The PEATBOG* Project: Science into Policy

*Impacts of Nitrogen Deposition on the Ecology and Biogeochemistry of European Peat Bogs

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Outline

1. The PEATBOG Project
2. Some science results
3. Policy/stakeholder communication
4. Conclusions

Background

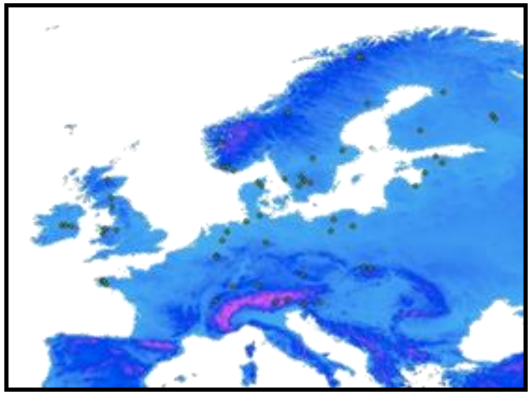
- Ombrotrophic bogs are *directly* influenced by precipitation chemistry
- In Europe they form in cool, wet conditions
- They support vegetation adapted to cool, waterlogged, low-nutrient environments (*Sphagnum*, sedges, ericacious plants, etc)
- They are potentially vulnerable to both N deposition and climate change

Aims of PEATBOG

To understand how the **biodiversity** and ecosystem **functioning** of peatlands across Europe are impacted by **nitrogen** pollution, and how this may affect sensitivity to **climate change**

To develop **policy** recommendations and **indicators** of risk to these impacts.

