Institution: The University of Manchester

Unit of Assessment: 17a (Geography)

Title of case study:
Peatland Erosion and Restoration for Carbon and Water Ecosystem Services

1. Summary of the impact

Research undertaken at the University of Manchester (UoM) has described peatland erosion and its impacts on hydrology and carbon balance; demonstrating the value of large scale peatland restoration via the re-vegetation of bare peat and erosion gully blocking. The primary impact can be seen within the Peak District National Park, where findings have formed the scientific underpinning for extensive investment in landscape-scale peatland restoration (totalling > £13m) by restoration practitioners such as the Moors for the Future Partnership (MFFP), which is significantly transforming degraded but iconic peatland landscapes. The MFFP mode is viewed as a national exemplar, with UoM research continuing to impact on upland policy, land use and restoration planning by regional, national and international bodies (National Trust, Moors for the Future, Natural England, DEFRA and the International Union for Conservation of Nature).

2. Underpinning research

British uplands landscapes are dominated by peat soils, with these peatlands providing crucial ecosystem services, including a capacity for carbon sequestration, significant to national carbon budgets and the regulation of water quality for both the ~60% of UK water supply sourced from the uplands and for wider aquatic ecosystem health. However, degradation of these peatlands in the form of peat erosion and gullying is widespread due to anthropogenic pressures such as air pollution and land use change. Over the past decade the policy and practice around restoration of these eroded upland landscapes has evolved rapidly with regional and national approaches being significantly influenced by research conducted at UoM. Led by Professors Martin Evans (1998-date) and Tim Allott (2000-date), the Upland Environments Research Unit (UpERU) has generated an extensive body of research on the erosion and restoration of UK peatlands, and the impacts of both erosion and restoration on ecosystem functioning. More specifically, the research has:

i. Established a process based understanding of peat erosion and its impacts on carbon budgets and hydrological conditions.
ii. Evaluated the effectiveness of the key measures used by practitioners for peatland restoration.

Initial research on the processes of peatland erosion and its impacts provided the first synthesis of peatland geomorphology and the impact of erosion on peatland environmental systems [D]. This volume was agenda-setting in research terms, but has also become a reference for practitioners. In the words of Des Thompson (Scottish Natural Heritage), it *"has the distinction of being essential to academics as well as practical conservationists"*. Related work on the hydrological impacts of erosion demonstrated both the direct and secondary effects of gullying on drainage waters [C], and emphasised the role of erosion in altering runoff mechanisms and pathways. This led to the development of an empirically supported conceptual model of the hydrological functioning of gully marginal areas. Crucially, this model identified gully margins as key zones of connectivity in the hydrological network of eroded peatlands that control runoff production, water quality and carbon release [C].

A critical contribution has been to demonstrate the importance of particulate carbon (POC) to peatland carbon budgets [A][D]. New algorithms for detecting gully erosion from LiDAR (Laser altimetry) data have allowed the mapping of gully systems, providing for the first time landscape-scale assessments of the impacts of erosion on a range of ecosystem processes, including POC release [A]. This research, together with previous work by the group on organic sediment budgets (synthesised in [D]) has established gully erosion as a major source of POC, which in eroding peatlands can represent the largest carbon loss from the system [A][D].

An additional strand of the group's research has been the direct evaluation of the effectiveness of practical conservation measures. The research reported here has formed the basis for a series of research reports which have addressed gully blocking and the re-vegetation of bare peat, with the aim of restoring the ecosystem functions of upland peatlands compromised by erosion [B][E]. Importantly, this research has provided some of the first empirical evidence of the

benefits of peat restoration for wider ecosystem functions and services. These reports have explicitly demonstrated the ability of gully blocking techniques to reduce particulate carbon loss and promote re-vegetation, and have quantified the hydrological benefits of landscape scale re-vegetation techniques.

Overall, the group's research on peatland carbon balances [A][D], the hydrological health of peatlands [B][C], and the impact of restoration practices [B][E] has provided a robust justification for the benefits of peatland restoration across a range of ecosystem services, and underpins the major investments in upland peat restoration currently being undertaken by conservation agencies and land managers.

3. References to the research (all references available upon request - AUR)

UpERU has produced 61 peer review journal articles, 22 research reports, and two major book volumes on peat erosion and restoration since 2004. Selected outputs include:

[A] (2010) Evans, M. G. & Lindsay, J. "The Impact of Gully Erosion on Carbon Sequestration in Blanket Peatlands" *Climate Research* 45(1) 31-41 (REF 2014) doi:10.3354/cr00887

[B] (2009) Allott, T. E. H. et al. 'Water tables in Peak District Blanket Peatlands: Moors for the Future Report 17', (Edale: MFFP) (AUR)

