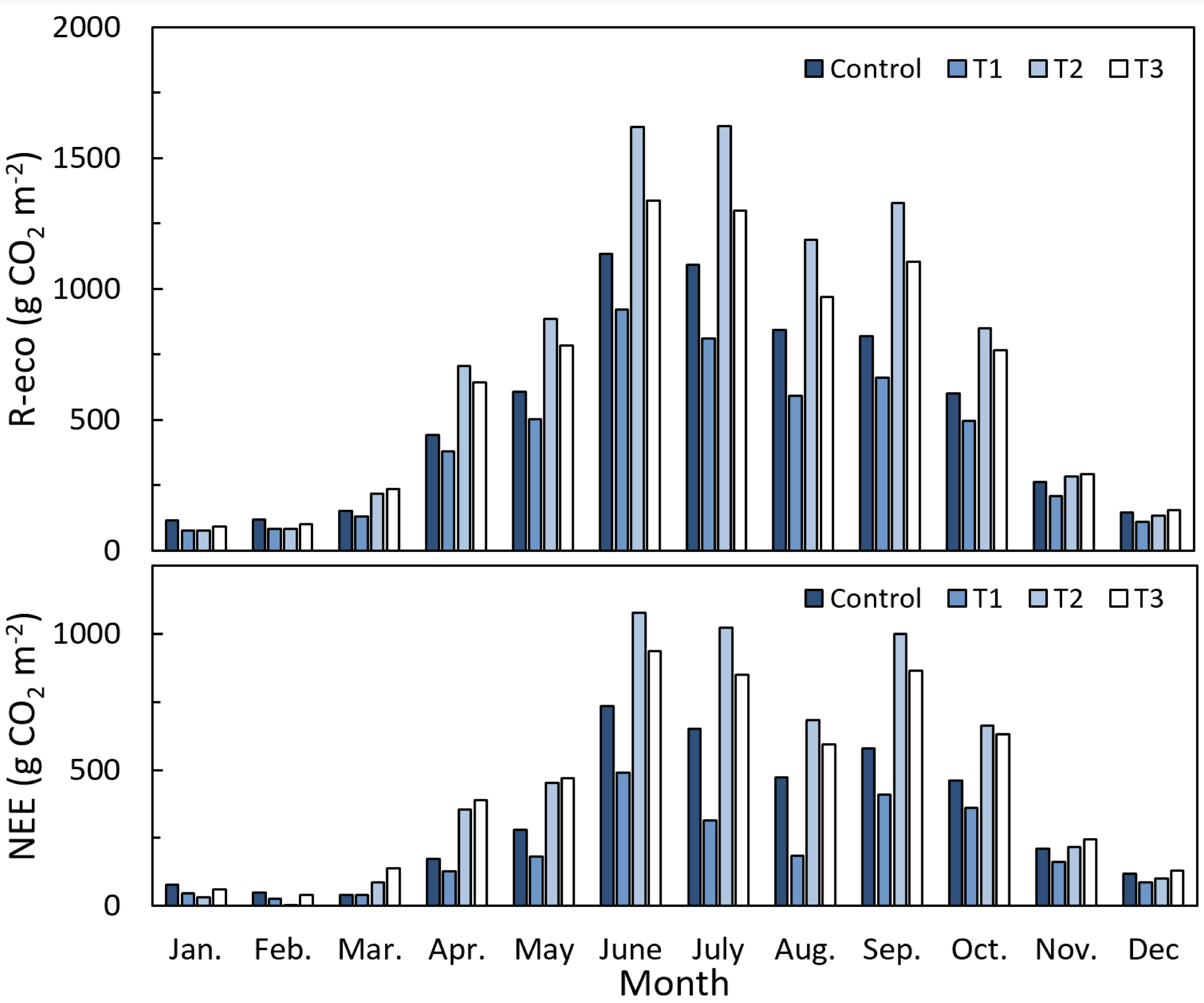
Mean soil surface temperature has increased over the past century, and it is predicted to increase in the future[1]. However, there is currently a lack of long-term studies on the effect of elevated temperature on carbon (C) and nitrogen (N) cycling in temperate grassland. Furthermore, most studies only focus on one temperature increment. This study looked at the long-term (6 years) effect of elevated temperature on C and N cycling, using three different temperature elevations.