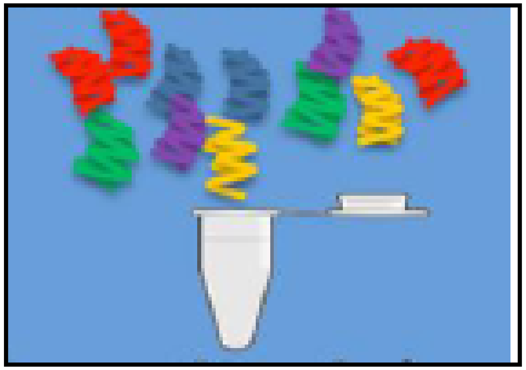
Project Structure



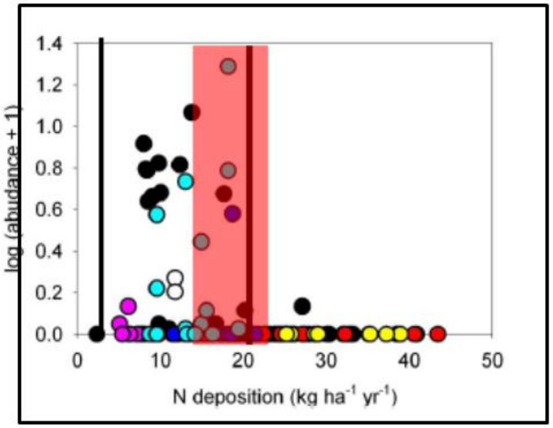
European Survey

Field Manipulations

Processes

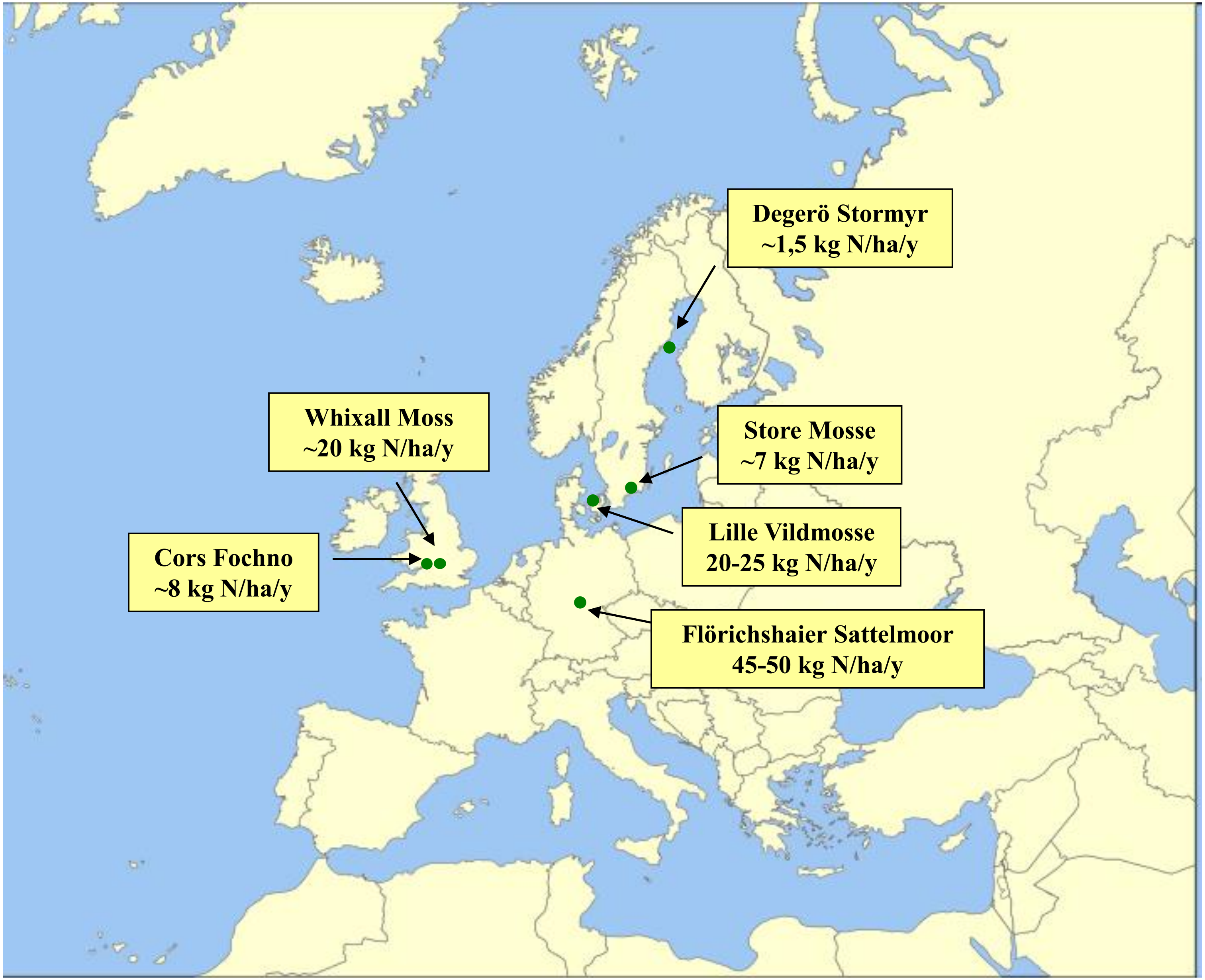


Microbial Diversity



Indicators, Models, Upscaling

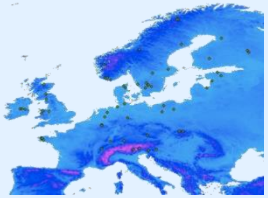
‘Intensive’ Sites



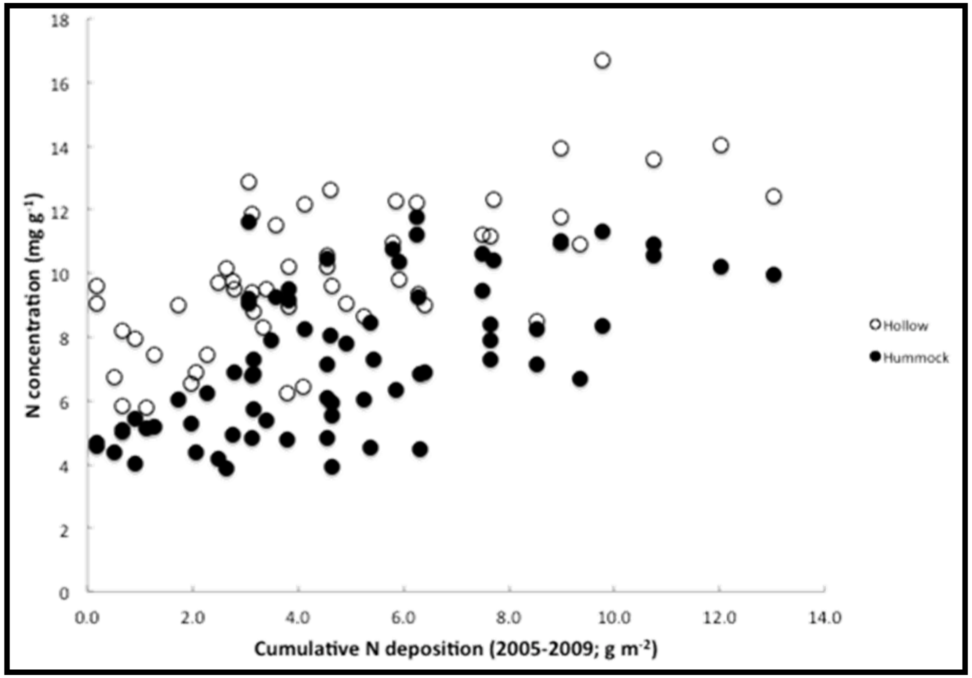
(some) Results:

Biogeochemistry

As atmospheric N deposition increases. . .



- *Sphagnum* accumulates N
- Vascular plants accumulate N
- The ecosystem becomes N-enriched



N breaks through to lower peat

N (kg/ha/y)

