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Towards a microbial process-based understanding of the resilience of UK peatland systems

Inside the black box

Martin Evans,
Clare Robinson,
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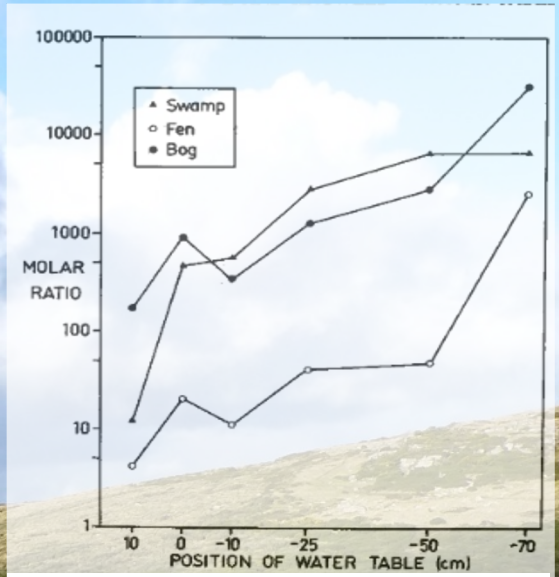
Jonathan Ritson

www.peatlandmicrobes.com

NERC UK Climate Resilience Programme

Aim to bring together peatland scientists, microbial ecologists and peatland practitioners to develop a research community with the multidisciplinary skills to investigate the role of microbes as a key mechanistic control on both the climate regulation function of peatlands and the resilience of that function to climate change.

Unlocking the microbial black box



Moore and Knowles, 1989 CO_2/CH_4 ratio vs water table

Empirical transfer functions

Peatland biophysical conditions

Microbial decomposition and respiration of organic matter

Greenhouse Gas Balance

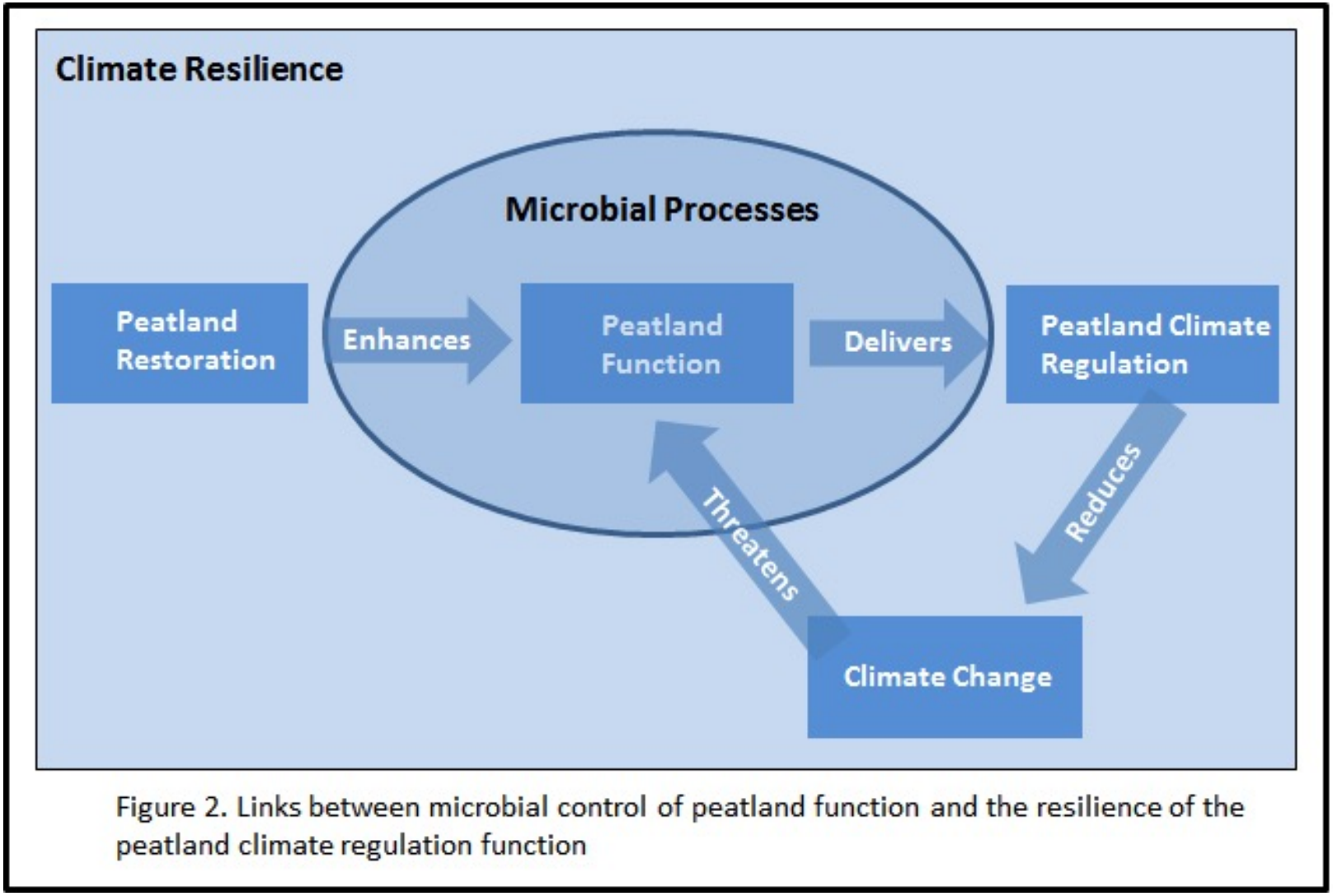


Figure 2. Links between microbial control of peatland function and the resilience of the peatland climate regulation function

