PhD Project Title: Modelling eco-hydrological feedbacks and resilience in blanket bogs undergoing restoration in the context of climate change

SUMMARY:

Peatlands are the Earth's most efficient terrestrial carbon store, regulate water and climate, and support unique biodiversity, but their degradation compromises the delivery of all those benefits. In the UK, the cool, wet climate supports a globally rare peatland type: blanket bogs. Most UK blanket bogs have been degraded by human activities and unprecedented efforts to restore them are currently underway, particularly in Scotland. Such large-scale and fast-paced peatland restoration interventions currently happening across the UK are only going to lead to successful outcomes if they increase the capacity of degraded blanket bogs to withstand future threats such as climate change, but also invasive species, wildfires or pollution. This capacity reflects resilience thresholds that relate to feedbacks between production, decomposition, eco-hydrology and mechanical properties of peat. It is unclear how quickly disturbances legacies can be overcome to enable these key feedback loops to re-establish following restoration interventions, in other words, how successful restoration is at bringing back resilience.

PROJECT BACKGROUND:

The Flow Country of Caithness and Sutherland is an area of blanket bog covering 4000 km^2, part of which is currently a candidate for World Heritage Site status. However, within the Flow Country, there are also thousands of ha of peatlands that were drained in the past for agricultural improvements, and 67,000 ha of open blanket bog that were afforested with non-native conifers during the 1960s-80s. Since the 1990s, many areas have subsequently been targeted for drain blocking and "forest-to-bog" restoration. The immediate effects of these land-use changes on peatlands was rarely studied at the time they happened, and the long-term legacies of those disturbances and restoration activities have only been assessed empirically at a limited number of sites. While it is possible to use field experiments to study early responses, there are also considerable uncertainties about the longer-term trajectories of both degraded and restoration areas, especially in the context of climate change.

With the ramping up of funding for peatland restoration activities, the development of novel techniques and the rolling out of large-scale programmes through initiatives such as the Scottish Government's Peatland ACTION programme since 2012, most of the restoration areas are still <10 years old. In recent years, the restoration techniques have been

developing fast, and there is currently a gap in our understanding of how these techniques compare in cost-effectiveness, particularly over the mid to long-long term and with the added pressure from climate change.

Modelling approaches are ideally suited to investigate how blanket bogs may respond to a range of management interventions under future climate change scenarios, and to generate hypothesis about what the key drivers of those responses may be. This project therefore aims to use two different peatland-specific process-based models (HPM and DigiBog) to simulate short- and long-term responses of blanket bog to a range of management interventions, testing the hypothesis that degradation and restoration trajectories are non-linear and relate to feedbacks between hydrological thresholds and shifts in dominant plant functional types.

RESEARCH QUESTIONS:

1. What are the effects and legacies of drainage and forestry on deep peat?
2. What key eco-hydrological thresholds need to be overcome to enable a return of peat accumulation post-restoration?
3. Which restoration interventions enable drained and drained afforested blanket bog to recover resilience under future climate change?
4. How does land management (near-natural, drainage, afforestation, drain blocking) recovery from extreme events (drought, wildfire) in blanket bogs?

METHODOLOGY:

There are several restoration sites of varying ages spread along a climate and topographical gradient in the Flow Country with adjacent degraded/reference areas from which the project will be able to validate modelled baselines and trajectories of change.

We will use DigiBog and the Holocene Peat Model to simulate conservation management, drainage and afforestation at a range of site across the climate gradient and compare outputs with empirical data (core). For restoration areas, we will simulate water table dynamics and Net Primary Productivity (NPP) using both models to explore how different management regimes perform over the short, medium and long-term. We will compare DigiBog and HPM outputs with existing empirical data (including GHG estimates from Eddy Covariance towers and associated micro-meteorological measurements, vegetation surveys,

hydrological measurements, remote-sensing, and peat core data) for the short-term responses.

We will use scenarios (cycles of drought, fire) to project these different land-use types in the future and explore how they will respond to extreme weather events occurring at likely frequencies predicted under future climate changes, and when resilience mechanisms will break down.