Elevated temperature field trial ('*Wärme-Experiment*')
Sixteen 2.5m x 2.5m plots were assigned to one of four treatments (control, +1°C, +2°C and +3°C). Temperature was elevated using IR-heaters, hung at different heights.

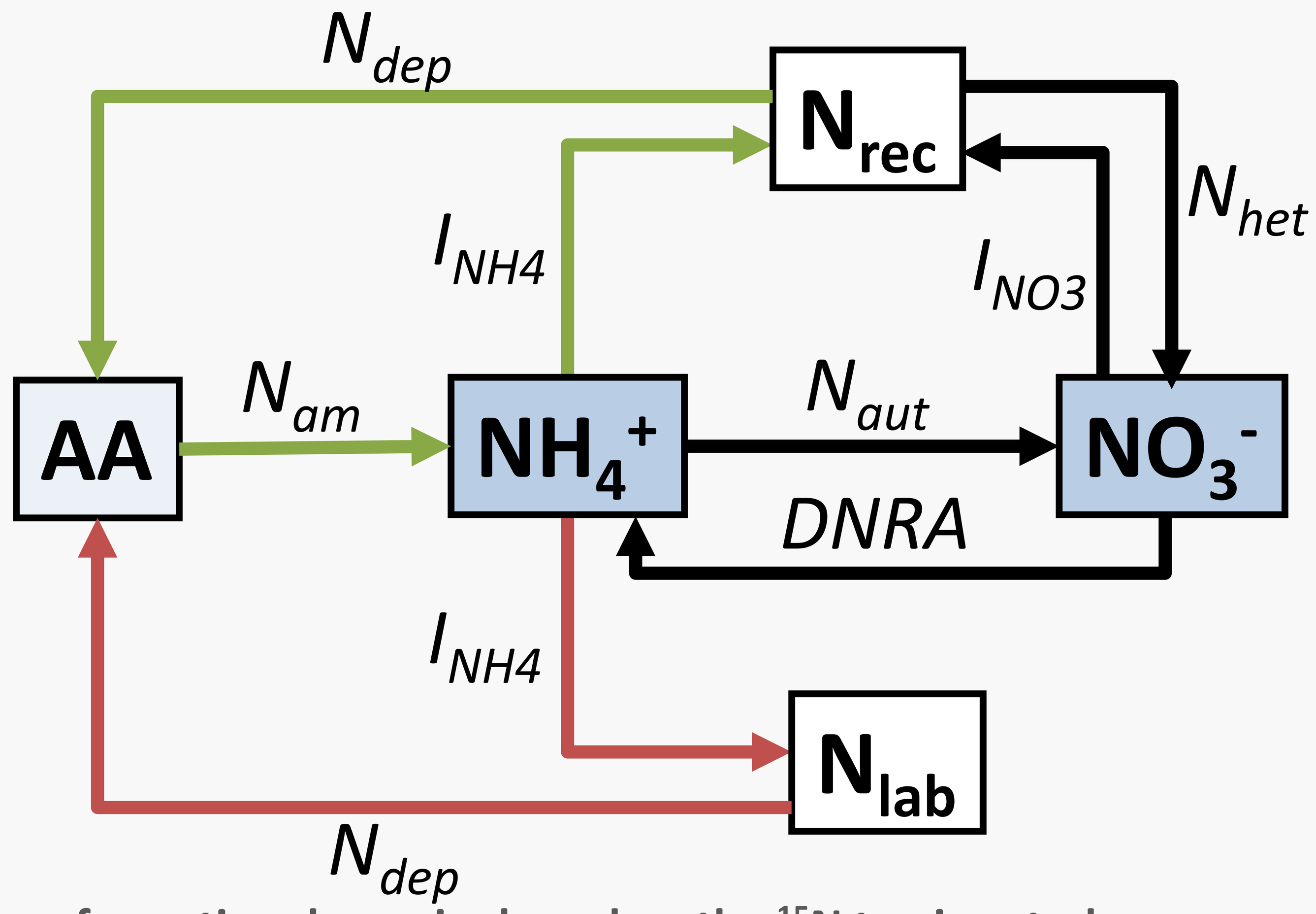
Material & Method

Before the start of the experiment soil carbon and nitrogen were determined. Subsequently, 16 plots were assigned to one of four treatments (control, +1°C (T1), +2°C (T2) and +3°C (T3)) according to a Latin square design, and temperature elevation using IR-heaters commenced. For six years, the