Durham University
Department of Earth Sciences

Prof. Fred Worrall: Fred.Worrall@durham.ac.uk
Dr. Catherine Hirst: Catherine.Hirst@durham.ac.uk

How can peatlands exist when they don't have enough electrons?

1. Background

The most efficient carbon (C) store in the terrestrial biosphere are our peatlands. The problem is that we do not know what controls the amount of carbon stored in peatlands. The very reason for the existence of the peatlands – is the balance between the rate of primary production and the rate of oxidation. Oxidation of organic matter can occur via a range of terminal electron acceptors (TEA) and will occur via the most energetically favourable TEA available. The most favourable TEA in natural environments is O_2, followed in succession by NO_3, Mn, Fe, SO_4 and ultimately methanogenesis. Boothroyd et al. (2021) have shown that a peatland could reduce all the SO_4 supplied to it even if that did not actually happen. Worrall et al. (2022) have shown that methanogensis is so energy consumptive that methane formation does not result in any long term deep peat formation. When comparing the SO_4 budget, the C budget and the CH_4 budget there is a gap – the amount of SO4 removed and the amount of CH4 produced and of peat formed do not match and means there is not enough electron capacity to explain the amount of peat formed. There is not enough electron capacity provided by inorganic electron acceptors in peatlands to give rise to the amount of carbon storage we observe. **Therefore, where is the electron capacity coming from that explains the existence of peat?**
This project proposes that the solution to this observed deficit in electron supply lies in dissolved organic matter (DOM) acting as an electron shuttle. Worrall et al. (2022) have shown that there is enough oxic DOM leaving a peatland that if only 8% would exchange with deep peat pore water then there would be sufficient electrons to explain the peat carbon storage.

2. Methods

The project will combine field and laboratory studies.

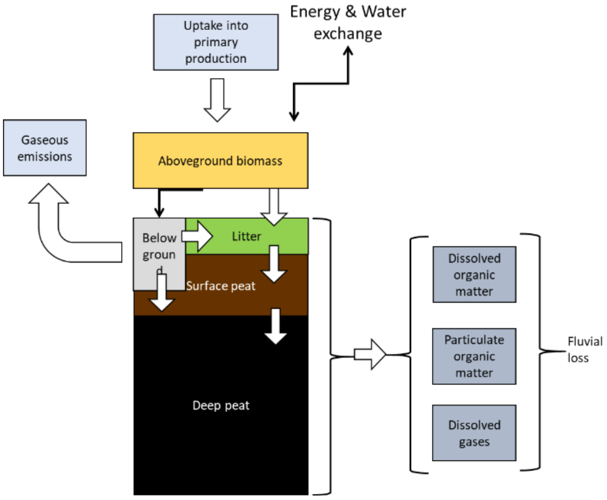

Fig.1. A schematic diagram of the carbon flows and transitions into and through a peat soil.

Field studies: multi-level piezometers will be installed across a blanket bog slope from the watershed to a first-order stream. The first purpose of the multilevel piezometers will allow access to the peat porewater at multiple depths meaning that the redox sequence can be studied relative to the flow and diffusion of DOM. In the sampled porewaters we will measure: pH, specific conductance and redox potential; concentrations of the inorganic redox species – NO_3, Fe, Mn, SO_4; and DOC concentration and composition. The composition of the DOC will be analysed for its oxidation state and also its age. The second purpose of multi-level piezometers will be to measure the potential of a vertical flux of water and of redox active ingredients. For the project's hypothesis to be true, the oxic DOM observed in first-order streams has to exchange with the reduced DOM in the porewater and so there must either be flow of water or diffusion in the vertical profile.
Laboratory studies: fieldwork will be supported by peat mesocosms established in Durham. These mesocosms are a set of 1 m deep peat cores outside of the department where we can control the water table and these enable us to performed controlled experiments and to monitor carbon fluxes relative the concentration of

redox species in porewater and redox conditions through the peat profile.

3. Scientific benefits

The project has a number of important benefits. If we can identify the importance of the each oxidation then we can create models for the prediction of the carbon balance of these globally important carbon stores. The approach to predicting carbon balance demonstrated by Worrall et al. (2022) requires a knowledghe of the roles of redox species.

4. Training

The student will work alongside other postgraduate students, post-doctoral researchers and staff working on this and allied projects. project will provide the necessary training in all tareas of research and so the project brings together three types of research – field measurements, laboratory experiments and statistical analysis. The project has secured access to Moor House National Nature Reserve.

5. Further information

Worrall, F., et al. (2022). Constraining the Carbon Budget of Peat Ecosystems: Application of Stoichiometry and Enthalpy Balances. *Journal of Geophysical Research - Biogeosciences 127, 10, Art. No. e2022JG007003*

Boothroyd, I.M., et al. (2021). Sulfur Constraints on the Carbon Cycle of a Blanket Bog Peatland. *Journal of Geophysical Research - Biogeosciences 126, 8, Art. No. e2021JG006435*

Contact: Fred.Worrall@durham.ac.uk