The close coupling of microbial community diversity and activity with vegetation and water table change in peatlands (Andersen et al., 2013) means that, in peatland systems, climate resilience, human impacts and climate change are significantly interdependent

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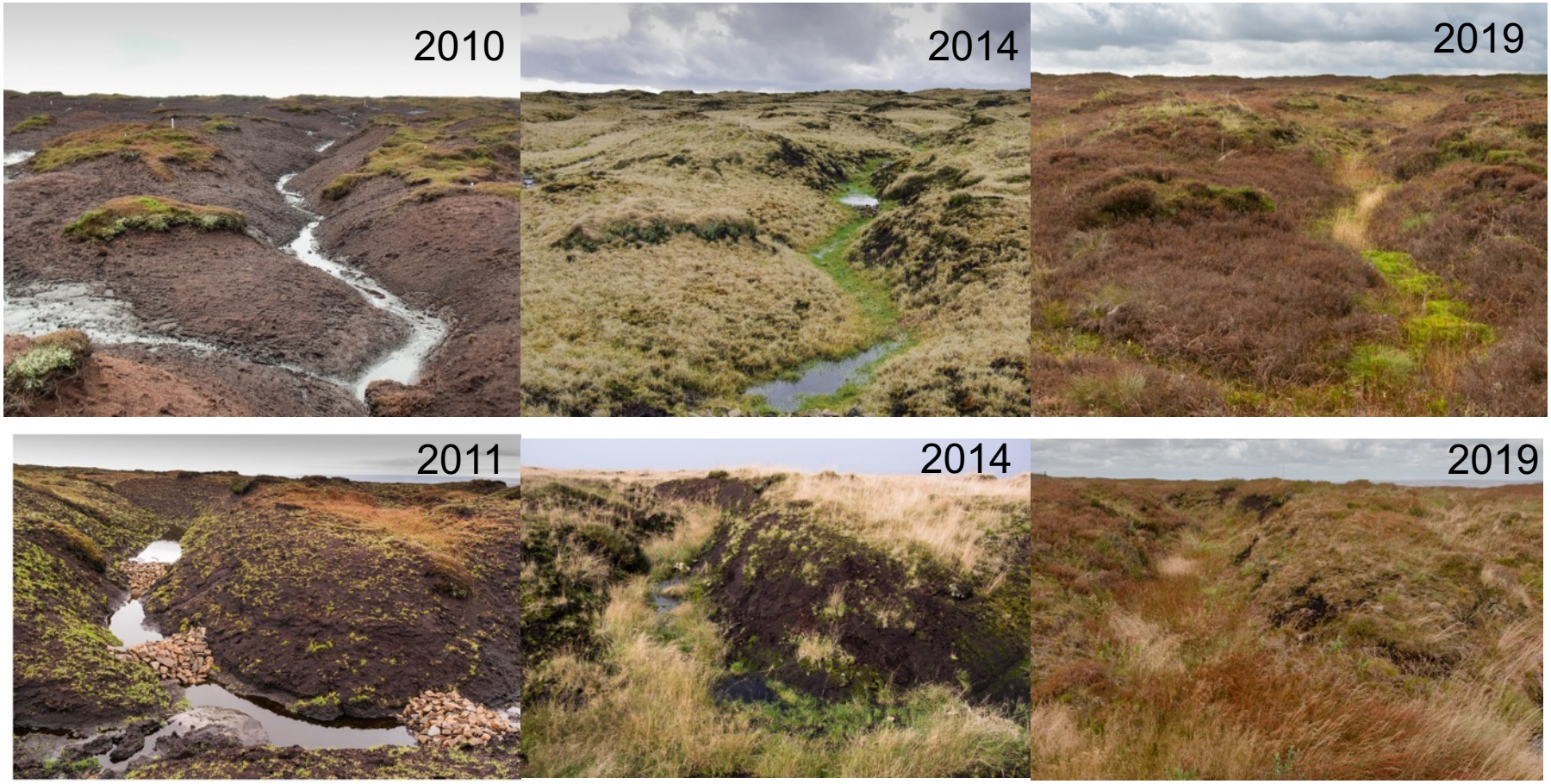

