The importance of phosphorus for nitrogen acquisition by ombrotrophic peatlands

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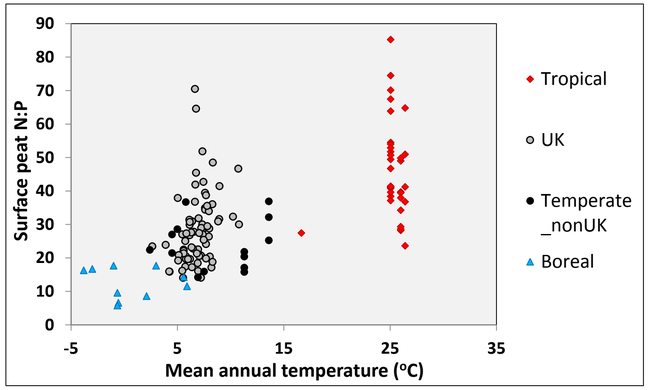

Fig. 2 The relationship between surface peat N:P & MAT for each site.

Introduction

- Interrelationships amongst C, N & P are of particular importance because primary production & all ensuing ecosystem pathways are frequently limited by N &/or P.
- Despite major advances in our understanding of C cycling & the role of N in peatlands, we know substantially less about peatland P dynamics.
- In ombrotrophic peatlands in particular P is a particularly scarce resource. Whereas N can be obtained by biological fixation from abundant atmospheric N_2, the only sources of P are atmospheric deposition, possible upward transfer from substrate, & for less extensive peatlands potential lateral transfer from surrounding ecosystems.
- We propose therefore that P availability is a critical factor controlling peatland systems, & that it is highly likely that P availability ultimately limits peatland N acquisition – either via limiting N fixation from atmospheric N_2 &/or by a stoichiometric restraint to the incorporation of N into biomass.
- There is a scarcity of research, however, considering the relationship between N & P in peat.
- In order to address this we collated measurements of surface ombrotrophic peat N & P from boreal, temperate & tropical regions.

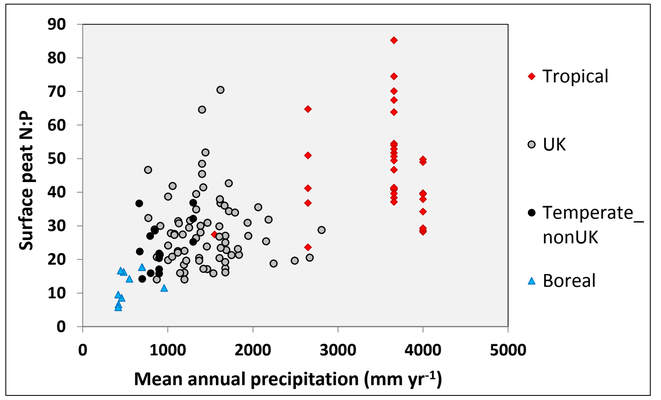

Fig. 3 The relationship between surface peat N:P & MAP for each site.

Results

- We collated data for surface % N & P from 134 ombrotrophic peatlands: 73 UK, 17 temperate non-UK, 34 tropical & 10 boreal sites (Fig. 1).
- Surface peat % N was significantly positively correlated (linear regression (LR)) with surface peat % P overall & for each region:

  Overall: $R^2 = 0.26$, $P<0.001$

  Tropical: $R^2 = 0.71$, $P<0.00$ UK: $R^2 = 0.51$, $P<0.001$

  Temperate_non-UK: $R^2 = 0.34$, $P = 0.014$ Boreal: $R^2 = 0.41$, $P = 0.046$
- The trajectory of the relationship between surface peat % N & P differed amongst regions, with the gradient of the slope being highest for tropical sites, lowest for the boreal sites & intermediate for the temperate sites, corresponding to mean N:P ratios of:

  Tropical: 47 ±se 2.5 UK: 29 ±se 1.3

  Temperate_nonUK: 23 ±se 1.9 Boreal: 12 ±se 1.5
- Overall, surface peat % N was also significantly positively correlated (LR) with MAT & MAP:

  MAT $R^2 = 0.14$, $P<0.001$; MAP $R^2 = 0.26$, $P<0.001$
- Overall, surface peat N:P ratio was significantly positively correlated (LR) with MAT & MAP

  MAT $R^2 = 0.42$, $P<0.001$ (Fig.2); MAP $R^2 = 0.38$, $P<0.001$ (Fig.3)
- There was no correlation between either % N or N:P & nitrogen deposition.