SUPERVISION TEAM

Dr Roxane Andersen – Lead supervisor, University of the Highlands and Islands
Prof Andy Baird – University of Leeds
Dr Jagadeesh Yeluripati – James Hutton Institute
Dr Andrew Duncan – University of the Highlands and Islands

TRAINING

A comprehensive programme will be provided comprising both specialist training and generic transferable and professional skills. The student will have access to a range of training opportunities within each of the project partner organisations, but also through SAGES (www.sages.ac.uk).

The student will form a core part of the Leverhulme Leadership Award "Blanket Bog Resilience" team and the ERI's "Carbon, Water & Climate" theme, attending regular meeting with the relevant postdocs, PhD students and collaborators. In addition, the student will join the "Flow Country Research Hub", a network of >60 organisations involved in peatland research in the north of Scotland, which will give further opportunities for training and non-academic skills development.

Fieldwork in the north of Scotland can be challenging, involving carrying kit over difficult terrain in sometimes cold and wet conditions, and often with the company of midges. While we do not expect this PhD to be field-work heavy, all essential and medical training (e.g. first aid training) relating to fieldwork will be provided.

ACADEMIC QUALIFICATIONS:

We expect an undergraduate degree (minimum 2:1) in a relevant field (e.g. mathematics, computational sciences, environmental sciences, physical geography, engineering, biological sciences) or equivalent. English language requirement: IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

ESSENTIAL ATTRIBUTES

- Strong interest in modelling
- Experience of coding, programming skills
- Good written and oral communication skills
- Willing to relocate to Scottish Highlands

DESIRABLE ATTRIBUTES

- Interest in modelling environmental processes
- Full clean driving licence

KEY REFERENCES:

Frolking, S., Roulet, N.T., Tuittila, E.S., Bubier, J.L., Quillet, A., Talbot, J. and Richard, P.J.H., 2010. A new model of Holocene peatland net primary production, decomposition, water balance, and peat accumulation. Earth System Dynamics.

Hancock, M.H., Klein, D., Andersen, R. and Cowie, N.R., 2018. Vegetation response to restoration management of a blanket bog damaged by drainage and afforestation. Applied Vegetation Science, 21(2), pp.167-178.

Taft, H.E.; Cross, P.; Hastings, A.; Yeluripati, J.; Jones, D.L. (2019) Estimating greenhouse gases emissions from horticultural peat soils using a DNDC modelling approach., Journal of Environmental Management, 233, 681-694.

Morris, P.J., Baird, A.J., Young, D.M., and Swindles, G.T. 2015. Untangling climate signals from autogenic changes in long-term peatland development. Geophysical Research Letters 42, 10,788–10,797.

Young, D.M., Baird, A.J., Charman, D.J., Evans, C.D., Gallego-Sala, A.V., Gill, P.J., Hughes, P.D.M., Morris, P.J., Swindles, G.T. 2019. Misinterpreting carbon accumulation rates in records from near-surface peat. Scientific Reports, 9, 1–8.

Young, D.M., Baird, A.J., Morris, P.J., and Holden, J. 2017. Simulating the long-term impacts of drainage and restoration on the ecohydrology of peatlands. Water Resources Research 53, 6510–6522.

ADDITIONAL INFORMATION:

Eligibility: To be eligible applicants must have no restrictions on how long they can stay in the UK (with some further constraint regarding residence for education). Note: EU, EEA and Swiss citizens who are entering the UK on or after 1 January 2021 will need a Tier-4 visa in order to work, live and study in the UK.

Funding: This project is funded through a Leverhulme Leadership Award to Dr Andersen and will include stipend and fees at RCUK rates for 42 months. The funding does not cover international fees, but EU and international applicants can still apply, and are invited to discuss their application with the lead supervisor ahead of submission deadline. The successful candidate will start no later than October 2021 (to be agreed with student).

Deadline for application: 06/04/2021

Shortlisted candidates will be interviewed in the week of the 19/04/2021

For information, contact roxane.andersen@uhi.ac.uk