2

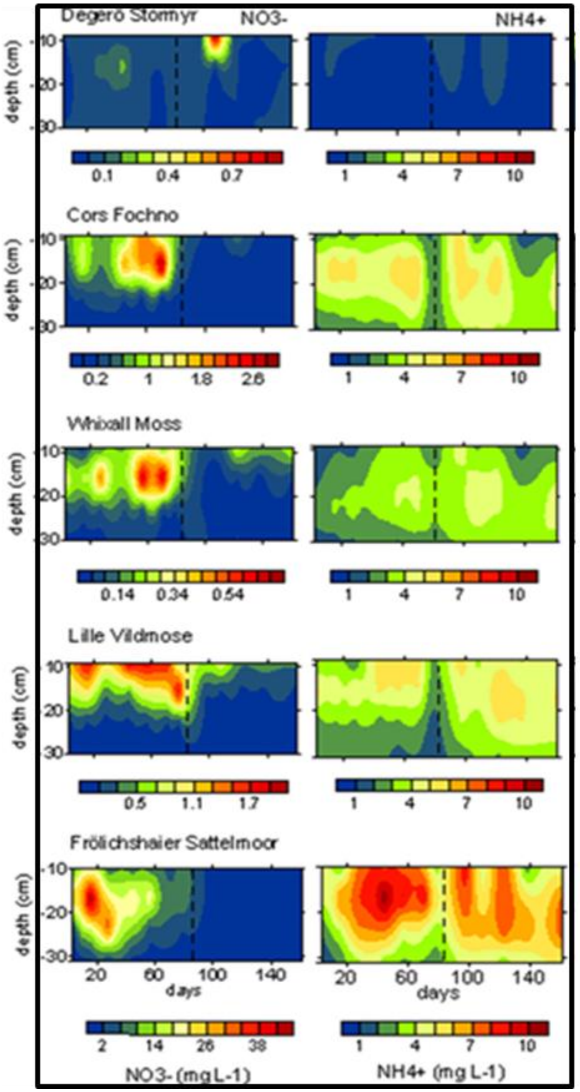
8

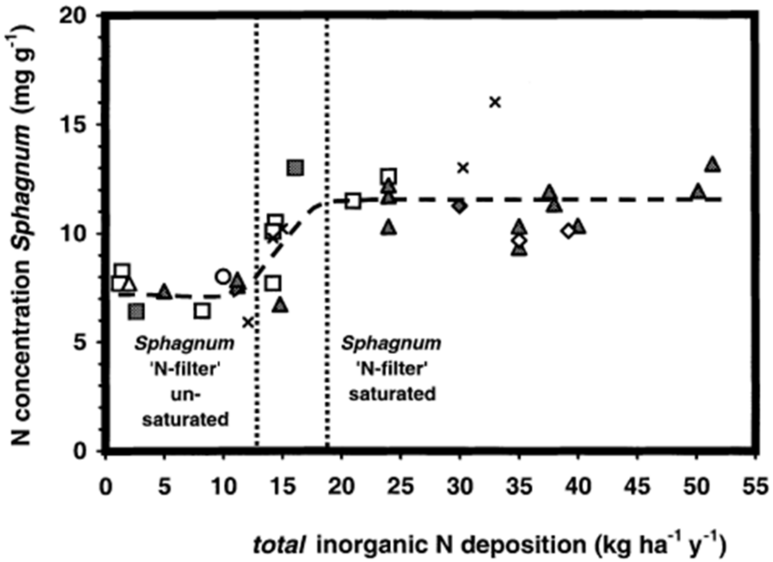
20

26

48

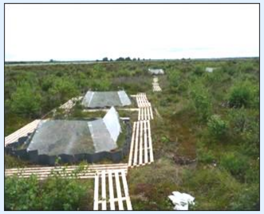
NO_3^- **NH_4^+**

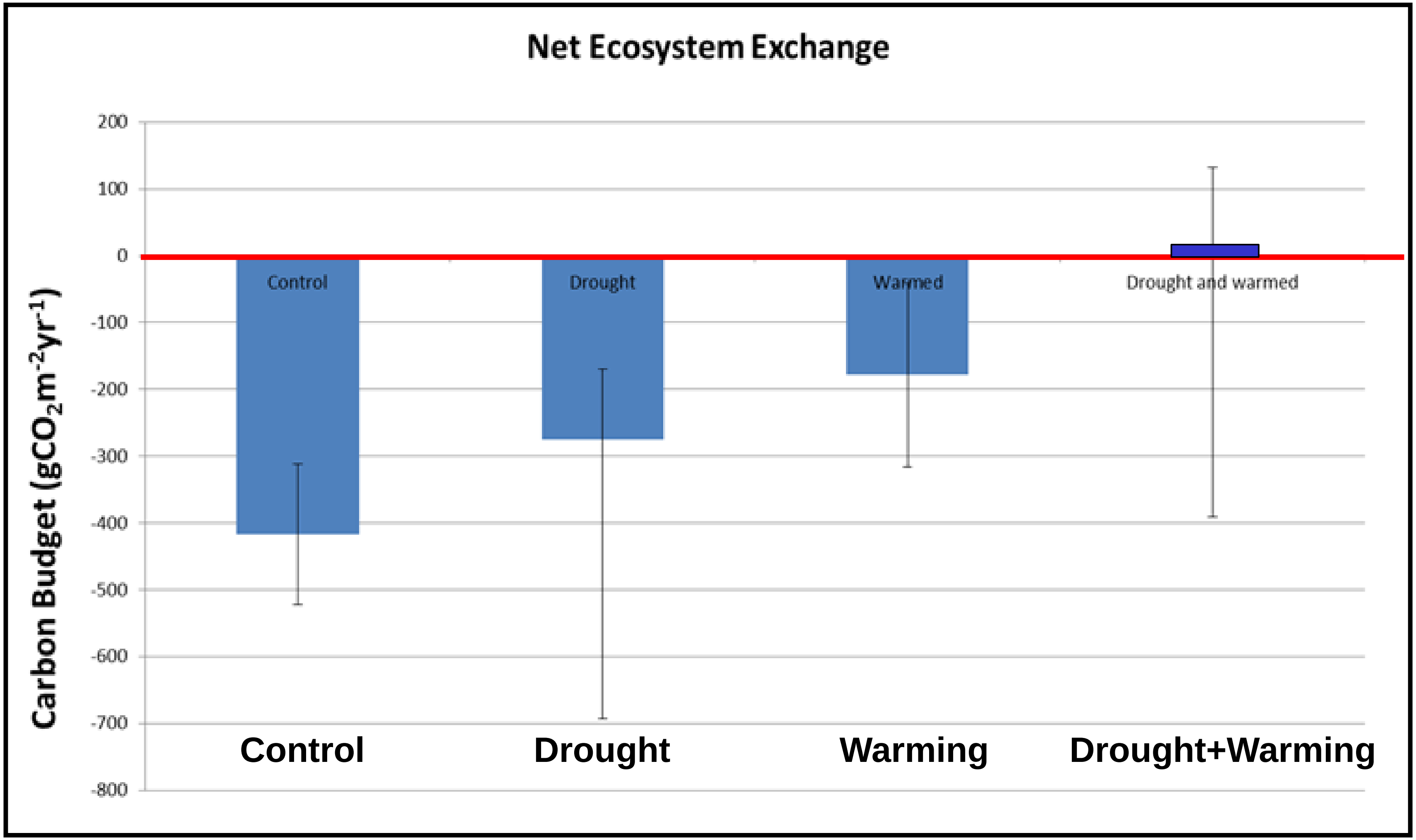




Lamars et al.., *GCB* 2000

C sequestration declines with warming and drought



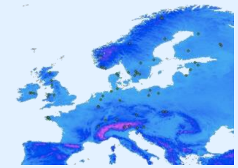


