

**Dr Jonathan Walker, Swansea University – Written evidence
(NSD0034)**

Questions addressed:

2. Which bodies should be involved in establishing an agreed evidence base to inform best-practice techniques for restoring peatlands?

6. How should nature-based solutions be planned and monitored at the national level?

What measuring, reporting, and verification requirements should be put in place to determine the degree of success of nature-based solutions? Which techniques and technologies are best suited to accomplishing robust monitoring?

Peatland monitoring and research should be coordinated and planned to efficiently and effectively deliver the required peatland restoration, sustainable management (SM) and NbS (Nature-based Solutions) evidence base. Such coordination would allow for the highest resolution data collection at a parsimonious network of research sites to calibrate and interpret more widespread monitoring across peatland restoration, sustainable management and NbS sites by a range of organisations. Integration and coordination of research and monitoring resources and systems will best deliver the required evidence base in the most efficient and effective way.

All peatland land management initiatives are required to evidence their outcomes. Many struggle to design and adopt a robust monitoring programme – especially within the short timescales of most restoration projects in which baseline monitoring, capital works and post intervention monitoring must be completed, typically within a 2-5 year window; yet peatlands can take a decade or more to fully respond to the impacts of land management. Evidence initiatives need to plan and resource long-term and full 'lifecycle' monitoring and evaluation of intervention techniques and materials. The same funding period is true for research projects. Given that peatlands form and respond to environmental change over decades to centuries, and at a landscape scale, this is problematic. Furthermore, while many of these short-term studies have advanced fundamental scientific understanding through well-cited research papers, this understanding does not always help to inform, or translate into, the development of peatland policy, strategies and practice.

Peatland and NbS funding organisations (Government arms-length bodies, UK Lottery, EU LIFE, Esmee Fairburn etc.) need to better coordinate their core monitoring and evaluation frameworks and outcomes for peatland and NbS projects. Adoption of unified methods and standards should be a condition of any funding allocation to ensure systematic data collection regardless of funding stream. UKRI should also adopt core outcomes and measures for peatland research again, adoption of which should be condition of receiving funding. Work is ongoing to develop these (Mark Reed, Scottish Rural College); however, outputs are not yet in the public arena. All of these organisations need to be included in establishing a solution for an agreed evidence base.

Evidence end-users and also the same organisations who are collecting and utilising the data to inform operational land management decisions need to be included both to ensure the right outcomes are being addressed, to ensure long-term support, sense of ownership and adoption of core monitoring methods. Major land management interests and responsibilities should be included: Government and their arm's length bodies, including protected areas etc; NGOs: Wildlife Trusts, National Trust, RSPB, Woodland Trust etc); Industry (Water Companies, renewable energy companies etc.) and farming interests (Farmers unions) and representatives of other significant land management interest groups.

There are a number of UK scientists and universities with significant expertise, involvement of peatland science and collaborating and supporting the peatland management community that should be involved in the development of the evidence base, including, University of the Highlands and Islands, James Hutton Institute, UKCEH, University of Leeds, University of Manchester, University of East London, Swansea University, University of Bangor.

The implementation of NbS should be to agreed standards and this should be verified for all works; however, the impact or outcomes of interventions may be subject to external impacts that might lower overall effectiveness and impact; for example intense storm events or drought may affect the success of a new peatland restoration intervention. This is not a result of the quality of the work but the effectiveness an impact of the intervention - the level of benefit - delivered by the works nevertheless needs to be measured to determine the impact, and to understand what the 'trajectory' of change is for the works on the site. Coordinated, systematic monitoring would enable the rapid creation of trajectories of change following restoration / NbS interventions for multiple sites and environmental conditions.

Ideally standardised monitoring would be supported with coordinated research, ideally through a network of sites where our research efforts are better targeted to more efficiently and effectively build our evidence base. In collaborate with the Welsh Peatland Action Group (Natural Resources Wales, Welsh Government, Brecon Beacons National Park, Snowdonia National Park, Welsh Wildlife trusts, IUCN UK Peatland Programme, Universities with peatland research interests and expertise) I have been working to establish such a network in Wales. Such a coordinated network across the UK would be of major value and potential impact.

The aim of a peatland research platform network would be to improve our knowledge of the condition and functioning of peatland ecosystems and their long-term response to environmental, societal, and economic drivers. Evidence generated will better inform policy and management options in response to societal needs and the conservation of biodiversity.