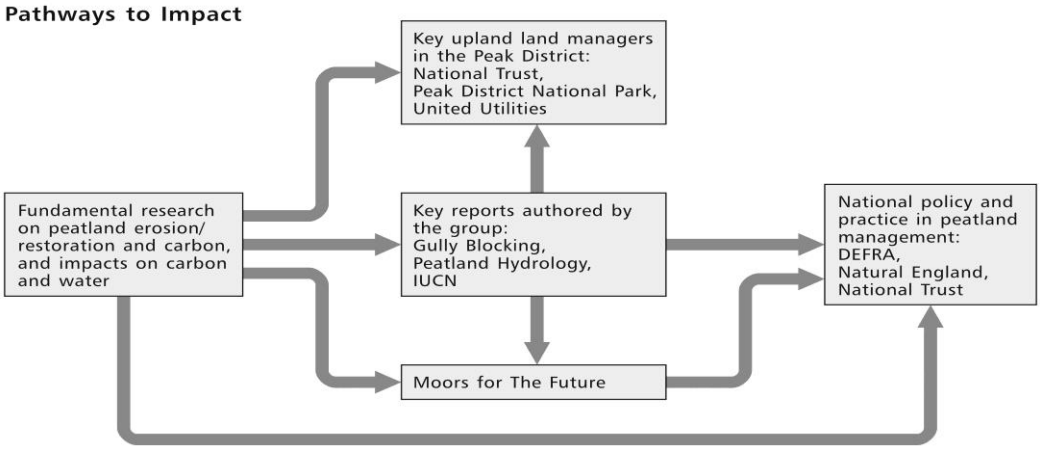
[C] (2008) Daniels, S. M., Agnew, C. T., Allott, T. E. H., & Evans, M. G. "Water Table Variability and Runoff Generation in an Eroded Peatland, South Pennines, UK" *Journal of Hydrology* 361(1-2) (REF 2014) 214-226 doi:10.1016/j.jhydrol.2008.07.042

[D] (2007) Evans, M. & Warburton, J. *Geomorphology of Upland Peat: Erosion, Form and Landscape Change* (Oxford: Blackwell) (RAE 2008) (AUR)

[E] (2005) Evans, M. H. *et al.* 'Understanding Gully Blocking in Deep Peat: Moors for the Future Report No. 4" (Edale: MFFP) (AUR)

4. Details of the impact

Context: Research conducted by UpERU has played an important role in guiding peatland restoration practice in the southern Pennines, and has made a significant contribution to the development of practice and the formulation of policy across the UK's peatlands.



As this diagram (above) highlights, the structuring of **pathways to impact** has led to significant influence on practice, and policy, relating to upland peatland management. A key pathway has been through the group's engagement with the Moors for the Future Partnership (MFFP) – a partnership between: the Environment Agency, National Trust, Natural England, Peak District National Park Authority, RSPB, Severn Trent Water, United Utilities, and Yorkshire Water. MFFP was set up to communicate the importance of peatland restoration work to restore peatlands and has a significant national role within upland conservation policy. UpERU has developed formal links with MFFP with Allott serving on the Advisory Group to the partnership, as well as a range of informal and ongoing collaborations, applying research evidence to guide landscape scale restoration projects. As a result, a number of **impacts** have emerged from both the foundational research, as well as via engagement with MFFP and its partners:

(1) UpERU research forms the rationale and scientific underpinning for the extensive investment in landscape-scale peatland restoration currently underway in the Peak District National Park. MFFP, United Utilities and the National Trust have used the research to justify both the investment in restoration, and the required restoration measures. Investment by MFFP to date totals >£13 million [1], and in line with UpERU recommendations has been earmarked to restore the ecosystem functions of these iconic but degraded systems, using re-vegetation and gully blocking techniques (the 'Peak District Model'). It is notable that impacts have emerged directly from findings garnered from peer reviewed research, from advice based on these findings and through ideas reported directly to MFFP through commissioned research reports informed by the original work [B][E]. As MFFP's programme manager has noted, UoM research *"provides a reliable and robust evidence base on which we have been able to develop a multimillion pound programme of works* [with]… *supporting evidence… from University of Manchester publications… instrumental in MFFP and National Trust securing 2.2M for blanket bog restoration work, {from the EA catchment restoration fund} by far the largest funding award within the programme"* [1]. Similarly, *Natural England's* Upland specialist has stated that: *"Without your work as a key part of the overall body of evidence we would be in a much weaker position to justify the use of public money for this type of restoration"* [2]. UpERU research has also assisted United Utilities as they seek to quantify the benefits of their moorland restoration work, with [E] recognised as a *"key document… used to direct several hundred thousand pounds of work"* [3].

(2) UpERU engagement with MFFP has led to significant secondary impacts, through the role of MFFP as a major contributor to national policy debate in this area, and also through the recognition of the MFFP model as a national exemplar. This has led to MFFP being cited as a template for the formation of similar regional peat restoration bodies in the North Pennines, the North York Moors National Park and in Dartmoor and Exmoor National Parks. As noted by the Exmoor Mires project manager:

> *"The early work carried out by the Moors for the future project in association with the Northern Universities and in particular the University of Manchester is the platform which underpins the research we are now carrying out in the South West. Not only was the* [MFFP] *projects' research work fundamental, but their programme work in the Peak District paved the way to secure the MotM* [Mires on the Moors] *project and buy in and investment from SWW and other partners."* [4]

The influence of the 'Peak District model' of restoration thus extends across the moorlands of Britain; MFFP's programme manager agreeing that *"University of Manchester evidence has been one of the pillars that has supported MFFP's success. Success that has been transferred nationally through the adoption of our restoration model and methods in other upland peatland areas"* [1].