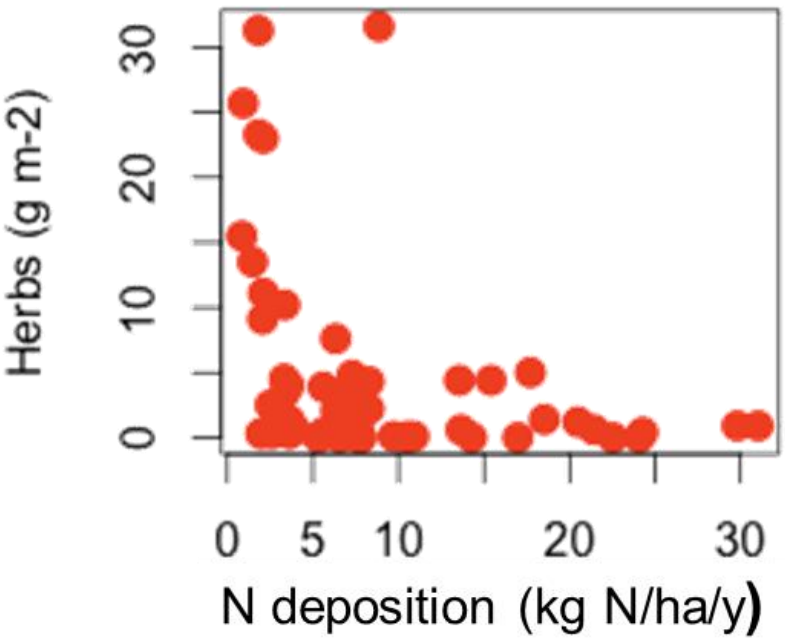
Cors Fochno, Wales

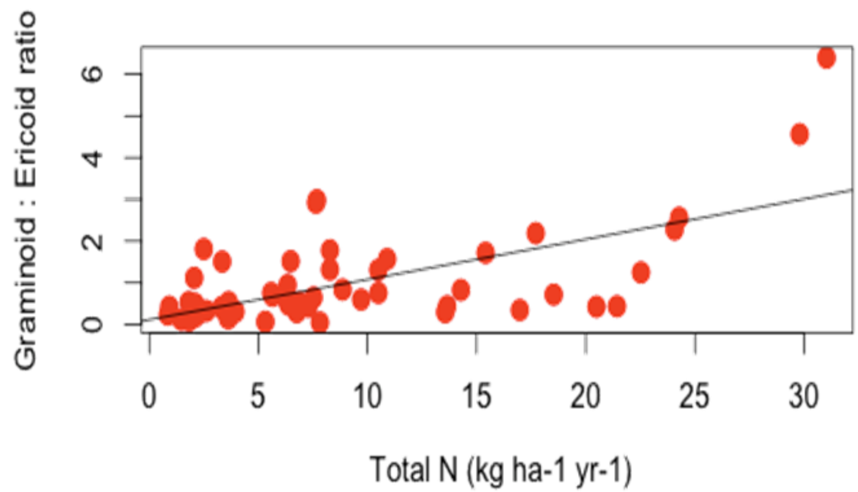
(some) Results:

Vegetation Community

Forb biomass declines, graminoid abundance increases







Most N-enriched sites showed highest growth of vascular plants with warming and aeration

