PEATBOG

Nitrogen Pollution and Climate Change Threaten Peatland Biodiversity and Biogeochemistry

OBJECTIVES

Meter for meter, peatlands store more carbon than any other terrestrial ecosystem. Peatlands also support unique biological communities and provide important ecosystem services such moderating flood risk and removing pollutants. These exceptional ecosystems are threatened by environmental change, particularly climate warming, increased summer drought, and atmospheric deposition of reactive nitrogen (N). Many studies have shown that increased N deposition favours fast-growing species such as grasses at the expense of species adapted to low nutrient levels, including many mosses. It is feared that the elevated N deposition due to intensified agriculture and fossil fuel combustion, together with warmer and drier summers, could favour grasses and shrubs over the characteristic peat-forming Sphagnum moss and specialised plants such as the insectivorous sundew. Beyond compromising the unique biodiversity of these habitats, it would severely impact the ability of peatlands to remove and store atmospheric CO_2 by growing and accumulating *Sphagnum* moss.

The aim of PEATBOG was to provide new understanding of both the sensitivity and resilience of peatlands to environmental change, and give meaningful guidance to policy-makers and managers on the risk posed to peatland ecological and functional integrity by air pollution and climate change.

APPROACHES

PEATBOG gathered researchers from five countries with the over-arching goal of understanding how N deposition, warming and drought impact the ecological communities and ecosystem services provided by European peatlands. They carried out a survey of the above- and below-ground biodiversity of 59 peatlands across Europe, combined with laboratory and field experiments on hydrology, temperature and carbon and nitrogen cycling and storage.

MAIN ACADEMIC FINDINGS

- PEATBOG discovered that European peatlands are increasingly accumulating N in *Sphagnum* moss and peat. With the highest N deposition, more N percolates down to lower layers [75, 76].
- By some measures, peatlands are more resilient to N pollution than other sensitive habitats. It appears that wet and cold conditions restrict the growth of non-peatland species, and that more pollution-tolerant *Sphagnum* can replace species adapted to nutrient-poor conditions [77, 78].
- 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. Should agricultural production continue to intensify, such direct damage to peatlands from N will increase [76, 79].
- In addition, 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. As these vascular plants sequester far less carbon over the long term than peat-forming *Sphagnum*, the key peatland quality of slowly removing and lastingly storing carbon would be lost if a replacement occurs [77, 79, 80].

Thus climate change, together with long-term elevated N deposition across large areas of peatland in Europe, render the risk of reaching a tipping point in peat land biodiversity and biogeochemistry very realistic. The team incorporated these results in the “PEATBOG model” [76, 81], a tool intended to predict long term responses of a peatland to different climate and pollution scenarios.

Consortium partners:

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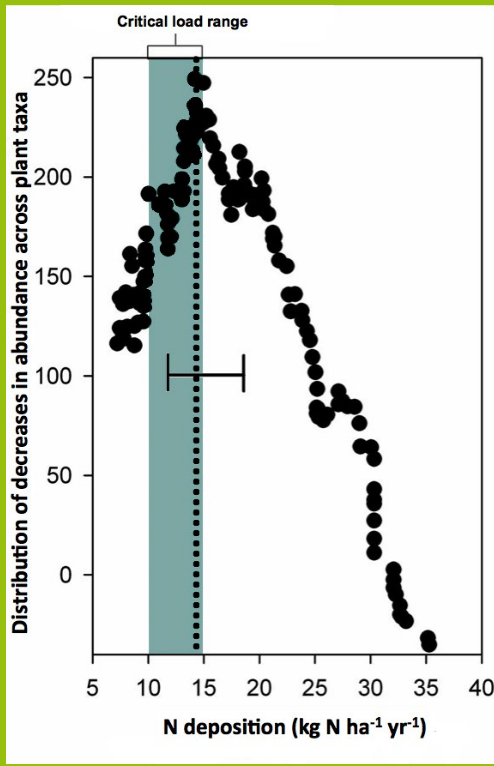
ACADEMIC RESULT HIGHLIGHT

Using a large data set from European peatland along a gradient of nitrogen deposition, the PEATBOG team evaluated critical nitrogen loads, a key index of policy tools for the assessment of air pollution. They found that close to 60% of vegetation species reduced in polluted environments start declining at or below the currently established critical N load range (see figure). If this result is verified more widely, the underlying principle of "no-harm in pollution" policy may need to evolve into one of "how much harm is acceptable".

* Payne *et al.* (2013) Impact of nitrogen deposition at the species level. *Proceedings of National Academy of Sciences of the USA* 110: 984-987

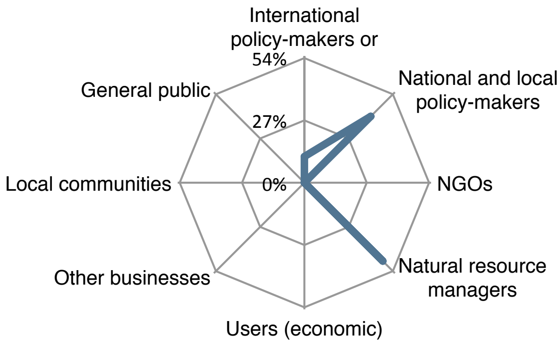


Vegetation community change for species reduced in abundance showing critical load, inferred community threshold (dotted line) and 5-95% bootstrap percentage range. After Payne et al. 2013 (PNAS)

STAKEHOLDER ENGAGEMENT AND PRODUCTS RELEVANT TO SOCIETY/POLICY

The PEATBOG team interacted with policy advisors and other stakeholders at European or local level (see Figure) using two bodies in the governance of the project:

- A Core Advisory Group gathered advisors in EU policy on climate change, pollution, and biodiversity and peatland conservation. They were involved very early in the process, providing advice on research aspects that were particularly relevant for policy. They were then kept regularly informed of project progress and results.
- A mixed scientist and stakeholder group collaborated during the cross-European survey for field work and data analysis, in some cases co-authoring papers.
- The large-scale survey was an opportunity for the team to exchange with an important number of local and national authorities and protected areas managers owning land of the study sites about the project's work and findings.



Types of stakeholders engaged in PEATBOG

- PEATBOG organised a science/policy conference during the 2013 meeting of the Society of Wetland Scientists on « Integrating science with policy and management priorities ».
- PEATBOG also suggested the need for a pan-European monitoring scheme acting as an early warning system.

HIGHLIGHTS ON SOCIETY/POLICY-RELEVANT PRODUCTS

- **PEATBOG tool to develop scenarios for peatlands under global change**, based on key project's findings (individual indicator plant species, efficacy of critical loads for biodiversity, …). The PEATBOG model can be used on demand by scientists, policy-makers and managers to predict the long-term response of a peatland to different scenarios of changing climate and pollution. (see reference 81).
- **Sensitivity maps:** using information on nitrogen-related changes in plant community composition, sensitivity maps were produced for grassland, peatland and heathland across the UK (Payne *et al.*, Nitrogen deposition impacts on national scale vegetation biodivesity over time, in preparation).