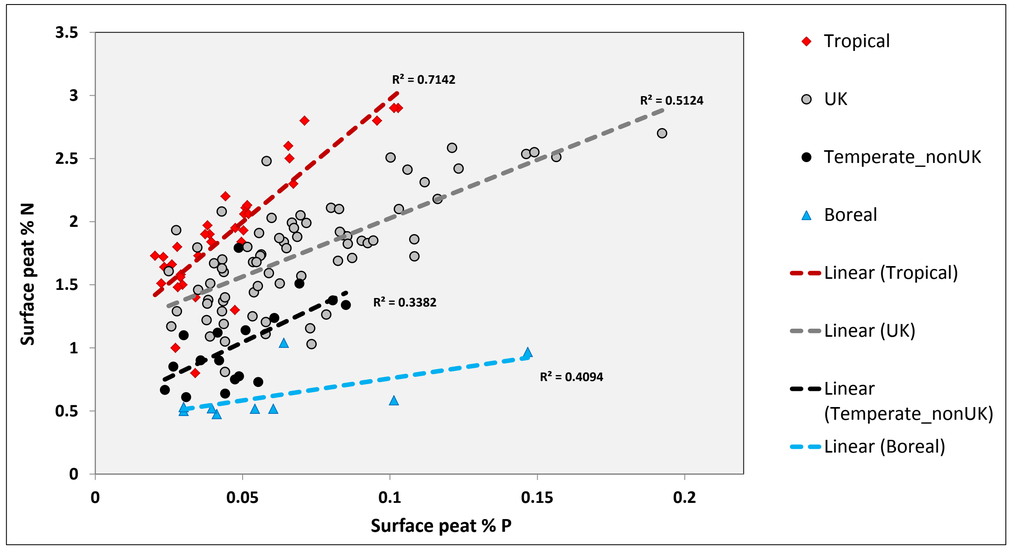

Fig. 1 The relationship between surface peat % N & % P for each site (regressions shown for each broad climate region separately).

Conclusions

- The strong positive relationship between N & P concentrations in surface ombrotrophic peat suggests that N fixation &/or immobilisation into peatland systems is dependent on P availability.
- This relationship between N & P availability is likely therefore to significantly influence peatland productivity, microbial processing & C storage.
- Alongside P, surface peat N concentrations were also positively correlated with MAT & MAP.
- Furthermore, that surface peat N:P ratios were positively correlated with MAT & MAP suggests that in warmer, wetter regions, proportionally more N is incorporated into surface peat per unit P than in colder, drier regions (as shown by the differing trajectories of the relationship between P & N for each climatic region).
- This suggests a more efficient use of P in peat N incorporation at warmer temperatures.
- Possible precipitation effects include high precipitation lowering the risk of summer drying of surface peat & associated impacts on N fixation/immobilisation.
- Strong positive correlation (LR) between MAT & MAP overall for the dataset (R^2=0.80, $P<0.001$), however, limits interpretation of their individual influence on peat N dynamics.

Methods

- Values for surface (0-20 cm max.) peat % N & % P were collated from ombrotrophic peat sites: UK values unpublished data from CEH & JHI; remainder from published literature.
- Data analysis was conducted for all sites overall & for sites grouped by broad climatic regions: tropical, temperate & boreal (temperate divided into UK & non-UK as UK data the largest dataset).
- To explore influences of climate & N deposition on peat surface % N, mean annual temperature (MAT) & precipitation (MAP) & total annual inorganic N deposition was collated for each site: UK MAT & P from the UK Met Office (means 1970-2000), & Ndep from 2006-08 derived by the CBED model (Smith RI *et al*. 2000 *Atmos.Env.* **34**). All other sites MAT & P either from each publication or Oak Ridge National Laboratory, DAAC Climate Collections Data archive, U.S.A, & Ndep for 1993 from Dentener FJ (2006) 'Global Maps of Atmospheric N Deposition' Oak Ridge National Laboratory.