Restoration on Kinder Scout

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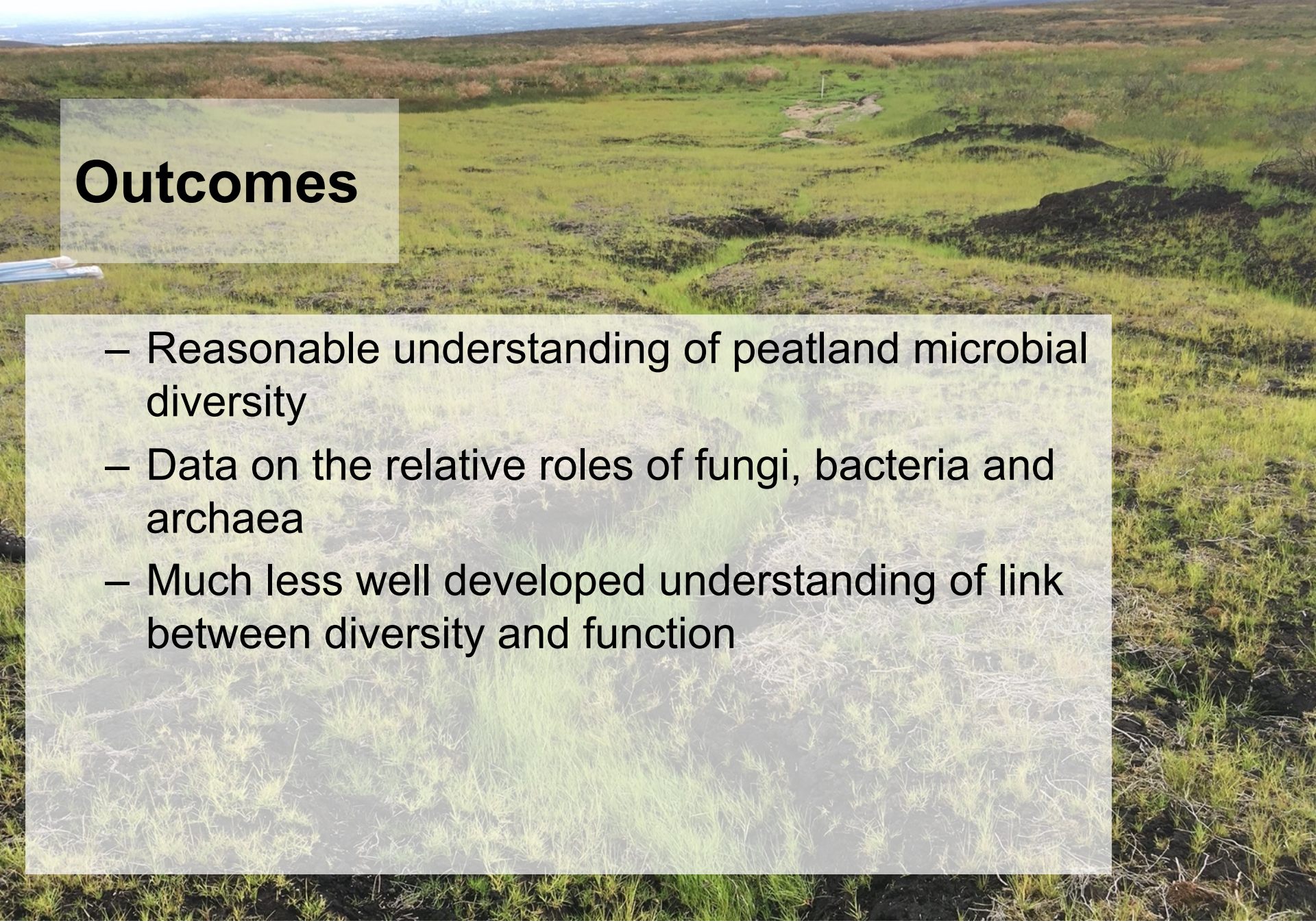
Four Workshops held in Manchester between May 2019 and February 2020

- aim to bring together peatland scientists, microbial ecologists and peatland practitioners to develop a research community with the multidisciplinary skills to investigate the role of microbes as a key mechanistic control on both the climate regulation function of peatlands and the resilience of that function to climate change.

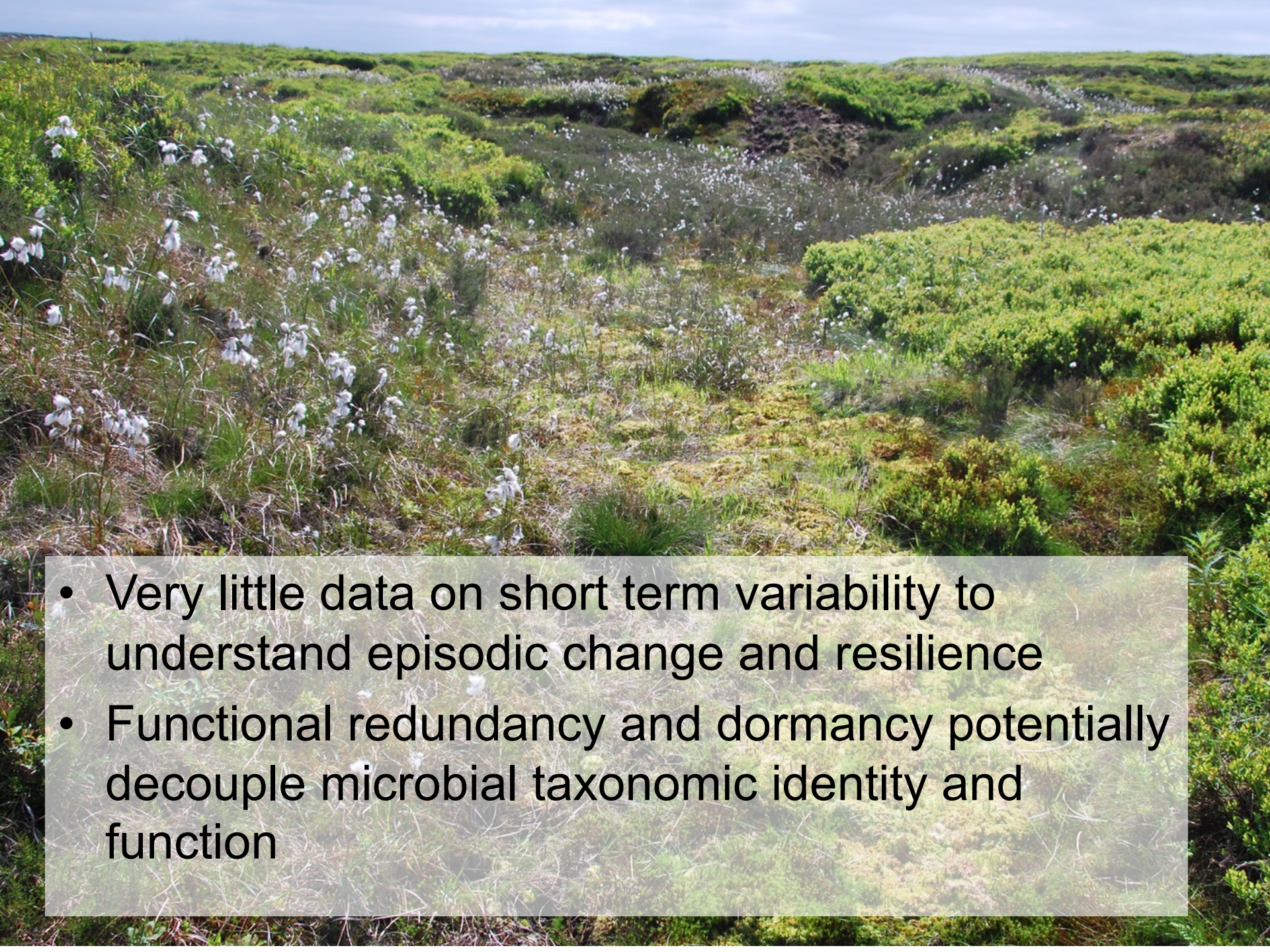
- Workshops 1 & 2 Peatland Function and Microbial Processes
- Workshop 3 Modelling and Remote Sensing Microbial Processes
- Workshop 4 Applications of Microbial Understanding in Managing Peatlands.

