Long-Term Large-Scale Project

In Situ Denitrification in Soils

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Introduction

Denitrification is the most uncertain component of the nitrogen (N) cycle due mainly to the difficulty in measuring *in situ* soil N_2 production.

We quantified *in situ* N_2 and N_2O fluxes due to denitrification in natural and semi-natural terrestrial ecosystems (Fig 1).

Methods: Using the ^{15}N Gas-flux method, denitrification was measured by injecting $^{15}N\text{-}NO_3^-$ into soil mimicking daily reactive N deposition for natural and N fertilisation rates for semi-natural ecosystems.

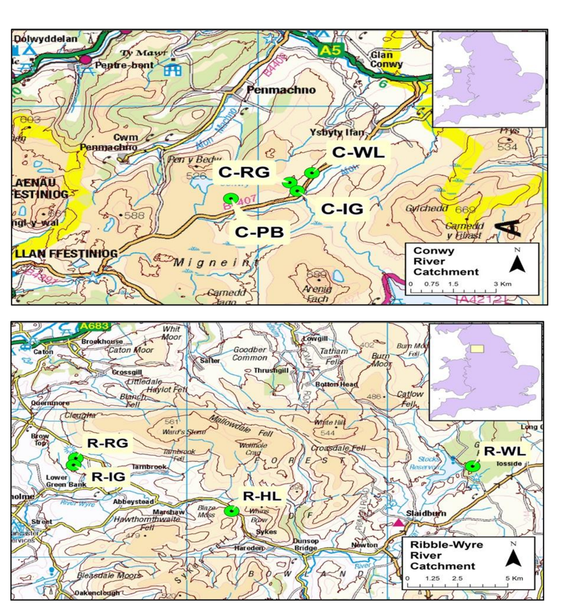


Figure 1: Field sites in the Ribble-Wyre (R) and Conwy (C) river catchments. RG= Rough Grassland, IG= Improved Grassland, WL= Woodland, PB= Peat Bog, HL= Heathland

