Evaluating the Effectiveness of Peatland Restoration Techniques

Image Credit: Jack Brennand

Peatland restoration aims to cap greenhouse gas emissions by rewetting and revegetating degraded sites[1]. A range of techniques exist, differing in materials, transport pathways, and installation methods[2]. These range from locally sourced materials installed manually to engineered products delivered through global supply chains and helicopter transport.

Brennand *et al*. (2025) shows different restoration techniques incur substantially different carbon costs associated with materials, transport, and installation[3]. When accounted for, these costs affect estimated carbon savings and early carbon credit claims. Despite this, multiple techniques are often prescribed for the same intervention goal. For example, peat, plastic, timber, and stone may all be used to block erosion gullies of similar dimensions[2], even though their carbon costs differ considerably[3].

In practice, technique choice is guided by site conditions, accessibility, and upfront cost. While carbon costs are increasingly considered[3], evidence on functional outcomes and benefits beyond carbon remains limited. Recent findings show carbon alone may be a weak metric of restoration success over decadal timescales[4], demonstrating the importance of considering broader outcomes such as biodiversity gain. Binary surface condition thresholds, such as those used in JNCC assessments of restoration success[5], can also mask differences in ecological recovery and near-surface hydrological function across degraded peat surfaces.

The effectiveness of peatland restoration is determined by how interventions influence sub-surface structure and function. Water retention, gas exchange, and long-term carbon storage are governed by the organisation and connectivity of peat pore networks beneath the surface, rather than surface indicators alone[4,6]. Techniques differing in how they disturb or recover peat porosity, including the treatment of compact, hydrophobic surface layers, can therefore deliver different functional outcomes, even when surface responses appear similar[4].

Evaluating restoration techniques using sub-surface structural recovery, bulk chemical indicators, surface condition, biodiversity response, and carbon cost provides a stronger basis for comparing effectiveness in practice. Integrating this evidence supports more informed technique selection and improves confidence in private investment by aligning restoration practice more closely with functional and carbon outcomes under Environmental Improvement Plan (EIP) targets.

Overview

This practice note compares peatland restoration techniques based on their functional performance and net benefit.

1. Commonly used peatland restoration techniques are evaluated beyond surface condition, using evidence on sub-surface structure and bulk chemical indicators relevant to long-term function.

2. Outcomes are compared across techniques, showing where binary surface condition criteria classify sites as similar despite differences in biodiversity.

3. Functional metrics are considered alongside carbon costs, supporting more informed technique selection and helping identify approaches delivering greater net benefit under different site conditions.

This note draws on research from Brennand, J. (2025), *Evaluating UK Blanket Peatland Restoration: Structure, Function, and Net Carbon Benefit*, undertaken as part of an ERDF-funded ECO-I NW PhD project within the Institute of Science and Environment at the University of Cumbria. Sub-surface 3D X-ray micro-computed tomography research was supported by the National Research Facility for Lab X-ray CT (NXCT) through EPSRC grant EP/T02593X/1.

Restoration techniques differed in their sub-surface structural and biogeochemical impacts. Turving delivered greater functional recovery than heather brash spread, forming a more intact acrotelm capable of surface water uptake and retention (Figure 1). However, even after a decade, turved profiles remained structurally distinct from near-natural, lacking a developed mesotelm. Turving acted as a physical and biogeochemical 'cap' that limited near-surface oxidation, but its influence on deeper, laterally connected drainage networks was limited, particularly in earlier restorations (~2 years).