- 50 participants from Academia, Government, NGO's and Practitioners



Outcomes

- Reasonable understanding of peatland microbial diversity
- Data on the relative roles of fungi, bacteria and archaea
- Much less well developed understanding of link between diversity and function



- Very little data on short term variability to understand episodic change and resilience
- Functional redundancy and dormancy potentially decouple microbial taxonomic identity and function

- Diversity measurements less useful than microbial traits/phenotypes (character environmental preference/metabolic capabilities) in understanding carbon storage
- Need for more studies of diversity (functional rather than taxonomic - metagenomics) and function (measurements of C flux)
- Rapid advances in genetic technique mean that this work can only be done by interdisciplinary teams

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Commentary piece

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Towards a microbial process-based understanding of the resilience of peatland ecosystem service provisioning – A research agenda

Jonathan P. Ritson [a,*], Danielle M. Alderson [a], Clare H. Robinson [b], Alexandra E. Burkitt [c], Andreas Heinemeyer [d], Andrew G. Stimson [e], Angela Gallego-Sala [f], Angela Harris [g], Anne Quillet [h], Ashish A. Malik [i], Beth Cole [j], Bjorn J.M. Robroek [k], Catherine M. Heppell [l], Damian W. Rivett [m], Dave M. Chandler [n], David R. Elliott [o], Emma L. Shuttleworth [a], Erik Lilleskov [p], Filipa Cox [q], Gareth D. Clay [a], Iain Diack [r], James Rowson [s], Jennifer Pratscher [t], Jonathan R. Lloyd [b], Jonathan S. Walker [u], Lisa R. Belyea [l], Marc G. Dumont [v], Mike Longden [w], Nicholle G.A. Bell [x], Rebekka R.E. Artz [y], Richard D. Bardgett [z], Robert L. Griffiths [aa], Roxane Andersen [ab], Sarah E. Chadburn [ac], Simon M. Hutchinson [ad], Susan E. Page [j], Tim Thom [ae], William Burn [d], Martin G. Evans [a]