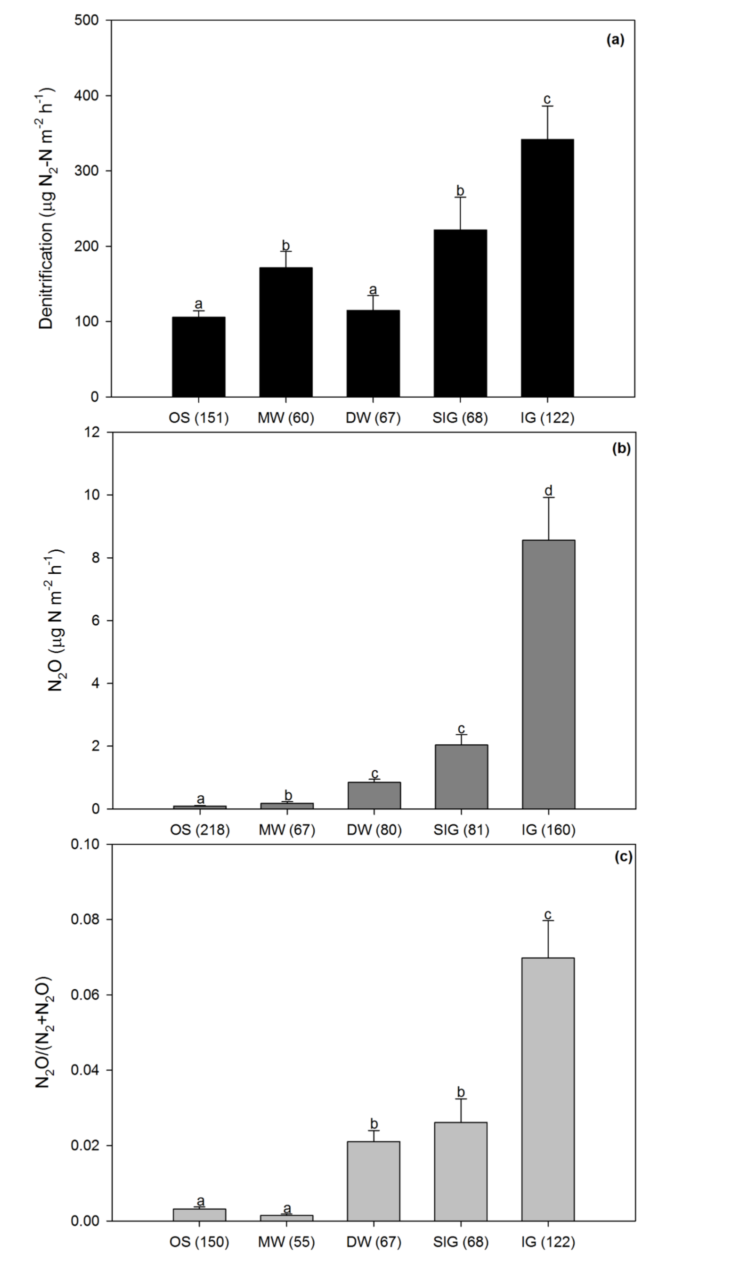


Figure 3: Mean rates of: (a) denitrification, (b) N_2O emission due to denitrification and (c) the denitrification product ratio $N_2O/(N_2 + N_2O)$. OS: Organic Soils; MW: Mixed forest; DW: Deciduous forest; SIG: Semi-improved and IG: Improved Grasslands

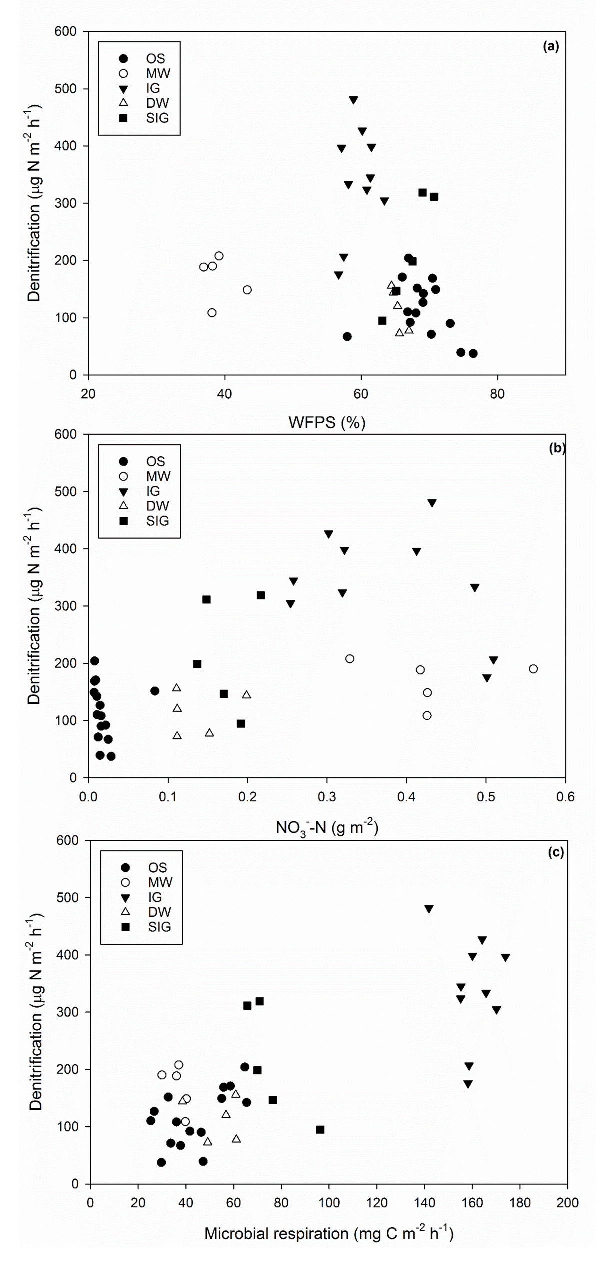


Figure 4: Relationships between denitrification and: (a) water filled pore space, (b) soil nitrate content and (c) soil respiration.