The proposed Network included major and priority peatland typologies where a consistent 'core' set of research outcomes are measured using standardised, or comparable, methods over the long-term (decades). The data collected across

sites within the network will provide robust and reliable evidence on the status, and changes in peatland condition and provision of ecosystem services for peatlands. At these sites, research-grade sensor technologies and methods could be run alongside cheaper Internet of Things monitoring solutions to verify and calibrate widespread monitoring efforts. Site selection should be informed by existing research and monitoring initiatives (e.g. Environmental Change Network sites etc). Each site, while contributing to the wider peatland evidence network across different typologies and locations, will function as a stand-alone research platform.

For Welsh Government and arms-length bodies the Network would provide peatland evidence to support reporting against statutory measures, including: Greenhouse Gas emissions (under the Framework Convention on Climate Change and Kyoto Protocol); and State of Natural Resources Reporting (including the four measures of sustainable management of natural resources; and reporting against relevant National targets and outcomes.

For environmental NGOs, protected areas, and farmers and land managers with peatland interests: the Network will provide relevant and practical evidence and understanding to inform peatland restoration targets and success, and the sustainable management of peatlands for multiple outcomes. Importantly, data collected at Network sites should provide these organisations with reliable and robust data against which the standardised monitoring data can be validated and interpreted.

For peatland researchers the Network will provide a network of observatories that act as platforms for peatland research projects – both to efficiently, effectively, and collaboratively address general peatland evidence gaps on peatlands, and to help leverage research income to Wales from UKRI and other UK and international funding sources.

A coordinated network would be designed not only to support focused, question-driven research, but to add value and ensure policy relevance by providing consistent data, collected at representative sites, over the longer time horizons relevant to peatland degradation, restoration, ecosystem responses (such as 'tipping points') to extreme events, and long-term environmental and land-use change. Such a network would be unique globally and would place Wales at the forefront of international peatland research.

Agreed monitoring outcomes and core measures would enable individual organisations to efficiently report on their progress yet combined provide data to inform national scale monitoring and evaluation. These measures should ideally be developed to work as ground-truthing data (verification data) for remote sensing data (earth observation) to enable large scale frequent assessment of changes and impacts.

The Research and monitoring network should be a collaborative endeavour. Each research platform site could be run by a lead academic institution, with support

for partner evidence -end users organisations. The entire programme would be run centrally run but with a steering group comprising evidence-end-user organisations. Data validation checks and 'core' analyses would be core funded and undertaken centrally to evidence national trends and trajectories. Data would be open-source and available subject to appropriate terms and conditions for research purposes, and research platform sites available, subject to steering group approval, to host research projects.

For Wales, we identified the primary objectives of a Peatland Evidence Network to be:

- Establish a core set of measurements across a small network of sites that provide comprehensive understanding of peatland functioning and ecosystem service provision for representative peatland types and condition states across Wales
- Evidence peatland response to land management (change) to inform the impact, and ongoing development and delivery of sustainable peatland management and restoration.
- Evidence peatland response to climate change including extreme weather events (storms and droughts) to understand peatland resilience, recovery, and environmental thresholds over both short and long-term timescales.
- Support 'national' scale reporting requirements and understanding (e.g. GHG emissions and biodiversity change through provision of data, analysis, reporting and interpretation for a suite of priority research / evidence outcomes.
- Each Observatory and the Network to function as platforms to attract and support additional research initiatives as a result of the available infrastructure, researcher network support and availability of 'core' data sets that benefit from standardised collection methods, rigorous and consistent protocols for data processing, Q&A and cataloguing.
- The network will be part of a wider network of peatland monitoring sites that have adopted the basic peatland monitoring method. The Network will provide validation data for the basic monitoring protocols and provide additional context and interpretation to the results from, and for sites undertaking, basic monitoring.
- Data collected will serve as ground-truthing data to support the validation and development of multisensory remote sensing approaches to measuring peatland condition, functioning and ecosystem services
- Observatories will serve as reference sites or condition types to international studies.

We identified priority research outcomes that addressed the essential data and evidence needs to assess current peatland condition, and future changes in condition. These data will enable the validation of 'basic' monitoring methods at other peatland sites and the development and delivery of earth observation approaches. It will also provide an essential basic suite of data on which to attract and develop additional targeted research initiatives and projects.

1. Weather, land management and external drivers (contextual data)
2. Water balance and water quality
3. Biodiversity (conservation status)
4. Carbon balance and GHG emissions
5. Soil biogeochemistry
6. Productivity (agricultural and fuel loadings)
7. Value, understanding, appreciation of peatlands by people, and benefit to the health and well-being of people.

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