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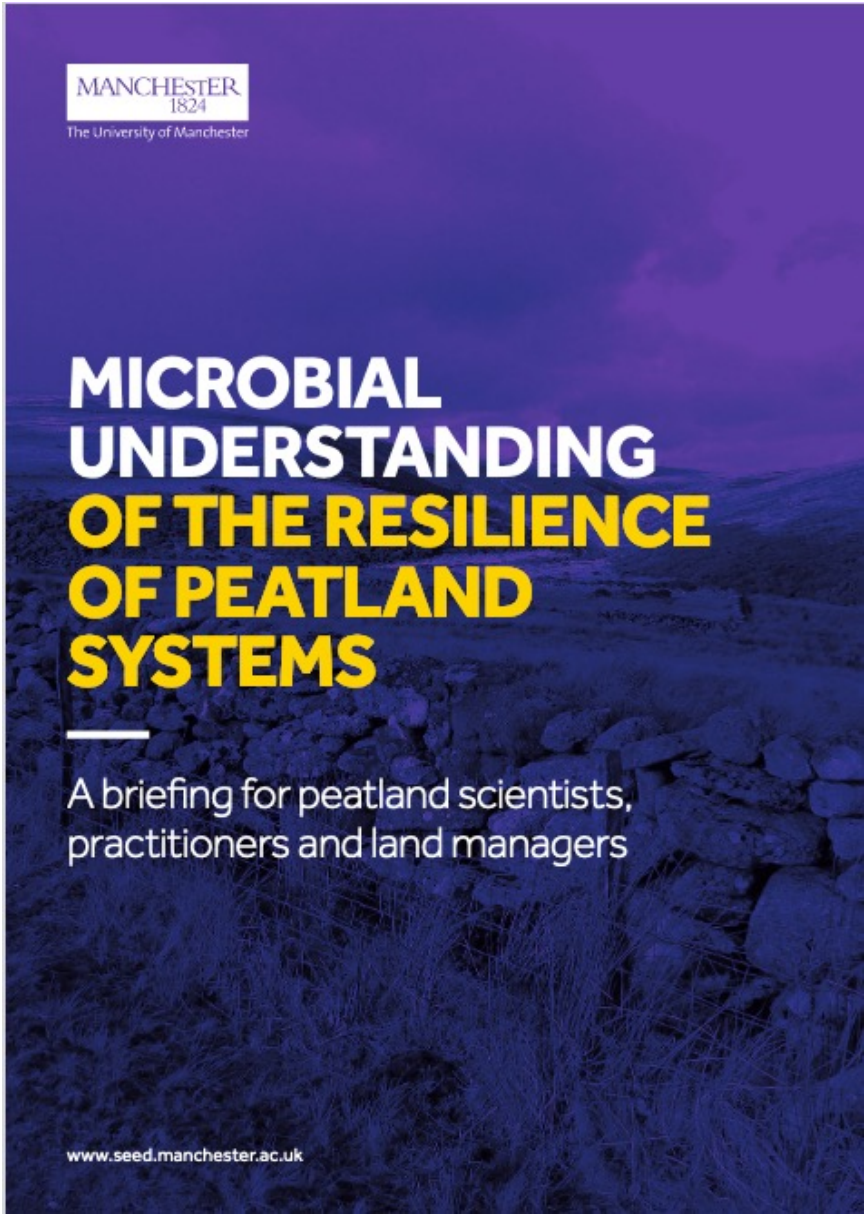

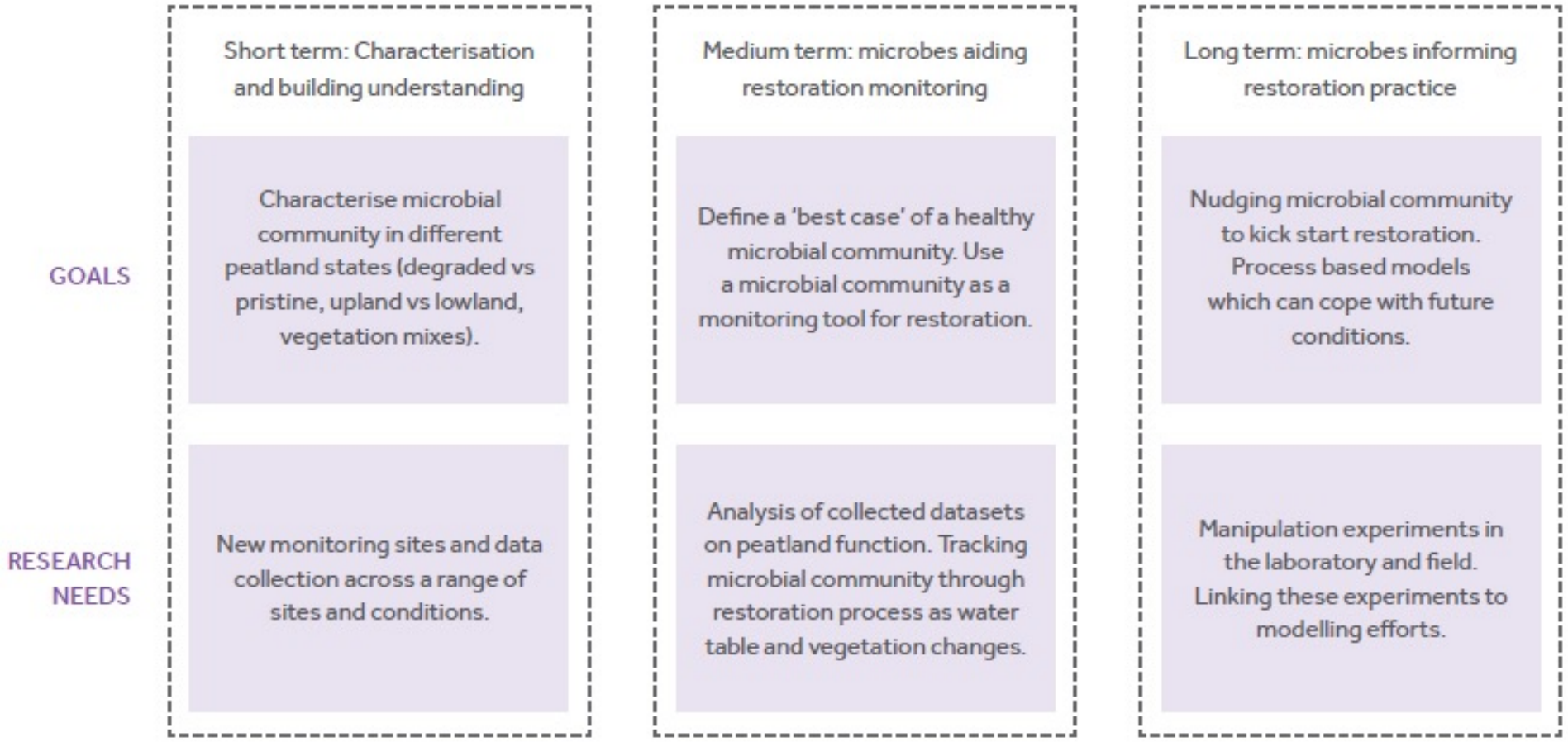

An approach to peatland carbon cycling rooted in microbial process understanding has huge potential for practical peatland restoration but there is a long way to go…the landscape transformations being delivered by current restoration work are ideal laboratories to explore the development of these ideas.