Results

- **Using an additional N_2 prep unit (Fig. 2) and low tracer addition (0.03 – 1 kg ^{15}N ha^{-1}), minimum detectable fluxes of 4 µg N m^{-2} h^{-1} and 0.2 ng N m^{-2} h^{-1} for N_2 & N_2O were achieved.**
- **$\delta^{15}N$ precisions were better than 0.08 ‰ for N_2 and 0.3 ‰ for N_2O.[1]**

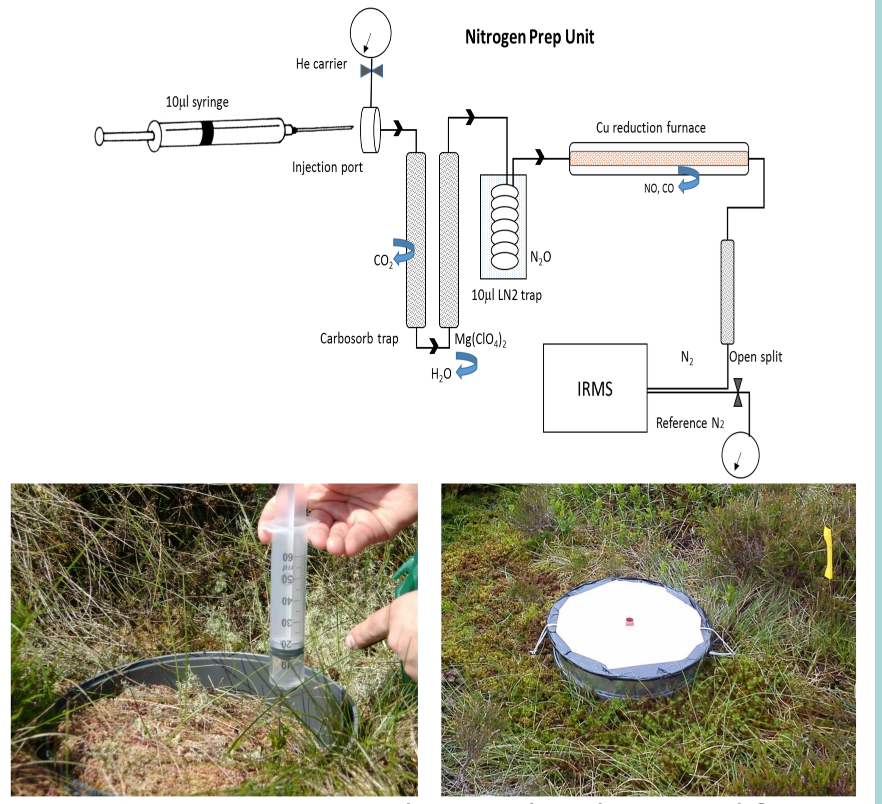


Figure 2: N_2 prep. unit and static chambers used for measuring field denitrification rates.

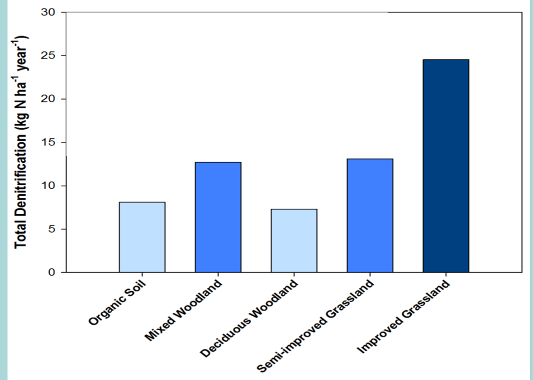
- **Denitrification and N_2O emission were 3.5 times higher from improved grassland soils than from the organic soils (Fig. 3a).**
- **N_2O fluxes due to denitrification ranged between 9 – 60 % of total N_2O emissions (Fig. 3bc).**
- **Denitrification rates were controlled by a gradient of nitrate and carbon availability across the sites, which peaked at 60 % moisture in grassland soils (Fig. 4).[2]**