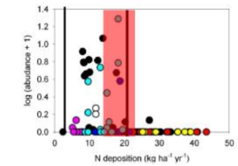
6.11.2009

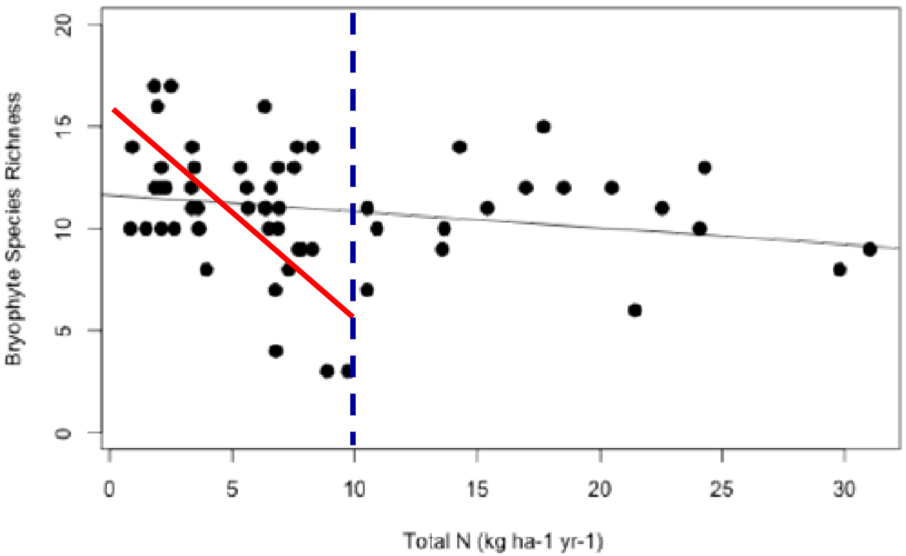
14.01.2010

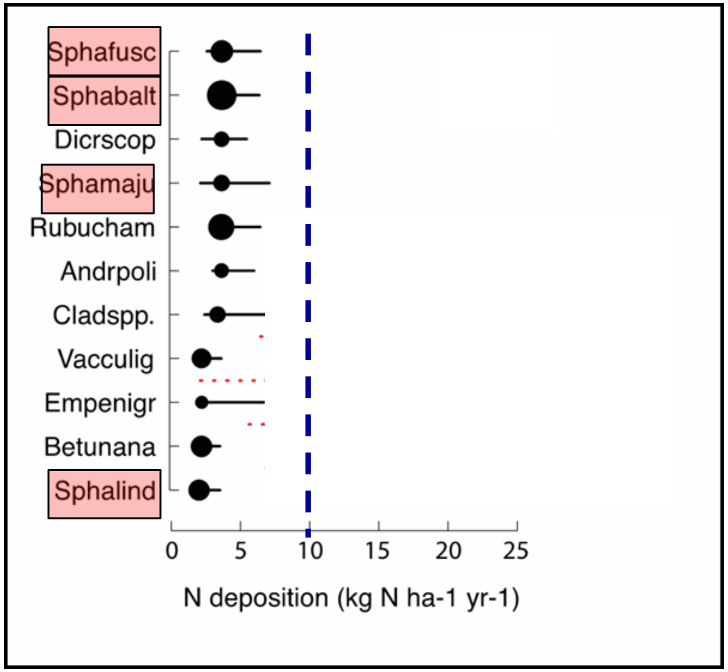
23.03.2010

Froelichshaier Moor

Species richness of bryophytes and forbs declines…

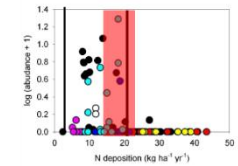