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Soil Biology and Biochemistry
Volume 42, Issue 2, February 2010, Pages 291-301

Changes in microbial community structure and function following Sphagnum peatland restoration

Roxane Andersen [a, b], Laurent Grasset [c], Markus N. Thormann [d, 1], Line Rochefort [b], André-Jean Francez [e]

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State of the Science Review – 10 years on

1 **The importance of microbial communities in peatland carbon cycling under a**
2 **changing climate**

3 **Clare H. Robinson[1*], Jonathan P. Ritson[2], Danielle M. Alderson[2], Ashish A. Malik[3]**
4 **Robert I. Griffiths[4], Andreas Heinemeyer[5], Angela V. Gallego-Sala[6], Anne Quillet[7],**
5 **Bjorn J. M. Robroek[8], Chris Evans[4], Dave M. Chandler[9], David R. Elliott[10], Emma L.**
6 **Shutttleworth[2], Erik A. Lilleskov[11], Ezra Kitson[12], Filipa Cox[13], Fred Worrall[14], Gareth D.**
7 **Clay[2], Ian Crosher[15], Jennifer Pratscher[16], Jon Bird[17], Jonathan Walker[18], Lisa R.**
8 **Belyea[19], Marc G. Dumont[20], Nichole G. A. Bell[12], Rebekka R. E. Artz[21], Richard D.**
9 **Bardgett[14], Roxane Andersen[22], Simon M. Hutchinson[23], Susan E. Page[24], Tim J.**
10 **Thom[25], William Burn[5], Martin G. Evans[2]**

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Key observations

- Peatlands are resilient systems, resilient microbiota may be part of this.
- Supporting the climate resilience function of peatlands (carbon sequestration) means putting the physical conditions in to support peatland preservation but also paying attention to microbial mediated services such as methanotrophy and role of mycorrhizal fungi.
- Models provide a valuable tool for exploring resilience and tipping points. At present microbial processes are not included in most models (complexity of community data) but incorporation of trait based work is a way forward. ..for example methanogen to methanotroph ratios

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Key observations

- What are peatland microbes (Andersen)? Some progress here, recent work suggests dominant bacteria are *Acidobacteria*, *Alpha*- and *Deltaproteobacteria*. There are few cultured representatives but whole genome sequencing leading to understanding of function

- For example, Hausmann *et al.* (2018) recently studied Acidobacteria from an acidic peat and revealed their genomes comprised potential for facultative anaerobic metabolism, oxygen respiration, fermentation, carbohydrate degradation, and hydrogen metabolism which demonstrates versatile metabolic capability for conserving energy required for life in peat systems

- This diverse strategy supports idea of functional redundancy (Andersen et al.) in peatland microbial systems but means that we need to distinguish active (RNA) from passive (DNA)

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The impact of climate change on peatland microbiota

	Archaea	Bacteria	Fungi
Warming	Evidence of both increase and decrease of methanogens	Evidence of decrease in methanotrophs	Mixed evidence – increases and decreases in biomass
Drainage	Archaeal communities sensitive to drainage. Changing methanogen/methanotroph ratios	Typically increasing biomass of methanotrophs One study shows reduction of methanotrophs under sedge but not under heather	Drying leads to short term increase and then decrease in biomasss due to changes in soil structure