1. Sgouridis, F., A. Stott, and S. Ullah. 2016. Biogeosciences, 13. 1821-1835, doi:10.5194/bg-13-1821-2016

2. Sgouridis & Ullah. 2015. Environ. Sci. & Tech. 49: 14110-19, DOI. 10.1021/acs.est.5b03513

Implications

The contribution of denitrification to reactive N (Nr) removal in organic and forest soils is ~50 % of the annual Nr input, making these ecosystems vulnerable to chronic Nr saturation.



Conclusions

- **Improved analytical precision and low ^{15}N tracer application rate allowed the quantification of *in situ* N_2 and N_2O fluxes from natural and semi-natural ecosystems**
- **Natural ecosystems (e.g. peatlands and forests) are vulnerable to chronic Nr saturation at current atmospheric N deposition rates**

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Terrestrial Plant Diversity

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- Data on vascular plant species richness were obtained for 2725 locations in the UK and related to net primary productivity estimated by semi-natural and agricultural models
- Soil pH and mean annual temperature were included as covariates
- The modelled relationship was used to predict vascular plant species richness change between 1800 and 2000

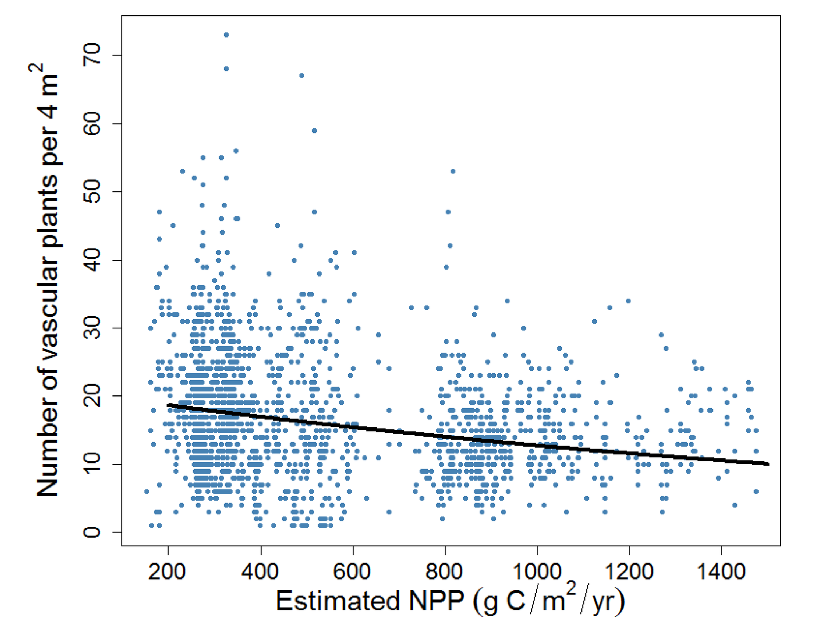

Figure: modelled relationship between vascular plant richness and net primary productivity (NPP).