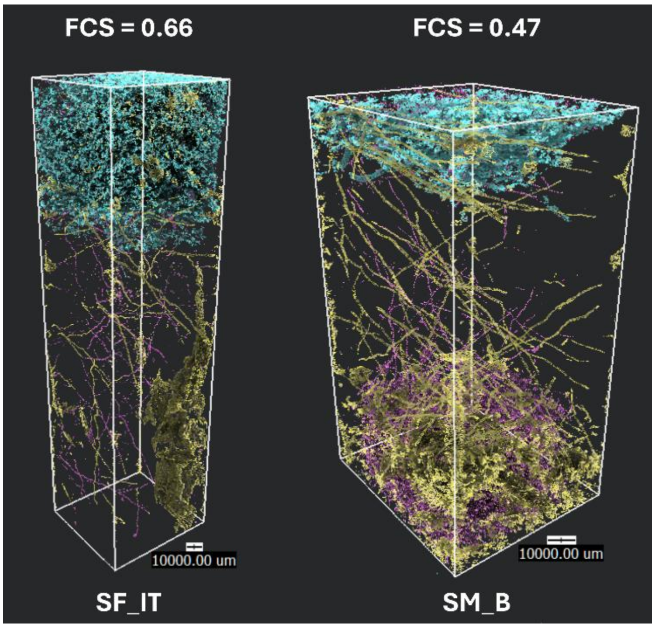

Figure 1: Surface favourable condition scores (FCS; 0.00 = unfavourable, 1.00 = favourable) for two contrasting restorations (SF_IT: ~2y/o, imported turving; SM_B: ~2y/o, heather brash spread), shown alongside 3D µCT renderings of sub-surface pore network structure. Networks are classified as atmosphere-connected (blue), laterally connected (orange), isolated (purple), illustrating contrasting sub-surface structure and condition.

All restored sites were classified as unfavourable under JNCC surface condition criteria, and sub-surface structural and functional metrics did not distinguish between locally sourced and imported turves. In contrast, biodiversity indicators revealed differences between techniques. Local turving supported higher indicator species abundance and cover, with fewer characteristics associated with degradation (Figure 2). This shows binary surface condition thresholds can mask ecological gains, and biodiversity outcomes can differentiate techniques where carbon metrics do not.

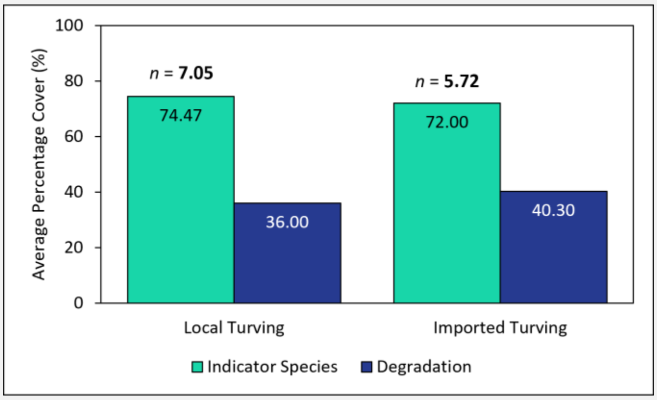

Figure 2: Average JNCC (2009) indicator species richness (n) and percentage cover, alongside degradation extent, for locally sourced and imported turved sites. Locally sourced turving shows higher indicator species abundance and lower degradation despite approaches classified as unfavourable under combined surface favourable condition scores (FCS).

Comparison across techniques shows higher carbon cost does not equate to greater functional recovery (Figure 3). More exotic material- and transport-intensive interventions did not deliver more favourable sub-surface structural or biogeochemical outcomes than lower-carbon alternatives. Local turving achieved the greatest functional benefit despite lower carbon costs, demonstrating intervention intensity does not guarantee improved restoration function. Evaluating techniques on net benefit, rather than carbon cost or delivery scale, provides a more robust basis for practice.