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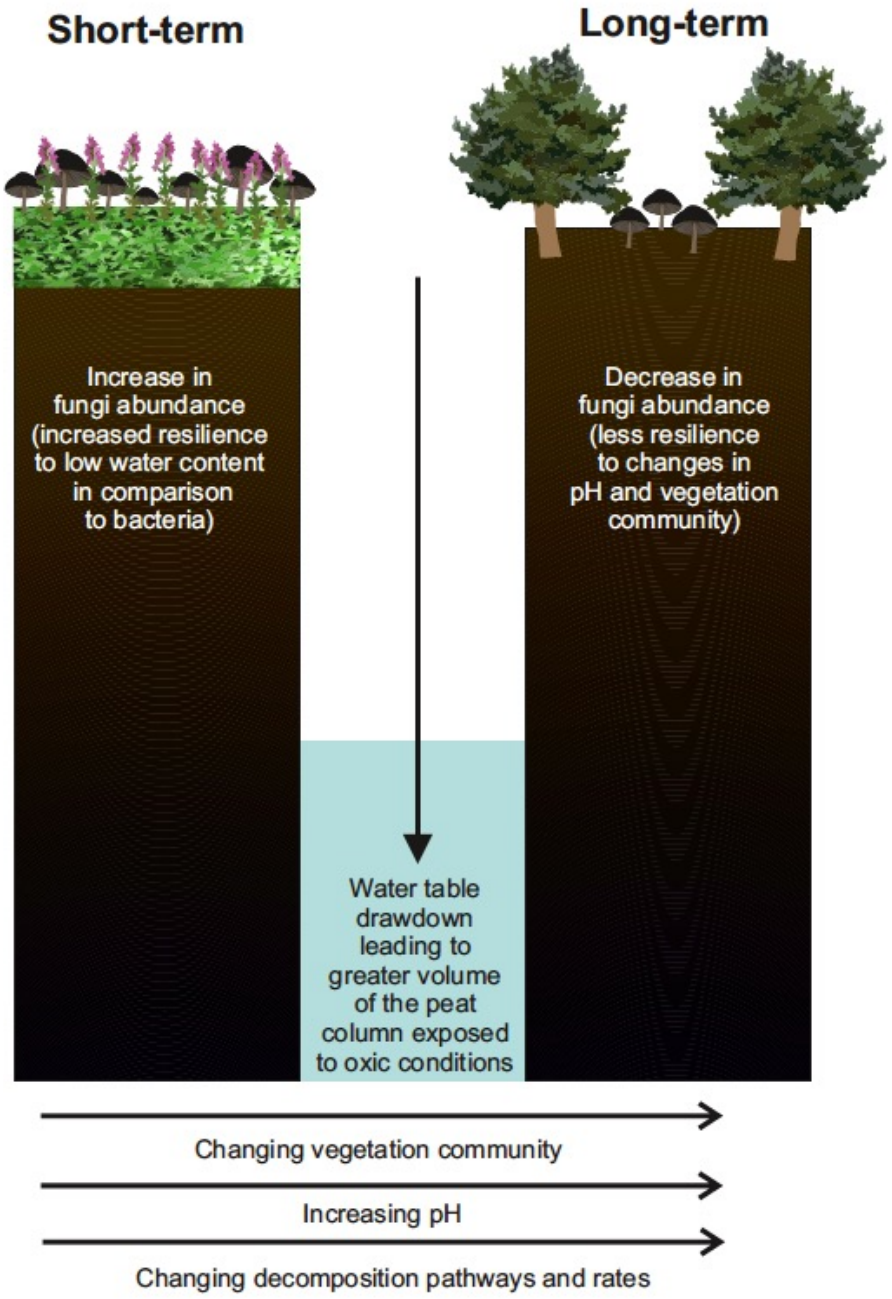
Short and long term change



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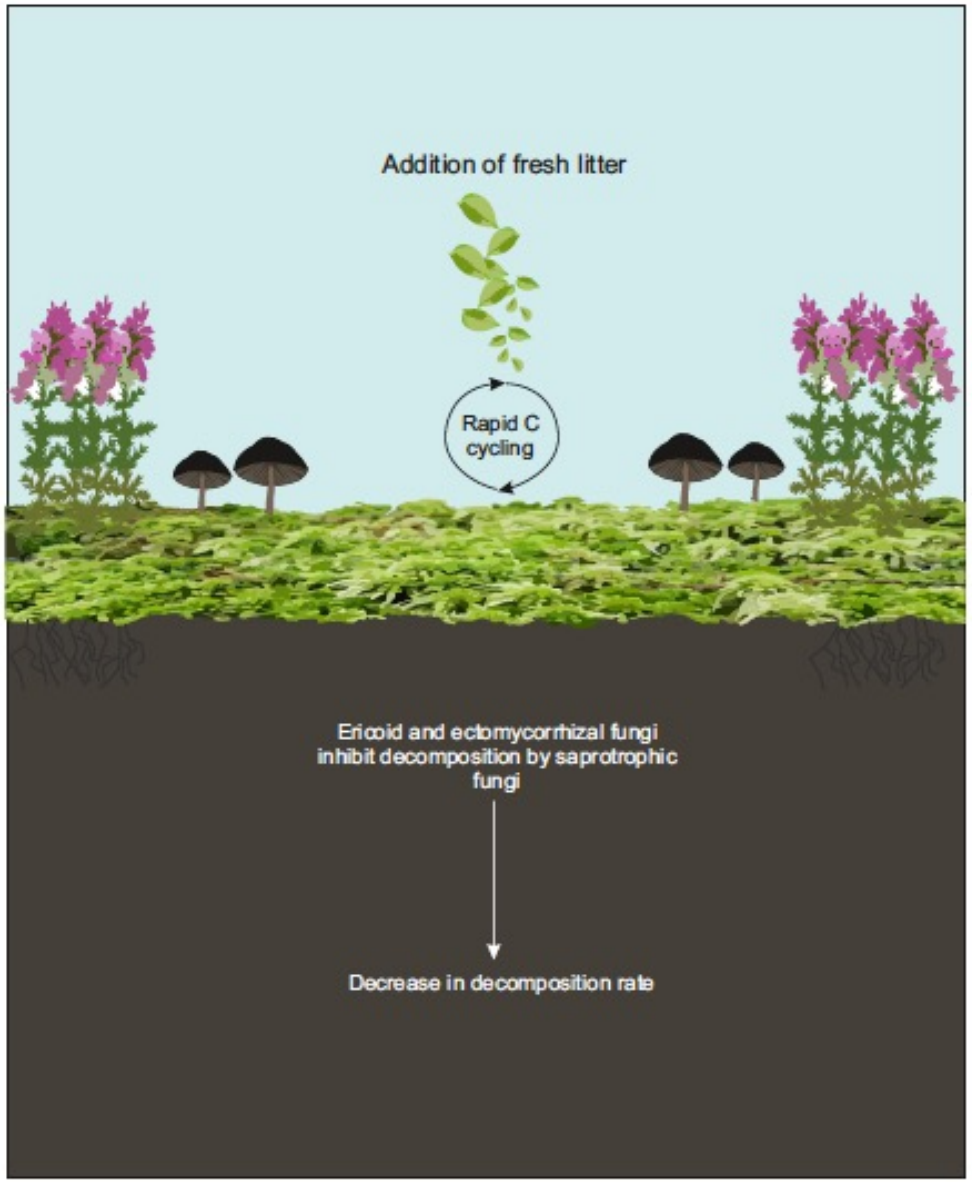
Vegetation cover