Plant species richness was negatively related to net primary productivity

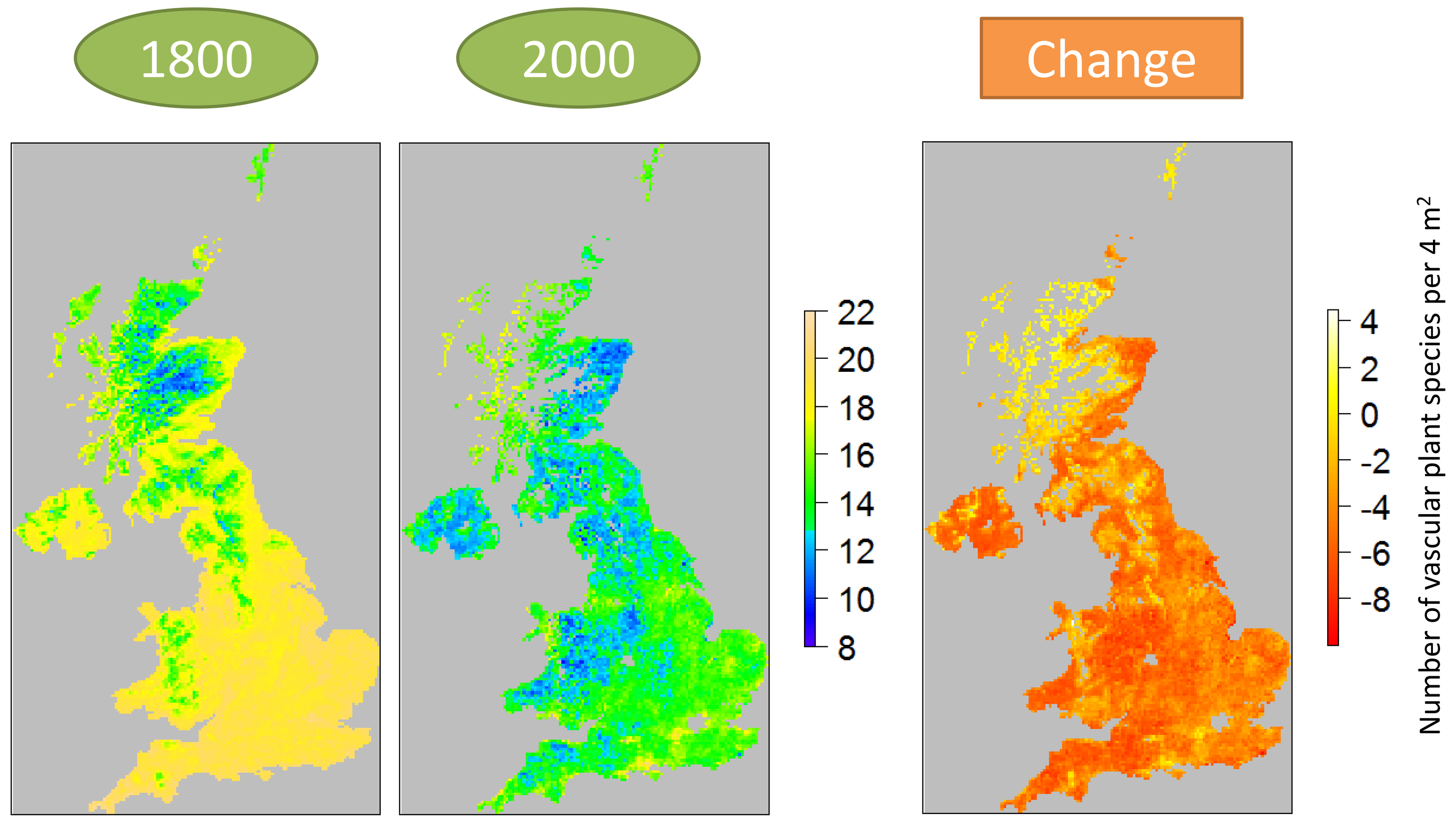

Figure: predicted vascular plant species richness per 4 m^2 for 1800 and 2000, with the change in predicted richness over this time period. Grey areas indicate no data.

Conclusions

- Plant species richness shows a negative relationship with modelled NPP, suggesting low-mid productivity habitats are most species rich
- The model indicates richness of vascular plants per 4 m^2 quadrat has declined substantially between 1800 and 2000, likely related to both land use change and increased nitrogen deposition
- Loss of taxa was estimated to be highly variable spatially, but least in north-west Scotland

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