(3) UpERU research has led to the development and adoption, by restoration practitioners, of new approaches for post- treatment monitoring of peatland restoration, the associated recovery of key carbon and water functions and the implementation of these in restoration programmes, both in the Peak District and more widely such as in MotM, where: *"The investment in the research and monitoring element of the Exmoor Mires project alone is approximately half of the total project budget at just over £1.3 million"* [4]. MFFP recognises that UpERU's work *"provides a scientific basis which we now use to monitor the impact of all our restoration works"* [1]. UpERU with MFFP have now also been able to effectively build monitoring capacity, based on the original research, via **citizen science approaches** such as the training of Peak Park Rangers and volunteers for restoration monitoring programmes.

(4) UpERU research has had wider impacts on land management policy in the uplands. Three areas stand out. Firstly, work on the role of particulate carbon in peatland carbon budgets, which has influenced Department for Environment Food & Rural Affairs (DEFRA) thinking on fluvial carbon *"as part of the body of evidence to the development of Defra's thinking on the need to better understand the full carbon and greenhouse gas budgets of peatlands…"* and led to the £300K DEFRA project 'Greenhouse gas emissions associated with non-gaseous losses of carbon

– fate of particulate and dissolved carbon' [5].

Secondly, work on peatland hydrology and carbon balance, which has formed part of the consultation for the National Trust 'High Peak Moors Vision and Plan: 2013–2038', that for the first time includes a specific policy to manage the landscape for carbon and water. The consultation response document noted that the plan would put *"into practice management that should, in time, improve carbon storage and water quality. At a wider level we have been working hard with DEFRA on the best ways to direct more public (and indeed private sector) resources towards schemes which support better soil, carbon, water and landscape-scale management."* This is confirmed by the Trust's General Manager (Peak District):

> *The Trust manages in excess of 14,000 hectares of land – approximately 13% of the whole Peak District National Park… One of the major activities for us over the last ten or so years in pursuit of the above has been restoration of the blanket peat soils of our moorland…* [Allott and Evans'] *2009 report provided clear evidence of the positive impacts of peat restoration for water tables and peatland health. Importantly, the report also developed monitoring techniques which are being employed by the Moors for the Future partnership to evaluate the success of the (£2.5million) Kinder Catchment Peat Restoration project (2010-2015). The Trust also invited Allott to provide expert hydrological advice for the development of the High Peak Moors Vision and Plan… University of Manchester research and advice was invaluable in embedding the new emphasis on carbon, water and climate change within the plan and the proposed management of the Estate into the future."* [6]

Thirdly, work on peatland erosion which has influenced Natural England responses to planning applications. In the words of Natural England's Upland Specialist, UpERU research: *"helped demonstrate that upland peat can be far more dynamic in terms of accretion and losses than was previously thought... currently heavily eroded areas are not lost and that natural recovery can take place… In recent years, large sums of public money have been invested in the restoration of blanket bog. Central to this has been a growing understanding of the hydrology of these sites"* [2].

(5) As a result of their research, Evans and Allott were invited participants in the International Union for Conservation of Nature (IUCN) expert inquiry panel on Peatlands. In response to the subsequent IUCN report, the environment ministers of all four home nations have written a joint letter outlining policy responses aimed at 'protecting and enhancing the natural capital provided by peatlands in the UK…' [7]. The director of the IUCN UK Peatland Programme recognised the importance of UpERU *"research work on particulate carbon from peatlands",* noting that it *"provided valuable background for UK scientists who are developing the Intergovernmental Panel on Climate Change (IPCC) guidance on peatland rewetting and has been used in providing the metrics for a peatland carbon code which could help secure private funding for peatland restoration. In conclusion, Professor Evans' work and that of colleagues at the University of Manchester has provided important evidence in securing action across a wide range of policy, science and practice activities aimed at restoring and conserving peatlands"* [8].

5. Sources to corroborate the impact (all claims referenced in the text)

[1] Testimonial from Programme Manager, Moors for the Future (29th April 2013); (2010) 'UK Landscape Award 2010: Moors for the Future Partnership Award Statement'
[2] Testimonial from Upland Specialist, Natural England (28th March 2013)
[3] (2013) Confidential document from United Utilities (24th September)
[4] Testimonial from Exmoor Mires Project Manager, South West Water (31st May 2013)
[5] (2013) Confidential document from DEFRA (30th May)
[6] Testimonial from General Manager, Peak District, National Trust (7th August 2013); (2012) 'High Peak Moors Vision and Plan 2013–2038: Consultation Draft' & Your Moors, Your Ideas: Summary Report of the responses….' National Trust
[7] Joint Letter to IUCN from UK Environment Ministers (5th February 2013)
[8] Testimonial from Director, IUCN UK Peatlands Programme (26th April 2013); (2011) IUCN 'Commission of Inquiry on Peatlands' (October)