- Ericoid mycorhizae can decompose complex organic matter but lead to wider C:N ratio in litter which inhibits saprotroph decomposition



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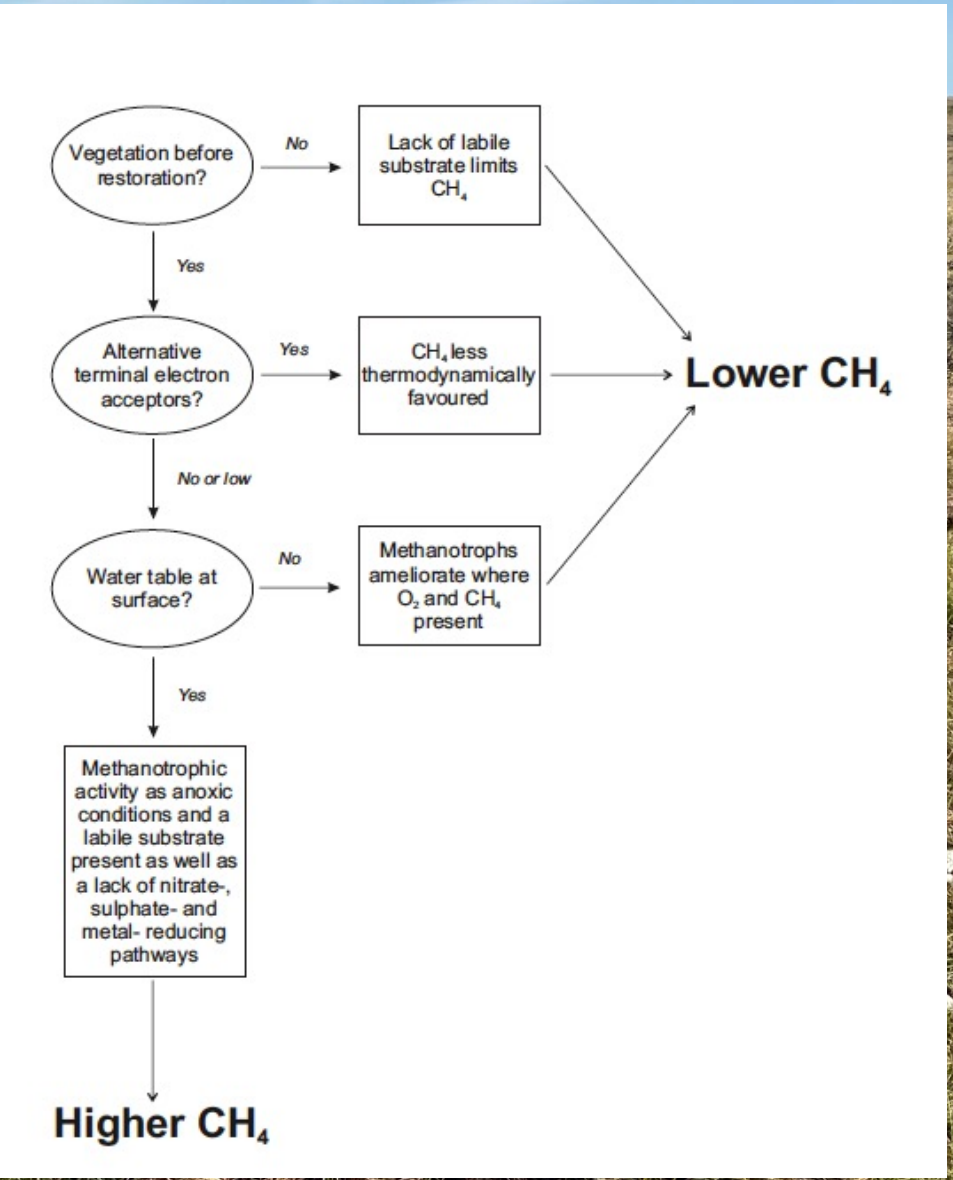
- Rewetting leads to methane spikes. Methanogen activity depends on absence of more thermodynamically favourable electron acceptors – negative correlation with nitrate, sulphate and metal reducing bacteria
- Importance of aerobic methanotrophs, over enthusiastic rewetting can lose these
- Sphagnum establishment aided methane oxidation due to endophytic methanotrophic bacteria



GGR-Peat

Demonstrator project on heather moorland - National Trust land in S Pennines.

Trialling Sphagnum establishment and sulphate addition to reduce methane flux

Trialling biochar - heather cutting and biochar additions to maximise C sequestration

Opportunity to test microbial controls.

UK invests over £30m in large-scale greenhouse gas removal

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24 May 2021

Research teams across the UK will investigate the viability of five innovative methods of large-scale greenhouse gas (GHG) removal from the atmosphere.

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This website hosts the output from the NERC funded project 'Towards a microbial process-based understanding of the resilience of UK peatland systems' at The University of Manchester.