temperature was elevated and, during these years, CO_2 flux measurements were taken, using a Li-COR IR analyser (LI-8100).

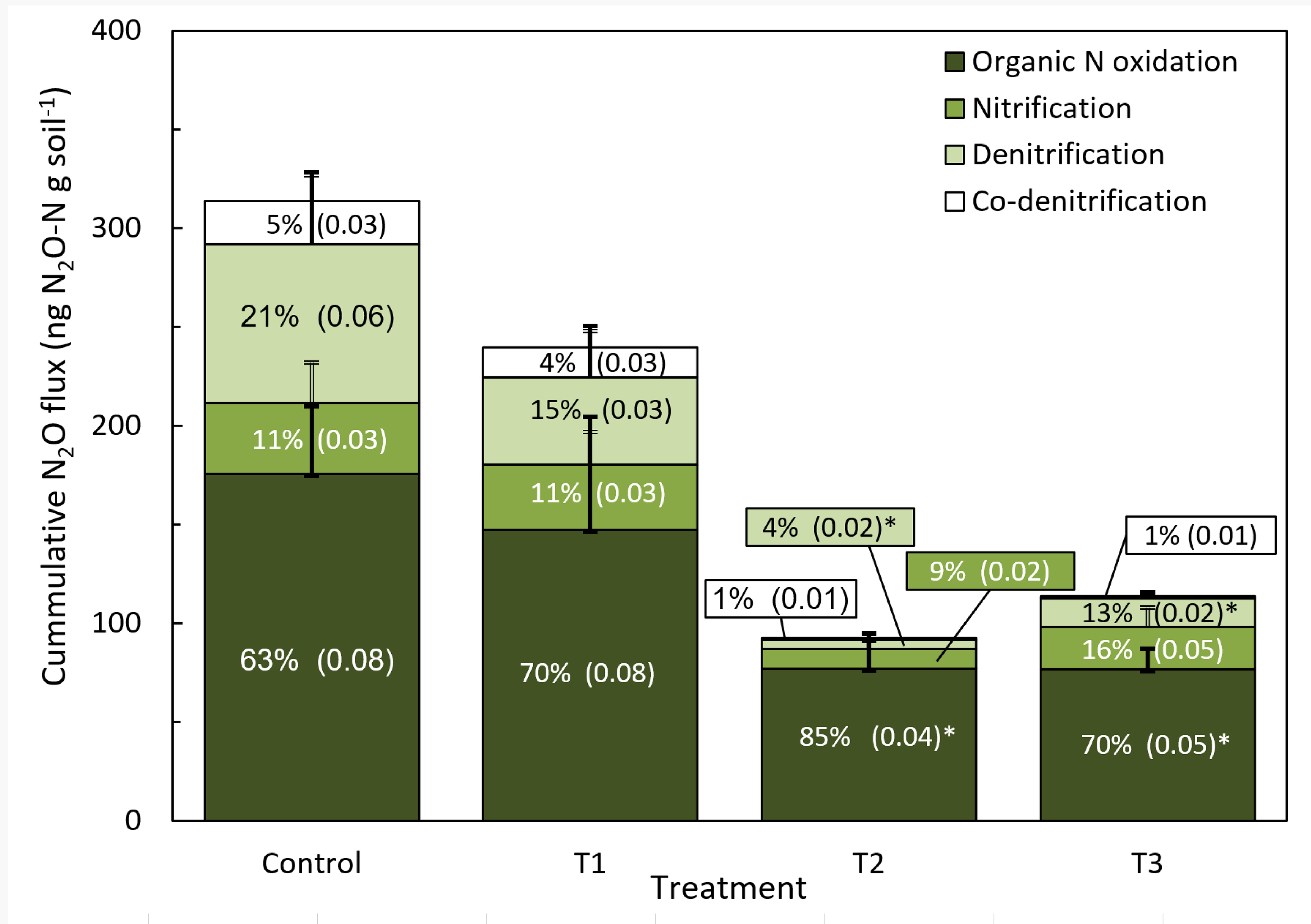
At the end of the field experiment soil samples from the 16 plots were taken to analyse gross soil N transformation rates. This was done by incubating the soil, labelling it with enriched NO_3^-, NH_4^+ and Glycine, and taking extractions and N_2O measurements at different time points. Data were analysed using a ^{15}N tracing model, and a newly developed method to distinguish different N_2O sources.