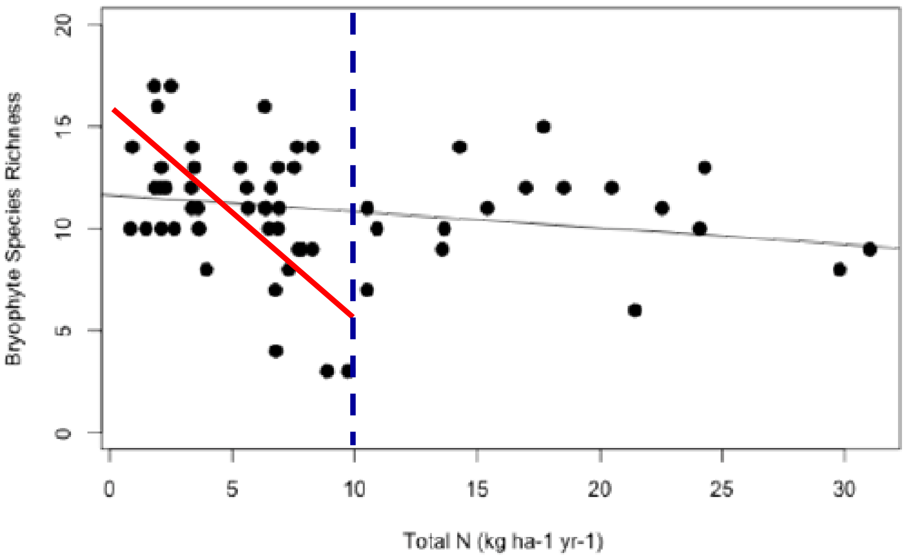


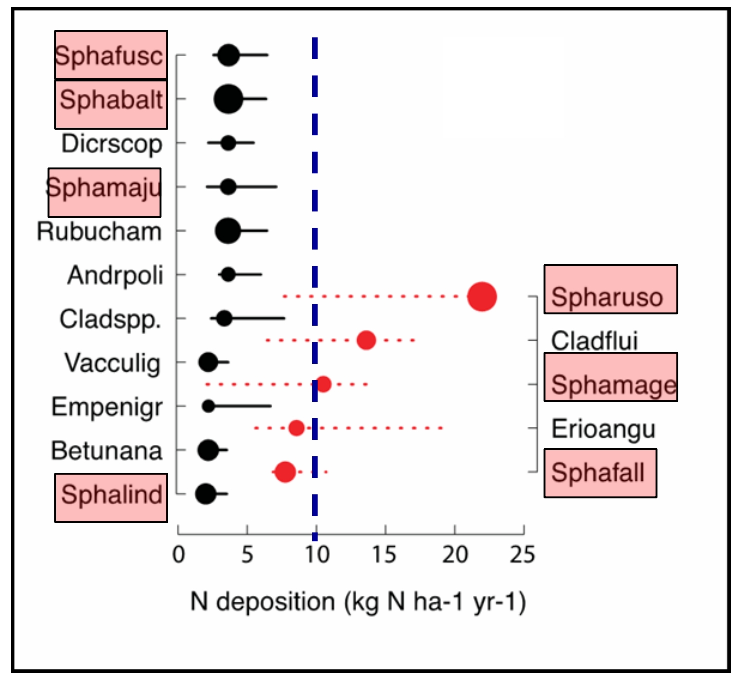


…and then partially ‘bounces back’.

Species richness of bryophytes and forbs declines…

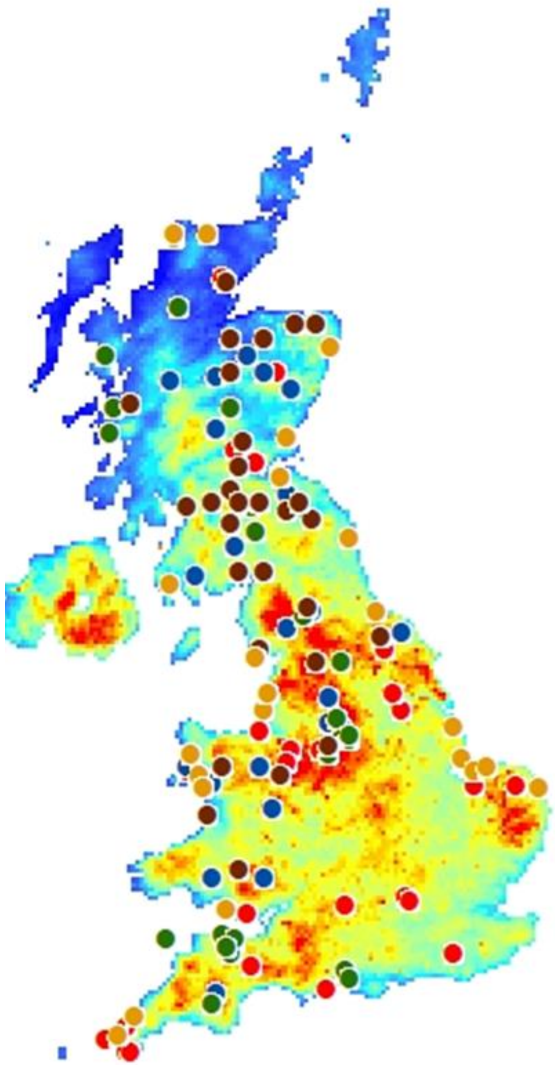


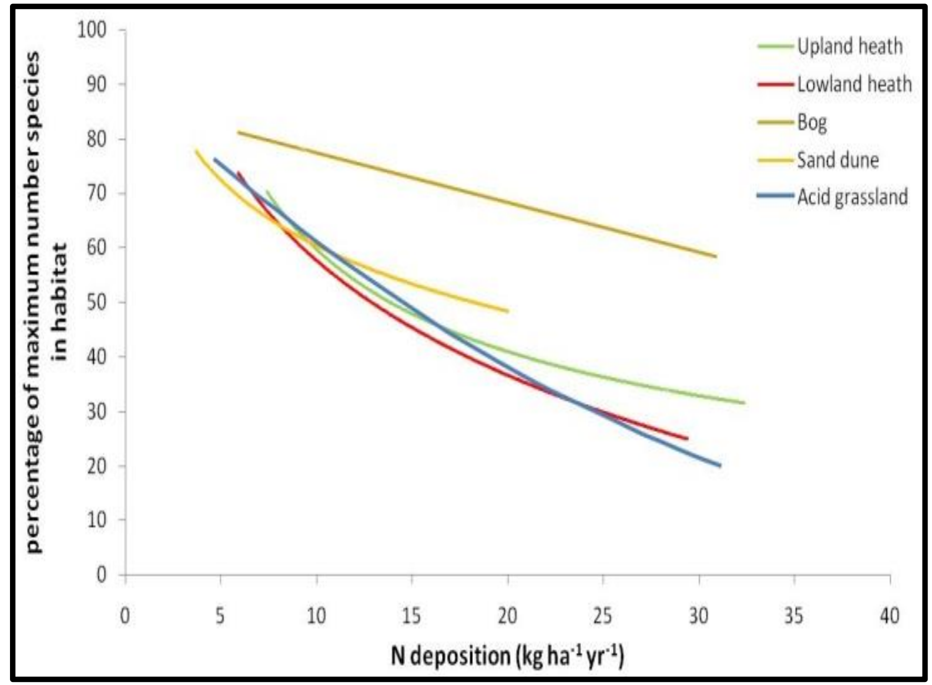




…and then partially ‘bounces back’.