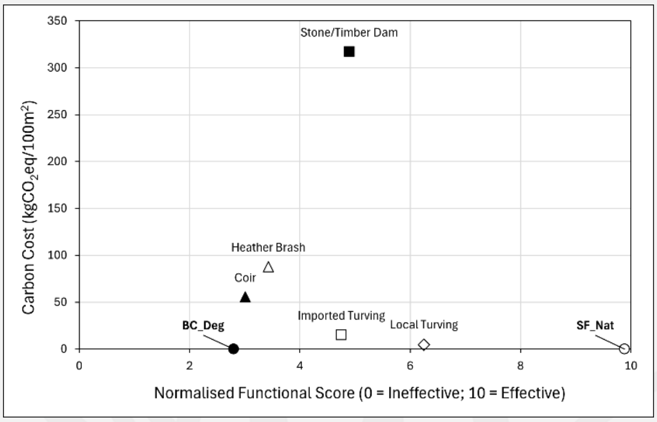

Figure 3: Comparison of mean normalised favourable condition scores (0 = ineffective; 10 = effective) and carbon costs (kgCO$_2$eq per 100m^2) for selected restoration interventions. Functional scores integrate sub-surface structural, bulk chemical, and surface condition indicators. Carbon cost estimates are derived from Brennand et al. (2025), illustrating higher carbon cost does not correspond to greater functional benefit.

Turving should be prioritised over alternative revegetation techniques. Turved sites formed a more intact acrotelm, supporting surface water uptake and retention and improving restoration effectiveness. Local turving, where materials were sourced on site, delivered greater functional benefit at a lower carbon cost than imported materials. Local turving also supported greater biodiversity gains, reinforcing the value of using locally sourced peat in promoting ecosystem service recovery beyond carbon. Findings are likely transferable to other restoration interventions, including gully blocking, where peat-based may better support vegetation recovery and peat-forming species establishment.

While turving delivered functional benefits, restored profiles did not exhibit a well-developed mesotelm (transitional layer between the acrotelm and catotelm) characteristic of near-natural peat. Degraded, bare peat surfaces lack atmosphere-connected porosity at the surface[4], indicating a compact and hydrophobic layer restricting surface water uptake and rewetting. Mechanical disruption of this hydrophobic surface prior to turve placement may improve contact between turves and underlying peat, increase surface roughness and friction on slopes, promote mesotelm development, and suppress deeper drainage pathways through collapse of preferential flow channels. This approach has the potential to accelerate functional recovery and improve long-term hydrological resilience (Figure 4).

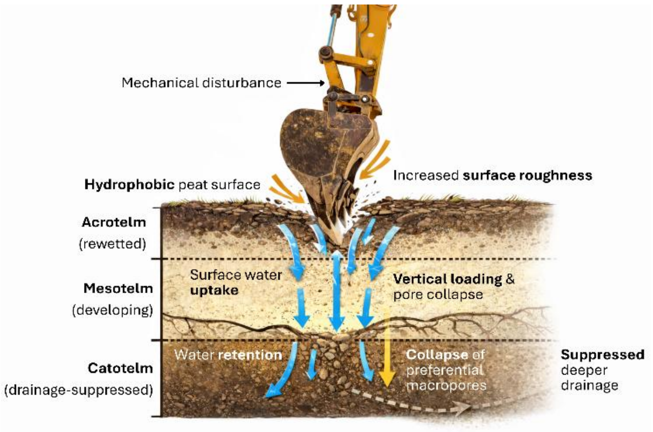

Figure 4: Conceptual illustration of mechanical disruption of a degraded, hydrophobic peat surface prior to turve placement, highlighting proposed functional and resilience benefits.

Key Findings

1. Turving delivers greater sub-surface functional recovery than heather brash spreading, forming a more intact acrotelm supporting surface water uptake and retention, although restored profiles remain structurally distinct from near-natural peat.

2. JNCC surface condition criteria mask differences between restoration techniques, with biodiversity assessment revealing local turving to be more effective than imported materials despite similar surface and sub-surface condition scores.

3. Higher carbon cost does not equate to greater functional recovery, with lower-carbon techniques often delivering greater sub-surface outcomes than more material- and transport-intensive interventions.

Findings demonstrate the importance of aligning restoration practice with functional outcomes rather than surface appearance or carbon cost alone. Prioritising low-carbon, locally sourced materials and incorporating simple surface preparation measures may enhance hydrological function, resilience, and biodiversity recovery, supporting more effective and credible peatland restoration.

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