Monthly modelled CO_2 fluxes between March 1, 2013 and Feb 28, 2014
R-eco is ecosystem respiration and NEE is net ecosystem exchange (Positive values are a net source of CO_2), Treatments: Control, T1 (+1°C), T2 (+2°C) and T3 (+3°C).



Gross N transformation dynamics based on the ^{15}N tracing study.
The colour of the arrows indicate if a certain transformation has increased (**red**), decreased (**green**) or was unaffected (**black**) by enhanced temperature (analysis based on regressions of temperature increase with N transformation rates). AA is the amino acid pool, N_{lab} and N_{rec} the labile and recalcitrant organic N pools. The transformations are as follows: N_{dep} is depolymerisation, N_{am} is ammonification, I_{NH4} is NH_4^+ immobilisation, I_{NO3} is NO_3^- immobilisation, N_{aut} is autotrophic nitrification, N_{het} is hetrotrophic nitrification and DNRA is dissimilatory NO_3^- reduction to NH_4^+.



Cumulative N_2O flux between 3 h and 6 days after label addition
Error bars are standard error of the mean (SEM). Percentages are the average percentage of flux produced via each process, SEM between brackets. *Significantly lower cumulative flux compared to control, Treatments: Control, T1 (+1°C), T2 (+2°C) and T3 (+3°C).

Outcomes

- Elevated temperature lead to higher CO_2 emissions. During day-time higher respiration rates could be offset by higher photosynthesis[2].
- After six years of warming, inorganic N and NO_3^- content were higher in soils subjected to warming of 2-3°C[3].
- Oxidation of organic N was found to be an important process in N_2O emissions and should not be omitted from analyses[3].
- Prior warming lead to reduced oxidation of organic N and denitrification[3].

Achievements

- A new N_2O source partitioning model was developed that is capable of distinguishing four processes including a hybrid process.
- Poster presentation at the EGU conference on the N_2O source partitioning model.
- Presentation at AGRI-I Forum (Ireland) on CO_2 emissions.
- Paper on carbon cycling accepted by Ecology & Evolution[2].
- Paper on nitrogen cycling published in SOILD, currently under review for SOIL[3].

Literature:
[1] IPCC (2013) Summary for policy makers, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
[2] Jansen-Willems, A., G. Lanigan, L. Grünhage, and C. Müller. 2016. Carbon cycling in temperate grassland under elevated temperature. Ecology and Evolution in press, IDECE-2015-12-00896.
[3] Jansen-Willems, A. B., G. J. Lanigan, T. J. Clough, L. C. Andresen, and C. Müller. 2016. Long-term elevation of temperature affects organic N turnover and associated N_2O emissions in a permanent grassland soil. Soil Discussion 10.5194/soil-2016-38.

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