Relative species decline in bogs is less than other sensitive ecosystems





Acid grasslands
Lowland heaths
M19 Bogs
Sand dunes
Upland heaths

Field et al., *Ecosystems* 2014

Science summary: as N increases…

- Peat bogs become N-enriched
- N can ‘break through’ to lower layers
- Species richness and diversity decline, but less than other ecosystems
- Long-term C storage may decline as peat-building *Sphagnum* species decline
- Vascular plants respond more vigorously to warming and aeration
- Warming and drought may shift peatland from C sink to C source

Science to Policy




Core Advisory Group

- Seven members encompassing European policy and conservation arenas
- Involved in project from the start
- Frame research into contexts that are relevant, useful and transferable to policy
- Members: ***Till Spranger*** (critical loads), ***Alastair Burn*** (peatland biodiversity), ***Ben Ten Brink*** (biodiversity policy), ***Jan Willem Erisman*** (nitrogen impacts), ***Matti Johansson*** (UNECE Convention on transboundary pollution), ***Hans Joosten*** (peatlands, carbon and climate), ***Sarah Raper*** (IPCC)

Stakeholder / Scientists Group

- Wider group representative of science, policy, management and the public ~50)
  - Registered on the project website: (www.egs.mmu.uk/peatbog)
  - Receive updates about the project
  - Invited to comment at any stage
- Input to the project via web-based communication, attendance at project meetings, and through visits and presentations by project members.
- Invited to final project presentation and conference

Policy Briefs

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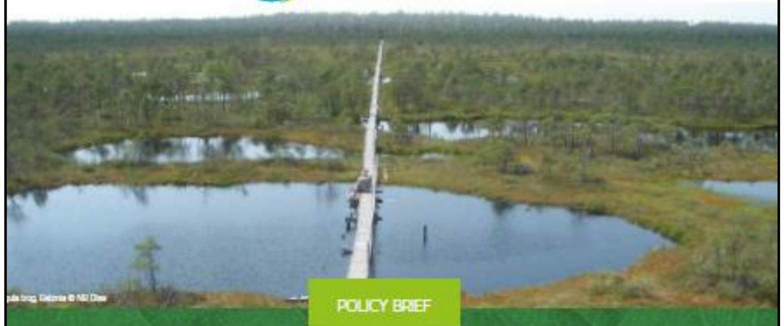

Nitrogen pollution and climate change reduce carbon storage and biodiversity of peatlands

Peatland ecosystems store exceptionally high amounts of carbon as peat. Globally, peatlands contain twice as much carbon as all forests combined, while only covering 3% of the Earth's land space. The average loss of only a centimeter of peat from the world's peatlands would release an amount of carbon dioxide (CO_2) equal to about one third of the global annual fossil fuel combustion. Peatlands have been drained and mined for centuries to exploit their carbon-rich soil for agriculture, forestry, fuel and horticulture. This turns peatlands from a carbon "sink" to a carbon "source", and drained peatlands now account for almost 6% of the world's man-made CO_2 emissions every year. The EU is the world's second largest CO_2 emitter from drained peatlands after Indonesia.

Much of the focus on peatland protection in Europe has been on mitigating direct physical impacts. This policy brief focuses on the far less recognized indirect and 'unseen' threats to peatlands: air pollution and changes in precipitation, temperature and nutrients. It is based on the results of the BiodivERsA PEATBOG project investigating the impacts of nitrogen pollution and climate change on the biodiversity and ecosystem functioning of peatlands across Europe.

Main findings

- Elevated **reactive nitrogen deposition can change the functioning and biodiversity of peatlands**, and **increase their sensitivity to climate change**;
- Enhanced reactive nitrogen increases the growth of vascular plants at the expense of peat-forming mosses;
- Warming and drought of nitrogen-enriched peatlands **threaten their long-term carbon storage capacity** and **release stored CO_2 into the atmosphere, contributing to climate change.**

Key policy recommendations

- It is advised that **a network of early warning systems be set up in peatlands across Europe** to monitor changes in nitrogen saturation, biodiversity, and carbon sequestration;
- **'Nitrogen pollution protected areas'**, analogous to marine protected areas, should be established in the most vulnerable peatland areas in Europe;
- It would be beneficial to **include the protection of peatlands in the aims of the EU Water Directive**;
- **Peatland restoration could be incorporated into carbon accounting rules** under the EU Climate Package and national accounting;
- Member States should be encouraged to **designate all potential carbon storage 'hot-spots', including peatlands, as sensitive areas under the reformed Common Agricultural Policy (CAP)**;
- Cross-compliance standards set by the CAP, particularly **the EU Nitrate Directive and its enforcement by Member States, could help limit nitrogen release via leaching or volatilisation from agriculture in sensitive peatland areas.**

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Synthesis of research results relevant to the European and Central Asia Assessment of the IPBES

Combined Nitrogen deposition and climate change leave European peatland at risk

Relevant for Chapters 2, 3 and 4 of IPBES assessment for ECA

C sequestration / Peatland environments / N fertilization & climate change

+ highlight on critical N loads and the notion of threshold value

The BiodivERsA PEATBOG project (funded over 2009 to 2013) conducted a Europe-wide study (59 peatland study sites in 14 countries) on the implications of nitrogen deposition and climate change on peatland biodiversity and biogeochemistry. We reported:

→ That European peatlands are increasingly accumulating N in *Sphagnum* moss and peat. With the highest N deposition, more N percolates down to lower soil layers[1, 2].

→ That peatlands appear to be more resilient to loss of species richness due to N pollution than other sensitive terrestrial habitats. Wet and cold conditions restrict the growth of non-peatland species, and *Sphagnum* species intolerant to pollution tend to be replaced by more pollution-tolerant species[3, 4].

→ That despite apparent resilience to background levels of pollution, *Sphagnum* is particularly sensitive to acutely high concentrations of gaseous or aerosol N such as concentrated ammonia downwind from intensive agricultural operations. Damage would increase should agricultural production continue to intensify[2, 5].

→That peatlands enriched with N accumulated over decades, even at modestly elevated levels, may be poised to change rapidly should the environment become more favourable for the invasion of grasses and shrubs through warming and drying (Figure 1). As these vascular plants sequester far less carbon over the long term than peat-forming *Sphagnum*, the key peatland quality of removing and storing carbon over hundreds or thousands of years would be lost if this occurred[3, 5, 6].

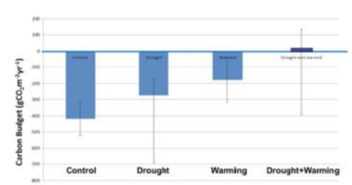

Figure 1: Net carbon balance of a peatland receiving intermediate background atmospheric nitrogen deposition (field experimental site at Cors Foncho, Wales), with experimental drought, warming and combined treatments as compared to control (ambient) conditions. Negative and positive values indicate a net carbon storage and emission, respectively.

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1 Phoenix G.K., Emmett B.A., Britton A.J., Caporn S.J.M., Dise N.B., Helliwell R., Jones M.L.M., Leake J.R., Leith I.D., Sheppard L.J., Sowerby A., Pilkington M.G., Rowe E.C., Ashmore M.R., Power S.A. (2012) Impacts of atmospheric nitrogen deposition: responses of multiple plant and soil parameters across contrasting ecosystems in long-term field experiments. *Global Change Biology* 18(4):1197-1215

2 Wu Y., Blodau C. (2015) Vegetation composition in bogs is sensitive to both load and concentration of deposited nitrogen: A modeling analysis. *Ecosystems* 18(2):171-185

3 Field C.D., Dise N.B., Payne R.J., Britton A.J., Emmett B.A., Helliwell R.C., Hughes S., Jones L., Lees S., Leake J.R., Leith I.D., Phoenix G.K., Power S.A., Sheppard L.J., Southon G.E., Stevens C.J., Caporn, S.J.M. (2014) The role of nitrogen deposition in widespread plant community change across semi-natural habitats. *Ecosystems* 17:846-877

4 Robroek B.J.M., Wubs E.R.J., Martí M., Zając K., Andersen J.P., Andersson A., Börjesson G., Bragazza L., Dise N.B., Keuskamp J.A., Larsson M., Lindgren P.-E., Mattiasson P., Solomonsson J., Sundberg C., Svensson B.H., Verhoeven J.T.A. (2014) Microclimatological consequences for plant and microbial composition in Sphagnum dominated peatlands *Boreal Environment Research* 19:195–208

5 Wu Y., Blodau C., Moore T.R., Bubier J., Juutinen S., Larmola T., (2015) Effects of experimental nitrogen deposition on peatland carbon pools and fluxes: a modelling analysis. *Biogeosciences* 11:1-23

6 Kuiper J.J., Mooij W.M., Bragazza L., Robroek B.J.M. (2014), Plant functional types define magnitude of drought response in peatland CO2

Main Findings and Recommendations

Main Findings:

-High N can ‘prime’ peatlands to rapid change

-High N increases vascular plant growth at the expense of mosses

-Warming and drought can shift bogs from C sinks to C sources

Recommendations:

-Early warning systems

-N-protected areas

-Include peatland protection in EU Water Directive, EU Climate Package, EU Nitrate Directive and reformed CAP

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PEATBOG Science into Policy…

Went well:

- Involving policymakers / stakeholders from the start
- BiodivERsA emphasis and action on science-policy communication
- Communicating a simple,visual message

Went less well:

- Scientists’ view of policy as an afterthought
- Reluctance of policy management to commit staff time to science projects
- Limited involvement of wider group
- Communicating a more complicated, less visual, or less ‘popular’ message

Peat Bogs Are Tougher Than We Thought

But N may prime them to change rapidly in response to an acute climate event.

This calls for **vigilance** in monitoring and protecting them.

Thanks to…

- European FP6 programme, BiodivERsA ERA
- UK funding agencies NERC, Defra
- National funding agencies of all partners
- PEATBOG Advisory and Stakeholder/ Scientists Group
- National resource managers, conservation organisations and landowners for access to sites

SIXTH FRAMEWORK PROGRAMME

Thank You!

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